THE GREAT ABALONE PLANT

Cooperation Between Divers –Amateur and Professional

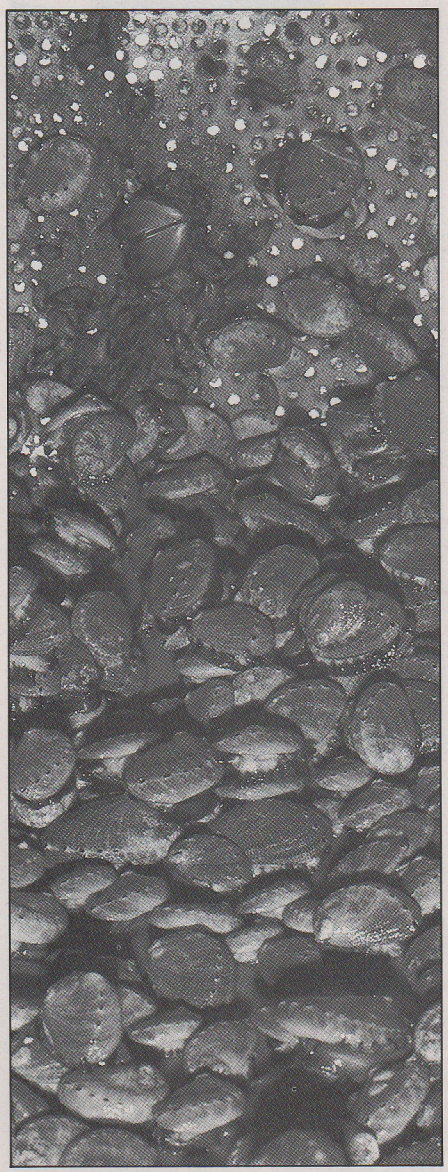
by D. B. Pleschner

THE *Conception* moved regally into Cuyler's Cove at San Miguel Island, its deck overflowing with sea bags and eager divers in various stages of undress. Just then, the skipper's voice boomed over the radio, "Where's the Great Abalone Plant?" The only other boat in the anchorage, a twenty-six-foot Radon a third the *Conception*'s size, with none of its creature comforts, seemed an unlikely target for the message. But Jim Finch, on the Radon, was glad to see the big boat arrive for the first time in his life. Grabbing the mike, he yelled, "It's right here! Anchor where you can and I'll tie up alongside." Within the hour, eight more commercial abalone boats as small and primitive as Jim's flanked the crown jewel of Southern California's sport dive fleet.

The two dive groups seemed strange allies, given their fractious past encounters. Yet their enthusiasm was as contagious as their interest in the 9,000 thumbnail-size snails squirming in coolers on the *Conception*'s deck. Many sport divers had never before seen live yearling abalone, although they had all picked and eaten the giant sea snails. Now, for the hundreds they had taken over the years, they were about to put back thousands in a precedent-setting event: the first joint sport-commercial effort to restore California's declining abalone resource.

Commercial divers of the California Abalone Association (CAA) had worked for years replanting abalone on reefs around San Miguel and other Channel Islands off the Southern California coast, a sport diving mecca and the commercial fishery's Waterloo, its last major harvest grounds. CAA veterans like Jim Finch, treasurer, and Win Swint, the group's president, were walking encyclopedias of abalone lore after exploring the ocean bottom dawn to dusk for decades.

Long hoping for sport participation to boost their reseeding work force and defray the cost of seed abalone (fifty cents to a dollar each), CAA divers brainstormed the co-op conservation project. They were elated when close to thirty sport "catchers" signed up, chipping in $100 each for seed, and owners Roy Hauser and Glen Fritzler donated the *Conception* for the Great Abalone Plant.



The Ab Lab, the abalone hatchery that supplied the young animals for the Great Abalone Plant, raises its juveniles to reseeding size in 55-gallon polyethylene drums. The holes in the end of the drum allow sea water to pass through, acclimating the yearlings to the marine environment. [D.B. Pleschner]

The *Conception*'s galley buzzed with anticipation the night before the plant as commercial divers shared their experience in a crash course on reseeding procedure. Narrating a film clip he had prepared, CAA veteran Jon Holcomb cautioned that young abalone are fodder for a host of species, all looking for a handout. Divers should relocate starfish, distract reef fish by cracking open a sea urchin, and watch out for hidden crustaceans, he said. In the film, divers first scraped invertebrate turf off the planting sites—narrow, smooth-faced crevices undercut in the reef near a sandy bottom and other abalone. Then they placed a few little snails in each clearing, pressing them gently until they clamped down, spacing the clusters at least two feet apart to minimize predation yet still allow the abalone to intermingle their spawn.

On film the job looked easy, although everyone at least suspected that the morning's going would be tough. Nonetheless, divers crowded the rails as the flotilla spread out along San Miguel's eastern shore. Armed with good will and ziplock Baggies full of sea snails, they plunged into the chill green ocean with Win Swint's advice ringing in their ears: "This will be just like planting trees. You'll dig a thousand little holes, and it will take time."

TIME HAS WORKED both for and against abalone. The simple gastropods have evolved in the ocean for 65 to 100 million years. Yet their slow growth, averaging an inch a year, has caused a general decline wherever the resource is exploited, in a multitude of countries.

As many as 100 abalone species, including hybrids, inhabit nearshore reefs in most of the oceans on Earth. California waters harbor seven species, including the world's largest, *Haliotis rufescens* or "reds". The legal sport length measures at least seven inches, commercial at least seven and three quarters. Found only on the West Coast between Southern Oregon and Baja and harvested commercially only in California, reds are the traditional mainstay of the fishery—the chief abalone industry in the United States.

Japan, the world's major abalone consumer along with Hong Kong, boasts ten *Haliotis* species; five provide the commercial catch. Australia, New Zealand, Korea, Mexico, and South Africa likewise produce much of the world's abalone.

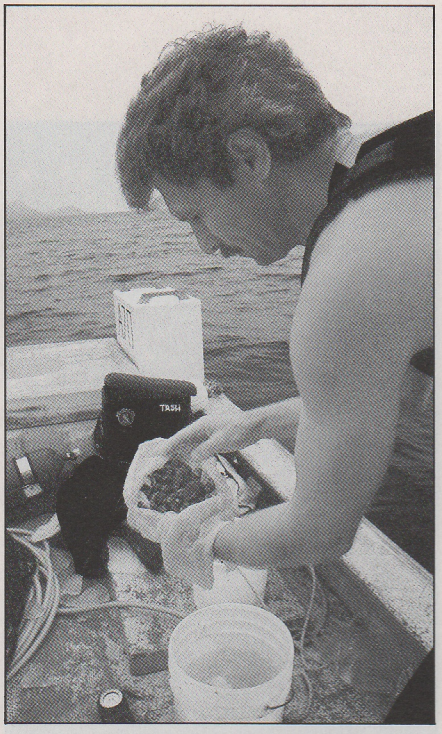
Indeed, abalone are one of the world's premier seafoods, whether dried and sliced, pounded and fried, poached, or eaten raw. Their decline in the face of mounting demand has spawned new, worldwide interest in abalone mariculture.

In California, open-ocean reseeding is one arm of a growing mariculture industry. Hatcheries have sprung up, making efforts like the Great Abalone Plant possible. Divers are also leasing tracts of seafloor to farm abalone. And scientists are developing new technology that is drawing attention even in Japan, world leader in ocean farming.

The Japanese, who dove for abalone as early as A. D. 425, began scientifically manipulating abalone reproduction in laboratories by the 1950s and pioneered the hatchery concept. Today, at least twenty-five or thirty government-subsidized Fish Farming Centers produce abalone in outdoor raceways and juvenile growing tanks. Such multi-species hatcheries raised over 10.7 million abalone seed in 1978. Fishing co-ops buy twenty-millimeter (about three-quarter-inch) abalone for some twelve cents apiece to restock their coastal waters; to protect the crop, they also control local fishing rights.

According to centuries-old custom, the co-ops set fishing seasons, decide who can fish (there is no sport harvest), and regulate restocking procedures. Fishermen also grow kelp and remove predators before planting their abalone. They harvest in three or four years, when the abalone are about four and two thirds inches long. But the harvest is limited to a few days a year—a bonus fishery. The Japanese resource cannot support yearlong pressure despite reseeding efforts.

By comparison, California's abalone industry is a Johnny-come-lately. Even so, it has expanded on Japanese methods, beginning with the "hardhat" deep-sea diving system that immigrant Japanese divers introduced around 1900 which revolutionized the fishery.



Top: Abalone from one-half to one inch long are usually used in open-ocean reseeding projects. Larger animals have a higher survival rate, but raising them to a larger size is economically unfeasible. Center: A sport diver unwraps a bundle of baby abalone, preparing to reseed a reef in California's Channel Islands. The Abalone Plant was the first joint sport-commercial reseeding project. Bottom: A diver prepares to plant a juvenile near a sea urchin, whose spines will both protect the abalone and catch drifting kelp for the snail to eat. The commercial divers had given the sport groups a crash course in abalone habits and habitat. [D.B. Pleschner]

In its heyday, the fishery centered on the central coast. Oldtime divers still recall how the reefs were then—cobbled with abalone—the most productive red abalone country in the world. Between 1916 and the 1960s California's red abalone catch averaged 2 million pounds a year, peaking at 2.8 million in 1961. Most of it came from a forty-six-mile stretch of ocean above Morro Bay.

As fate would have it, abalone flourished because the nearshore's keystone predator, the sea otter, was absent. A single adult otter, requiring at least a quarter of its body weight in food daily, eats over two tons of shellfish a year, including sea urchins and crabs as well as abalone. Sea otters once ranged along the entire eastern Pacific rim. By the early 1900s, however, California's otters were thought to be extinct, victims of the fur trade. Of course, they were not: from a group of two or three hundred discovered near Big Sur in 1938, they miraculously recolonized the central coast between Monterey and Morro Bay, numbering an estimated 1,000 by 1968. But by then, abalone were rapidly disappearing.

What happened to the central coast's red abalone is a question that still evokes controversy. In the years from 1950 to 1970, California's human population almost doubled, bringing more divers and increased pollution. Some observers argue that taking two million pounds of abalone every year was asking too much of the resource. And some blame the return of the otter.

Senior marine biologist Earl Ebert headed the Department of Fish and Game investigation at the time, diving reefs in and outside the expanding sea otter range. "The decline occurred right where otters happened to be and followed them down the coast," he declares. "Where otters were established, most of the exposed abalone were gone, regardless of size. Outside their range, we saw reefs with hundreds of abalone just under legal size. The evidence is documented," he adds, "but I still can't convince the man on the street. He looks at the shell piles behind processors' shops and thinks that's where all the abalone went."

Whatever the reason, the central coast abalone decline changed the course of the fishery. Morro Bay's abalone industry finally closed shop in the early 1970s. Picking pressure shifted south to the Channel Islands at a time when new, fast boats and streamlined gear sparked a diving boom in California. The islands' biological climate—warm water and swift currents, unlike conditions on the central coast—may have

hastened the reduction of abalone stocks. Nearshore pollution also decimated the resource in some areas. Still, divers agree that the prime culprit was overfishing.

As a result, the commercial all-species catch dropped from an average four million pounds to 1.1 million in 1982. Only 363,000 pounds were reds. The shortage has pushed abalone steaks to $25 a pound wholesale, removing the landmark entrée from most restaurant menus.

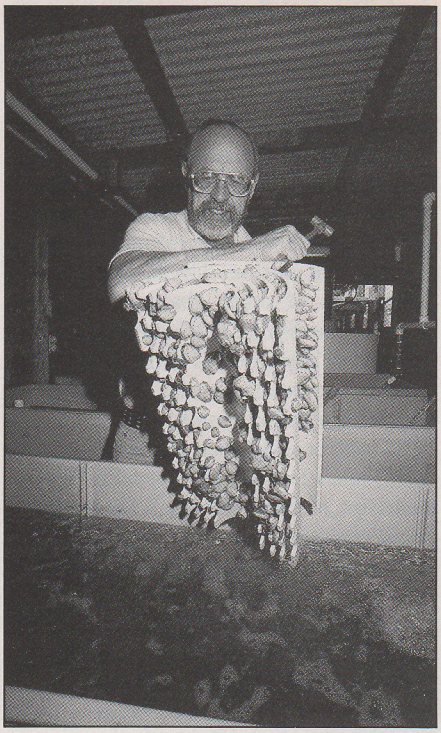
THE ADVENT OF HATCHERIES and reseeding programs offers some hope that these trends can be halted. The earliest hatcheries were developed around 1968, thanks to the groundbreaking work of Dr. David Leighton, who began studying abalone in the 1950s; and in 1970 Earl Ebert, drawing on Japanese technology, set up the Department of Fish and Game's shellfish research laboratory. He has been disseminating information ever since.

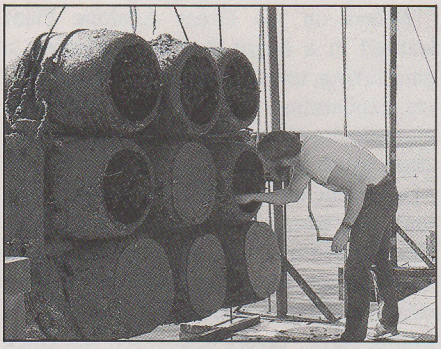
One beneficiary of Ebert's advice has been John McMullen, owner of the Ab Lab, a prototype hatchery operating at Port Hueneme in Southern California since 1974. With its innovative techniques, the Ab Lab has drawn mariculturists from the world over; it is California's first self-supporting hatchery. McMullen raises abalone in fifty-five gallon polyethylene drums that originally stored Argentinian apple juice concentrate. He calls the method "barrel culture".

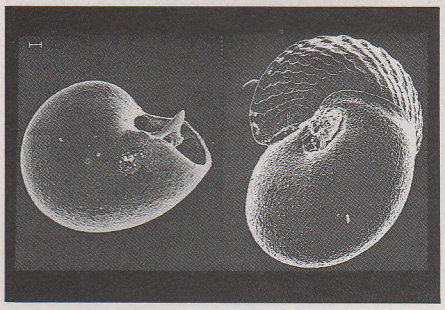
Refining the Japanese system, McMullen racks the barrels and suspends them off the pier, taking advantage of a natural supply of raw, clean sea water and eliminating expensive pumping. The Ab Lab can house a million fertilized larvae at a time in its fifty juvenile rearing tanks. Early survival is low, at five to eight percent; and after about five months, only 1,500 to 2,000 animals per tank live to see the grow-out barrels. But this rate exceeds the Japanese recovery average of one percent at the twenty-millimeter size.

"I believe a three- to four-inch abalone is the maximum size we can culture in a contained environment," he comments. "The space requirement alone for a five-inch animal is prohibitive. The availability of kelp is another limitation that will restrict operations like ours. We hope someday to produce over a million abalone a year; in an operation like that, you need seven to fourteen tons of kelp a week."

McMullen raised over 75,000 abalone, one to three inches in size, during 1983, and he sold them all. The smaller animals went to reseeding projects: because McMullen's containers acclimate young abalone to a marine environment, the snails are prime candidates for open-ocean reseeding. In fact, he supplied the animals for the Great Abalone Plant.







Top: Marine biologist Earl Ebert of the California Department of Fish and Game holds up a tiered snail "condo" containing some 800 juvenile abalone. The condos are placed in concrete habitats, which protect the snails while they acclimate to the ocean environment; after a few days, the doors open, and the abalone crawl out to find spots on the reef. Center: The barrels at the Ab Lab are winched up out of the water once a week for maintenance and to feed the abalone. [D.B. Pleschner] Bottom: The amino acid GABA, derived from red algae, induces abalone larvae to metamorphose into bottom-dwelling snails. In this electron micrograph, the growth of the shell on the left is contrasted with that in an uninduced sibling larva on the right. [Greg Young and Dan Morse]

The larger abalone McMullen sold to restaurants. About three years ago, he created a market for two-inch abalone hors d'oeuvres. He sells the snails for $1.25 each. Some restaurants marinate them in lemon juice and olive oil; some fry them, a minute a side. One published a recipe for *ormeau comme chez nous*, serving the bite-size novelty with beurre blanc.

Estero Bay mariculture, on the central coast at Cayucos, markets another treat: "medallions" of abalone, four-inch snails that yield about one ounce of meat each and sell for $2.10 an ounce. Founded in 1968 by Dr. David Leighton and partners, Estero Bay operates 27 concrete raceways and plans 123 more on its fifteen-acre site, looking for peak annual production of two million abalone. "We anticipate producing a half-million seed and selling 150,000 four-inch abalone in 1984; 1985 should be our turnaround year," says Frank Oakes, associate biologist in the venture.

To get around the problem of supplying the animals with food, Oakes is experimentally stockpiling kelp. But, he asserts, water quality control is the most imortant factor in land-based production. Poor water can damage the animals' gills and stunt growth.

"Actually," he adds, "the biggest limiting factor is money. You have production costs, labor costs, space costs. Every abalone in the container needs a place to put its foot. There's room for operations like this," he chuckles, "but I don't think any of us will get rich."

In containerized mariculture, production costs skyrocket with the age and size of the abalone. Hatcheries world wide still estimate growth at an inch a year; however, scientists at the University of California at Santa Barbara (UCSB) are working to raise that figure. Dr. Dan Morse, a Harvard biochemist, began studying abalone at UCSB over ten years ago, expanding research on molecular mechanisms that turn genes on and off, regulating reproduction, development, and growth. Funded by the California Sea Grant College Program and other agencies, Morse's award-winning UCSB team first discovered that hydrogen peroxide induces spawning by causing abalone to produce prostaglandin, the same hormone that regulates reproduction in humans. So far, the method works on thirteen abalone species and twenty-nine other molluscs from California to China, including scallops, oysters, clams, and mussels.

The team won another World Mariculture Society prize by solving the metamorphosis puzzle. Morse found that aba-

lone larvae have specialized chemoreceptors that trigger settlement on specific substrates. The presence of red coralline algae induces swimming larvae to metamorphose into benthic snails. In his laboratory, Morse exposed larvae to the amino acid GABA, extracted from algae, and got virtually 100 percent settlement and survival through one month. "Healthy, rapidly growing juveniles, all the same size," he exclaims. "In the absence of GABA you get less than 10 percent survival, no matter what you do. Bacterial contamination causes most of the mortality." Because GABA is known to work as a chemical messenger in the human brain, discovering that it also controls development may help explain certain neurological diseases.

Still, the team's most futuristic research involves abalone growth requirements. "Commercial divers have seen growth in the wild triple the published norm," Morse observes. He and his colleagues have isolated a natural growth hormone and are employing recombinant DNA technology in an attempt to clone and modify the gene which codes for that hormone, hoping to optimize hormone production and accelerate hatchery growth rates. "We'll also attempt to reintroduce the improved gene into abalone," Morse says. "Land-based mariculture would be more feasible if we could produce three-inch abalone in one year instead of three."

HATCHERIES MAY SOMEDAY produce cocktail or scallop-size abalone, but in California they cannot erase the demand for big, mouth-watering abalone steaks. The only way to restore legal-size abalone is open-ocean reseeding, and to expedite that process, Morse advocates planting "miniseed". "With hydrogen peroxide and GABA you get very high numbers of healthy small animals with very low cost," he says enthusiastically. "We need to develop ways to plant out large numbers of miniseed effectively."

Albeit the jury is still out on GABA's long-term effectiveness, the miniseed concept is gaining support. Japanese fishermen are considering alternatives like miniseed and submersible grow-out cages because they recover only 10 to 30 percent of their hand-planted abalone. In California, recovery fell below two percent in scientific experiments.

Marine biologists from Scripps Institution of Oceanography and the Department of Fish and Game have planted almost 100,000 abalone in a five-year study also supported by the California Sea Grant College Program. In some experiments, half the abalone are unaccounted for, either alive or dead. They just disappeared. "We can't rule out that they got up and walked away," says project leader Mia Tegner, from Scripps. "We've found identifiable abalone up to a half a kilometer outside our plant sites.

"There are positive effects of reseeding," she points out. "In some areas, populations of small native abalone seemed to go way up." The observation reinforces Japanese findings that abalone larvae settle on the slime trails of other abalone. However, Tegner believes that hatchery abalone conditioned to daylight and hand feeding may behave abnormally in the wild—another reason for planting younger seed.

To protect small seed in the ocean, Fish and Game's Earl Ebert is developing a release cage, a "halfway house". His model is a tiered abalone "condo" set into a concrete gas-meter box. Fastened with magnesium links that decay in seawater, the cage will, in theory, allow abalone to acclimate and then escape. If it works, divers will be able to set down hundreds, perhaps thousands, of tiny snails at a time, at a fraction of the cost and labor required in hand planting.

Divers on the Great Abalone Plant learned in a hurry that hand seeding is painstaking, time-consuming, exhausting—yet exhilarating. They found reefs honeycombed with likely-looking crevices, but close inspection revealed no bare space. Many of the holes were too jagged for abalone: like hemophiliacs, once cut they can bleed to death. Often, after spending minutes searching for a good spot and scraping it clean, working nearly upside down in the rolling surge, divers discovered the crack was already occupied, a tiny camouflaged crab or the like glaring at the intrusion. Evicting the resident, divers then had to slide an abalone from the baggie, again no easy feat since the snails were usually stuck together like little suction cups. And the open bag attracted plenty of curious fish. Finally perched on the divers' fingers, the yearlings entered their new homes. But even then, sometimes they refused to clamp down, or they inspected the premises and crawled right back out.

Despite its snail's pace, though, reseeding went like clockwork. Commercial divers ferried sport divers and abalone to the plant sites and led groups across the reefs, pointing out suitable habitat and demonstrating technique in a new kind of buddy system. Some sport divers worked off commercial boats, taking a turn on commercial hookah gear for the first time, "flying" with unlimited air, time, freedom. They saw reef life through new eyes in the process.

At day's end, 2,000 abalone remained unplanted; commercial men would spend two extra days at the task. Yet before the *Conception* left for port, bone-weary divers brimming with new appreciation of the resource and each other were already planning the second Great Abalone Plant. Win Swint applauded their spirit as he thanked the group, adding, "I hope you all take home good feelings, mainly that you've just given something back to the sea."

SO THEY HAD—and it is just the beginning. Foreseers like Earl Ebert envision large areas reserved for open-ocean farming, where divers can practice predator and competitor control, supply artificial habitats, and even farm kelp. "We're talking about the future, although the pioneers are already out there," he says.

Some of these same foreseers, however, point to a threat from an expansion of the sea otter population and range. The history of Morro Bay offers evidence that while otters do not eliminate all abalone, they do preclude an abalone fishery. State Fish and Game managers advocate establishing otter refuges and shellfishing zones to preserve both natural resources. But California's otters are protected under the Marine Mammal and Endangered Species Acts, transferring authority to the United States Fish and Wildlife Service. The federal agency plans to translocate part of the herd as a safeguard against a possible oil spill, and the site receiving the most attention is San Nicolas Island, outermost of the Channel Islands.

Federal officials recognize that some type of zonal management ultimately will be required, and scientists are investigating safe sea otter containment methods. However, a lot of people balk at the thought of managing such a winsome creature as the sea otter, believing that otters have first right to the nearshore and first rights to shellfish—after all, they were here first.

Besides, groups such as Friends of the Sea Otter point out, even without management the existing sea otter population in California does not seem to be expanding. From 1938 to 1976, the herd grew at a rate of 4 to 5 percent a year, reaching an estimated peak of nearly 1,800 animals. (Sea otters in Alaska, by contrast, have expanded at a rate of 10 to 14 percent and now number about 200,000.) Recent censuses put the California population at 1,300 to 1,500.

The otter's former home along the central coast is less hospitable than it once was. One hazard is oil in the water, which mats down the otter's fur, eliminating the insulating layer of trapped air and leading to hypothermia and pneumonia. Between 1968 and 1980, biologists from the California Department of Fish and Game examined tissue

samples from dead otters and identified DDE, PCBs, and some toxic metals, but none at a level thought to be harmful to the animal. However, recent evidence suggests that 50 to 100 otters a year might be drowning in gill nets. The Department of Fish and Game has therefore closed Monterey Bay to gill nets within fifteen fathoms and is contemplating closure throughout the otter range.

The purpose of the proposed San Nicolas Island translocation is to establish a reserve breeding colony, ensuring that a single disaster, like a major oil spill, would not eliminate the bulk of California's sea otters. Sea otter enthusiasts are confident that the colony can be confined to that island. They claim that abalone mariculture deserves all the support it can get, but not at the expense of the otter.

On the other hand, past translocations in Alaska have revealed that otters tend to emigrate, some traveling thirty to fifty miles from their release site. Shellfishermen and many scientists fear that a translocation to San Nicolas would jeopardize shellfishing and open-ocean mariculture—sooner or later—around all the Channel Islands.

Ultimately, the conflict goes beyond the question of who gets the shellfish. The final issue boils down to multiple use of the ocean: man's place in the marine environment. Win Swint declares, "Sea otters have a right to be here, certainly; but we think we do, too. We'd like the chance to replenish the resource we have left—a resource hammered down by its popularity. We're encouraged that we can do it."

Though still in its infancy, abalone farming has already enriched man's knowledge of marine ecology. The reseeding program's success will not be visible for three or four years, but CAA's earliest efforts appear promising: abalone are abundant on reefs where there used to be few. And since the first Great Abalone Plant, divers have noticed little abalone "crawling all over the reefs" at San Miguel.

California Abalone Association has now established an abalone "bank" where divers can withdraw seed for the abalone they pick. The sport-commercial alliance has just concluded the second plant, held in early August near Santa Catalina Island. The divers know they are fighting an uphill battle, both biologically and politically. Even so, sport divers are sporting CAA T-shirts these days. Beneath the abalone logo is their slogan: We're Growing for It.

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