

INVASIVE SPECIES

California Tries to Rub Out The Monster of the Lagoon

With the seaweed *Caulerpa* a global threat, the world is closely watching an eradication effort in California

SAN DIEGO—In a planet increasingly flooded with invasive species, victories are rare. But a dogged team of scientists and resource managers in California is hoping to beat the odds and triumph over the world's most formidable seaweed.

The target is *Caulerpa taxifolia*, an alga native to the tropics. One cold-water strain thrives in aquaria. But that trait also makes it a threat to temperate coastlines around the world. All that's needed to seed an invasion is one saltwater hobbyist or aquarium store owner carelessly dumping algae-laden water.

Officials in the Mediterranean and southeast Australia have already abandoned any hope of eradicating this strain in their waters. But 21 months after the exotic alga was discovered flourishing in a San Diego County lagoon (*Science*, 14 July 2000, p. 222), officials are hopeful that California's decision to act quickly will help it succeed where others have failed. At the same time, some scientists feel that those managing the eradication campaign could better fight their foe by trying to learn more about it.

As invasive organisms go, the aquarium strain of *C. taxifolia* is an ecologist's nightmare. It crowds out native flora, knocking out the base of the marine food web, diminishing biodiversity, and impairing fisheries.

Spreading outward with runners, it grows several centimeters a day and forms a dense green carpet that excludes all other plants. Its toxins deter herbivores that might otherwise keep its growth in check, and it does not die back in winter. It reproduces asexually from even the tiniest fragments of any part of the plant, so a single torn frond can begin a new colony. Its only weakness is an inability to reproduce sexually, as do its wild relatives. Scientists don't know if the cause is genetic or environmental, but they say

that this *C. taxifolia* strain could become unstoppable if it finds a way to disperse eggs over long distances.

Those characteristics, combined with boat propellers and fishing nets, have allowed the strain to spread from its humble start beneath the Oceanographic Museum of Monaco in 1984 into a monster covering 30,000 hectares of coastal sea floor off six Mediterranean nations. More recently, the global aquarium trade apparently also brought it to six locations near Sydney, Australia, and in June 2000 to biologist Rachel Woodfield's doorstep at the Agua Hedionda lagoon north of San Diego.

Woodfield consulted experts to help identify what had been encroaching on the native eelgrass, and within days a team of scientists, industry managers, and gov-



Liquidation. Divers pump liquid chlorine into the mud and water to kill the unwanted strain of seaweed, *Caulerpa taxifolia*.

ernment officials had coalesced into the Southern California *Caulerpa* Action Team (SCCAT). Lacking clear federal or state guidelines, they cobbled together funding and set to work. "We didn't want to duplicate the problems the Europeans had [and] get involved in a long, bureaucratic process," says Robert Hoffman of the U.S. National Oceanic and Atmospheric Administration, one of the partners in the action team.

The power company that owned the lagoon immediately funded its consulting

firm, Merkel & Associates, to send divers into action, running surveys, taking growth measurements, and testing herbicides. Crews used tarps to quarantine patches of the weed and pumped deadly liquid chlorine into the water and mud that anchors the plants. SCCAT also produced and distributed 100,000 copies of an educational brochure describing the danger. In short order, San Diego's City Council banned the sale and possession of *Caulerpa*.

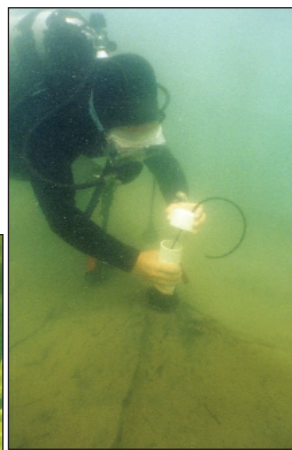
But there were limits on the public's commitment to waging a seaweed war. Although recreational restrictions were imposed, SCCAT's proposal to prohibit boats for an unspecified period "went over like a lead balloon," admits head consultant Keith Merkel: "It's a careful balance. You don't want to alienate people who are supportive."

While SCCAT worked to educate aquarium retailers, Susan Frisch and Steven Murray of California State University, Fullerton, surveyed *Caulerpa*'s commercial availability. They found that 52% of Southern California retailers were selling *Caulerpa* and that 95% were selling "live rock" (rock or coral covered with organisms), some containing *Caulerpa* fragments. Such data helped convince state legislators to ban nine species of *Caulerpa*. "If this thing gets out of the bottle, we're going to have a real problem on our coasts," says Assembly Representative Thomas Harman, whose Huntington Beach district was the second site of infestation.

So far it's still in the bottle. Over 99% of the original biomass has been treated, and surveys are turning up fewer and fewer new plants. Tests of cores from within the tarps have found no evidence of viability. "Cautious optimism" is the operative phrase.

But daunting challenges greet the start of the new growing season. One is money. SCCAT's current funding will dry up at year's end, and the team is still looking for the \$1.5 million a year needed to sustain the eradication effort.

SCCAT also needs to resolve internal debate over the role of science in the management process. Its eradication policy barred researchers from obtaining samples and performing fieldwork for fear that researchers might inadvertently fragment the plants and hasten their spread. Susan Williams, an ecologist at the University of California, Davis, and director of the Bodega Bay Marine Laboratory, would have liked to see studies of the effectiveness of eradication methods, including collateral effects of



chlorine treatment, as well as ecological and life-history studies. But eradication leaders express few regrets about the way things were done, and some outside observers agree. “The Californians chose to shoot first and ask questions later,” quips Australian phycologist Alan Millar of Sydney’s Royal Botanic Garden. “And I think in this case that was necessary.”

Tension between eradication and research is “a recurring theme in biological control,” says Edwin Grosholz, a University of California, Davis, biologist, who organized a *Caulerpa* conference last month in San Diego. “But you can eradicate at full speed [while] also learning something about what you’ve done.”

Scientists believe that they already know enough to fear other species in the

genus. A strain of *C. racemosa* with similar biological traits and impact on ecosystems is spreading rapidly in parts of the Mediterranean. Of the world’s more than 70 *Caulerpa* species, invasive behavior has been documented in five, Williams says. But few species are well studied, and many are involved in the aquarium trade; Frisch and Murray’s survey found 16 species in 26 California pet shops alone.

For this reason, and because identifying *Caulerpa* species can challenge taxonomic specialists, let alone enforcement officers, scientists had urged the California legislature to ban the entire genus. But the aquarium industry lobbied successfully to restrict Harman’s bill to only nine species. Sure enough, shortly after the ban went into effect last September, inspectors in San Fran-

cisco let through a shipment of live rock from Indonesia containing “*Caulerpa* species,” according to the state Department of Fish and Game. The inspectors apparently were unable to identify the algae to the level required under the law.

That’s not good enough, says French phycologist Alexandre Meinesz of the University of Nice, who first sounded the alarm in 1989. Many countries with temperate coasts, from Japan to South Africa, should be preparing to confront *Caulerpa*, he says, noting that New Zealand is among the few that so far seem willing to step up to the challenge. Nations hoping to root out the invader will need a model of success, however, leaving all eyes on California.

—JAY WITHGOTT

Jay Withgott writes from San Francisco.

U.S. DEMOGRAPHICS

New Annual Survey Brings Census Into 21st Century

The new American Community Survey will let researchers and public officials get their hands on fresh data annually rather than having to wait 10 years

The U.S. census offers demographers a wonderful snapshot of the country’s population. But snapshots are static pictures of an ever-changing world, and recent history has exposed their limitations. The longest economic boom in U.S. history went bust shortly after the 2000 census was conducted, for example. Then came the 11 September terrorist attacks.

Starting next year, the entire nation will begin to get feedback about dozens of social indicators on an annual instead of decennial basis. The exercise, called the American Community Survey (ACS), will, when fully implemented, be “the most important innovation [in census history] at least since sampling theory,” says former census director Kenneth Prewitt.

Began in 1790, the U.S. census has two purposes. The first is to determine the distribution of seats in the U.S. House of Representatives, based on population. The second—what Prewitt likes to call “the nation’s longest continuous science project”—is to probe social and economic conditions through questions about topics such as income, race, education, disabilities, military service,

jobs, and commuting time to work. For 150 years, every household received what was known as the long form. That changed in 1940 with the introduction of sampling; in 2000, the long form was sent to one in six households, covering some 30 million people.

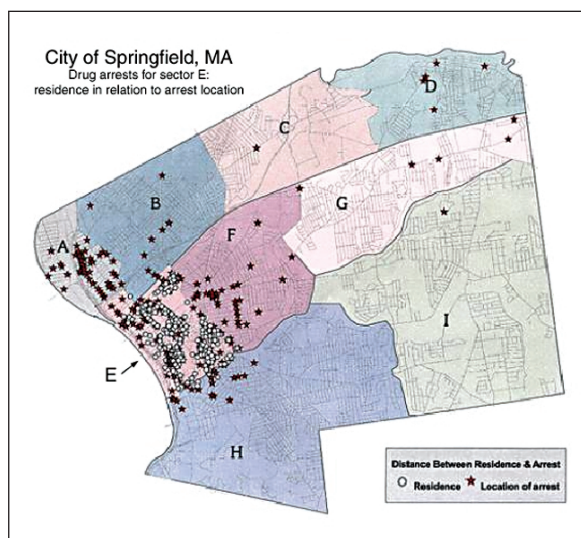
Every piece of data is devoured by one government program or another: in planning transportation systems, zoning, schools, health care facilities, and housing as well as

in targeting and budgeting social services. But whereas “business and commerce operate on instantaneous information,” says Prewitt, “the federal government operates on 10-year-old data.” It takes 2 years to process answers from the long form, and by the end of the decade the information can be more than a little stale.

The Census Bureau wants to jettison the long form forever and substitute the ACS, a continuous pulse-taking of 39,000 local jurisdictions. Using an approach called “rolling samples,” the bureau each month will mail questionnaires to a different sample of households within each jurisdiction. Officials began testing the ACS in 1996. Next year it’s expected to go into high gear, with questionnaires going to 250,000 addresses each month, or 3 million a year. By 2010, 30 million addresses will have been sampled, almost doubling the 16 million covered by the long form. Communities of 65,000 or larger will have fresh numbers every year, thanks to sufficient sampling size; smaller areas will take several years to accumulate meaningful data.

Improved timing isn’t the only advantage to the ACS, says Nancy Gordon, associate director for demographic programs at the bureau’s headquarters in Suitland, Maryland. Administering the long form has gotten increasingly inefficient and expensive, she says. In 2000, for example, the bureau needed to hastily train nearly 1 million temporary workers to conduct follow-up interviews of people who didn’t respond to the original mailing. In contrast, the ACS will be handled by a permanent regional staff of some 2000 to 4000 people who will contact nonresponders first by telephone and then, if necessary, in person.

The ACS arrives on the wings of 21st century technology that makes the long form superfluous. The heart of a census,



Mapping drug traffic. ACS demographic data combined with where drug dealers live (white dots) and work (stars indicate arrests) helps Springfield, Massachusetts, officials tackle youth violence.