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## USA: California: Eradication of the Invasive Seaweed *Caulerpa Taxifolia* from Agua Hedionda Lagoon and Huntington Harbour

### Overview

In the summer of 2000, the first known Western Hemisphere infestations of the invasive strain of the tropical marine alga, *Caulerpa taxifolia*, were discovered in Agua Hedionda Lagoon, Carlsbad, California and in Huntington Harbour, Huntington Beach, California. Commonly used in saltwater aquarium systems, earlier releases of *C. taxifolia* into coastal European and Australian waters have resulted in the establishment of extensive dense carpets of the seaweed, smothering diverse natural communities and dramatically reducing biodiversity by displacing native seaweeds and animals. Based on the aggressive nature of this species and the displacement of native marine resources observed upon its discovery in California, it was recognized that the infestations posed a major threat to coastal ecosystems, and recreational and commercial uses dependent upon coastal resources. Therefore, a large-scale, multi-agency eradication effort was undertaken to curb the spread of this prolific invader.

### Quick Facts

**Project Location:**

Agua Hedionda Lagoon, Carlsbad, CA, USA, 33.1414291, -117.31993829999999

**Geographic Region:**

North America

**Country or Territory:**

United States of America

**Biome:**

Coastal/Marine

**Ecosystem:**

Coral Reef, Seagrass & Shellfish Beds

**Area being restored:**

43.4 hectares

**Organization Type:**

Governmental Body

## Location



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### TIMEFRAME

**Project Stage:**

Implementation

**Start Date:**

2000-06-06

**End Date:**

2000-06-06

### DEFINING THE PROBLEM

**Primary Causes of Degradation**

Invasive Species (native or non-native pests, pathogens or plants)

**Degradation Description**

The highly invasive aquarium strain of the tropical marine alga *Caulerpa taxifolia* was discovered in Agua Hedionda Lagoon in June 2000 and later confirmed in July 2000 at a second site in Huntington Harbour, Orange County. These discoveries represented the first known infestations of this strain within the Western Hemisphere (Jousson et al. 2000). The Agua Hedionda Lagoon and Huntington Harbour infestations are believed to have arisen from separate introductions. The resulting infestations were distinctly different due to the physical dissimilarity of the two sites.

When discovered at Agua Hedionda Lagoon, the infestation consisted of numerous dense patches, located primarily where native eelgrass beds had previously existed. Lagoon-wide surveys found approximately 0.13 hectare of *C. taxifolia* distributed over a 42.3-hectare (104.6-acre) area of the eastern basin. *Caulerpa taxifolia* was likely released from a home aquarium into the lagoon either directly or through one of the adjacent storm drains.

In Huntington Harbour, the *C. taxifolia* infestation was located primarily in two shallow artificial ponds connected to the northern portion of the harbor. The *C. taxifolia* growth pattern in Huntington Harbour was much different from Agua Hedionda Lagoon, with the alga typically growing as hundreds of small, scattered plants. Because there were few distinct patches with discrete boundaries, quantification of the area covered by each occurrence of *C. taxifolia* at the site was not possible. All occurrences of *C. taxifolia* were distributed over a 1.1-hectare (2.6-acre) area.

### PLANNING AND DESIGN

**Project Goals**

The goals of the SCCAT are the eradication of the known infestations of *C. taxifolia*, and the prevention and detection of new infestations through outreach and surveillance.

**Monitoring**

The project does not have a monitoring plan.

## Stakeholders

(see project description)

## PROJECT ACTIVITIES

### Description of Project Activities:

At the time of its discovery in California, no technique had been demonstrated to effectively eradicate similarly sized *C. taxifolia* infestations. After initial containment and treatment investigations both in the field and laboratory, application of chlorine bleach proved the most promising treatment. Bleach was chosen due to its lethal effect on *C. taxifolia*, readily detectable effect (visual bleaching), ease of application, low cost, and non-toxic residuals. The tendency of *C. taxifolia* to easily fragment and grow into new plants from even very small fragments dictated that the *C. taxifolia* should be treated in-place, with minimal disturbance. Treatment efforts consisted of covering *C. taxifolia* with heavy black PVC tarps under which chlorine was either injected as sodium hypochlorite, or placed as a solid, pelleted formulation, which provided full containment of *C. taxifolia* while minimizing the water quality impacts of the treatment on the surrounding waters. The containment and treatment efforts lasted approximately two years, and intensive surveillance was undertaken concurrently to search for remaining *C. taxifolia*. These surveys were conducted by closely-spaced divers moving systematically at a measured pace along the bottom. In order to evaluate the reliability of the surveillance effort at both infestation sites, patches of artificial *Caulerpa* were placed within each of the two sites during the regular diver surveys. Confidence in the results of each survey for live *C. taxifolia* could then be quantitatively estimated based on the amount of artificial *Caulerpa* found during the surveys. The results of these consecutive assessments of the surveys ultimately allowed for an estimation of the eradication certainty, the certainty that all real *C. taxifolia* existing at the two sites had been found and that eradication had been achieved. The assessments determined that there is a 97.71% certainty that eradication has been achieved at Agua Hedionda Lagoon, assuming the worst conditions, and a 99.86% certainty if the average conditions are assumed. There is a 99.99% certainty that eradication has been achieved at Huntington Harbour under all conditions.

## PROJECT OUTCOMES

### Ecological Outcomes Achieved

#### Eliminate existing threats to the ecosystem:

Over the course of the eradication effort at Agua Hedionda Lagoon, hundreds of patches of *C. taxifolia* were tarped and treated; the largest patch was estimated to have a biomass in excess of 18 metric tons (20 tons) of the alga. The amount of *C. taxifolia* found in the lagoon was reduced with each consecutive survey, with the coverage in fall 2001, winter 2001, spring 2002, and summer 2002 measuring 33.6 m<sup>2</sup>, 2.7 m<sup>2</sup>, 0.5 m<sup>2</sup>, and 0.4 m<sup>2</sup>, respectively. Similarly, at Huntington Harbour there were fewer, and generally smaller, patches of *C. taxifolia* found in each subsequent survey. The total sizes of patches found in fall 2001, winter 2001, spring 2002, summer 2002, and fall 2002 measured 9.9 m<sup>2</sup>, 1.2 m<sup>2</sup>, 1.3 m<sup>2</sup>, 0.5 m<sup>2</sup>, and 0.5 m<sup>2</sup>, respectively. *Caulerpa taxifolia* was last detected in Agua Hedionda Lagoon in September 2002 and in Huntington Harbour in November 2002. No *C. taxifolia* has been discovered at either site during intensive, systematic surveillance conducted through December 2005. Evaluations of the treatment effectiveness have been performed both in the laboratory and at the infestation sites. The laboratory experiments involved the collection of previously infested sediment from under the treatment tarps. The sediment cores were planted into laboratory aquariums and monitored in a controlled study for regrowth of *C. taxifolia*. No *C. taxifolia* grew from any of the treated cores. Additionally, removal of portions of the treatment tarps at the infestation sites resulted in no regrowth of *C. taxifolia* after four years of monitoring. These data indicate that the treatment approach used was lethal to *C. taxifolia* and that the containment of *C. taxifolia* at the infestation sites has been achieved.

#### Factors limiting recovery of the ecosystem:

Recovery was not limited by any factors, as extensive surveys have shown that the eradication was complete.

### Socio-Economic & Community Outcomes Achieved

#### Economic vitality and local livelihoods:

The infestations posed a major threat to coastal ecosystems, and recreational and commercial uses dependent upon coastal resources.

## KEY LESSONS LEARNED

### Key Lessons Learned

The following is a list of the critical elements of a successful eradication response: 1) rapid response; 2) assumption and belief that eradication is possible; 3) incorporation of the lessons from other responses; 4) adequate funding to maintain a sustained, persistent response; 5) intensive, repeated surveys over an extended period of time after the last discovery; 6) quantitative evaluation of the effectiveness of survey and treatment elements; 7) identification and engagement of stakeholders; 8) adaptation and adjustment to approach in response to financial circumstances, stakeholder response, or independent review. There is wide agreement that the key elements of the *C. taxifolia* eradication effort were the quick recognition of the threat posed by *C. taxifolia*, prompt organization of a response team, effective acquisition of funding, and an immediate field response to assess the extent of the infestation and develop a response plan.

## LONG-TERM MANAGEMENT

## Long-Term Management

The need to detect new infestations of *Caulerpa*, to identify potential sources or pathways of *Caulerpa* movement, and to prevent new introductions of *Caulerpa* into California waters requires an effective outreach and education program. The Southern California *Caulerpa* Outreach and Education Program currently underway is one mechanism to address this need, and it is recommended that similar efforts be initiated and maintained in other coastal regions of the state. This program targets groups such as saltwater aquarists, SCUBA divers, harbor masters, anglers, public aquariums, environmental groups, and governmental agencies.

Additionally, it is recommended that legislative efforts to prevent new introductions of *Caulerpa* species to the coastal waters of California be continued. Legislation banning the transport, sale, and possession of nine potentially invasive species of *Caulerpa*, including *C. taxifolia*, was enacted in the State of California in September 2001 (AB 1334). However, many resource managers, invasive species experts, and SCCAT believe that due to the difficulty associated with distinguishing various species of *Caulerpa*, a ban on the entire *Caulerpa* genus is necessary and critical to controlling the importation, distribution, or release of invasive *Caulerpa* species in California.

It is also recommended that a permanent rapid response fund be established for an effective and immediate response to newly discovered infestations of *Caulerpa* or other marine invasives, and for increased support of enforcement of existing state laws banning marine invasive species.

## FUNDING

### Sources and Amounts of Funding

7,000,000 USD The Southern California *Caulerpa taxifolia* Eradication Program has received funds from many sources since it began in 2000. This funding was provided by the State Water Resources Control Board (through Cleanup and Abatement Account funds, Proposition 13 grants, and an EPA Clean Water Act Section 319h grant), California Coastal Conservancy (Southern California Wetlands Recovery Project grant), California Department of Fish and Game, NOAA National Marine Fisheries Service, Cabrillo Power LLC, U.S. Fish and Wildlife Service, California Department of Parks and Recreation, the National Fish and Wildlife Foundation, the FishAmerica Foundation, the NOAA Community-Based Restoration Program, and the Agua Hedionda Lagoon Foundation.

## LEARN MORE

### Other Resources

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