

Rapid Response and Eradication Plan for the Invasive Green Alga *Caulerpa prolifera* in San Diego Bay



Adaptive Management Memorandum #2 (December 2023)

December 4, 2023

SUMMARY OF KEY POINTS

- The eradication plan was drafted in September after the initial discovery of *Caulerpa prolifera* and prior to completion of surveys at nearby areas.
- This memo provides an estimate of the costs associated with eradicating the known *C. prolifera* infestation in the Coronado Cays and surveying for it in the surrounding waters.
- A proposed schedule is detailed for the eradication and the survey of surrounding waters extending for a two-to-three-year period.

INTRODUCTION

This memo is written to develop an estimate of the potential costs associated with eradicating the known infestation of *Caulerpa prolifera* in the Antigua Village area of the Coronado Cays (as of December 2023). The Coronado Cays is a residential community located in South San Diego Bay where *C. prolifera* was discovered in October 2023. Cost estimates are also made for surveillance of the surrounding areas in the Cays for undiscovered infestation areas or additional infestation areas that establish prior to treatment of the current infestation.

ERADICATION COSTS

Based on the very limited treatment of *C. prolifera* that has occurred to date at Antigua Village, it is estimated that the price to cover one square meter of seafloor with benthic barrier would cost approximately \$72. It is currently estimated that 3,471 square meters of seafloor require treatment (Figure 1). Thus, to cover the current distribution of *C. prolifera* that has not been treated would cost approximately \$250,000 (Table 1).

Once the barriers have been placed, the known infestation site, defined as the area of seafloor with recorded occurrence of *C. prolifera* plus a 10-meter buffer, must then be promptly examined again at the eradication level to locate and treat missed or resprouted *C. prolifera*. This examination is done with a team of approximately five to seven *Caulerpa* Certified divers systematically surveying the infestation site as described in the Rapid Response and Eradication Plan for the Invasive Green Alga *Caulerpa prolifera* in San Diego Bay (RREP). The next survey to find and treat will be done one month later, and then approximately quarterly thereafter until all *C. prolifera* has been found and treated.

The cost to survey under docks versus open water varies substantially within this area. The costs per hectare are estimated at \$14,450 and \$8,050 for areas under docks versus open water, respectively, based on eradication level surveys already performed over 6.86 hectares at the site in October and November 2023. These values can be used to estimate the cost of surveying the known infestation site.

Given the difficulty of searching underwater in low visibility conditions, it is possible that *C. prolifera* exists nearby but outside the known boundary of the infestation site. Moreover, it's possible *C. prolifera* will have spread between the time since the initial delineation and the time at which treatment is complete. Given these factors, the area shown in Figure 2 is the anticipated area over which repeated surveys should occur to find and remove *C. prolifera*. This area is defined as the infestation action area (8.64 hectares). Application of the dock mask used to determine the relative proportion of dock and open water area is shown in Figure 2. Application of the above costs to the proportionate amount of dock and open water was used to determine the per survey cost estimates shown in Table 1.

If a 60% diver efficacy rate is assumed, it would take 4 quarterly surveys without finding *C. prolifera* to be 97.4% certain that all *C. prolifera* had been found within the infestation action area. If it assumed that all *C. prolifera* can be found and treated within the first two surveys after the initial treatment, then 6 surveys of the infestation management area would be required to achieve the 97.4% certainty level. These assumptions were used to determine the number of survey units provided in Table 1. However, if the 60% efficacy goal cannot be achieved, or if *C. prolifera* is discovered during the third to sixth pass, additional surveys will be necessary to ensure no *C. prolifera* remains to spread further within the infestation management area. That possibility is reflected in the schedule in Figure 3 but is not included in the cost estimate in Table 1.

Removal of benthic barriers is an integral part of the eradication. Test holes will be made in the barriers at a time agreed on by SCCAT, assumed in this case to be seven months after the start of barrier installation and following at least one complete resurvey with no *C. prolifera* found (Figure 3). If inspection of the holes during the next two surveys (and potentially lab assay of the sediment) reveal no regrowth, the tarps could be removed in month 13 after the start of barrier installation. The sixth resurvey would serve as a verification survey after the barriers were removed. It is estimated that barriers could be removed for approximately half of the installation cost. This estimate is based on the fact that supplies do not need to be purchased for removal. Moreover, while removal can be a demanding task, less time is needed because installation requires special planning and underwater navigation to get barriers oriented properly. Thus, the estimated cost to remove barriers would be \$125,000 (Table 1).

SURVEY COSTS FOR SURROUNDING AREAS

Coronado Cays

The entirety of the Coronado Cays should be surveyed at least one time at the eradication level (100% coverage). Given that there is no penetration connecting the water area across Grand Caribe Causeway, if no *C. prolifera* is identified in the southern portion of the Coronado Cays, that area would require no further investigation. However, it would be prudent to survey the northern Coronado Cays again at some point after treatment of all known *C. prolifera* and prior to any determination that *C. prolifera* has been declared eradicated. The costs to survey within these additional areas used the same estimated costs per hectare to survey under docks and within the channels as provided above for the infestation action area. Refer to Figure 2 for the relative locations of the infestation action area, north Coronado

Cays, and south Coronado Cays. The surveys would be performed by a team of approximately five to seven *Caulerpa* Certified divers in the same manner as in the infestation site.

South San Diego Bay

Like the need to survey all the Coronado Cays, at some point it is critical to survey the remainder of South San Diego Bay at the high intensity level (50%) to ensure that *C. prolifera* does not exist beyond the limits of the Coronado Cays. The surveys would be performed again as detailed in the RREP, with the modification of spacing the dive team further apart from each other along each transect to inspect 50% of the bottom. If those surveys are performed at 50% coverage, it is estimated that 4.05 hectares can be surveyed per day at a cost of \$9,927 per day. It is anticipated that up to 250 hectares would be selected for surveillance beyond the Coronado Cays extending into south San Diego Bay.

COST SUMMARY

Table 1 provides estimates based on the descriptions above. The eradication costs are based on the placement of 3,471 square meters of barrier using the known distribution of *C. prolifera* in October 2023. There are considerable uncertainties in the execution of the eradication including timing of funding (delay will result in additional survey needed prior to barrier placement to delineate current boundaries after spread), weather delays, discovery of additional *C. prolifera* in the infestation area prior to barrier placement, or repeated discovery of new growth during the six surveys necessitating additional resurvey work.

Table 1. Table showing the required actions, cost per unit of those actions, the estimated units to achieve eradication, and the costs to complete the eradication effort and surrounding survey work.

Action	Cost per Unit	Anticipated Units	Cost
<u>Eradication</u>			
Application of benthic barriers over 3,471 square meters of seafloor	\$250,000	1	\$250,000
Resurvey and treatment in 8.64-hectare survey management area	\$94,960	6*	\$569,760
Removal of benthic barriers from 3,471 square meters of seafloor	\$125,000	1	\$125,000
<u>Survey of Surrounding Areas</u>			
Survey entire Coronado Cays	\$272,926	1	\$272,926
Survey north Coronado Cays	\$154,862	1	\$154,862
High-intensity survey 250 hectares	\$615,474	1	\$615,474
Total			\$1,988,022

*any discovery of *C. prolifera* during the third to sixth survey may trigger the need for additional surveys.

INITIAL ACTIONS

The eradication of *C. prolifera* from the Coronado Cays requires immediate attention to minimize further spread and increase the probability of successful eradication. Critical to initiate are the application of benthic barriers and the first two surveys of the 8.64-hectare infestation action area to find and treat remaining *C. prolifera*. These actions will be performed in an iterative manner with initial application of benthic barriers, followed immediately by a follow-up survey. It is anticipated that the first survey following treatment will identify additional areas where minor additional application of benthic barriers would be necessary. After this secondary treatment, a second resurvey roughly a month later will find and treat additional *C. prolifera* that may have sprouted from fragments. This timing will allow any missed *C. prolifera* to reach a detectible size while not being so large as to cause significant loss of containment. The actual timing of the treatment and survey events will be dependent upon the timing of funding, winter storms, and results of initial efforts. The SCCAT Steering Committee will oversee and direct the eradication team in the timing of events.

If funding were secured quickly, barrier installation could begin in December 2023 as described in Adaptive Management Memorandum #1 for the RREP, with the first two surveillance and treatment events being completed by March 2024.

Additional future actions will include the continued surveillance of the infestation action area until eradication has been achieved and surveys of adjacent areas in the Coronado Cays and south San Diego Bay have been performed. Funding opportunities will be sought to implement all of these actions as well as any additional actions as deemed necessary by SCCAT to achieve eradication, prevent additional infestation and distribution of *Caulerpa* species, and declare eradication of *C. prolifera* from San Diego Bay.

SCHEDULE

Figure 3 lays out a schedule for the treatment and surveillance necessary for the eradication work, starting with the installation of the benthic barriers. The eradication surveillance timeline assumes a scenario where additional *C. prolifera* is found and treated during the first two surveys and is not found during the third to sixth. The repeated survey and retreatment would be extended as indicated in Figure 3 if *C. prolifera* was found during surveys three to six or if the measured efficiency was not as assumed. Figure 4 provides a simplified eradication probability matrix assuming a fixed per survey efficacy. A proposed timeline for cutting test holes in the barriers, removing the barriers, and examining the infestation area an additional time (survey six) is proposed. However, this element of the eradication has not been fully strategized and will be detailed in a future adaptive management memo.

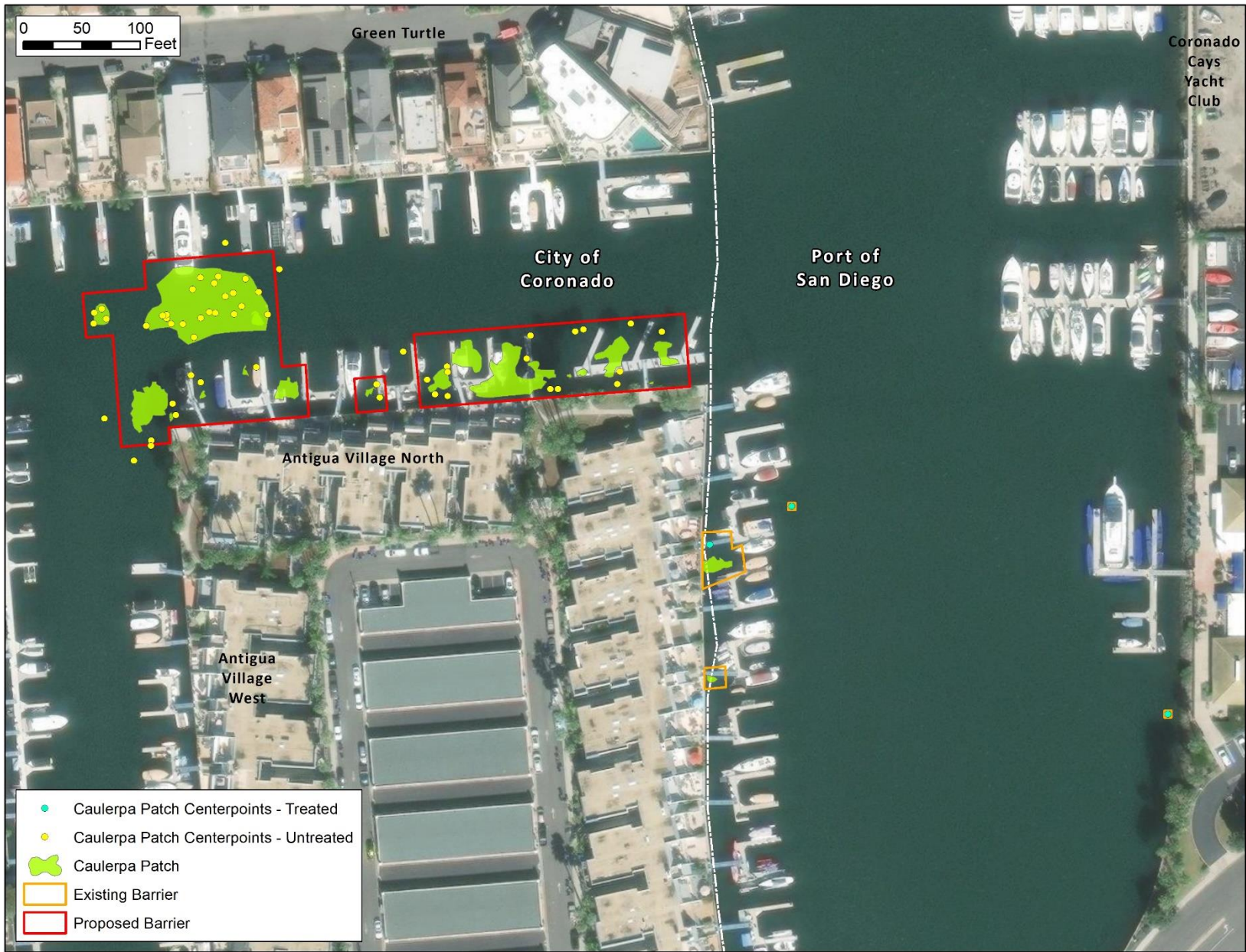
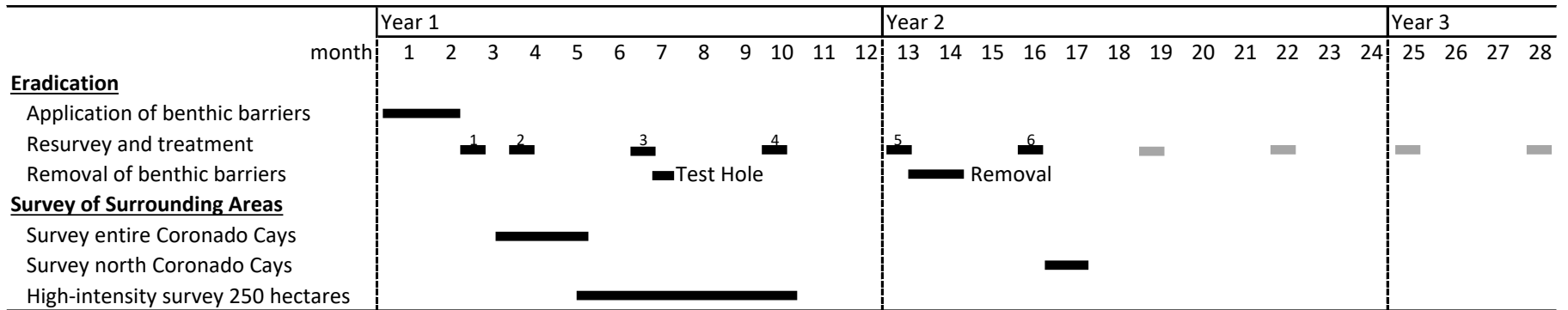


Figure 1. The above figure shows a potential barrier arrangement that covers all of the larger *C. prolifera* beds and most of the small patches. Additional small barriers not shown or hand picking would be used to treat any small patches not shown to be covered by the large barriers shown above in red. Proposed barrier area is 3,471 square meters.



Figure 2. The above figure shows the infestation action area (green), north Coronado Cays (red), and south Coronado Cays (blue). Areas in white are the dock areas used to help partition costs between dock areas and open water.



* Assumes resurvey 1 and 2 find *C. prolifera* and resurveys 3-6 do not.

■ Potential additional resurvey events needed if additional *C. prolifera* found during surveys 3-6

Figure 3. Schedule for *Caulerpa prolifera* eradication efforts, and survey of surrounding areas, in Coronado Cays, San Diego Bay.

Efficacy (Per Survey)	Survey Number					
	1	2	3	4	5	6
20.0%	20.0%	36.0%	48.8%	59.0%	67.2%	73.8%
30.0%	30.0%	51.0%	65.7%	76.0%	83.2%	88.2%
40.0%	40.0%	64.0%	78.4%	87.0%	92.2%	95.3%
50.0%	50.0%	75.0%	87.5%	93.8%	96.9%	98.4%
60.0%	60.0%	84.0%	93.6%	97.4%	99.0%	99.6%
70.0%	70.0%	91.0%	97.3%	99.2%	99.8%	99.9%
80.0%	80.0%	96.0%	99.2%	99.8%	100.0%	100.0%
90.0%	90.0%	99.0%	99.9%	100.0%	100.0%	100.0%

Figure 4. The above figure provides a simplified matrix of eradication probability based on the number of surveillance events and the per survey efficacy assuming a constant efficacy across surveys. Actual eradication probability can be determined based on the measured survey efficacy for each survey event as they occur. Shaded cells are those cells where the per survey efficacy and the number of repeated surveys results in a greater than 95% eradication probability.

REFERENCES

[SCCAT] Southern California *Caulerpa* Action Team. 2023. Adaptive Management Memorandum #1 for the Rapid Response and Eradication Plan for the Invasive Green Alga *Caulerpa prolifera* in San Diego Bay, November 2023.

[SCCAT]. 2023. Rapid Response and Eradication Plan for the Invasive Green Alga *Caulerpa prolifera* in San Diego Bay, September 2023.