

Project Title: Distribution and Ecological Impacts of Non-indigenous Invasive Marine Algae in Cabrillo National Monument and the Greater San Diego County Coast

Introduction:

The introduction and spread of non-indigenous invasive species is one of the largest threats to global biodiversity. In the marine environment, non-indigenous marine algae have specifically gained attention due to rapid expansions in the number and frequency of introductions and associated impacts around the globe. Algal invasions have occurred worldwide, and variable but often negative impacts on native species and communities have been documented. These impacts include reductions in biodiversity and the abundance and performance of native species, and changes in community structure and function. Further, marine algal invasions have threatened and continue to threaten economically important species and industries such as aquaculture and tourism. In San Diego, multiple non-indigenous seaweed species have become established, yet little is known about their abundance, distribution or impacts to native communities. This project has aimed to document the abundance and distribution of invasive algal species, specifically *Sargassum horneri* and *Undaria pinnatifida*, in Cabrillo National Monument with high spatial and temporal resolution, and to determine their impacts on the area. This work represents a detailed focal study embedded within a larger project investigating non-indigenous marine algae across the entire San Diego coast. To determine whether invasive algae are present in the Monument, and if so, how they are affecting the Monument's coastal systems, we conducted presence/absence and benthic community surveys throughout Cabrillo's coastline.

Objectives:

The main objective of this research is to provide baseline information on Cabrillo's subtidal communities which will complement the existing intertidal monitoring which has been conducted for years. These novel data will allow the park to document changes in its subtidal ecosystems and to make informed management and policy decisions. These data will also allow us to compare Cabrillo to other national monuments and protected areas, as well as unprotected areas throughout San Diego, to see how protection status and anthropogenic disturbance influences benthic community health and invasion success. Another main objective of our proposed research is to broaden public awareness of marine invasive species in San Diego. Because this is a poorly understood topic despite the fact that it has the potential to influence a huge number of people in San Diego, it is crucial that the public is informed on the topic. As an area with high visitation, Cabrillo is an optimal location to provide information to the public.

Status of Research:

As proposed, both rapid and in-depth surveys were conducted at locations throughout the San Diego County Coastline. While originally only ten study sites were proposed, with one within Cabrillo National Monument, the total number of sites that were established and surveyed was expanded to twenty sites, three of which are within Cabrillo National Monument (see website for dive site locations). At each site, we established three semi-permanent 5 m transects in the 0-5 m range. In five 1-m² quadrats along each transect, we recorded 1) percent cover of benthic functional groups, and 2) macroalgal stipe counts (figures 1-3).

In 2013, two benthic surveys were conducted at all sites, during the summer from July 23rd to August 7th, and the winter from December 6th to December 19th. Additionally, the three Cabrillo sites -- where sampling is conducted seasonally to get greater temporal coverage-- were sampled in the Fall of 2013 (October 20th). Two additional rapid absence-presence swim surveys, where the entire western coast of the park was searched for invasive algae, were also conducted in summer and fall. Spring and fall surveys of Cabrillo sites are scheduled for March and September of 2014, and summer and winter surveys of all 20 San Diego Coast sites are scheduled for June and December 2014. By the end of 2014, all sites will have been surveyed 4 times, and sites within Cabrillo will have been surveyed 8 times.

Additionally, to determine herbivores' potential role in controlling invasion success, a series of herbivore grazing assays have been added to compliment the field component of the study. These grazing experiments will determine if non-indigenous algae are palatable to native herbivores and if native herbivores show a preference for native or non-indigenous algae. By providing the dominant grazers from our study sites with a variety of algal taxa we will be able to determine the degree to which herbivores may exert top-down control on these algal invaders. We will begin by assessing the feeding rates and preference of the common turban snail (*Tegula funebris*) and the purple urchin (*Strongylocentrotus purpuratus*), two abundant herbivores along the San Diego coastline.

Public outreach has been achieved through several avenues of direct and indirect engagement with the public. We maintain a blog, which provides information on our project and the issue of invasive algae in San Diego in general: <http://scrippsseaweedresearch.tumblr.com/>. We created and distributed informational posters at our study sites and engaged with the public during our surveys. Currently, we are teaching a grazing assay lab for a UC San Diego phycology, in which we are exposing students to lab techniques and educating them on invasive algae and our efforts to study them. Additionally, we are planning to install an herbarium exhibit at the Cabrillo National Monument visitor's center which will contain information about the sub-tidal community and Cabrillo's algal species.

Findings:

During our surveys, non-indigenous algae were found at six of twenty sites: 2 in Oceanside Harbor, 2 in Bird Rock, 1 in Shelter Island, and 1 in Harbor Island (Fig. 2). This is the first documented record of *S. hornerei* in San Diego County. It was determined that when established, the invasive species *S. horneri* and *U. pinnatifida* were among the most prevalent macroalgae in the area, indicating they are directly competing with native macroalgae for space and resources. For example, at Oceanside Harbor, *U. pinnatifida* has been recorded in average densities of 4.5 stipes/m², more prevalent than any native macroalga. Similarly we have recorded densities of *S. horneri* at densities of 8 stipes/m² in Mission Bay (Fig. 2).

We have documented the spread of these species and begun to develop a sense of their invasional patterns. In the Summer 2013 surveys, *S. horneri* was found at three locations where it had previously not been documented: Bird Rock, Shelter Island, and Hospitality Point (Fig. 1). In the Winter of 2013, *S. horneri* was found at two more locations: Ski Beach on Vacation Isle and Oceanside Harbor, and *U. pinnatifida* was found in two new locations in San Diego Bay: the east end of Harbor Island, and the Coronado Ferry Landing. These findings indicate that these species are spreading quickly within the San Diego area. Their prevalence in harbors on man-made jetties and relative absence in locations on the open coast suggests that they are more capable of

invading harbors and man-made jetties. This also may suggest that these species are being transported by boats, through hull foaling and ballast water transport, though more research must be carried out to say if this is true definitively.

Benthic surveys conducted at the Cabrillo National Monument have begun to provide a picture of the benthic composition of subtidal ecosystems within the park (fig. 3). These data are novel, as benthic subtidal surveys have not previously been conducted within the park. Benthic composition data provide a baseline of how the ecosystem is composed, which will be valuable for documenting changes to this ecosystem in the future.

Collections:

At all locations where non-indigenous algae were documented, specimens were collected, preserved, and sent to the University of California Herbarium in Berkeley for a permanent record. No algae were collected within the Cabrillo National Monument.

Funding:

This project is being funded through two main sources: the Southern California Research and Learning Center and the Ledell Family Endowed Research Scholarship, UCSD (Table A).

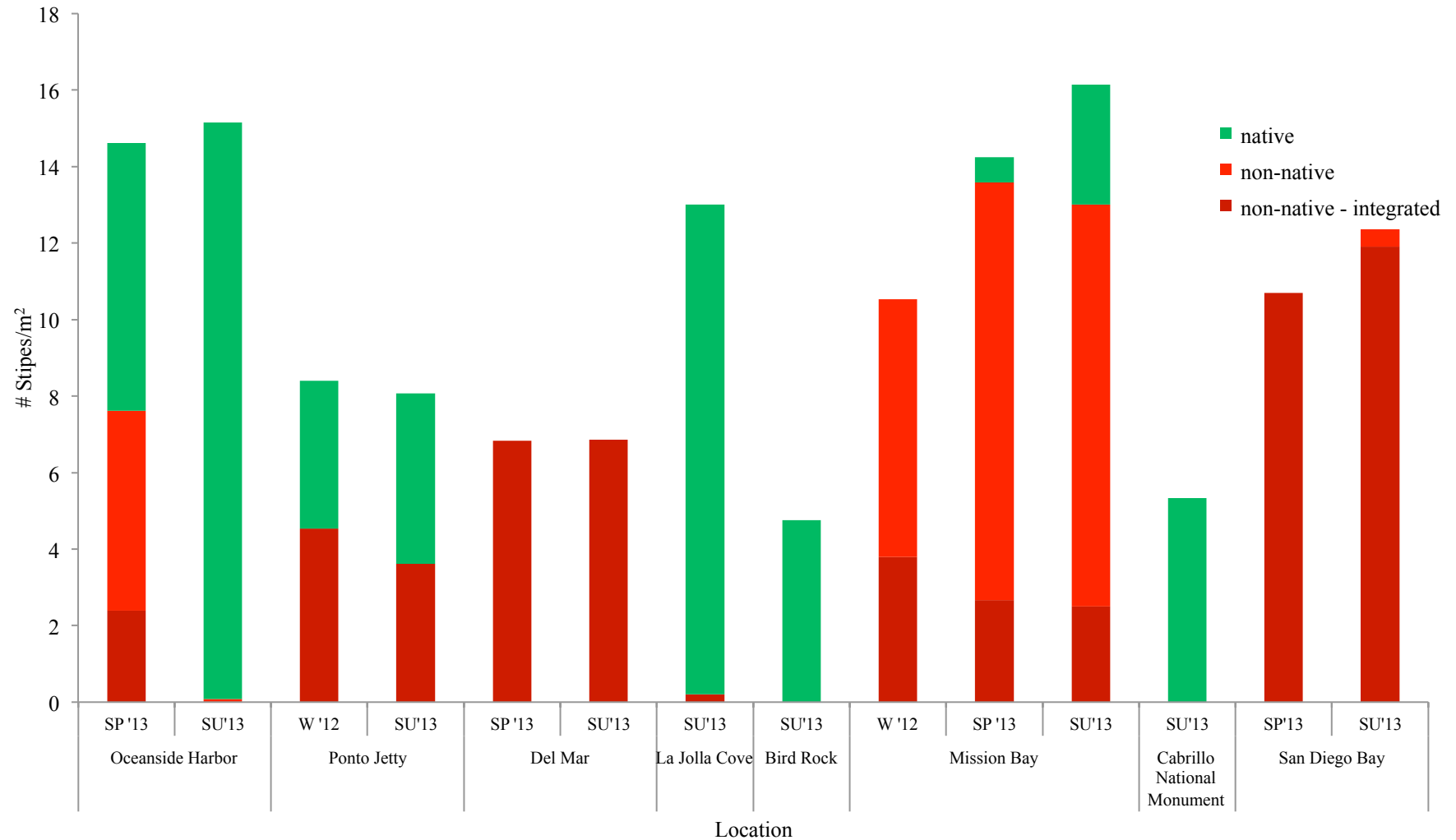


Figure 1. Mean density (# stipes / m²) of non-indigenous (red) and native (green) macroalgae across 3 seasons and 8 locations in San Diego County.

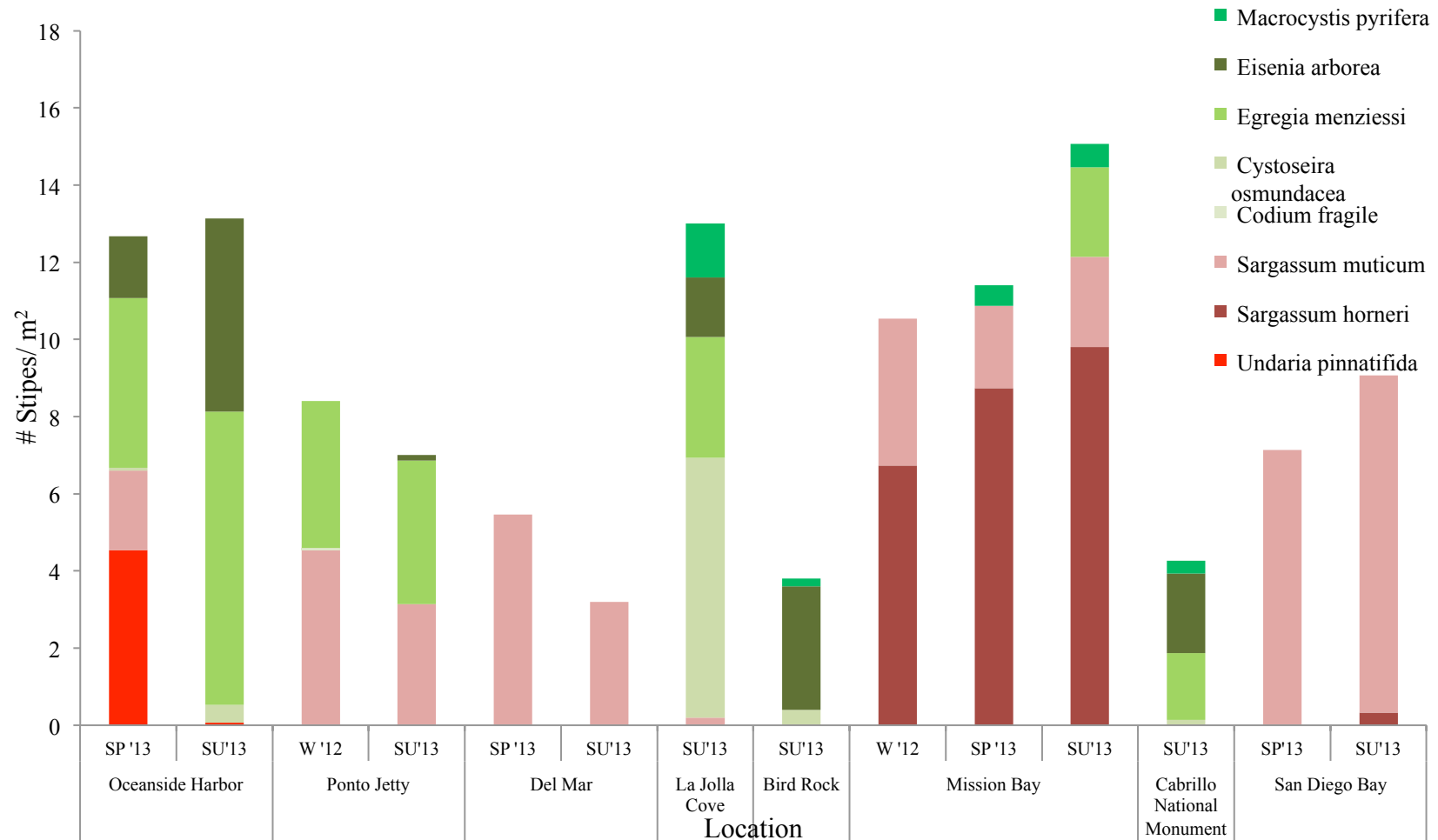


Figure 2. Mean density (# stipes / m²) of non-indigenous (red) and native (green) macroalgae across 3 seasons and 8 locations in San Diego County, to species level.

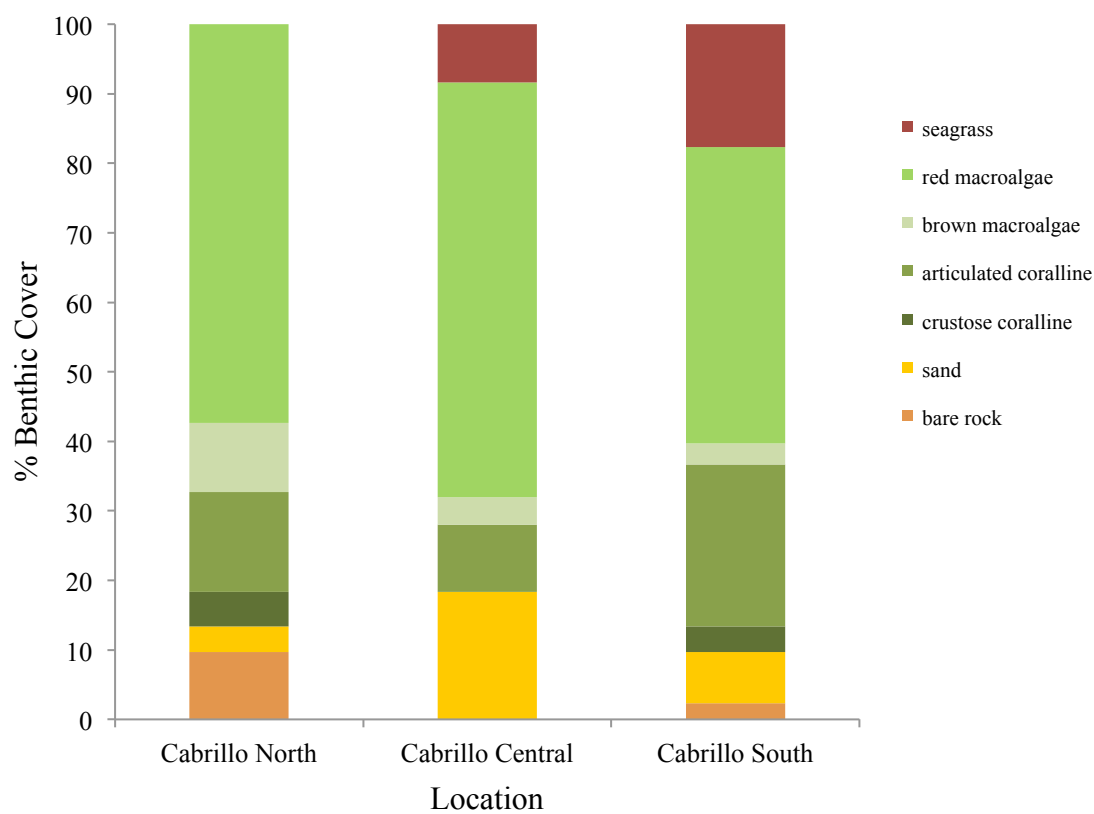


Figure 3. Functional group composition of subtidal benthic communities at three sites in Cabrillo National Monument.

Table A: Funding Summary

Funding Source	Amount
Ledell Family Endowed Research Scholarship	\$3,500.00
Southern California Research and Learning Center	\$7,500.00
Total:	\$11,000.00