MPA Baseline Program

Annual Progress Report

Principal Investigators - please use this form to submit your MPA Baseline Program project annual report, including an update on activities completed over the past year and those planned for the upcoming year. This information will be used by the MPA Baseline Program Management Team to track the progress of individual projects, and will be provided to all MPA Baseline Program PIs and co-PIs prior to the Annual PIs workshop to facilitate discussion of project integration. Please submit this form to California Sea Grant when complete (sgreport@ucsd.edu, Subject [Award Number, project number, PI, "Annual Report"].)

Project Information			
Project Year	Year 2 (2012-2013)	**MLPA Region**	South Coast Region – Southern California
Project Title & Number	*Nearshore Substrate Mapping and Change Analysis using Historical and Concurrent Multi-spectral Aerial Imagery." R/MPA-30 Grant No 10-049*		
PI name	Jan Svejkovsky	**Co-PI name**	

PI Contact Info *(please list additional PIs and contact info in the "Project Personnel" section if necessary)*		**Co- PI Contact Info**	
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Project Goals & Objectives

The overall goal of this project is to create a baseline database of kelp canopy, shallow subtidal and intertidal bottom substrate, at very high spatial resolution (40cm-2m) covering all Marine Protected Areas (MPAs) in the California South Coast (CSC) region.

The goals of the project's second year were to: 1) Complete acquisition of multispectral aerial imagery of inter/subtidal zones within and around CSC MPAs; 2) Complete mosaicking of acquired intertidal imagery and classify the intertidal habitat; 3) conduct partial field sampling for the classification training and results validation; 4) Collect kelp canopy imagery for 2011 and 2012 and process the imagery for kelp classification; 5) Begin work on multi-year kelp persistence analysis; 6) Begin work on 2001/2002 vs. 2011 inter/subtidal change detection analysis.

The progress toward these goals is discussed in the next section.

Summary of Project Activities Completed to Date

Overview of Project Year 2 Activities, including progress towards meeting goals & objectives

1) **Inter/subtidal imagery acquisitions:** The originally proposed work plan included the use of Ocean Imaging's (OI's) DMSC-MkII aerial system for these image data acquisitions. Subsequently, in 2011 OI got the opportunity to utilize a Microsoft UltraCamX aerial sensor, albeit at a higher acquisition cost. OI decided to take advantage of this opportunity and has financed the increased cost (approximately $16,000) internally as co-funding.

   Digital multispectral data were acquired using a Microsoft UltraCamX Digital Sensor (UCX). This sensor is a 16-bit, 4000x4000 pixel, 4-channel instrument imaging in the red (580-700nm), green (480-640nm), blue (380-540nm) and near-infrared (680-960nm) wavelengths flown in tandem with a high accuracy airborne geographical positioning system (ABGPS) and inertial measurement unit (IMU) to achieve high geolocation accuracy and precision. The data were acquired at a ground sampling distance (GSD – i.e. horizontal spatial resolution) of 30 cm. during specific tide, sun angle and weather conditions. This reduces the possibility of sun glint contamination and ensures an acceptable level of solar illumination during times when as much of the substrate/vegetation in the intertidal zone is exposed as is possible. Requirements dictate that the data be collected during periods of seasonally low tides within a 3 hour time window, +/- 1.5 hours from the mean low water level (MLW). In most cases, the data were acquired +/- 1.5 hours of the mean lower low water lever (MLLW) which is lower than the required level.

   Imagery from the UCX sensor was used in place of the proposed DMSC sensor for a variety of reasons. The bit depth of the UCX is 16-bit as opposed to the DMSC's 12-bit sensitivity which offers greater spectral fidelity and hence improved ability to classify substrates. Given the wide swath width of the UCX, 30 cm spatial resolution can be collected for the entire study region compared to the proposed 1 meter and 35 cm data which would have been collected with the DMSC. This did provide more detailed and precise imagery resulting in a better classification product. Finally, geolocation capability of the UCX is superior to that of the DMSC, delivering more geographically accurate imagery and data products.

   To date, 100% of the imagery covering the MPA regions as defined in the proposal has been collected. 90% of the data were acquired between 06/07/2012 and 10/16/2012 and the remaining datasets were collected on 11/12/2012 and 11/13/2012. The November imagery was collected during low tide levels and favorable weather and so, like the rest of the data, are of very high quality and show excellent spectral and spatial definition. Water penetration in areas of calm seas appears to be more than sufficient to classify submerged substrate as depth and water clarity permit.

2) Inter/subtidal image data processing and habitat classification: All of the multispectral data have been georeferenced and orthorectified. Georectification errors were found along some areas of the coast and islands. These data have been re-georeferenced/orthorectified to ensure +/- 2 meter horizontal spatial accuracy. All of the imagery have been geo-corrected and re-mosaicked into geographical segments showing either one or multiple South Coast Region (SCR) Marine Protected Areas (MPAs).

Processing Priority was placed on subsection mosaics of areas requested by a few of the SCR Principal Investigators (PIs) in order to deliver the imagery covering locations in selected MPAs to them as soon as possible. Specifically, Dr. Kevin Hovel of SDSU and Rani Gaddam of USCS requested smaller image mosaics of several areas relevant to their research and SCR projects. In order to keep the data files to a manageable size, imagery were generated covering roughly a 2 kilometer radius surrounding each of the locations requested by the PIs. Areas of interest (AOI) were prioritized by the requesting PI so as not to over task Ocean Imaging (OI), however OI was able to processed and deliver custom imagery for all of the locations for which data were acquired (a few requested areas were outside of the geographical scope included in this project). The work to provide these customized imagery products is discussed in further detail in the June 18, 2013 quarterly report. All of these data have been shipped to the requesting PIs.

Classification of the data into the macro and micro substrate classes is ongoing. As was done for the Northern California classification work also funded by Sea Grant, the intertidal region is first segregated into elevation sections within and above the intertidal zone in order to eliminate cross correlation of reflectance values for marine and terrestrial vegetation with similar radiometric signatures. Where available and appropriate, LIDAR data are being used to accurately aid in this segmentation process. The different elevation segments are then classified and ultimately merged together into a final product. Given the high quality and resolution of the data, we have been able to confidently distinguish and map the classes below. As opposed to the NCC region where the coastal bathymetry, excessive whitewash, and turbidity prevented depth penetration into the water column, a few classes showing submerged substrate will be included in the SCR habitat classification products. ***Figure 1*** (below) shows an example of a classified product.

- Sandy beach
- Cobble
- Bare/Unvegetated rock
- Red/brown algae covered rock
- Submerged rock reef
- Submerged sandy bottom
- Blue-Green algae
- Green algae
- Surf Grass
- Eel Grass
- Kelp
- Terrestrial vegetation
- Salt marsh vegetation
- Driftwood
- Wrack
- Manmade structures
- Deep water
- Shadow/Dark tide pool
- Whitewash (if present)

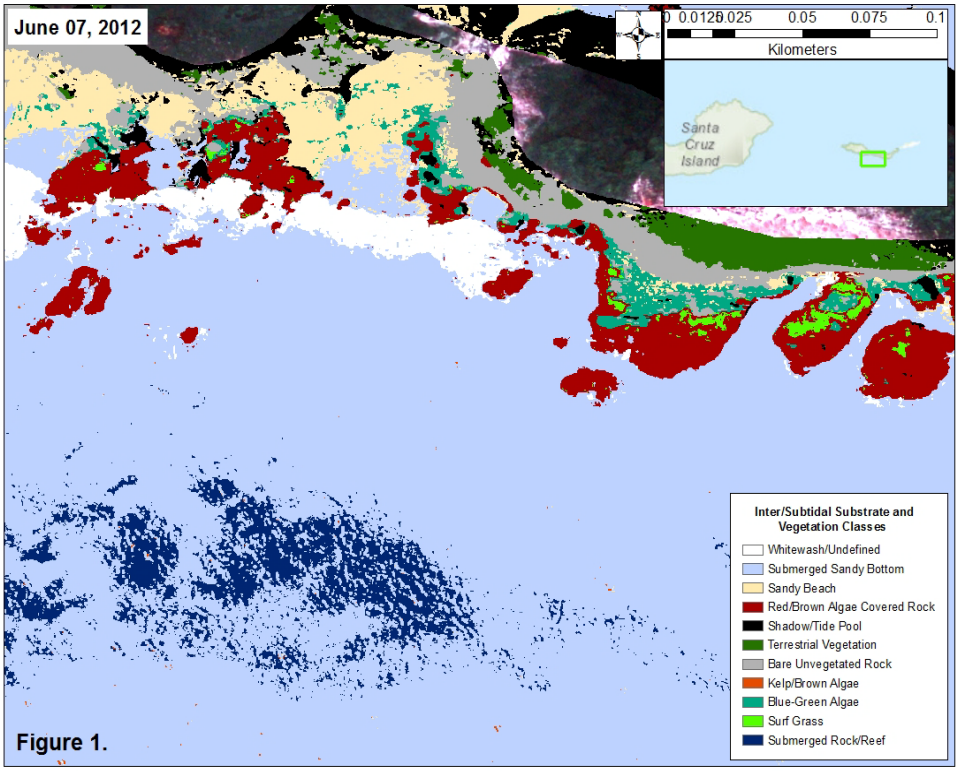

Figure 1.

3) **Intertidal field sampling:** A limited amount of field sampling work was done along San Diego County. Field sampling along the Southern California coastline from San Diego up to Santa Barbara will be performed in October-December of 2013. The majority of field sampling for the Channel Islands will be conducted during the project's final year. The delay in the classification work and other scheduling obstacles prevented this trip in the Summer/Fall of 2013. In addition, several calls have been put out to SCR partners for any field data which may aid in the classification process as well as the accuracy assessment of the final products. Aside from Rani Gaddam, there has been no data provided to date from any of the SCR partners in response to these requests. OI is working with Ms. Gaddam to obtain the field data she is able to supply. So far data from a few sites have been received and utilized in the training of the classifications. We expect all of the data to be received from Ms. Gaddam over the next month and used in the classification and assessment process. ***Figure 5*** shows a comparison between the multispectral imagery-generated classification on the south side of Anacapa Island and the field samples provided by Ms. Gaddam. More discussion regarding the use of these data is highlighted in the following sections.

4) **2011 and 2012 kelp imagery acquisition and classification:** All kelp imagery for the years 2011 and 2012 has been collected and processed. The 2011 imagery were collected on 11/22/11, 12/07/11 and 12/08/11 at a ground sampling distance (GSD – horizontal spatial resolution) of 2 meters using OI's DMSC multispectral imager configured with the four bands at 451, 551, 710 and 850 nm. The 2012 imagery were collected between 10/14/12 – 12/10/12 using a RGB-NIR Microsoft UltraCam-X digital imager at a GSD of 0.3 meters. Data coverage for the imagery and corresponding kelp classifications are shown below in Figure 2. Due to weather and aircraft flight plan clearance issues, we were unable to collect data covering all of the California Fish and Wildlife (CDFW) Administrative Kelp Beds in 2011, but were able to acquire data for all areas in 2012. The 2 meter 2011 and 0.3 meter 2012 imagery will be delivered to Sea Grant via the OceanSpaces web site in late 2013 to early 2014. Final kelp classification products showing exposed and submerged kelp as separate classes were generated at a spatial resolution of 2 meters for both years and will also be delivered via the OceanSpaces server in late 2013 to early 2014, but can be made available to SCR partners earlier on a per request basis.

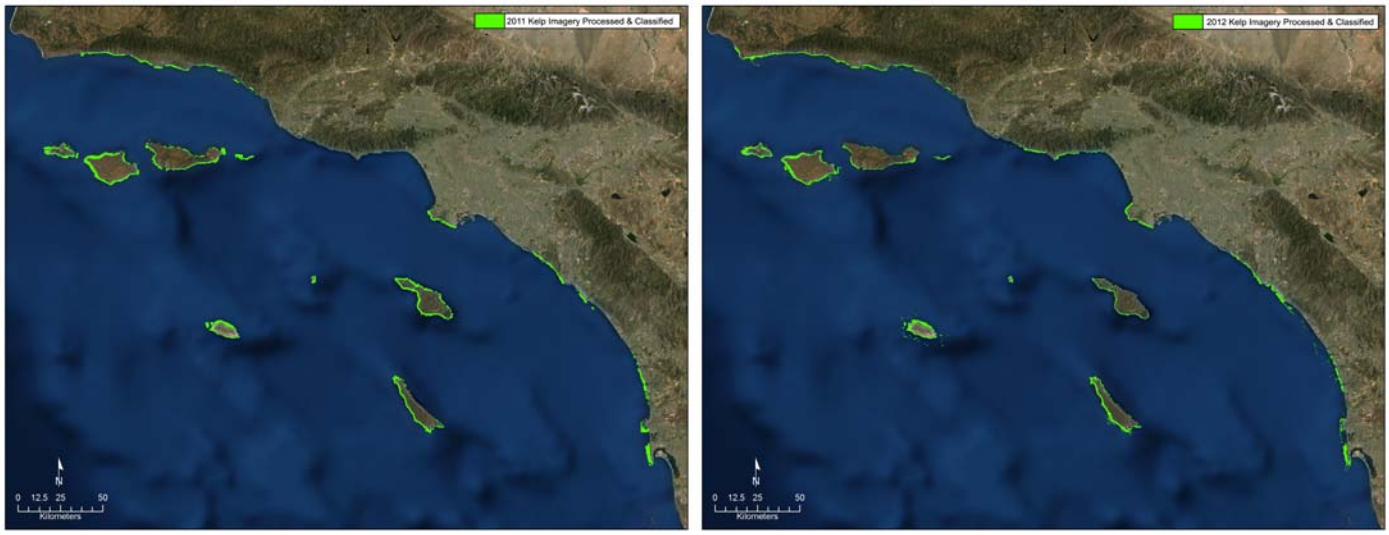

Figure 2. Green areas show where the multispectral imagery have been collected, processed and used to generate kelp canopy thematic maps for 2011 (left) and 2012 (right). Both the imagery and the kelp classifications for these regions will be delivered in GIS format and as PDF files via the OceanSpaces server.

5) **Multi-year kelp persistence analysis:** Work has begun on the kelp persistence analysis using the 2011 and 2012 kelp canopy classification products to create a statistical analysis showing the persistence of the kelp canopy in number of years for every 2 meter cell within the MPA zones and important surrounding areas throughout the SCR. The analyses will use data for the years 1989, 1999, 2002, 2003, 2004, 2005, 2006, 2008, 2010, 2011 and 2012. ***Figure 3*** (below) provides an example of the 2011 and 2012 kelp canopy coverage for a relatively large bed on the coast of Santa Rosa Island (CDFW Administrative Kelp Bed # 115) which includes the Carrington Point SMR. It also shows the variability in kelp coverage for the years between 2002 through 2012. These OI and CDFW data as well as CDFW data from the years 1989 and 1999 will be used to generate the final persistence analysis which will be delivered as a GIS-compatible file and in PDF format via the OceanSpaces web site.

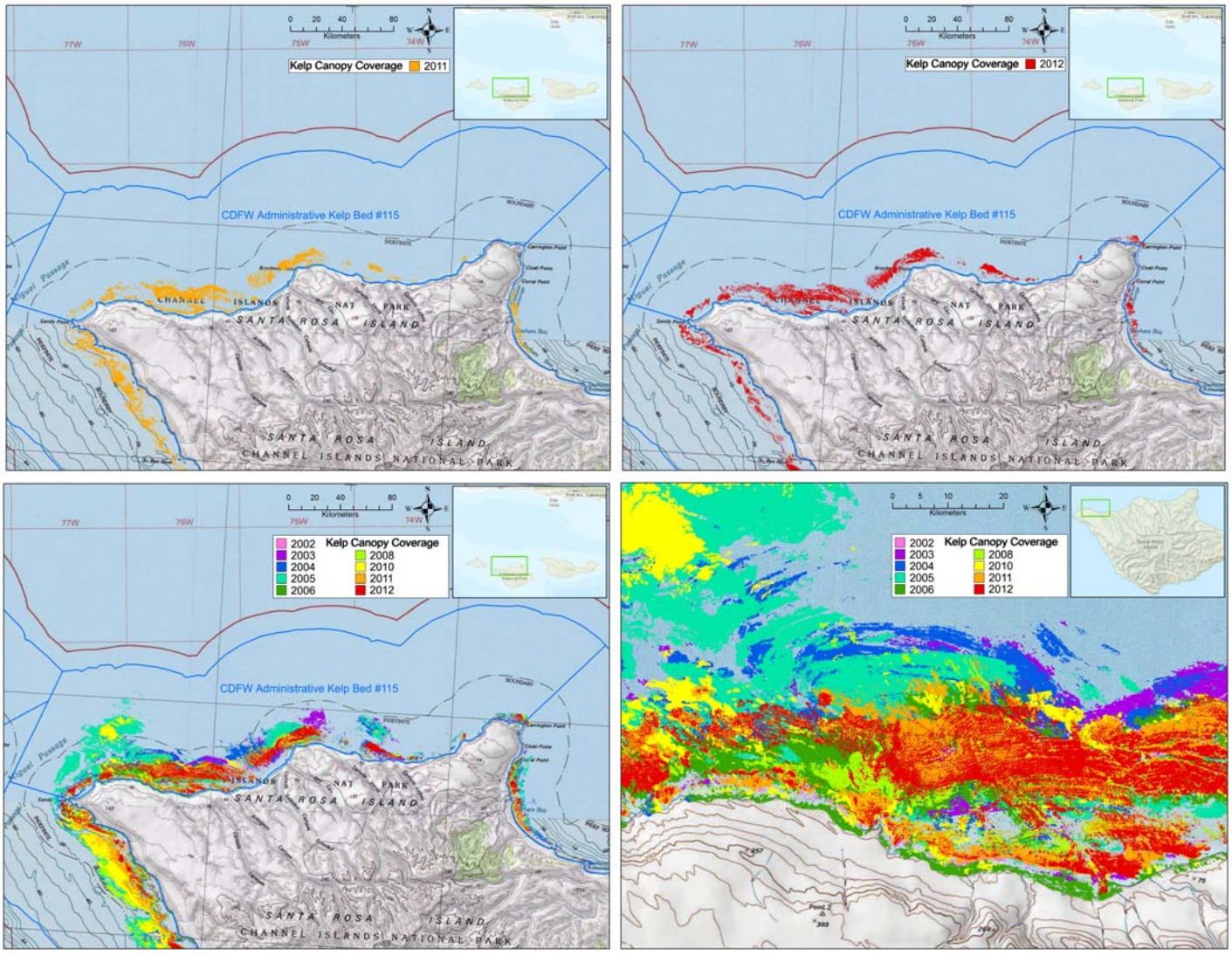

Figure 3. Kelp coverage on north side of Santa Rosa Island in CDFW Bed #115 including the Carrington Point SMR. Top images show coverage for the years processed as part of this study 2011 (top left) and 2012 (top right). Bottom images show years 2002-2012 with the most recent years layered on top of each successive year of data. Bottom left image shows a more detailed view of the western part of the bed. Note the significant inter-year variability in coverage over the 10-year span. *(Note: Years 2007 & 2009 not shown due to lack of available data.)*

6) **2001/2002 vs. 2011 Inter/subtidal change detection analysis:** Work has begun to characterize and analyze the decade-long change in several sub/intertidal, general substrate/vegetation classes identified in habitat classifications created as part of 2001-2002 work completed for the San Diego Association of Governments (SANDAG) compared to the same classes identified and mapped as part of this project. As the sub/intertidal classifications are finalized from the 2012 SCR imagery, the substrate/vegetation classes will be pared down to the same general classes identified using the 2002 data: Bare/Unvegetated Rock, Vegetated Reef/Rock (exposed and submerged), Surf Grass, Kelp and Sandy Bottom (exposed and submerged). The prime focus is to identify any significant changes in the total area of vegetated hard bottom vs. sand-covered bottom and unvegetated rock (i.e. loss of gain of algae habitat) as well as decadal changes in surf grass bed distributions within and around the proposed MPA areas. Kelp change analysis will be delivered in the form of the kelp persistence analyses discussed in section 5 above. The change in coverage of these classes over the 10-year period will then be delivered as a change detection analyses in both GIS-compatible format as well as PDFs. This work has begun and is expected to be completed in the Spring of 2014. ***Figure 4*** (below) shows an example of the classification products used for this analysis.

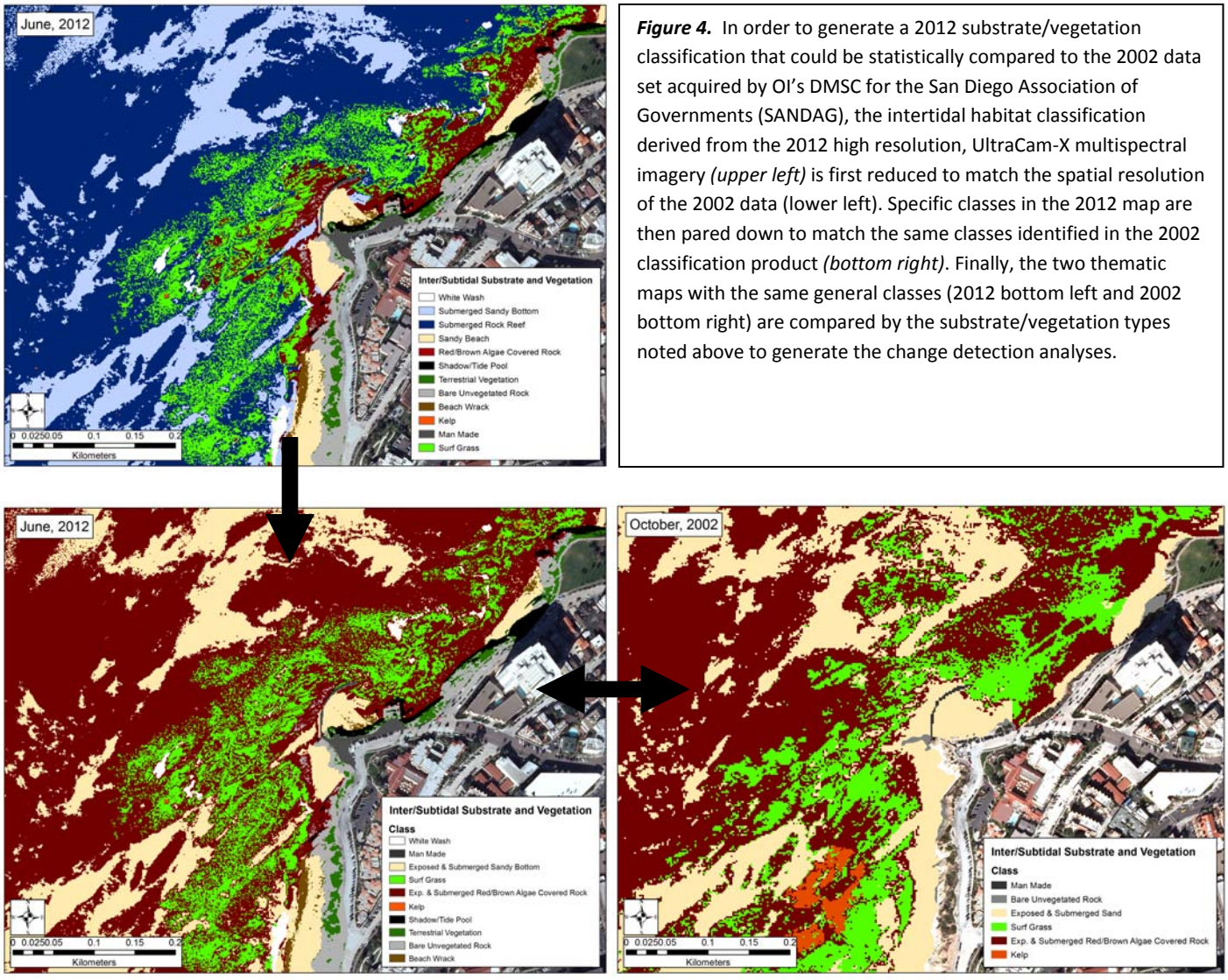

Figure 4. In order to generate a 2012 substrate/vegetation classification that could be statistically compared to the 2002 data set acquired by OI's DMSC for the San Diego Association of Governments (SANDAG), the intertidal habitat classification derived from the 2012 high resolution, UltraCam-X multispectral imagery *(upper left)* is first reduced to match the spatial resolution of the 2002 data (lower left). Specific classes in the 2012 map are then pared down to match the same classes identified in the 2002 classification product *(bottom right)*. Finally, the two thematic maps with the same general classes (2012 bottom left and 2002 bottom right) are compared by the substrate/vegetation types noted above to generate the change detection analyses.

Highlights from project progress so far, such as successes achieved, new collaborations or partnerships, or interesting stories from the past year that may be suitable for a blog post or other media venue

In addition to field data collected (and to be collected) by OI staff, OI put out a call for field data from our SCR partners. While the response to this request has thus far been limited, as mentioned above, Ms. Rani Gaddam has agreed to provide OI with her sample data from 13 biodiversity surveys completed in 2012. Each of the sites contain approximately 1,100 GPS-located biodiversity sampling points gridded inside survey bolts which can be located in the OI imagery and classifications. The points are spaced roughly 33cm apart which is a convenient match in spatial resolution to the 30cm imagery used to generate the classification products. We are using these data to aid in the training and accuracy assessment of our classifications which is and will continue to be a valuable addition to the classification process and increases the quality of the final products. ***Figures 5A-D*** show an example of how the classifications are re-trained to produce a more accurate product using Ms. Gaddam's field data obtained from the "Frenchy's Cove" survey area (violet square) on the south side of Anacapa Island. A portion of the field survey data will be set aside in order to assess the resulting accuracy of the re-trained classifications.

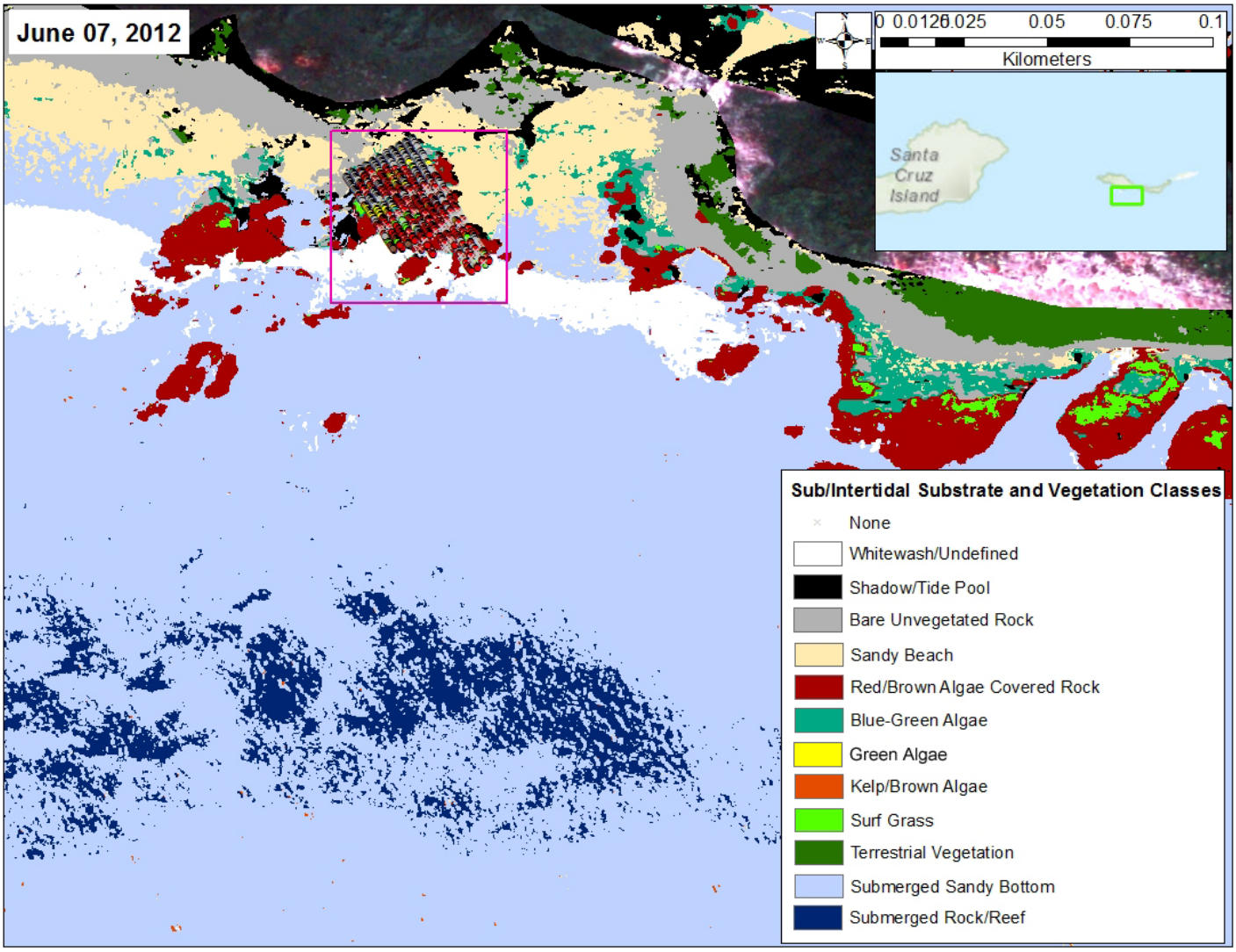

Figure 5A. Preliminary image-derived sub/intertidal classification of the south side of Anacapa Island with GPS-located field data points overlaid in the "Frenchy's Cove" survey area (violet square). The field data are first grouped into the same classes as identified in the preliminary image-derived sub/intertidal classifications. Then the field data are spatially compared to the image-derived classes to assess the classification results *(see Figures 5B and 5C below)*.

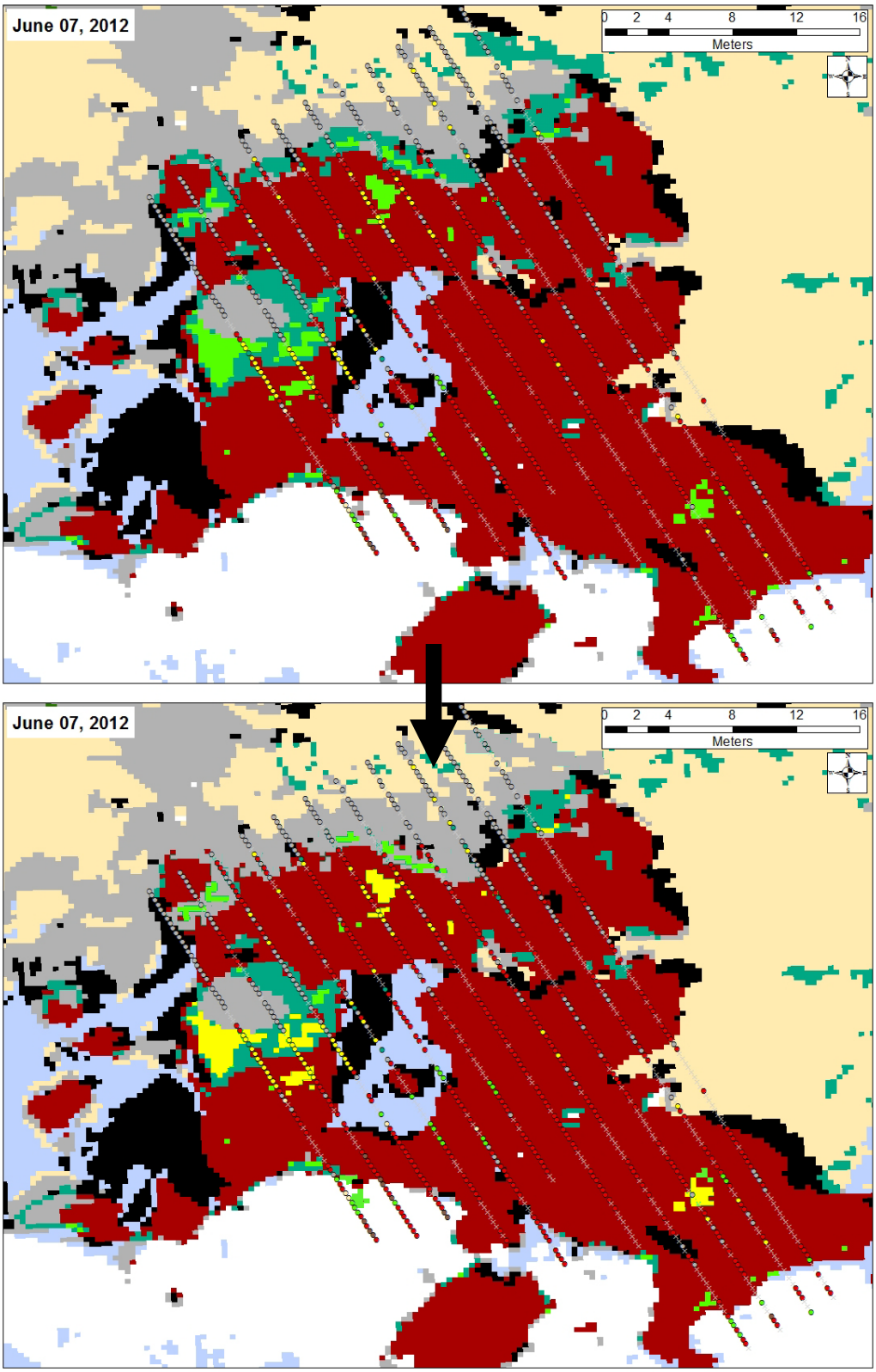

Figure 5B (upper): A close-up of the "Frenchy's Cove" survey area with GPS-located, colorized field-sample points overlaid onto the classification analysis. Each field sample was grouped into the same classes as the image-derived classification and displayed as a circle of the same color. A small 'x' represents points at which there were no field samples taken or the substrate identified was of an unknown class. The field data are then used to re-train the image.

Figure 5C (lower): The resulting adjusted classification after re-training via the field-data verification.

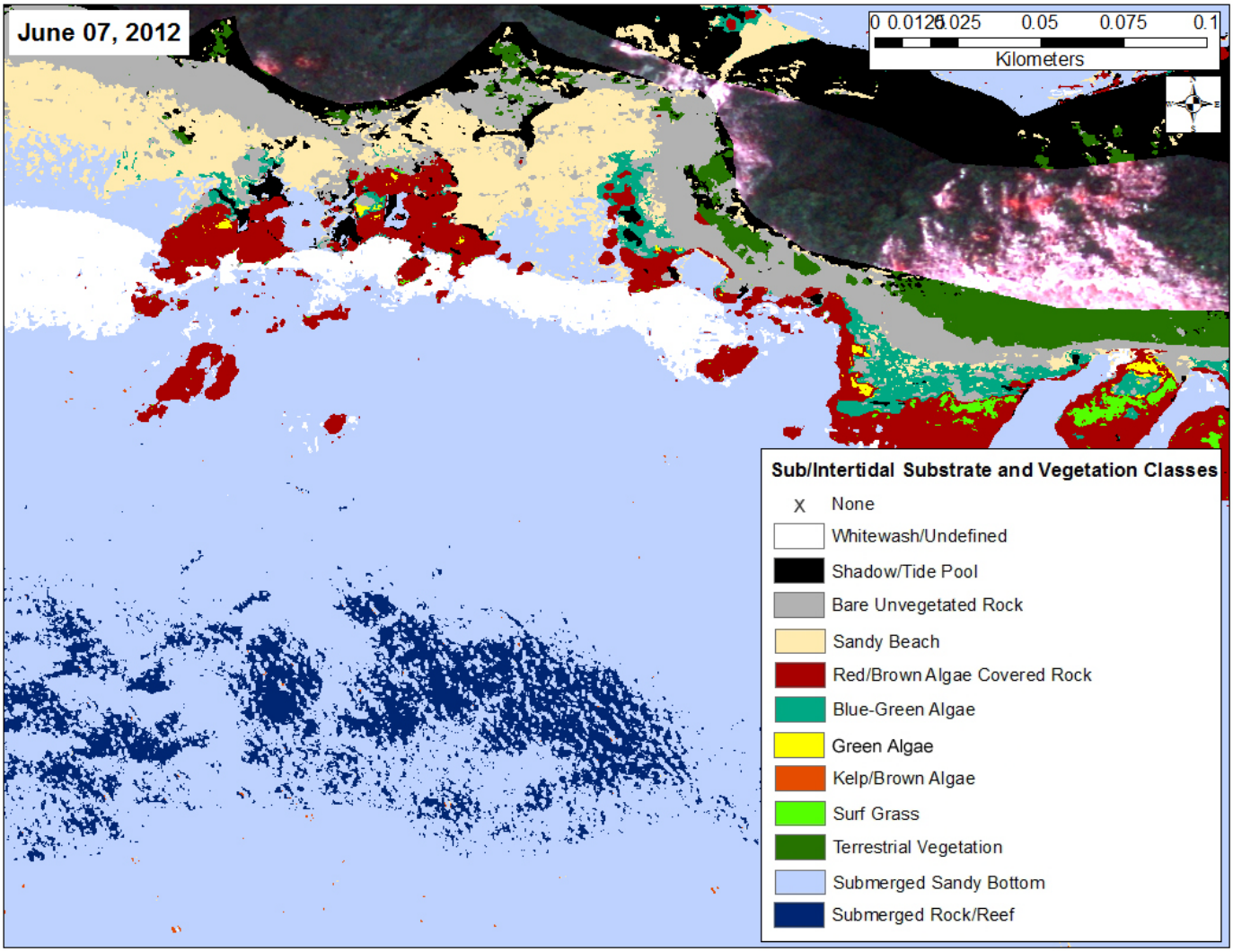

Figure 5D. Taking into consideration the spectral signatures of the points correlating with the field samples as well as the height of the samples in the intertidal zone, corrections are then applied to a larger area surrounding the survey site.

Description of any unforeseen events and substantial challenges, and resulting effects on project activities and progress. Please indicate any issues that may affect other PI's or require coordination with other Baseline partners (e.g., ME, DFG, Sea Grant).

Weather conditions unfavorable for the aerial imaging surveys (i.e. persistent low cloud cover) in the first half of 2012 during appropriate low-tide windows prevented completion of all the data acquisitions at that time. Obtaining optimal imagery requires collection during peak low tides to expose as much of the intertidal habitat as possible. The next opportune low-tide/low sun angle data-acquisition windows occurred in October-November, 2012. The postponed data collection, necessity to correct the geospatial accuracy of the imagery and desire to incorporate the valuable field data (described above) along with custom image mosaic generation for several SCR partners has delayed the original classification schedule. We are projected to be back on schedule with all of the preliminary classification products ready for final field validation by the end of 2013. We expect that all the imagery and classification deliverables will made available on OceanSpaces during May-June of 2014.

Data status (i.e., paper/raw format or digitized; if digitized, what format?)

All data, including UltraCamX multispectral imagery, LIDAR and field survey photo imagery are in digital formats compatible with standard (e.g. ARC-GIS) GIS software systems. File formats include GeoTif (.tif), ERDAS Imagine (.img), ESRI Shapefiles, Adobe Acrobat (.PDF) and .JPG. Ancillary data such as geolocation and ground substrate type/species information for the field sample locations are in MS Excel file format. A significant amount of time was spent in 2013 working to make the OI deliverables and associated metadata from the NCC project compatible with the OceanSpaces server. Several obstacles to efficiently deliver these types of files and their metadata via this server were discovered during this process. OI will continue to work with the OceanSpaces.org managers to better facilitate the delivery of the Southern California aerial multispectral imagery and associated habitat classification products via their system.

Activities Planned for following Project Year 3 (if applicable) – *Please describe remaining work and approximate timelines for completing that work, including any anticipated budget variances necessary to complete the project.*

As stated above, we aim to complete all remaining inter/subtidal habitat classifications by late 2013 to early 2014. Once the classifications are complete the remainder of the project's study period up to June of 2014 will include the following activities:

- Complete all field data collection for final classification training and accuracy assessment
- Complete kelp persistence analyses
- Complete 10-year inter/subtidal change detection analyses
- Deliver all imagery, thematic maps and analyses products to OceanSpaces along with their required metadata in the .eml format
- Work with SCR partners to facilitate easy access to OI imagery and data products as well as to ensure effective integration and fusion of OI products with their datasets and results
- Write and deliver final project report

Project Personnel – *Please indicate additional project personnel involved in your MPA baseline project, including students and volunteers, or additional PI contact information if necessary, as well as the nature of their assistance in the project project.*

	New Employees on Project	*Student Volunteers*	*Nature of Assistance*
Masters	*Michael Lekan*		*Habitat classification*
Masters	*Keith Jackson*		*Habitat classification*

Number of other Volunteers not counted above and the nature of their assistance in the project:

0

Additional PI contact info not listed on first page:

Cooperating Organizations and Individuals - Please *list organizations or individuals (e.g., federal or state agencies, fishermen, etc.) that provided financial, technical or other assistance to your project since its inception, including a description of the nature of their assistance.*

Name of Organization or Individual	*Sector (City, County, Fed, private, etc.)*	*Nature of cooperation (If financial, provide dollar amount.)*
Keystone Aerial Surveys	Corporation	Provides UltraCamX data collection support
NOAA Coastal Services Center	*Federal*	*LIDAR Data Clearance*
California Coastal Conservancy	*State*	Lidar & ADS-40 Data (financed original collection by Fugro and released data to SeaGrant)

Project Outputs and Materials: *Please provide any other project-relevant information, such as descriptions of attached materials, media coverage your project has received, presentations, publications, images etc.*