High Resolution Nearshore Substrate Mapping and Persistence Analysis with Multi-spectral Aerial Imagery.

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1. Goals and Objectives

The overall goal of this project is to create a baseline data base of **kelp canopy, shallow subtidal and intertidal bottom substrate, and estuarine ground cover** at very high spatial resolution (40cm-2m) covering all Marine Protected Areas (MPAs) in the California North Central Coast (NCC) region. Kelp canopy, bottom substrate and limited estuarine areas will also be mapped outside the MPAs, resulting in a spatially continuous data base for the entire NCC region. This comprehensive goal will be accomplished in a very cost-efficient manner by utilizing state-of-the art aerial imaging and multispectral image processing technologies. Substrate classification accuracy will be carefully validated with field sample data provided by other collaborating research teams as well as new sampling done specifically for this project. The resulting data base will provide much-needed (and presently nonexistent) baseline characterization information that will be utilized by numerous researchers targeting both ecological and socioeconomic impacts of MPAs in the NCC region. The inclusion of areas outside the MPAs will provide data over possible “control” sites for future studies.

Most natural resources tend to exhibit interannual variability in abundance and spatial distribution due to factors not related to the creation and maintenance of the MPAs. For a useful baseline characterization, it is thus important to include intelligence on such non-MPA variability so that future studies and monitoring projects can account for it in their results. Therefore, in addition to the data base described above, we intend to utilize image time series analysis to provide a quantitative measure of persistence and/or spatial distribution variability for several important coastal resources including kelp, eel grass, surf grass and pickle weed species.

In order to provide other research groups timely access to the various baseline products from this project, OI will create and maintain a dedicated web site where, upon authorization by SeaGrant and the CDFG, each processed data set will be posted for downloading as soon as possible.

Through the creation of the remote sensing-derived baseline characterization data base and the resource persistence/variability analyses we also hope to attain insights useful for evaluating these novel technologies for possible implementation and enhancement of a long-term monitoring plan.

2. Rationale

MPAs in the NCC region encompass numerous ecosystem types, including Estuarine, Beach, Rocky and Soft-bottom Intertidal, and Kelp ecosystems that have been identified as prime focuses for the region's MPA monitoring. These resources cover very large areas and the utilization of field sampling and measurements to establish a baseline characterization data base over their entirety at relatively high spatial resolution is economically and logistically impossible. At the same time, a high resolution, accurate subtidal, intertidal and estuarine bottom cover data base is of great importance for establishing the existing locations and spatial extents of various ecosystem and species types, and for use as a base layer by researchers studying the distributions and abundance of invertebrates and vertebrates with specific habitat requirements. Such base data will also be used by researchers studying socioeconomic impacts of the created MPAs – for example, any shifts in fishing activities from the MPA areas to other locations including kelp beds and related rocky substrate areas outside the MPAs.

Over the past decade, large amounts of funds and effort were expended in the NCC region to acquire a data base of subtidal and deep bottom characterizations using such technologies as multi-beam sonar arrays (Calif. Seafloor Mapping Project 2007). Over most of the area, however, such surveys provide information on bottom characteristics at depths of 10+ meters, because of logistical, technical, safety and other complications inherent in using the boat-based equipment closer to shore. A shoreline characterization is available for the region from NOAA map surveys (NOAA 2006, 2007) but such <u>linearly mapped</u>, generalized category classifications (e.g. intertidal rocky, sandy, coastal marsh) offer no detail and are not suitable for any future research related to impact of the newly created MPAs. Some very localized eel grass map data exist for several locations in the NCC region (Spratt 1989, Brown and Becker 2007), and spatially coarse surf grass distribution data were generated by the US Minerals Management Service in 1982 (no more contemporary data covering the entire region are available) (Woodward Clyde 1984, Tenera 2007). Kelp canopy has been surveyed annually by the CDFG until 2007 and by Ocean Imaging Corp. (under contract) in 2008. California's financial problems caused an indefinite suspension of the annual kelp survey program in 2009. Any other shallow subtidal, intertidal and estuarine ground substrate mapping data in the NCC zone are limited to research project-specific plots surveyed by various researchers on a very spatially limited, localized level.

Hence, a universally available, comprehensive, high resolution baseline characterization data base of shallow subtidal, intertidal and estuarine substrate distribution for the NCC region does not presently exist. The continued characterization and monitoring of kelp canopy resources in and around the NCC MPAs is also uncertain. At the same time, obtaining these data near the time of the MPAs' creation is vital for future research of these areas, and fits directly into the prime purposes of the North Central Coast Marine Protected Areas Baseline Program. **Our proposed utilization of state-of-the-art multispectral aerial remote sensing technologies to create this needed data base provides the Program with an opportunity to not only enhance its initial baseline characterization data gathering capabilities, but also to introduce and evaluate aerial remote sensing as a new, potentially long-term monitoring methodology.**

In preparation for this proposal Ocean Imaging (OI) discussed the potential of the proposed remote sensing-derived data base with other research teams that are either working on MPA-related projects in the Central and NCC regions and/or are planning to propose research activities in the NCC region (e.g. Laura Rogers Bennett – CDFG, Peter Raimondi – UC Santa Cruz, John Peterson – Impact Assessment Inc.). All expressed major interest in various aspects of the data base for their own work as soon as they become available, and offered collaborative support (e.g. ground truthing data from existing PISCO and future intertidal sites by P. Raimondi, see below) for this project. We plan to retain close association with these and other research groups and will seek their guidance and advice during the project to maximize the usefulness of the baseline characterization products to be developed.

3. Approach to be Used

OI has owned and operated various aerial multispectral sensors for coastal applications since the 1990s. Presently, OI owns two DMSC Mk-II aerial sensors manufactured by SpecTerra Ltd. in Australia. The DMSC sensor provides 4 channels at 12-bit radiometric resolution. Each channel's scanning wavelength can be customized with narrow-band (10nm) interference filters. This customization capability allows configuration of the sensor for maximum detection capabilities of the targeted substrate types. The imaging system is integrated with an Oxford Technologies Inertial Motion detection Unit (IMU) and differential GPS, which provide very precise geolocation information for each captured image frame.

OI has extensive experience in aerial image data acquisition and processing of coastal resources. As was already mentioned, OI has provided the CDFG with coastwide annual kelp surveys. OI also regularly maps intertidal and shallow subtidal resources, including annual surveys of Morro Bay and surrounding estuary for the National Marine Estuary Program, periodic surveys of San Dieguito, Tijuana, and Carpinteria estuaries for the California Coastal Commission, eel grass mapping surveys of several Mexican lagoons for the USGS and Ducks Unlimited, and intertidal and subtidal bottom substrate surveys of the entire San Diego County shoreline for the California Coastal Conservancy. This last project was done in conjunction with multibeam sonar mapping of bottom substrate in deeper waters and the two data types were then merged to create a seamless baseline data base from the shoreline out to 1km offshore

(Figure 1). Where possible, a similar approach will be utilized in the NCC region with the existing multibeam data sets (see below).

We propose a 2.5 year timeline for this project. Timing of data acquisitions for the various components of the proposed baseline characterizations is critical. The intertidal/subtidal zone data will be collected in spring of the first year, which provides the most favorable combined low tide and sun angle conditions and will allow timely distribution of these data to other research groups. Estuarine surveys will be done in late spring of the first and last years, corresponding (from past experience) to the growth cycle interval that allows the best species separation. Kelp surveys will be done in the fall of each of the 2 full years, corresponding to the timing adopted by CDFG in the past. Since more than 10 years' of past annual kelp canopy survey data are available from CDFG, the kelp persistence analysis can be readily done within the first-to-second year of the project. No similar data exist for the intertidal estuarine regions, however. We thus propose two data acquisitions at a 2 year interval, which will provide highly useful data for a persistence/variability analysis of eel grass, surf grass, and estuarine pickle weed resources.

For the data acquisition flights we propose (and include in the budget) utilizing a San Diego-based Cessna 206 aircraft owned by SanLo Aerial Surveys. OI presently utilizes this aircraft and higly skilled pilot for numerous projects. It may also be possible, however, to utilize CDFG's Sacramento-based Partenavia aircraft for some of the data collections (e.g. kelp surveys?) under a contractual agreement between OI and CDFG air services. OI has used their aircraft in the past for a number of CDFG-related missions including oil spill response and the coastwide kelp surveys. The advantages of the Partenavia are a significantly lower cost, proximity to the NCC region, and more efficient space setup within the aircraft. If funded, OI will work with CDFG's air services to fit some of the planned data acquisition missions into their schedule.

3.1 Baseline Intertidal Data Collection and Processing

The purpose of the intertidal (and subtidal where possible) surveys will be to acquire baseline characterization data along the NCC coast (both within and outside the MPAs) for the minimum following macro and micro substrate classes (additional differentiations will be made when possible):

- Soft Bottom
    - Surf Grass
    - Eel Grass
- Bare Rock
    - Cobble
- Algae-covered Rock
    - Red/Brown Algae
    - Green Algae (*Ulva* spp.)
- Kelp

Figure 2 shows the proposed extents of the intertidal mapping along the NCC region. We propose to cover the entire coastline with the exception of Tomales Bay. We propose to acquire the data at an **unprecedented 1.0-1.3m ground resolution.** In previous projects of this nature (see Figure 1), OI has found this resolution to provide very high spatial detail and substrate identification accuracy, while maintaining a sufficiently wide imaging swath to cover the targeted zone in a continuous flight line (hence offering best flight time cost efficiency). At 1m resolution, the DMSC's imaging swath width is approximately 1000m. Centered on the intertidal zone, this scan width will be sufficient to cover most targeted areas and provide additional coverage of the shoreline (useful for georeferencing corrections) and subtidal areas. In coastal sections requiring a wider swath width, multiple side overlapping lines will be flown and the data will be seamlessly merged.

The ability to accurately map submerged bottom substrates is, obviously, highly dependant on existing water clarity. In Southern California, OI has been able to accurately map substrates as deep as 7 meters (see Figure 1). Since water clarity in the NCC region tends to be less than in Southern California, we cannot establish *a priory* a definite depth range to which submerged resources will be mapped. From previously acquired aerial data in the NCC region, however, we feel confident that most of the region will be classifiable to a depth of at least 2m. Such depth penetration coupled with the peak low tide conditions should allow us to fill large portions of the existing habitat mapping void between the shoreline and the existing offshore multibeam sonar data base. An example using data from last year's kelp survey is shown in Figure 3. The Figure also exemplifies the possibility of merging available boat-based multibeam sonar data sets with the newly acquired aerial imaging-based data.

We propose to conduct the aerial surveys in the spring months to take advantage of maximal low tide conditions during daytime intervals with relatively low sun angle (morning and afternoon) to minimize sun glint effects. The flights will be scheduled to allow data acquisition within ±1.5 hours of peak low tide. We estimate that the NCC region can be imaged in 8 flight hours, corresponding to 3 days' of flights. Additional multiple flight days with the optimal tide/sun angle conditions will be scheduled to allow for possible cancellations due to inclement weather, wave or cloud conditions. It should be noted that due to the vastly different flight altitudes (7000' for intertidal substrate vs. 12,500' for kelp), different flight line logistics, and different acquisition season preferences, it is not possible to combine the baseline intertidal data acquisitions and kelp canopy survey flights.

We realize that spring/early summer may not coincide with the maximum annual density conditions for some of the targeted resources, e.g. surf grass which tends to peak in the fall (Miner et al. 2005). We believe, however, that for the baseline characterization purposes maximum offshore reach and depth penetration offered by the peak low tides in the spring is more critical than trying to record maximum growth conditions of specific resource types. As was already noted, we propose to acquire and process the image set in the spring of 2010 and make the final baseline characterization map available to all other research teams with 5 months.

Following the aerial data acquisitions, OI will obtain field sample data that will be used for both, initial classification algorithm training and final classified product accuracy evaluation. Dr. Peter Raimondi and his group from UC Santa Cruz has offered to provide OI with useful field data from his existing PISCO sites. He is also proposing additional field work sites in the NCC region and will share relevant field data from those areas if funded. Additionally, most likely on the same trip to the North Central coast as for the aerial data collection, OI staff will spend several days obtaining additional ground substrate field samples over various intertidal areas along the NCC coastline (during peak low tide conditions). The locations of these sampling sites will be established in consultation with Dr. Raimondi and other research teams. The field sampling will consist of obtaining positive identification of ground substrate at a DGPS logged location and obtaining photographic evidence. We will aim to obtain 200 – 300 sample points in various locations, one half of which will be utilized during the classification algorithms application, and the rest will be utilized for final product accuracy assessment (see Section 4).

The acquired image frames will be radiometrically calibrated, corrected for vignetting effects and mosaicked into a series of shoreline segments (to ease subsequent substrate classification processing). The data will be rectified to a base layer with known and acceptable spatial error characteristics (most likely 1m USGS orthoquads). Following methodologies successfully implemented in similar past projects, OI technical staff will then utilize a combination of commercial (Erdas) and custom developed neural network-based multispectral image classification software to classify each image segment for bottom substrate type. The algorithms will be trained with subsets of the gathered field data points, with the remainder of the field samples to be utilized for quality control and error assessment of the final classification products. Application of the classification algorithms is an iterative (and relatively labor intensive) process, in which subsets of the validation field measurements are used to refine the classification accuracy during each iteration.

As is mentioned above, part of the obtained field sample data will be used to assess final accuracy of the deliverable baseline characterizations. As we have done in the past, we propose to utilize Cogalton Matrix statistics (predicted vs. observed) (Congalton and Greene, 1999) which are often used to assess classification accuracy of remotely sensed data. In past projects, OI has repeatedly achieved accuracies in the 80+% range for intertidal and salt water marsh substrates using the proposed methodologies.

3.2 Baseline Kelp Data Collection and Processing.

In 2001 Ocean Imaging was contracted by the CDFG to acquire aerial imagery for its annual kelp survey and classify it for kelp and successfully completed the project. OI subsequently sold the aerial imager used in that project to CDFG and provided training in the use of the instrument as well as establishing CDFG's aerial kelp imaging mission protocols that were followed by CDFG staff until the in-house annual survey work ended in 2007. Since 2008, CDFG has again contracted with OI to produce the annual coastwide kelp surveys. California's financial problems recently caused the indefinite cancellation of the kelp contract for 2009 and following years. For this reason, we propose to include an annual kelp survey in this project's work plan. We intend to maintain data continuity with the past CDFG surveys by following the same image acquisition and processing protocols as were followed for the past CDFG surveys. This includes the annual timing of the data acquisitions, which will be done in the fall months (most likely in October), corresponding to a period of generally high kelp biomass, favorable sun angle and tide conditions, and before the effects of winter storms. OI plans to map the entire NCC region, as shown in Figure 2.

The NCC region kelp data supported by this project will thus be collected in the fall of 2010 and 2011. At present it appears unlikely that CDFG will re-initiate their kelp mapping program for 2010. Should CDFG reinstall its funding for the kelp mapping efforts, however, the effort and costs associated with an independent kelp survey of the NCC region could then be recinded from this project's plan.

Because of OI's extensive experimental and operational background for kelp detection and mapping, the DMSC's 4 channels are customized with a wavelength combination that maximizes both kelp detection and water penetration. This includes one channel in the IR range for surface kelp detection and three channels at experimentally-determined shorter wavelengths for submerged kelp detection. The custom configuration DMSC imagery allows accurate detection and separation of surface and subsurface kelp canopy using multispectral classification algorithms (see below). By maximizing water penetration depth capability, the system also makes it unnecessary to limit the kelp mapping activities only to hours around peak low tides. Similarly, imaging can also continue under cloudy conditions (provided the clouds are above the desired aircraft altitude), as well as light and moderate wind induced chop.

From OI's 2008 and previous kelp mapping experience, we estimate data acquisition will require 1-2 days for the NCC coastline. OI will suspend imaging on any day if weather or oceanic conditions begin to significantly affect data quality for accurate kelp assessment. As was noted above, it is likely that OI will be able to utilize CDFG's Partenavia aircraft based in Sacramento for the kelp work. OI's staff will travel to Sacramento on a commercial aircraft and will remain in the region until either all needed imagery is collected or prolonged bad weather or sea state conditions prevent data collection. In the latter case, OI will coordinate with CDFG to arrange a second data acquisition mission out of Sacramento, as needed. If the CDFG aircraft will remain unavailable for this project, OI will utilize SanLo's San Diego-based Cessna for the imaging work.

Original data will be collected at aircraft altitudes yielding 1.7m ground resolution (as requested by CDFG in the past, the final product will be resampled to 2m). With the DMSC's 1024 pixel CCD, most kelp beds along the NCC coast will be fully captured in a single shoreline-following flight line (with approximately ¼ of each frame containing land). As OI routinely does with the CDFG and San Diego-based pilots, a pre-determined flight line plan will be generated prior to each flight day and the pilot will then follow each flight line section using a dedicated DGPS. In a few cases, the existing kelp beds are either too large or too far offshore to be fully contained in a single flight line. In those cases multiple flight lines (with 60% overlap) will be acquired and mosaicked together before kelp classification. If other areas require multiple flight lines, these can be added to the flight plan in-flight.

Processing will consist of initial data pre-processing (channel-to-channel alignment correction, autogeoreferencing, data calibration), manual-assisted precise georeferencing correction using a validated base-layer, and image frame mosaicking and balancing. The surface and submerged kelp canopy will then be classified using OI's proprietary neural network classification software which has been validated for this application in previous projects. Multispectral classifiers in commercial ERDAS image processing software may also be utilized. Final products and metadata files will be generated using the ESRI ArcGIS software suite. An example of the initial image data and final classification from the 2008 survey is shown in Figure 4.

OI abides by the Federal Geographic Data Committee's Geospatial Positioning Accuracy Standards. The NSSDA uses root-mean-square error (RMSE) to estimate positional accuracy. RMSE is the square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy for identical points. Accuracy is reported in ground distances at the 95% confidence level. Accuracy reported at the 95% confidence level means that 95% of the positions in the dataset will have an error with respect to true ground position that is equal to or smaller than the reported accuracy value.

Spatial accuracy shall be tested by comparing the planimetric coordinates of well-defined points (e.g. exposed rocks, headlands, etc.) in the dataset with coordinates of the same points from the most recently available USGS Orthoquads. A minimum of 40 check points shall be tested within each 200km section of coastline. This procedure will be utilized for both QC (i.e. during processing) and QA (to assure final spatial accuracy reported with the final deliverables conforms to the desired ±2 RMSE). Classification accuracy will be assessed by utilizing series of high resolution (10-20cm) aerial photographs intermittently taken during the DMSC data acquisition. The final kelp class will be carefully analyzed with respect to features in the photographs to assure that the classification algorithm correctly isolates and maps the full kelp canopy. As part of QC procedures during processing, additional resources such as near-contemporaneous high resolution satellite images and past aerial data sets will also be consulted. The classifications will be re-run if identification or canopy omission errors are discovered. Another important QA component of OI's processing work is the exclusive use of processing staff with very high expertise in all processing steps required for accurate kelp mapping (versus the use of interns or lesser skilled technicians for some of the processing steps).

3.3 Baseline Estuarine Data Collection and Processing

Estuarine baseline characterization data will be collected and processed following successful methodologies developed by OI for the monitoring of estuaries and estuarine habitat restoration in Southern California for the California Coastal Commission (CCC) which primarily include marsh areas above the water line, and annual estuarine habitat mapping in Morro Bay for the Morro Bay National Estuary Program (MBNEP) which includes large areas of intertidal and submerged habitats. Figure 2 shows the proposed estuarine areas to be targeted. They include all estuarine habitats included in the NCC region's MPAs and one (Bodega Bay) outside the MPAs. Based on the CCC and other past similar work, we propose mapping the estuarine habitats at 40cm resolution, which we deem a practical compromise between spatial detail needed by future studies and cost of the data acquisitions and processing. Following the CCC and MBNEP project protocols, we propose to image estuarine areas with large intertidal and subtidal portions in the spring to take advantage of favorable peak low tide conditions. The acquisitions may be done during the same time intervals, and possibly during the same flights as the alongshore intertidal surveys. Imaging of estuary areas consisting primarily of above-waterline habitats will be done either at the same time or, if not enough flight time is available, in early summer. Our experience shows that for such habitats, early summer data acquisitions offer the most species differentiation capability due to the various plants' growth cycle stages present at that time. As with the alongshore inter/sub-tidal data collection and processing, we plan to image the estuarine regions twice during the project to allow persistence/variability analysis – in the spring of 2010 and again in the spring of 2012.

Also following the CCC and MBNEP protocols, the acquired multispectral data will be processed to yield, at a minimum, the same classes as for the alongshore inter-tidal map products, plus the following ground/bottom cover classes:

- Drainage Channels
- Bare Ground
- Salt Marsh Native spp.
    - Pickle Weeds (*Salicornia* and *Arthrotnemum* spp.)

    - *Frankenia* spp.
    - *Spartina* spp.
- Macro Algae
    - Red/brown spp.
    - Green spp.
- Salt Marsh Invasive spp.

Data processing and class generation procedures will be similar to those used for the alongshore inter/sub-tidal data processing. Field sampling will also be done similarly to the procedures described for the alongshore intertidal habitat (Section 3.1). Final quality control parameters and accuracy evaluations will be included in the metadata as described in Section 4. Figure 5 shows exemplary initial data and final products produced from a Morro Bay annual survey for the MNEP, which exemplifies and area containing primarily intertidal and subtidal estuarine habitat. Figure 6 shows the final product from Carpinteria Marsh done for the CCC, which exemplifies habitat mostly above the water line.

3.4 Persistence Analysis

As was already discussed, a useful baseline characterization data base should include some measure of habitat or resource variability due to natural or anthropogenic causes not related to the creation and maintenance of the MPAs. Without such data, the causal effects of variability in abundance or extents of certain resources could be misinterpreted in future studies. We propose to provide such a metric for several main resources of interest: kelp, eel grass and surf grass.

The CDFG has a high quality aerial imaging data set available for the NCC region between 1999 and 2008 (some of it collected by OI). These data will be obtained and utilized to create a first-ever data base of kelp persistence in the NCC region. The CDFG kelp classification data will first be inspected for georeferencing errors (some of the earlier data sets may be somewhat compromised) and corrected if necessary. The available data sets will then be run through a statistical algorithm on a pixel by pixel basis which will create a GIS layer of kelp persistence rendered as persistence classes in numbers of years. An example of a persistence map of the La Jolla bed in Southern California is shown in Figure 7.

In addition, future researchers may be interested in any growth/persistence trends for individual kelp beds. For this reason an additional data base will be created which will list each year's total kelp canopy area within each administrative bed section. This will allow assessment whether a particular bed which, for example, has shown 50% persistence over its maximum extents in the past 9 years, has been steadily increasing or decreasing in the most recent time period, or has fluctuated randomly throughout the measurement period.

As was discussed above, no suitable high resolution data exists from past years covering the estuarine regions that could be utilized for an assessment of interannual resource variability or persistence. For that reason we propose to acquire such data as part of this project, with the two acquisitions being temporally separated by a 2 year interval. The acquired data sets will be classified for ground substrate as described above and will then be run through a change detection algorithm targeting the eel grass, surf grass and pickle weed classes. From our multi-year mapping of these resources in Morro Bay and other estuaries, significant interannual variability of these important substrates does occur. Although two data sets do not provide for as comprehensive a persistence analysis as does the available decade-long kelp data series, our change detection analysis will still provide a variability metric that can be utilized in future surveys and research work.

3.5 Evaluation of Aerial Remote Sensing for Future Long-term MPA Monitoring.

As part of the final assessment of deliverables from this project, OI will conduct an evaluation of the used remote sensing technologies to help the MPA Baseline Program assess the usefulness of aerial remote sensing for future long-term monitoring of the created MPAs. The assessment will include an e-mail survey of all research groups that were provided with or utilized the aerial imaging-based baseline characterization products during the project. The survey will address the researchers' use of the data, and their opinions for usefulness for future periodic updates. The assessment will also include a thorough labor and cost analysis for the various potential monitoring products. Results will be reported in the project's final report.

4. Outcomes and Deliverables

As per the MPA Monitoring Enterprise's instructions, deliverables from this project will include raw image data files (calibrated and mosaicked), final GIS-compatible kelp, intertidal and estuarine ground substrate classification files, EML-standard metadata for each classification set including accuracy statistics, as well as annual progress and final reports.

Consultations with CDFG and academic researchers active in the NCC region prior to writing this proposal indicated that a number of research teams will benefit from obtaining the proposed baseline classifications as soon as possible. For that reason we propose to deliver the final products and metadata sequentially throughout the project (rather than as one complete set at the end of the project). OI will create and maintain a web site/data server through which the completed and QCed data sets will be downloadable by other research teams and the public. Prior to making each data set available through the site it will be first delivered to appropriate representative(s) of the MPA Baseline Program for approval. The data sets will also be available for distribution on DVD media. All raw data will be made available on DVD at the end of the project. The final baseline ground substrate classification product sets and estimated delivery times are as follows:

Russian River Estuary – Summer 2010 and Summer 2012
Estero Americano - Summer 2010 and Summer 2012
Estero de San Antonio - Summer 2010 and Summer 2012
Drake's Estero – Late summer 2010 and Summer 2012
Estero de Limantour – Late summer 2010 and Summer 2012

Coastal Intertidal Substrate (Southern half of NCC) – fall 2010
Coastal Intertidal Substrate (Northern half of NCC) – spring 2011

Coastal Kelp – winter 2011 and winter 2012

Kelp Persistence Analyses – summer 2011
Estuarine Persistence Analyses – summer 2012

CDFG's Office of Spill Prevention and Response (OSPR) has expressed keen interest in the proposed baseline data bases, since such information would significantly increase their abilities to assess resource damage potential during an oil spill in the NCC region, as well as could be used in follow-on damage mitigation work. OI has developed a remote sensing oriented GIS web-based server for OSPR in a previous project that has been utilized since in several spills. We will add the data layers from this project to that system as they become available.

5. Milestones and Project Management

The proposed timeline for this project covers a period of 2.6 years, beginning in February, 2010 and terminating in August of 2012. The initial year will cover the most data collection effort. The second year will include annual kelp data collection but most effort will be concentrated on processing the previously acquired data sets, generating the baseline characterization products and conducting the persistence analysis for kelp. One field sampling trip is also planned in the second year to allow an opportunity for additional verification data collection during the alongcoast intertidal and estuarine image classification work. As was already discussed, the final products will be made available to other research teams and the public sequentially through the project. Their estimated delivery times are shown in the previous section.

The project primary liaison with members of the Baseline Program management team and collaborating research groups will be Dr. Jan Svejkovsky. He will also be responsible for all reporting requirements and day-to-day management of the project. Logistics planning for the data acquisitions and interaction between OI and CDFG and other agencies/groups relevant to specific work tasks will be done by Jamie Kum. He will also manage all data processing, as he has done in similar past projects. The timeline of key tasks is shown below:

Task	2010												2011												2012											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Intertidal Substrate Data Acquisition		←	—	→																																
Estuary Data Acquisition			←	—	→																						←	—	→							
Intertidal Substrate Data Processing				←	—	—	—	—	—	—	—	—	→																							
Estuary Data Processing							←	—	—	—	—	—	—	—	—	—	—	→										←	—	—	—	→				
Field Data Acquisition			←	—	→										←	—	→									←	—	→								
Kelp Data Acquisition										←	→											←	→													
Kelp Data Processing												←	—	—	—	→								←	—	—	—	→								
Kelp Persistence Analysis																←	—	—	—	—	—	→														
Estuary Variability Analysis																													←	—	→					
Reports												***X***												***X***									***X***			

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