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	2011	**Study Region**	North-Central Coast
Project Title & Number	Integrated Ecosystem Assessment and Multivariate Indicators		
PI name	William J. Sydeman	**Co-PI name**	
PI Contact Info		**Co- PI Contact Info**	
(please list additional PIs and contact info in the "Project Personnel" section if necessary)			
Address	101 H St. Suite Q Petaluma, CA 94952	**Address**	
Email	wsydeman@comcast.net	**Email**	
Phone	707-981-8033	**Phone**	

Project Goals & Objectives

The North-Central Coast (NCC) Marine Protected Areas (MPA) are being established during a period of substantial temporal environmental variability and change. The impacts of climate change on marine ecosystems are not well known (Richardson and Poloczanska 2009), though clearly over the past 50 years ocean temperatures have increased considerably (Levitus et al. 2001). This trend is "highly likely" to continue for the foreseeable future (IPCC 2007). Indeed, the warmest global ocean temperatures on record were recorded in 2009 (NOAA, unpubl.). Therefore, there is critical need to assess climate-related ecosystem variability in addition to effects due to changes in fishing practices in order to comprehensively evaluate the efficacy of NCC MPAs during baseline and future monitoring.

There are predicted regional variations in marine climate change and ecosystem dynamics. In particular, upwelling-dominated ecosystems, such as the California Current, are expected to show significant regional variability in temperature, salinity, sea level, currents, ocean color, and other variables known to influence primary, secondary, and tertiary (fish and fisheries) productivity. As land masses are heating faster than the ocean, increased pressure gradients (ocean-based high pressure systems vs. land-based low pressure systems) may cause alongshore winds may intensify and lead to increased offshore Ekman transport and upwelling in these regions (Bakun 1990). Indeed, we understand the North-Central Coast (NCC) of California to be a region where upwelling intensification is already evident (Schwing and Mendelssohn 1997, Garcia-Reyes and Largier 2009). Ecosystem observations in the NCC have also been remarkable in recent years. In 2005, upwelling was delayed (a possible regional consequence of global warming; Schwing et al. 2006) and productivity reduced, with appreciable ecosystem consequences from plankton to rockfish to seabirds and marine mammals (Mackas et al. 2006, Brodeur et al. 2006, Sydeman et al. 2006, Wiese et al. 2006). In 2006, a similar "low-productivity" event was recorded. However, in 2007 and 2008, upwelling returned to near normal values, ocean temperatures dropped, and productivity improved. In 2009, upwelling was intense early in the season, but stopped, almost entirely in late May and June before increasing again in late summer. Nevertheless, biological productivity for many species was low. Indeed, the sequence of events, with interrupted or delayed upwelling in the NCC region in 2009 was reminiscent of the 2005 and 2006, both in terms of its physical driver(s) and biological consequences. Notably, in 2010 the NCC may be affected by an impending El Nino/Southern Oscillation event.

To date, a synthesis of these physical and biological changes in the NNC ecosystem has not been accomplished. Therefore, as part of our overall NCC MPA baseline monitoring project, we propose to integrate and describe trends and variation in physical and biological attributes of the regional ecosystem that have and are likely to affect the species and communities we will monitor in the NCC region. To make this investigation and report, we will design and develop an Integrated Ecosystem Assessment (IEA) for the region. The IEA will provide an evaluation of trends in physical and biological variables, in measures of central tendency (mean/median monthly or annual values) and variability (variance) leading to and during initial baseline monitoring, as well as a statistical analysis design to derive meaningful and interpretable "multivariate indicators" of (i) physical drivers and (ii) a variety of biological responses. In this manner, we will provide a report on ecosystem dynamics to the Monitoring Enterprise and MPA Management Community.

Summary of Project Activities Completed to Date

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

In 2011 we gathered data sets necessary for establishing baseline information for our Integrated Ecosystem Assessment (IEA) describing the status and trends of the North-Central Coast ecosystem prior to 2010 when the MPAs were implemented. We have organized data sets of physical measurements on multiple spatial scales relating to this specific area of the California Current ranging from large-scale sub-tropic and sub-arctic climate indices to local atmospheric and oceanic data such as air temperature, wind stress, upwelling, and sea level. We present these data on two time scales, 1990-2010 to examine trends and 2002-2010 to examine ecosystem state directly prior to MPA implementation. Biological indicator data that we integrated are ocean color (chlorophyll-a concentration), juvenile rockfish abundance, and Chinook salmon abundance.

We calculated monthly anomalies of physical data to account for seasonal variation and we tested for residual trending with Spearman rank correlation. For variables with multiple measurement sites, such as sea surface temperature (seven sites), we consolidated all sites into one measurement using principal component analysis (PCA). The resulting first principal components (PC1) are suitable for comparing physical drivers to each other and also to the biological variables. Additionally, we created a Multivariate Ocean Condition Indicator (MOCI) using PCA from all physical variables by season.

We plotted climate indices and variable type PC1s for each time series (1990-2010 and 2002-2010), MOCI by season, variable loadings for the MOCI in PC-space (PC1 vs. PC2), and biological variables.

As of March 15, 2012, we have nearly completed a draft report describing our methods and results for this IEA.

Our principle findings on trends in the physical environment (1990-2010) are as follows:
1) The frequency and intensity of ENSO appears to be decreasing
2) The intensity of the NPGO is increasing
3) Upwelling favorable winds are increasing
4) SST and air temperature are decreasing
5) There is no trending change in the velocity of the California Current, sea level, precipitation, or salinity

Our principle findings on trends in biological populations are:
1) Chlorophyll abundance is increasing
2) Though there appears to be cycles in abundance, there is no trend in the abundances of juvenile rockfish or Chinook salmon.

Highlights from project progress so far, such as successes achieved or interesting stories from the past year

The chlorophyll-a concentration data provided to us by Mati Kahru (Scripps Institution of Oceanography) are a novel production from the integration of data from four different satellite measurements of ocean color. SeaWiFS and MODIS are different ocean color satellite sensors and therefore have slightly differing time series. Though SeaWiFS data have been well-utilized, the time series ends in 2006. This new chlorophyll-a data product integrates outputs from four major ocean color sensors, including SeaWiFS and MODIS, and these data are matched to *in situ* chlorophyll-a data collected in the Northeast Pacific Ocean. The full time series from this data consolidation effort is 1996-2010. There is a paper in press describing this data set, and for this IEA we are among the first users of these data.

Manuscript in press: Kahru, M., Kudela, R.M., Manzano-Sarabia, M., Mitchell, B.G. Trends in the surface chlorophyll of the California Current: Merging data from multiple ocean color satellites. Deep-Sea Research Part II.

Description of any unforeseen events and substantial challenges, and resulting effect on data collection

We originally intended to include more than three biological data sets in our IEA, encompassing more trophic levels and species. We found, however, that data providers do not have recent years of measurements (later than 2007 or 2008) available for use. This hinders our ability to examine the status of these populations in the couple of years directly prior to 2010 when MPAs were implemented. We reduced number of the biological variables included to three and though fewer than we originally intended, we are satisfied with the coverage of trophic levels and species biodiversity.

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

All data are digital in MS Excel files. We will provide indicator variable data with the submission of our final report.

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

We will finalize our IEA report and expect to have it completed by June 30, 2012.

Project Personnel – *Please indicate additional project personnel involved in your MPA baseline project, including students and volunteers, or additional PI contact information if necessary.*

	Students Supported	*Student Volunteers*
K-12		
Undergraduate		
Masters		
PhD		

Number of other Volunteers not counted above:

Additional PI contact info not listed on first page:

Co-PI Sarah Ann Thompson, sathompson@farralloninstitute.org

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.)*
John Field, Southwest Fisheries Science Center, NOAA	Federal	Data provider
Mati Kahru, Scripps Photobiology Group, University of California San Diego	State (CA)	Data provider
Pacific Fishery Management Council	Federal	Data provider
Emanuele Di Lorenzo, Georgia Institute of Technology	State (GA)	Data provider
Earth System Research Laboratory, NOAA	Federal	Data provider
Howard Freeland, Fisheries and Oceans Canada	Federal (Canada)	Data provider
Bodega Ocean Observing Node, Bodega Marine Laboratory, University of California Davis	State (CA)	Data provider
Environmental Research Division, Southwest Fisheries Science Center, NOAA	Federal	Data provider
Marisol Garcia-Reyes, Bodega Marine Laboratory & Farallon Institute	State (CA) and Private	Data provider
Jim Hurrell, Climate Analysis Section, National Center for Atmospheric Research	Federal	Data provider
Climate Analysis Section, National Center for Atmospheric Research	Federal	Data provider
National Weather Service, Center for Climate Prediction, NOAA	Federal	Data provider
Joint Institute for the Study of the Atmosphere and Ocean, University of Washington	State (WA)	Data provider
Scripps Institute of Oceanography Shore Stations Program	State (CA) and Federal	Data provider
National Data Buoy Center, NOAA	Federal	Data provider
University of Hawaii Sea Level Center	State (HI) and Federal	Data provider
National Weather Service Cooperative Network	Federal	Data provider
National Climate Data Center, NOAA	Federal	Data provider

Additional Information – *Please provide any other project-relevant information, such as descriptions of attached materials, media coverage your project has received, etc.*