**NASA DEVELOP National Program**

**2018 Summer Project Proposal**

**California – JPL**

**Southern California Water Resources II**

*Predicting Grunion Migration Patterns and Spawning Areas in Response to Changes in California's Oceans*

**Project Overview**

***Project Synopsis*:** The California grunion is an endemic fish species found along the coast of California and Baja California. This project aims to help beach management stakeholders use remote sensing tools to observe the grunion spawning environment in order to make proactive decisions regarding this species’ habitat. This study will analyze sea surface temperature and chlorophyll-a concentration measurements from NASA JPL Multi-scale Ultra-high Resolution (MUR) and Aqua MODIS, respectively, and will pair these satellite data with various *in situ* data to analyze spatio-temporal patterns of environmental conditions that influence grunion spawning runs. The project will also explore whether salinity patterns have impacted the health of embryos using data from SMAP. The results will support the Grunion Greeters Project to help enhance the understanding of grunion migration patterns and will be shared with the California Department of Fish and Wildlife to support their efforts to conserve the grunion population.

***Community Concern:*** California grunion are found historically in the coast of California between Point Conception and the Mexican border. The grunion plays a critical role in the marine food web,

since the fish acts as a versatile food source for marine animals, seabirds, and other fishes. A population decrease of the grunion will negatively impact the species abundance at the higher trophic levels. It is also believed that the changes in the surrounding environment and over-harvesting by the human population will continue to decrease the grunion population. Grunion runs are free for visitors to engage with and learn from, providing opportunities for children to engage with wildlife. However, if the grunion population is too low, some beaches may have to be closed decreasing the accessibility of these educational programs.

***Source of Project Idea:*** This project idea came from discussions between DEVELOP mentor Benjamin Holt and Dr. Karen Martin, professor of biology at Pepperdine University and Executive Director of the Grunion Greeters Project, who is interested in beach management and ecology of marine animals.

***National Application Area Addressed:*** Water Resources

***Study Location:*** Coastal California, CA

***Study Period:*** January 2003 – December 2017

***Advisors:*** Benjamin Holt (NASA Jet Propulsion Laboratory, California Institute of Technology), Chelle Gentemann (NASA Jet Propulsion Laboratory, California Institute of Technology), Vardis Tsontos (NASA Jet Propulsion Laboratory, California Institute of Technology)

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Grunion Greeters Project** | Dr. Karen Martin, Professor of Biology, Pepperdine University | End User | Yes |
| **California Department of Fish and Wildlife** | Loni Adams, Marine Environmental Scientist | End User | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:***The Grunion Greeters Project is a collaboration of 30 different organizations, including greater entities such as US Fish and Wildlife Service, California State Parks, and the California Coastal Coalition. The Grunion Greeters Project conducts citizen-science based data collection on grunion spawning sites where volunteers submit population assessments, build staging tables for embryonic hatching mechanisms, and study the effects of altered salinity. These observations are then submitted online via Grunion.org, where results and datasets are made available for use by scientists, beach managers and government agencies. The California Department of Fish and Wildlife manages their marine protected areas and decides whether or not an outside project (recreation and restoration) implemented at the beach will impact the spawning areas. They make site specific recommendations to avoid and minimize impacts to spawning habitat and incubation period. They request grunion monitoring in their marine protected areas and decide if other projects should be located at a different location.

***End User’s Capacity to Use NASA Earth Observations:***

*Grunion Greeters Project* – Our partner has minimal familiarity with using NASA Earth observation data. Datasets collected by citizen scientists do not include Earth observation data. The results from the first term exposed the partners to the capabilities of Earth observation data. Creating a more refined end-product and tutorial will help the partners learn how to use GIS applications for their decision-making.

*California Department of Fish and Wildlife* – Our partner is not familiar with NASA Earth observations and has never used it in their management practices and decision making.

***Collaborator & Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*Grunion Greeters Project* – Dr. Karen Martin is one of the Board of Directors from the Beach Ecology Coalition, which is a non-profit organization dedicated to improving beach management in ecologically-sensitive areas. As Executive Director of the Grunion Greeters Project, Dr. Karen Martin plans to disseminate the results to the local beach managers and ecological scientists from both organizations.

*California Department of Fish and Wildlife* – Loni Adams may publish or discuss some of the maps or conclusions on the grunion spawning website or on a marine management blog, so it is available for public viewing if appropriate. Loni plans to distribute the project results to the Coastal Commission, which works on regulating the use of land and water in the coastal areas.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The main points of contact will be Dr. Karen Martin, Loni Adams, and the project lead. The team will schedule, at a minimum, biweekly telecon meetings to discuss the status of the project. They will send information via email if a telecon is not possible.

***Transition Plan*:** The results from this project will be handed off to Dr. Karen Martin and Loni Adams by email and through a separate videoconference during the last week of the term or at an in-person during closeout at JPL, depending on the time availability of the partners. During the hand-off, the team will show a presentation and a tutorial, so Dr. Martin can replicate the results in the future. Dr. Martin will share the project results with the beach managers with which she works closely. Loni will coordinate with her organization for a media post of the project results on the organization website. Software release is anticipated.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Aqua MODIS** | Chlorophyll-a | Data from this satellite will be processed and analyzed to create a time series of chlorophyll-a concentrations from 2003-2017. |
| **SMAP** | Salinity | Data from this satellite will be used to observe the long-term change in sea surface salinity and how it relates to the embryonic development. |

***Ancillary Datasets:***

Grunion Greeters Project citizen-science *in situ* data – This dataset contains the spawning locations of grunion and environmental conditions at field sites

Farallon Institute Multivariate Ocean Climate Indicator (MOCI) – California coastal ocean ecosystem index derived from local and regional ocean and atmospheric conditions

NASA Multi-scale Ultra-high Resolution (MUR) – These data will be processed and analyzed to create a sea surface temperature time series

NASA Ocean Surface Current Analyses Real-time (OSCAR) – These data will be used for sea surface current speed, direction, convergence, vorticity, and alignment data

NASA Cross-Calibrated Multi-Platform (CCMP) Ocean Surface Wind Vector Analyses– This will be used to create time-series of ocean surface wind vectors

NOAA Pacific Fisheries Environmental Laboratory (PFEL) Coastal Upwelling Indices – This dataset provides the latitudinal daily upwelling indices along the west coast of North America

NOAA NESDIS World Ocean Database 2013 – *in situ* air temperature data

WorldClim – this dataset will be used to obtain the monthly projected mean temperature

***Software & Scripting:***

Esri ArcGIS – data analysis, processing, and visualization

QGIS – map creation and visualization

MATLAB – data processing and statistical analysis

R – data processing and analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Time Series Maps of Climate Indices, Ocean Surface Currents, Wind Vectors, and Upwelling Indices** | These maps will allow partners to see where historical ocean observations have changed in relation to grunion spawning and migration patterns. This will enhance management practices in determining which environmental factors may play a role in grunion migration patterns. | *In Situ* MOCI, OSCAR, CCMP, and upwelling indices rasterization and composites | I |
| **Time Series Maps of Sea Surface Temperature, Chlorophyll-a, and Sea Surface Salinity** | These maps will allow partners to predict future scenarios of grunion migration patterns from the temperature, chlorophyll, and salinity changes. This will simplify and enhance management practices to help sustain the spawning habitat of the fish. | MUR Level 4, daily composite, 1 km resolution; Aqua MODIS Level 3, 8-day composite, 1km resolution; SMAP Level 3, monthly or daily composites, 0.25° resolution | I |
| **Grunion Spawning Site Suitability Maps** | These maps will assist partners to protect and establish regulation of the most suitable beaches for grunion spawning. | Grunion site suitability index based on ‘optimal’ conditions determined from SMAP, MUR, and Aqua MODIS time series maps, *in situ* MOCI, OSCAR, CCMP, and upwelling index data, and historical grunion spawning data | I |
| **Grunion Spawning Site Suitability Tool** | This tool will be built with ‘R-Shiny’ and will allow the partners to replicate the Grunion Spawning Site Suitability Maps with future Aqua MODIS, MUR, SMAP, and *in situ* data. It will incorporate the code used to create the Grunion Spawning Site Suitability Maps, as well as a user friendly GUI platform. | A tool to generate grunion site suitability index based on ‘optimal’ conditions determined from SMAP, MUR, and Aqua MODIS time series maps, *in situ* MOCI, OSCAR, CCMP, and upwelling index data, and historical grunion spawning data | V |
| **Grunion Spawning Site Suitability Tool Tutorial** | This tutorial will be a written, step-by-step instructions manual for the partners as a reference on how to use the Grunion Spawning Site Suitability Tool, including required inputs and expected outputs. | An instruction manual detailing the use of the Grunion Spawning Site Suitability Tool | V |

***End-User Benefit*:** The time series maps will help the Grunion Greeters Project and other stakeholders predict areas where future grunion spawning may take place. The maps will also help the partners to save time and resources in guiding their citizen scientists’ collection of *in situ* data. The end user will have an improved ability to assess current management approaches and will be empowered to improve conservation management practices based on the results of this project. The California Department of Fish and Wildlife may incorporate the end results into a grunion minimization guidance document.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2017 Summer to 2018 Summer

***Multi-Term Objectives:***

* **Term 1:** 2017 Summer (JPL) – Southern California Oceans
  + The first term focused on creating a time series of sea surface temperature and chlorophyll-a patterns to help predict if there was a correlation between these factors and where the grunion chose to spawn. The initial end products were promising and were shared with the partner for review. However, the team stressed the need for *in situ* data to aid in detecting patterns from the remote sensing data.
* **Term 2 (Proposed Term):** 2018 Summer (JPL) – Southern California Water Resources II
  + The second term will focus on creating a larger time series of sea surface temperature, salinity, and chlorophyll-a for the entire coast of California and the nearby Pacific Ocean with a better array of *in situ* data. The time series will be compared at different latitudes to determine if sea surface temperature and chlorophyll-a are significant factors affecting grunion spawning patterns, and if changes in salinity are impacting embryo health. A tool is anticipated, so the partners can easily replicate the methods for future satellite and *in situ* data.

***Previous Terms:***

2017 Summer (JPL) – Southern California Oceans: Analyzing NASA Earth Observation Data to Evaluate Grunion Response to Ecosystem Changes Forced by Recent Environmental Conditions in California’s Oceans

***Related DEVELOP Work:***

2014 Summer (GSFC) – Argentina Oceans: Analyzing Harmful Algae Blooms in Southern right Whale Habitat Using a Suite of Satellite Earth Observations.

2015 Summer (GSFC) – Maryland Ecological Forecasting: Utilizing NASA Earth Observations to monitor and Strengthen the Survivorship of Maryland’s Sea Turtles

2017 Spring (LaRC & JPL) – Mississippi Sound Water Resources: Synthesizing Trends in Water Quality Parameters that Affect Oyster Reef Health in the Mississippi Sound Using NASA Earth Observations

2017 Summer (LaRC) – Mississippi Sound Water Resources II: Analyzing the Impact of Environmental Disturbances on Oyster Reef Health in the Mississippi Sound Using NASA Earth Observations

**Notes & References:**

***References:***

Martin, K. L. M., Van Winkle, R. C., Drais, J., & Lakisic, H. (2004). Beach-spawning fishes, terrestrial eggs, and air breathing. *Physiological and Biochemical Zoology*, *77*(5), 750-759.

Martin, K. L., Moravek, C. L., & Flannery, J. A. (2009). Embryonic staging series for the beach spawning, terrestrially incubating California grunion *Leuresthes tenuis* with comparisons to other Atherinomorpha. *Journal of Fish Biology*, *75*(1), 17-38.