Capstone 1 Proposal

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Using Acoustic Telemetry Data and Environmental Variables to Predict White Shark Presence in Southern California

1. *Background*

Acoustic telemetry is a common tool used in research projects that focus on the movement patterns of species that are resident to seawater environments. Individuals are tagged with small, acoustic transmitters (hereby transmitters) that emit an ultra-sonic signal that can be heard by acoustic receivers (hereby receivers) that are deployed nearby (within 0 m to 1 km away, depending on the environmental conditions). Similarly to the FasTrak lane on the highway, receivers act as a toll booth, listening for transmitters that come into its detection radius, and transmitters act as the FasTrak beeper in your car, sending out a signal to be picked up by the toll booth (receiver). When a transmitter is within the detection range of a receiver, the receiver then records the date, time, and transmitter ID code of the tagged animal in the area. This method of acoustic telemetry is termed “passive” acoustic telemetry, because it does not require researchers to actively follow individuals in real-time. Instead, the receivers remain stationary in a single area for as little as a few days and to as much as an entire year, collecting data streams as they come. When receivers are recovered and downloaded, the resulting dataset tells researchers when a particular individual was within a specific area.

2. *The Problem*

Research studies that focus on large, predatory species like sharks typically attract more media attention and public enthusiasm than other, less charismatic species. White Sharks (*Carcharodon carcharias*), in particular, appear to be one of the more popular species, as they are commonly addressed by news broadcasters and the entertainment industry (e.g., Jaws). In southern California, juvenile White Sharks show seasonal and sometimes annual fidelity to particular coastal beach habitats, meaning that individuals return to the same beaches year after year. These beaches are often coined ‘hotspots’ for juvenile White Sharks, and individuals may stay in these hotspot areas for up to a few months before moving to another region. Researchers hypothesize that these movements are primarily temperature driven, as juvenile White Sharks are not yet capable of fully controlling their internal body temperatures; the sharks move towards warmer waters when it becomes too cold. However, no studies have explored whether this hypothesis is correct, or how other parameters affect White Shark movement. By determining which parameters are most influential in White Shark movement, we may be able to predict when and where future hotspots will arise. Because juvenile White Sharks frequently use coastal beaches that are shared with beach-goers, predicting White Shark movements may help to reduce the probability of shark-human interactions by giving lifeguards advanced notice of when White Sharks are likely to be present. Therefore, the purposes of this project are 1) to determine which combinations of environmental conditions and inherent properties (e.g. sex, age, shark tagging location) are most likely correlated with juvenile White Sharks presence in southern California, and 2) to predict the ranges and categories of conditions that are most likely to result in the presence of a White Shark.

3. *Specific Clients*

This project is geared towards researchers who may be studying similar species or may be trying to answer similar research questions and lifeguards or other public safety personnel who may benefit from advanced knowledge of potential threats within their jurisdictional region.

4. *Datasets and Approach*

Passive acoustic telemetry data were collected by the California State University, Long Beach Shark Lab between 2012 and 2019 from regions as far north as Morro Bay, CA and as far south as San Diego, CA. However, receiver coverage during these times varied greatly on the spatial scale. The dataset provided for this project includes data from several juvenile White Sharks that were tagged opportunistically during the study period. Variables within this dataset include: DateTime, Latitude, Longitude, and Transmitter Code. These data will be parsed using a log of acoustic receiver deployments, which include the receiver serial number, the latitude and longitude of deployment location, the time the receiver was put in the water, and the time the receiver was retrieved from the water. Acoustic receiver data will be parsed to only include durations of time in which there is confidence that the receiver was in the water, in order to reduce the probability of false positives, in which a receiver records a detection when no transmitter is present.

A transmitter deployment log is also provided by the Shark Lab, which includes the following data: Transmitter Code, Species, Size at Tagging, Tagging Location (City), Tagging Date, Sex (M, F, or Unknown). From the Tagging Date, a ‘tagging cohort’ category will be created, as behaviors may change as individuals age. For the purpose of this study, acoustic receiver data will only include the transmitter codes that are present in the transmitter deployment log (White Sharks only). In order to reduce the probability of false positives during a receiver’s deployment and to remain consistent with previous acoustic telemetry literature, only sharks that are detected by a receiver two or more times per day will be included in analyses.

Using ArcGIS, I created a ‘fishnet’ (grid) shapefile that partitions the oceans within the southern California jurisdiction from ~ 10 m onshore to ~ 300 km offshore. Each individual grid cell (0.01 x 0.01 decimal degrees) is paired with an identification code.

Historical environmental data will be collected from a suite of online resources, including: daily sea surface temperature (NOAA Coastwatch), daily sea surface salinity (NOAA Coastwatch), daily chlorophyll-a levels (NOAA Coastwatch), and estimated seafloor depth gradient (NOAA Coastwatch). These datasets have different spatial resolutions, but similar temporal resolutions. Therefore, the White Sharks that are detected and the number of receivers that are deployed will be evaluated each day. Calculations will occur for the entire date range of the acoustic receiver dataset, even if no sharks were detected on that day. Because the spatial resolutions are different across datasets, all data will be standardized to the fishnet shapefile that was created, by finding the GPS locations that overlap with particular fishnet grid cells. For environmental datasets that have more than one value in a single data cell, mean values will be calculated.

Data will also be generated from *pylunar* to calculate the moon phase for each day at each grid location, as several marine species show movement patterns that correspond to the lunar cycle.

Separate datasets will be combined to include the following fields: Date, Grid Identifier, Receiver Density (receivers deployed per grid cell), Shark Transmitter ID, Shark Size (at tagging), Sex (M, F, Unknown), Shark Cohort (categorical), Shark Tagging Location (categorical), sea surface temperature, sea surface salinity, chlorophyll-a, mean seafloor depth gradient, and lunar phase (categorical).

Using a supervised machine learning approach, I will determine which environmental variables influence shark presence most and I will build a series of environmental thresholds and inherent shark properties that may serve to classify shark presence if the conditions are met.

5. *Deliverables*

The code from this project will be made available on GitHub, and a thorough report will be written that addresses background, methodology, results, discussion points.