# Dynamics of foraging interactions between cookiecutter sharks (Isistius spp.) and short-finned pilot whales (Globicephala macrorhynchus) in Hawaiʻi

## Project summary

This project investigates the foraging patterns of cookiecutter sharks (<em> (Isistius spp.) </em>) on short-finned pilot whales (<em> (Globicephala macrorhynchus) </em>) around the Hawaiian Islands. Utilizing photo-identification data from 2003-2012, the study analyzes the spatial and temporal distribution of shark bites on pilot whales. The findings suggest seasonal migrations and dietary shifts in cookiecutter sharks influenced by factors such as lunar phases and sea surface temperature.

The study was conducted off the leeward (western) side of Hawaiʻi Island, covering approximately 2500 km², with depths ranging from shallow coastal waters to about 5000 meters.

From 2003 to 2012, data were collected during research surveys and opportunistic sightings by the Wild Whale Research Foundation. During these surveys, groups of short-finned pilot whales were approached to confirm species, take photos for individual identification, and collect sighting data, including date, GPS location, and group size. Efforts were made to photograph both sides of each individual, although field conditions sometimes limited this. Photos were then sorted by individual using unique natural markings on the dorsal fin and compared to an existing photo-identification catalogue.

Photos from each sighting were examined for cookiecutter shark bites, categorized as fresh, healing, or scarred. The whale's body was divided into sections (head, mid-lateral, dorsal fin, and peduncle) for bite analysis. Fresh bites were identified by their pink or red color and signs of early immune response, healing bites by their orange color due to cyamid presence, and scarred bites by re-pigmented tissue. The proportion of the body visible in photos was calculated to determine the extent of bite marks.

## Data Structure

Raw data for all recorded sightings are in .csv format and contain the maximum number of all bite states, breakdown of number of bites of each state, bite location on body, degree of pilot whale body observed in each sighting. This was subsequently used to calculate observed versus expected number of bites on body locations. Weekly average sea surface temperatures were obtained from National Oceanic and Atmospheric Administration using AVHRR Pathfinder Sea-Surface Temperature v5 and v5.1 for the study area. The area used for SST was from 19oN to 20.25oN and from 156oW to 158oW. Lunar phase and lunar illumination were obtained using the lunar package in R (Lazaridis 2015), for each survey date. Phases were combined into groupings of similar illumination: waxing crescent and waning crescent were combined, as were waxing gibbous and waning gibbous. All details on calculation of these statics can be found [here](https://github.com/NWMilne/cookiecutters).

### Data analysis

Species distribution modelling of presence/absence (PA) for bite probability was undertaken with a binomial Generalised Additive Mixed Models (GAMM) using the [gamm4](https://github.com/cran/gamm4) package, with pilot whale social cluster included as a random effect to account for potential grouping of data. Model accuracy testing was conducted on a 25% split of the data and results of a confusion matrix using the [caret](https://github.com/topepo/caret/) R package. Prediction of PA was visualised from GAMM models using [ggplot2] https://github.com/tidyverse/ggplot2).