
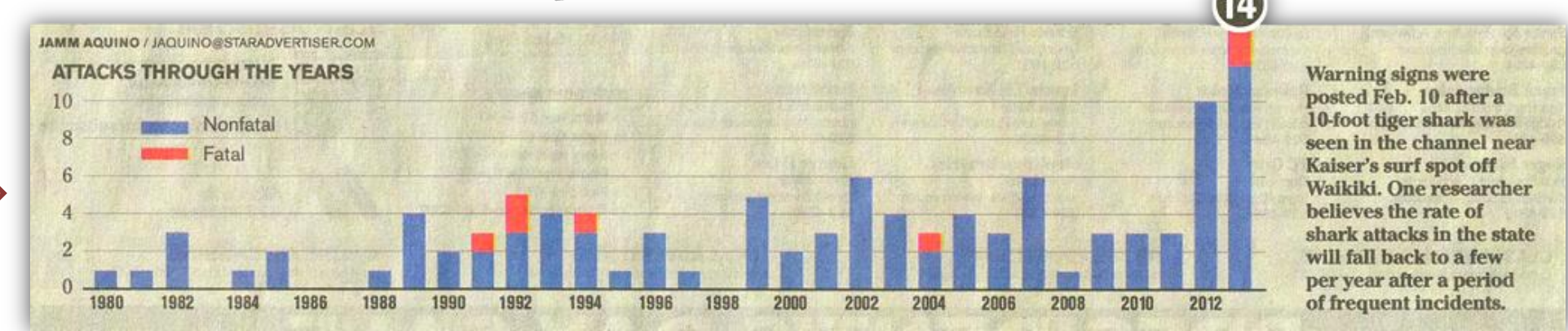


Near Real-Time Tiger Shark Monitoring Around Maui

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why?:

Maui has witnessed a higher number of unprovoked shark attacks than in previous years. What is the appropriate management response? Are tiger sharks around Maui more resident (more "site-attached") than they are around the other Hawaiian Islands? And do they exhibit greater use of **inshore habitats** than in other locations?

Warning signs were posted Feb. 19 after a blood tiger shark was seen in the channel near Kaunoi's reef spot-off Waikiki. One researcher believes the rate of shark attacks in the state will fall back to a few per year after a period of frequent incidents.

Front page news February 15, 2014. Credit: Honolulu Star Advertiser. Used with permission.

To help answer these questions, the State of Hawaii has commissioned a **two-year study** to track the movements and behavior of tiger sharks around Maui. University of Hawaii investigators **Carl Meyer** and **Kim Holland** lead the effort. The Pacific Islands Ocean Observing System (**PacIOOS**) is disseminating the data to the public in near real-time via their Hawaii Tiger Shark Tracking website at: <http://pacioos.org/projects/sharks/>

tagging:

Three broad **target areas** for tagging expeditions after consultation with a variety of Maui ocean users and resource managers encompasses both locations of previous shark bite incidents and reported "near-misses":



Satellite tags utilize **radio transmissions**, requiring the tag to have contact with air to send data. For studies of shark movements, Smart Position or Temperature Transmitting Tag (**SPOT** tags) are commonly attached to the **dorsal fin**. SPOT tags transmit a signal to the **Argos** satellite array whenever the dorsal fin breaks the surface of the water.

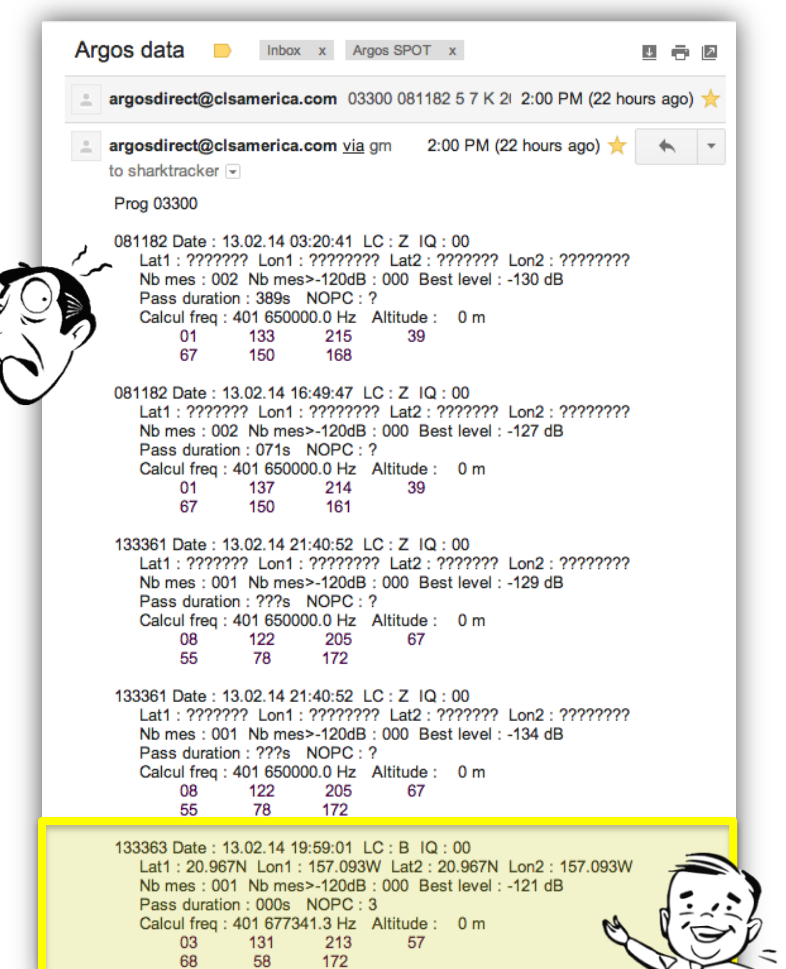
Tiger sharks are captured using baited hooks on the ocean floor a couple of miles off shore and restrained by tail-roping and inverting them (turning them belly side up). This places sharks in a temporary trance-like state referred to as "**tonic immobility**" allowing the researchers to quickly identify, sex and measure the sharks, and to equip them with dorsal fin-mounted satellite (SPOT) tags without harm to the sharks.



data:

01011
11000
00110

[1] When tags breach the ocean's surface, they send a message to an available **Argos** satellite.



[2] Argos sends e-mail updates with recent tag locations in 24-hour intervals.


[3] E-mails are manually screened to discard bogus data points that are on land or that exceed the expected swim rate of ~4 mph.

Argos location accuracy varies with the geometrical conditions of the satellite passes as well as the number of messages collected while the tag breached the ocean surface.

Argos location classes:

- 3 = < 250 m
- 2 = 250-500 m
- 1 = 500-1500 m
- 0 = 1500+ m
- A = unknown
- B = unknown
- Z = invalid

This range in accuracy motivates our manual screening for additional quality assurance.



[4] Data that passes the screen is uploaded to a custom CGI web interface for translation to **GeoJSON** format.

[5] GeoJSON files are fed into PacIOOS Voyager where custom **JavaScript** allows the public to map and animate tracks using the **Google Maps API**.

JavaScript:

GeoJSON locations are rendered as map markers using the **Google Maps API** Version 3 via a PacIOOS-engineered custom JavaScript library (**DynaTrack**) for mapping and animating tracks such as tagged organisms, drifting buoys, autonomous ocean gliders, and shipborne surveys.

Changing the map **viewport** (pan or zoom) automatically updates the set of displayed markers.

Clicking on a marker provides an **info window** with ancillary information gleaned from the GeoJSON data file:

```

Tiger Shark Tracking
ID: 133369
lat, lon: 20.9540, -156.7440 (dms)
date: Feb 23, 2014 12:25 pm HST (show UTC?)
sex: male
length: 9.3 ft (2.8 m)
positional accuracy: unknown
Hawaii Institute of Marine Biology
    
```

While hovering over a marker with your mouse, an **ELabel** is used to indicate the timestamp for that location.

Markers are rendered as **SVG symbols** for dynamic control over icon shape, size, color, and opacity.

MarkerManager is used to optimize memory management and performance for displaying hundreds of map markers within the browser.

Legend graphic can be dynamically tailored for other color palettes and observed properties; image made draggable via **jQuery UI**:

Animation is enabled by updating an array of displayed map markers at set time increments via JavaScript **setInterval**.

viewer:

Voyager by observing we learn
<http://pacioos.org/voyager/>

PacIOOS Voyager is an integrated online map viewer and data access portal for a wide variety of oceanographic observations, forecasts, and other data.

Includes active as well as historic tracks of tagged tiger sharks and other marine organisms with a wide variety of visualization options and geographic utilities.

Save an image or share a URL to your existing map settings.

Use as a **web app** or download the native **iOS app**.



website:

PacIOOS Voyager is embedded into our Hawai'i Tiger Shark Tracking site: <http://pacioos.org/projects/sharks/>

[1] Landing page shows most recent location of each shark.

[2] Then pick a shark at left to animate its track.

So far we have data for **13 tiger sharks**: 11 females and 2 males ranging in length from **9.3 ft (2.8 m) to 14.2 ft (4.3 m)**, 8 tagged in mid-October 2013 and 5 tagged in mid-January 2014. More will be included in the future after additional sharks are tagged.

