

# Correlations in the migratory patterns of the Sooty Shearwater

Erica MacIntosh - 2019

The Sooty Shearwater, *Puffinus griseus*, is a seabird found in large numbers in both the Atlantic and Pacific Oceans. This study follows one particular bird named "Atlantis" as it goes through its migratory path in the Atlantic Ocean. Data was collected from three different years; 2007, 2009, and 2010. The locations where this bird was found was compared to other data in order to find correlations between the location of the bird and physical ocean and environmental features in order to determine the motivation for migrating to specific locations during specific times.

Figure 1 When sitting on the water it is an all dark shearwater. Photo by Scott Spangenberg (1)



Hypothesis: When I compare the location data of Atlantis the Sooty Shearwater to other environmental factors I hypothesize that I will find direct correlations to high levels of phytoplankton more than other factors because more phytoplankton will mean more smaller fish and other food sources.

The Sooty Shearwater are known to spend summer and autumn in the Northern Hemisphere then moving toward the Summer Hemisphere in winter and spring, traveling more than 12,000 miles per year (6). The location of our Sooty Shearwater, Atlantis, follows this pattern. In late summer/early autumn in both 2007 and 2009 Atlantis stayed in a particular area of the Northwestern Atlantic Ocean. In 2007, Atlantis was found In the Northeast Atlantic off the coast of Grand Manan Island, New Brunswick from August 24<sup>th</sup> through September 20<sup>th</sup>.

## Sooty Shearwater (Final Map for 2007)

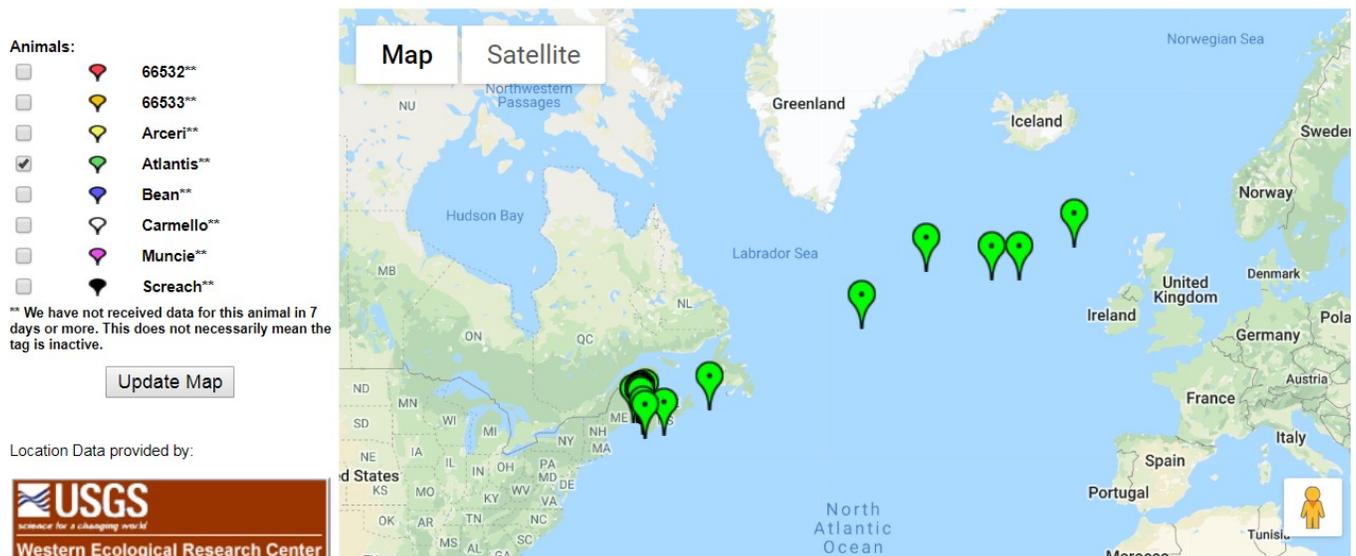


Figure 2 Location Map - Atlantis - ACES

On September 21<sup>st</sup> Atlantis began traveling toward the Northwest Atlantic Ocean, just east of Scotland, where he ended up on September 29<sup>th</sup>. He traveled over 2300 miles in 8 days. This is as far as the data goes for this year.

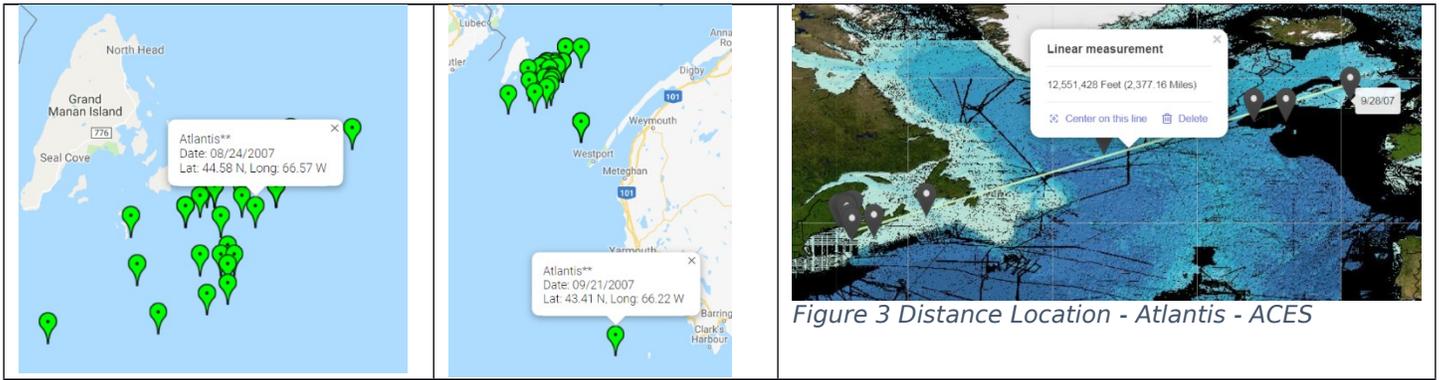


Figure 3 Distance Location - Atlantis - ACES

In 2009, Atlantis reappeared on the location data. There is more data this year than there was in 2007 beginning a little earlier on August 9<sup>th</sup> in the same general area as August 2007. The data continues much longer; August 2009 through March 2010 where he was found in the Southcentral Atlantic Ocean.



Figure 4 Location - Atlantis - ACES

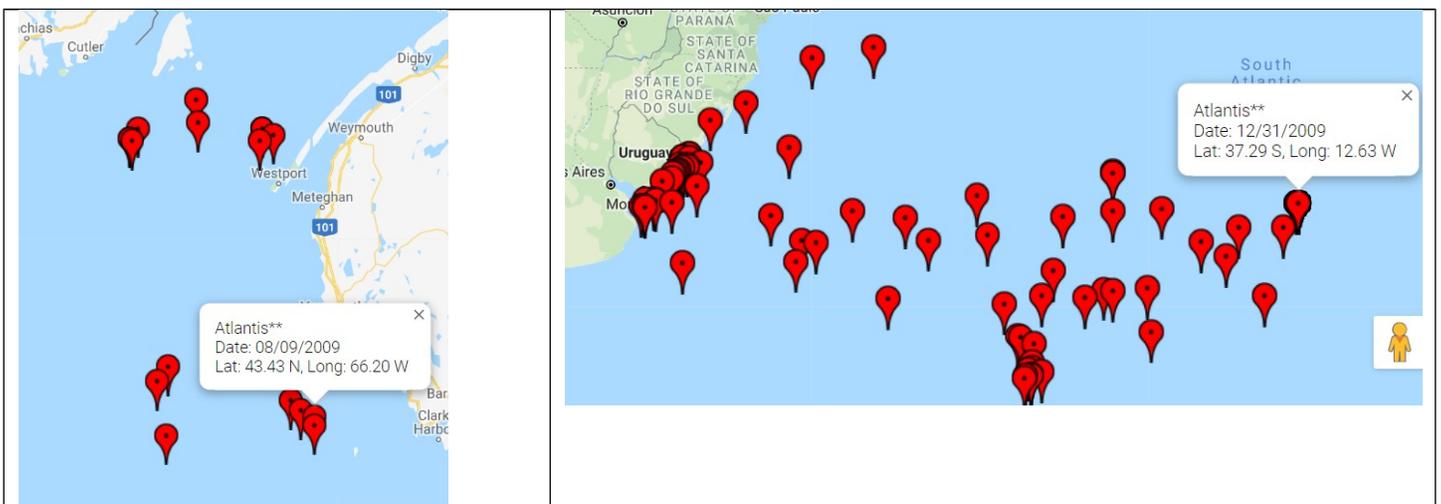
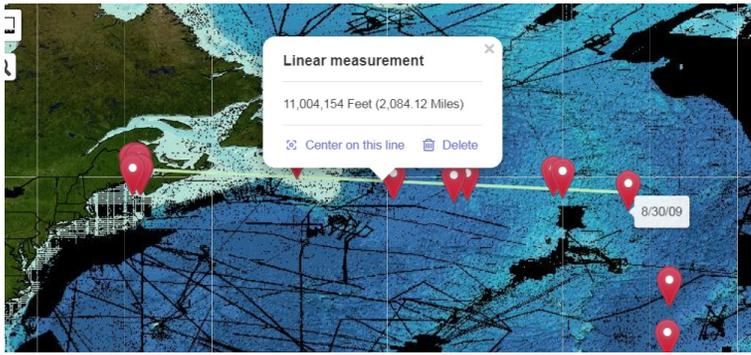


Figure 5 Distance - Location - ACES



The beginning of his journey, while not exactly the same, was similar to 2007 where Atlantis began in the Northeast Atlantic in August and then, on August 24<sup>th</sup>, headed on a journey to the Northwest Atlantic where he traveled over 2000 miles in 6 days, east of Europe on August 30<sup>th</sup>. This sudden long distance traveling was very similar to the distance and general locations of 2007.



Atlantis then heads south toward the east coast of North Africa, traveling over 2300 miles in 7 days.

This meets the expectation of birdwatchers who claim that the Sooty Shearwater can be found in New England and Canada from April to September on Stellwagen Bank. It is also south of the Cape and north into Bay of Fundy and the Gulf of St. Lawrence (1). They can be seen moving south across the UK waters in the autumn months. (2)

Figure 6 Distance - Location - ACES

Now Atlantis makes another transatlantic journey, continuing southwest for most of September. He travels over 3200 miles until September 25<sup>th</sup> where he reaches his destination of the northeast coast of Argentina. He remains in this area through October, for nearly 6 weeks, before heading to a new location.

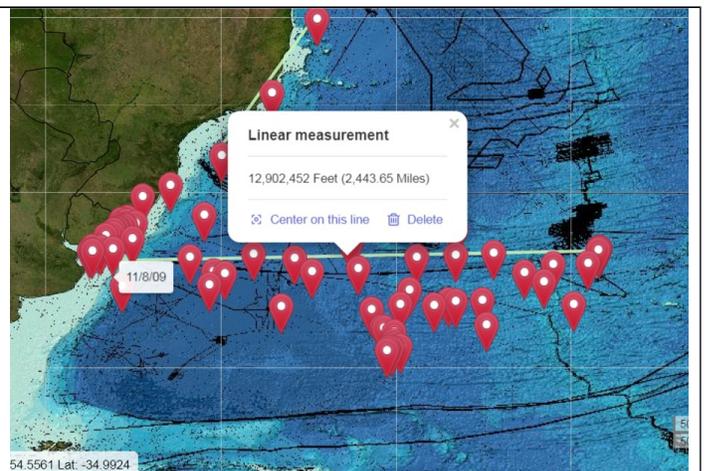
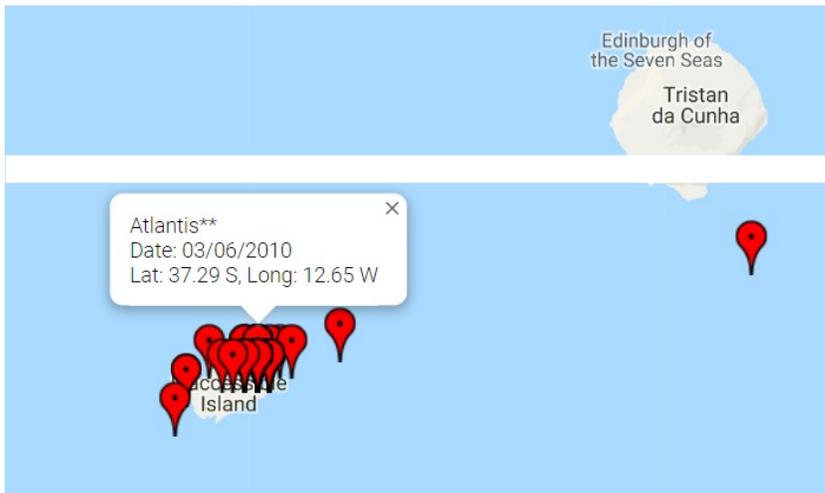


Figure 7 Distance - Location - ACES 2009

On November 8<sup>th</sup> Atlantis begins a slow journey east, once again across the Atlantic Ocean. He travels over 2400 miles, but now takes his time, traveling this distance over 7 weeks. They are known to be sociable while at sea where they fly together and feed together in groups up into the thousands (3).

Figure 8 Breeding Location - ACES



Atlantis spent the late winter and spring in central south Atlantic Ocean surrounding an unnamed island near Tristan De Cuna. He was on this Island from December 7<sup>th</sup> 2009 through the end of data on March 6<sup>th</sup> 2010.

The Sooty Shearwater are known to breed in the Southern Hemisphere on islands with rocky coastal slopes and light vegetation. They make a loose nest up to 10ft in width. These birds are known to mate for life. Both male and female guard the nest and feed the young beginning around age 5. Egg incubation averages

52-56 days. They take care of their young for around 3 months before they are ready to leave the nest (4) (5).



These birds tend to roost at night and leave at dawn to look for food, although they have been known to travel for days finding food before returning to the nest (6). Atlantis was shown to travel 23 miles away then return to the same Island on March 3<sup>rd</sup> 2010.

Once the young leave the nests, in late spring/early summer, these birds are known to travel back to the Northern Hemisphere to complete their figure 8 shaped migration pattern (1). This is verified by the following map with Atlantis and other birds of his

species as they travel the entire migration route.

### Sooty Shearwater (Final Map for 2009)

[Open in New Window](#)

Animals:

- Atlantis\*\*
- Carmello\*\*
- Keisha\*\*

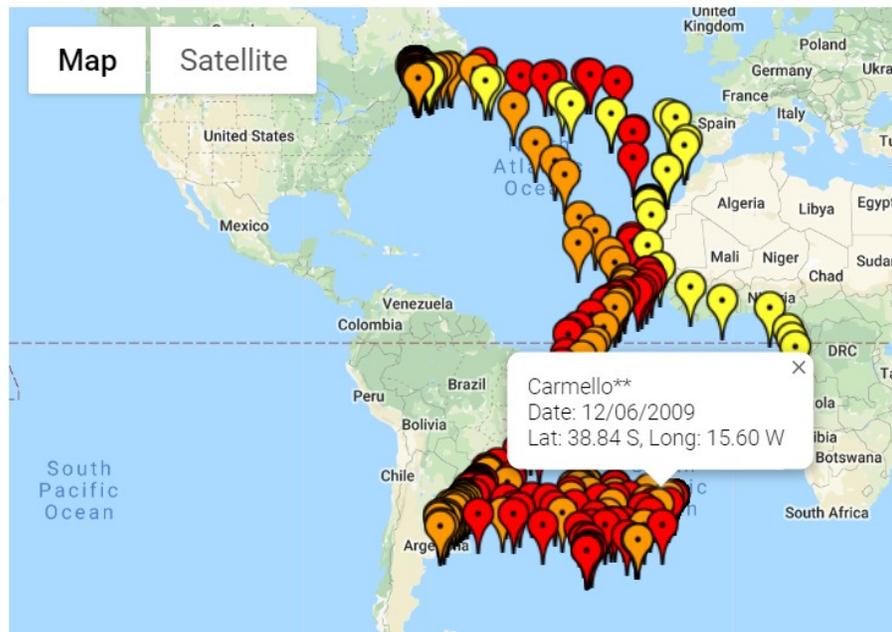
\*\* We have not received data for this animal in 7 days or more. This does not necessarily mean the tag is inactive.

[Update Map](#)

Location Data provided by:



[Dalhousie University](#) and [the Grand Manan Whale and Seabird Research Station](#)



### Summary of location data

I infer that Atlantis the Sooty Shearwater has an annual migration pattern in a figure 8 shape covering most of the Atlantic Ocean. He was returned to the same location the following year which reinforces the recurring pattern.

During the summer they are found in the Northern Hemisphere and then move south for the winter months.

Atlantis was likely nesting in March since they are known to nest and raise young in the southern hemisphere in Spring.

The two comparison maps show that the North - South migration is consistent with all Sooty Shearwater birds, no matter if they live in the Pacific or Atlantic Ocean.

**Correlation** - The location of Atlantis will now be compared to other factors such as ocean floor features, phytoplankton, coral reefs, Sea Surface Temperature, and El Nino. The correlation data will be used to draw conclusions about the motivation for the migration patterns of the Sooty Shearwater.

## Bathymetry

I will be my comparison with bathymetric maps. Below are bathymetric maps of areas where Atlantis was known to spend periods of time, not just traveling.

The area where Atlantis spent late summer is near land and Islands and over the continental shelf. I infer that the upwelling that occurs near coastal waters brings nutrients up closer to the surface. I also predict that there will be higher levels of phytoplankton in these areas due to the higher nutrients which will enrich the food chains in that area.

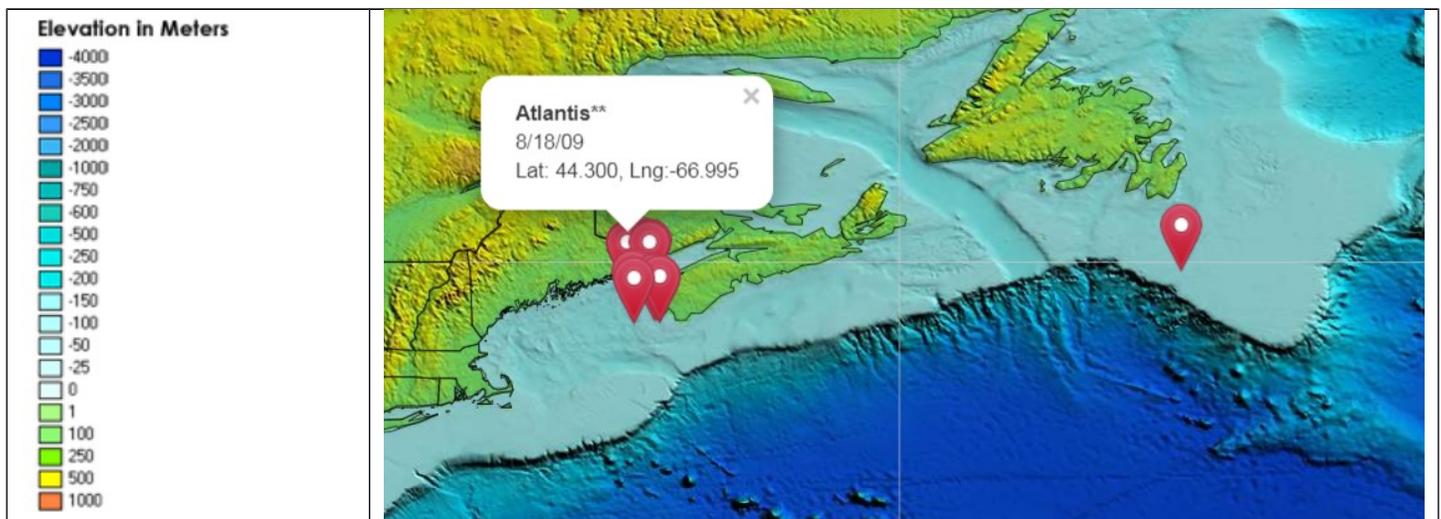
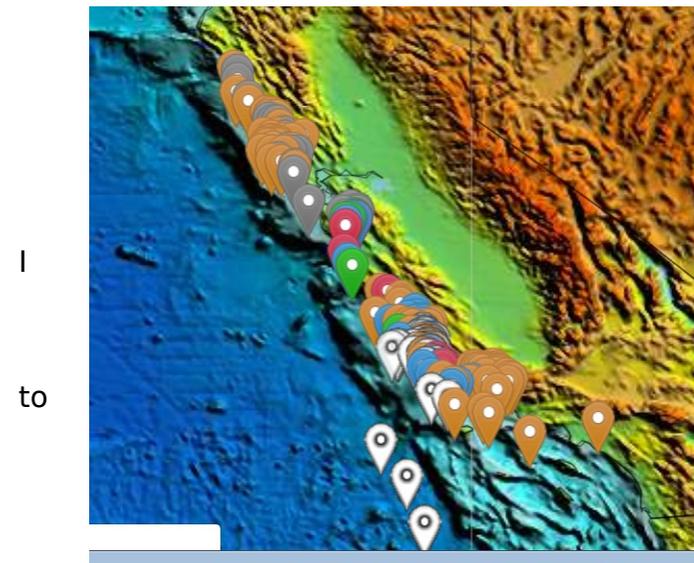
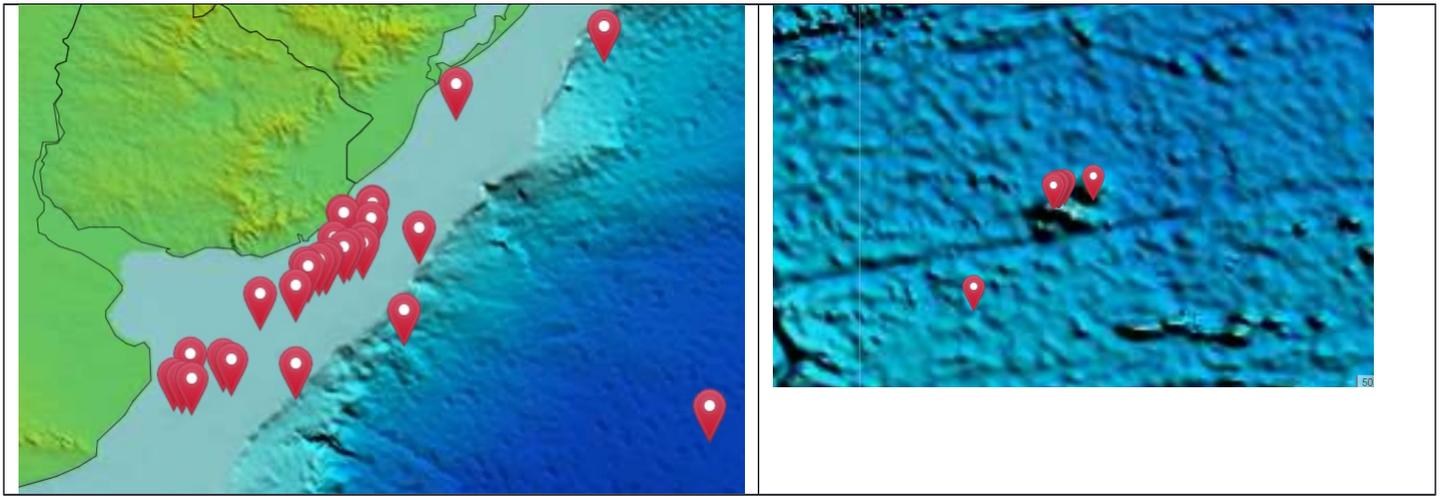


Figure 10 Bathymetry - NE US Coast - Canada

The next area where Atlantis spent a longer period of time in the Fall is also near a coastline and over the continental shelf. This is the Eastern Coast of South America.

The area where Atlantis spent the spring nesting is an isolated Island, with only a very few small islands nearby. It is not near the coast of any continent, but instead surrounded by open ocean.



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**Comparison Bathymetry Map** Other Sooty Shearwater specimen were found to also spend most of their time near coastlines and over the continental shelf.

**Bathymetry Summary** conclude that Atlantis, and most Sooty Shearwaters, spend most of their time near coastlines and above a continental shelf. The exception is during nesting time when they prefer be in an isolated location, such as mid-ocean islands. This is likely due to upwelling and an abundance of food in these areas.

## Phytoplankton

The following maps show levels of chlorophyll and will be compared to specimen location in order to see if there is a correlation between location and phytoplankton (the main source of ocean chlorophyll).

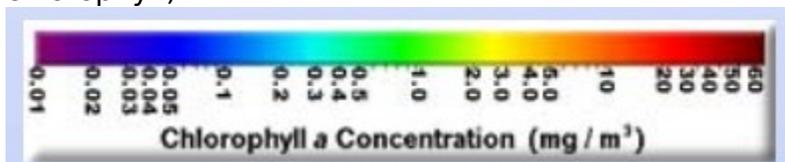


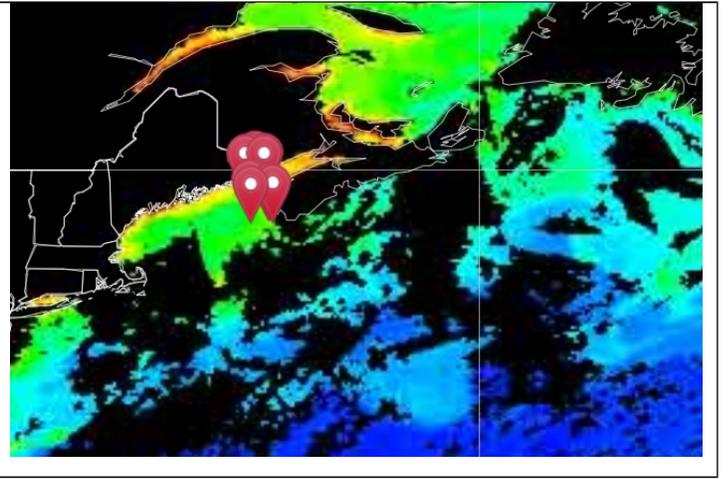
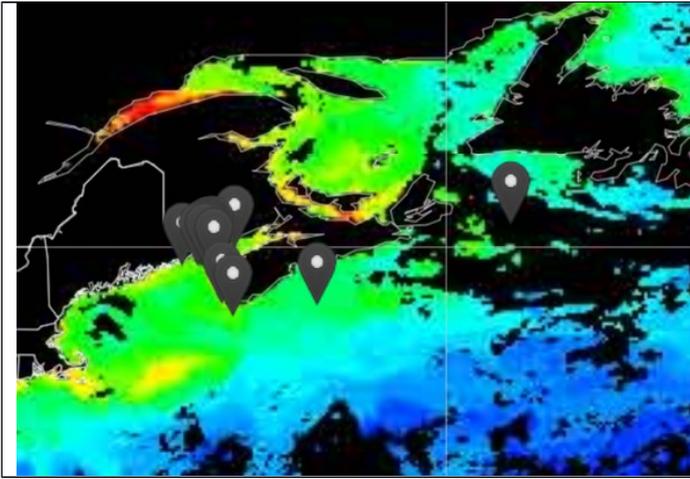
Figure 11 Chlorophyll level key - ACES

First, we will look at chlorophyll levels in early August (both 2007 and 2009). Both maps show high chlorophyll levels over the continental shelf in the area where Atlantis spent late summer.

Location 1 - Northwestern Atlantic Ocean

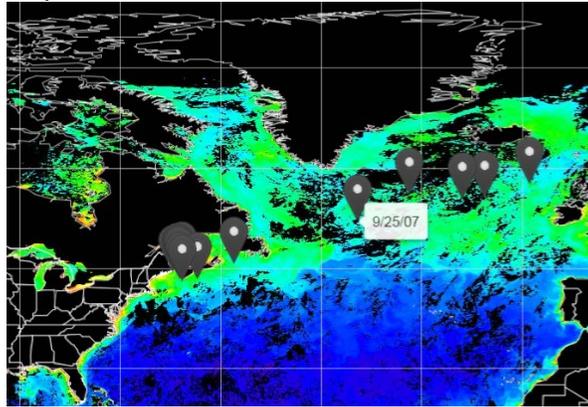
August 3<sup>rd</sup> 2007

August 8<sup>th</sup> 2009

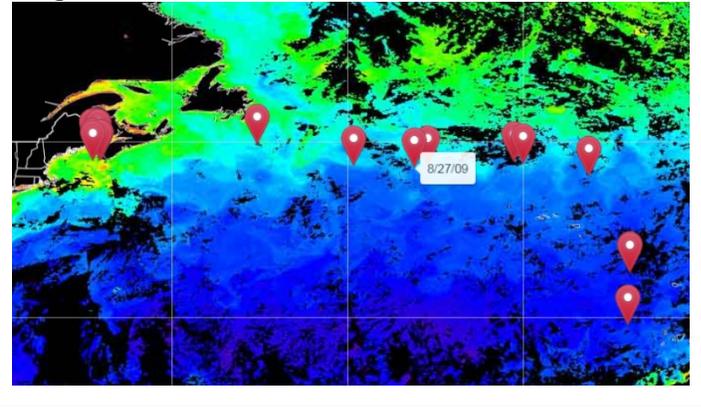


The following maps show chlorophyll levels in late August 2009 and mid September 2007, when he began to migrate east.

September 20<sup>th</sup> 2007

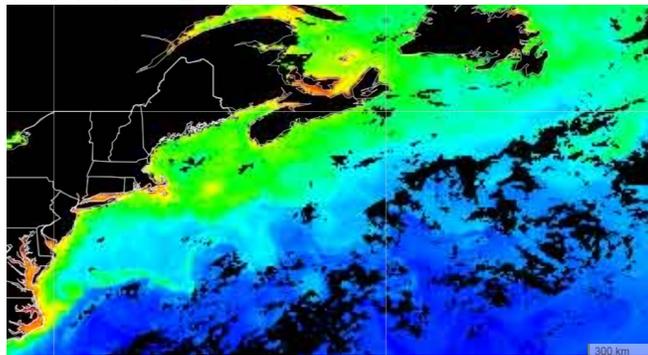


August 28<sup>th</sup> 2009

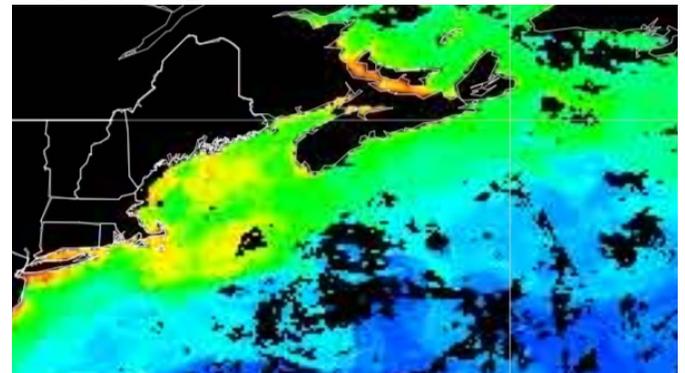


These maps show chlorophyll data in early October. At this time, Atlantis had recently moved on another location. There is some indication of chlorophyll levels dropping. With summer disappearing there is less sunlight due to fewer daylight hours and angle of sunlight which means that phytoplankton will be dying off somewhat. This would lessen the numbers in the entire food chain for the area and would be a good reason for the birds to move on to someplace else.

October 6<sup>th</sup> 2007

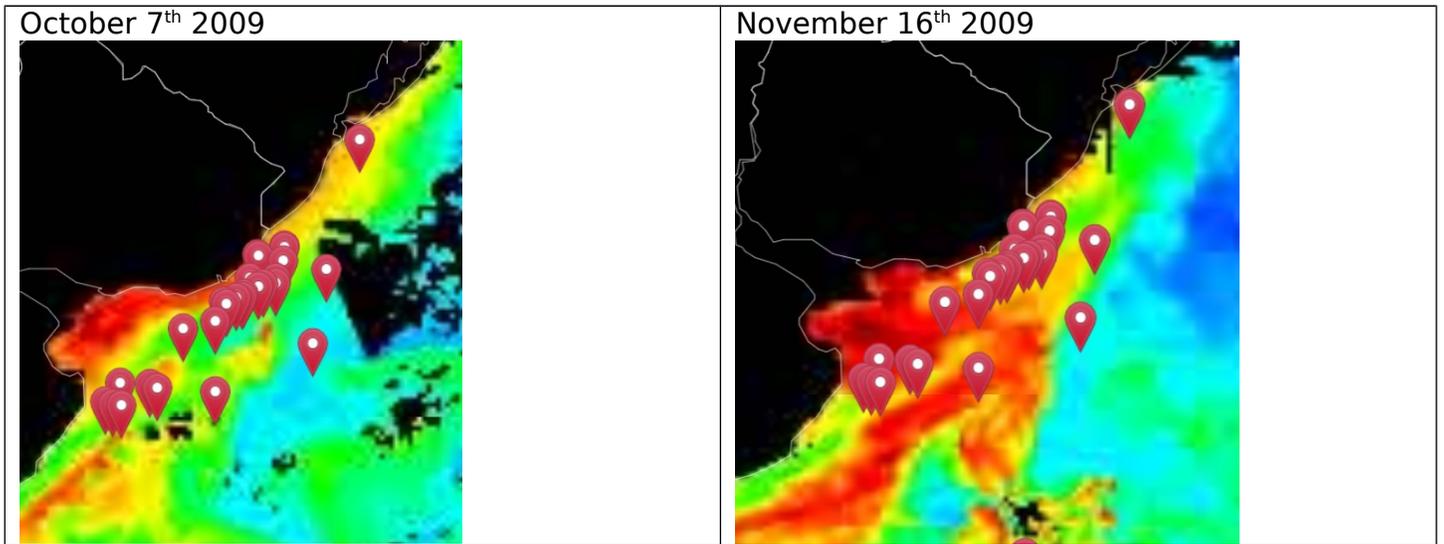


October 7<sup>th</sup> 2009

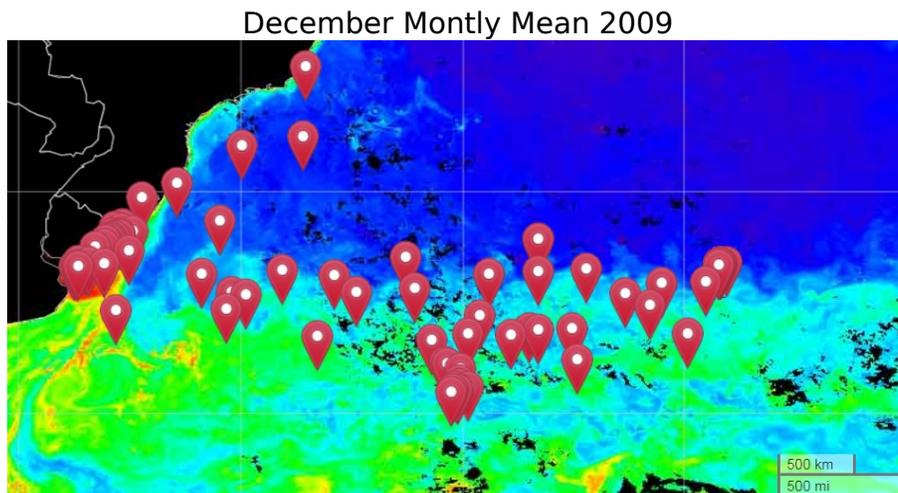


Location 2 - Southwestern Atlantic Ocean. As shown previously, the birds move fairly continuously until they reach the Southwest Atlantic Ocean where they spend a significant amount of time off the coast of South America. These maps will show the chlorophyll levels for

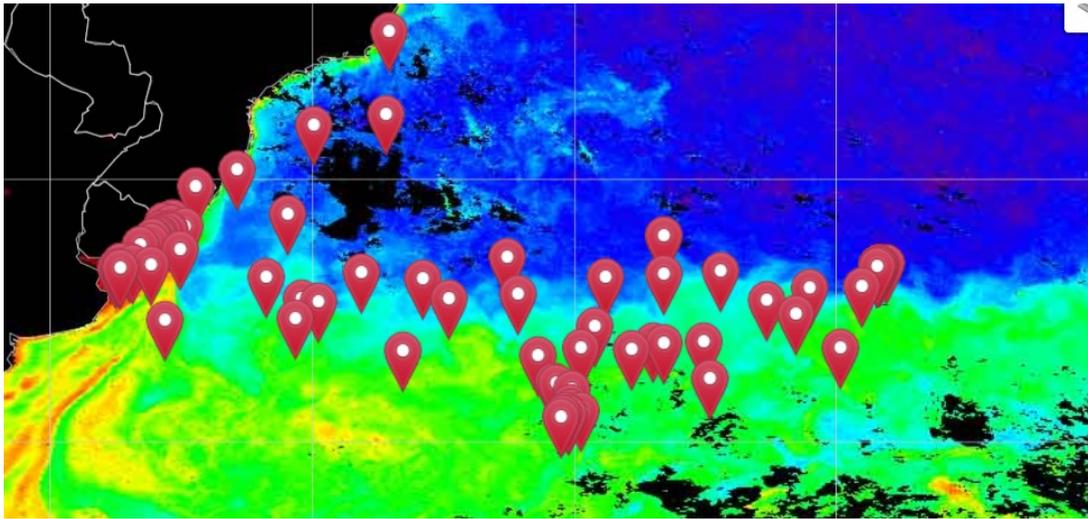
this area at that time. As seen on these maps, the chlorophyll level is very high at this time. This is the beginning of summer for the Southern Hemisphere which means more light, enriching the entire food chain.



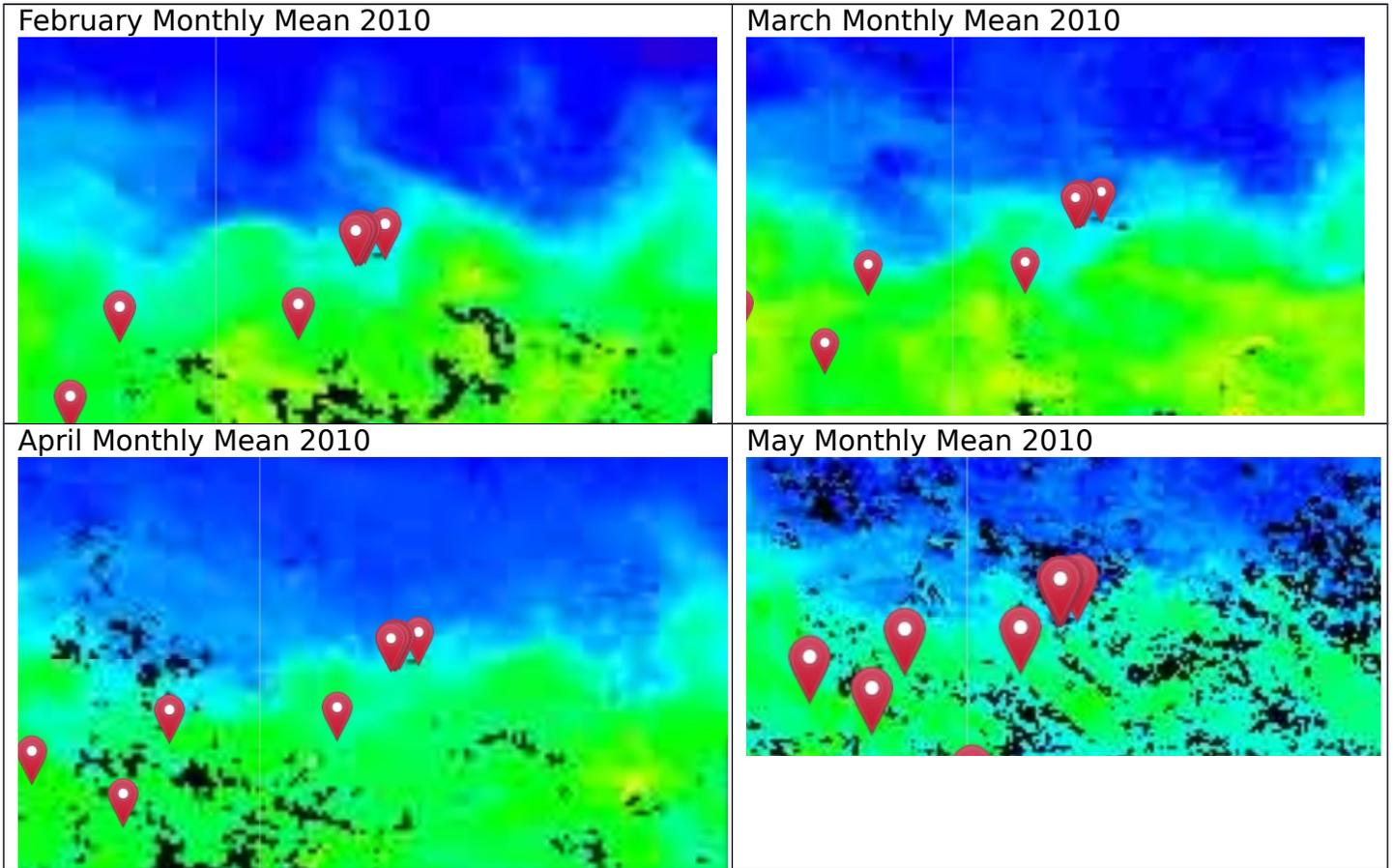
Location 3 - Open Ocean between Southwest Atlantic and Southern Atlantic Island. The birds began their slow journey toward the island where they will nest. The chlorophyll levels will indicate the food supply in that area as they travel.



January Monthly Mean 2010



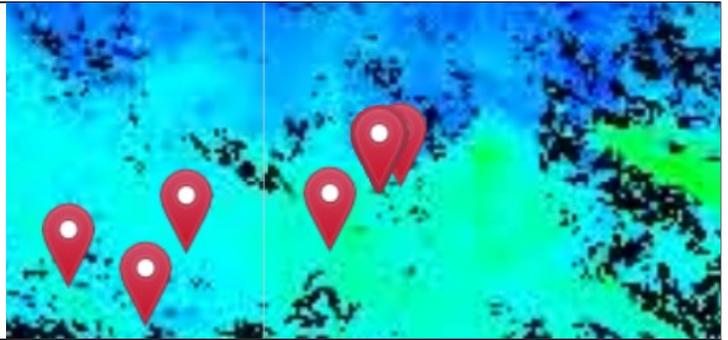
Location 4 - Southern Atlantic Island - Nesting Area. The Sooty Shearwater population will spend many months in this area hatching eggs and raising their young. Even though they prefer areas away from coastal waters while they do this, they will still need to eat.



These maps show chlorophyll data around the time that Atlantis, and the other birds,

June Monthly Mean 2010

would have left and immediately after they left.  
 This is for comparison data and shows that the chlorophyll levels were much lower during this time as winter was beginning in the Southern Hemisphere.



July Monthly Mean 2010 (Atlantis should have left by this time)



August Monthly Mean 2010 (Atlantis would have left by this time and returned to the Northern Hemisphere)



### Phytoplankton Summary

Throughout Atlantis' journey he stayed where plankton levels were moderate to high, between 1 - 10 mg/m<sup>3</sup>. While traveling, Atlantis stayed on the edge of the higher plankton levels. In the south, where Atlantis was believed to be nesting, he chose an island that was on the edge of high plankton levels and is believed to have left that area around the time when the plankton levels began to drop.

Sooty Shearwater are observed to feed mainly on small fish, squid, and crustaceans. While they do not directly eat plankton, the prey that they do eat are dependent on the plankton (both phytoplankton and zooplankton) levels in the area. It makes sense that they would migrate seasonally to stay in a summer climate where more plankton would power the food webs in the area. The chlorophyll map data supports this showing that when chlorophyll levels begin dropping, the birds begin their migration.

### Sea Surface Temperature

The following maps will compare the location of Atlantis to Sea Surface Temperatures. Since we are looking at a species of bird, this will be a secondary correlation. The SST will affect phytoplankton levels, weather patterns (including wind), and ocean currents. My assumption will be that the birds are not following changes in SST directly, but instead the factors that are affected by the SST. It is still a valid point of data that can give more meaning to the other, more direct, factors.

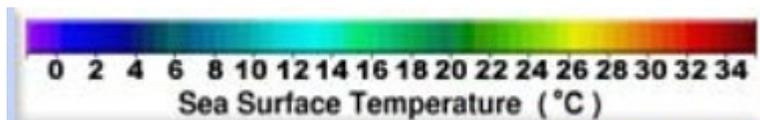
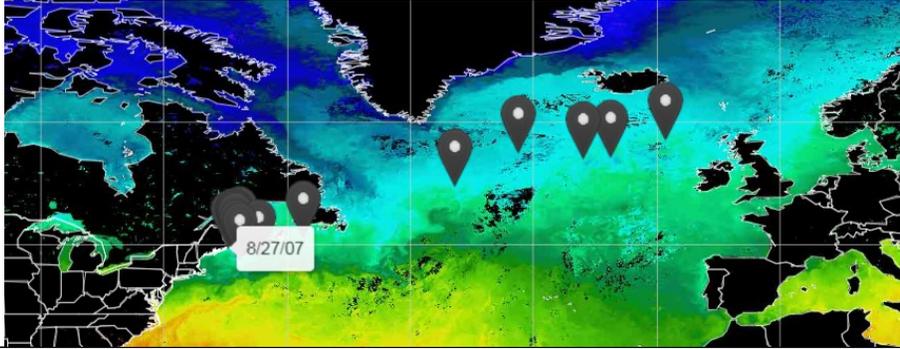


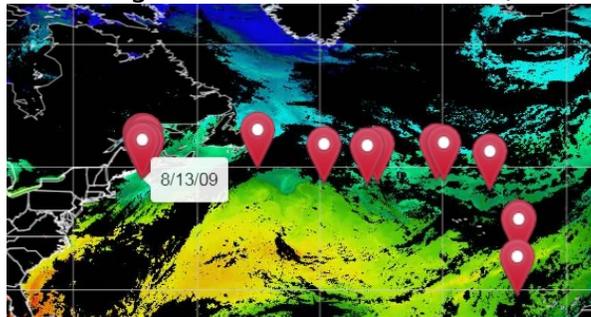
Figure 12 SST map key - ACES

Location 1 and traveling - We will begin where our other data begins, in the Northern Hemisphere toward the end of summer. Maps are shown from both 2007 and 2009 for comparison.

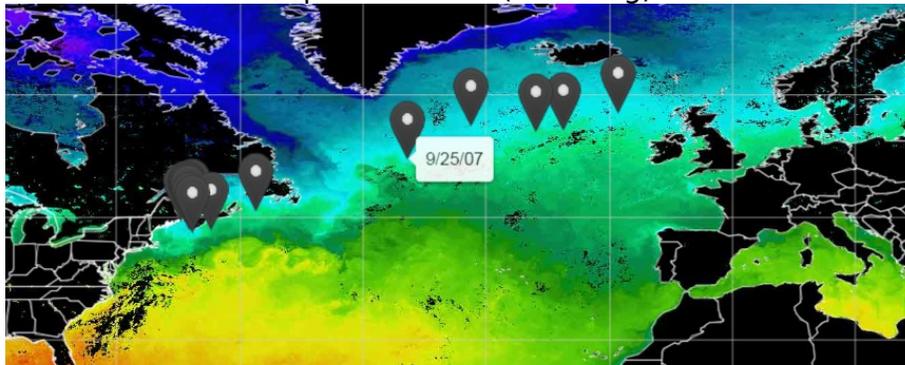
August 28<sup>th</sup> 2007 (location 1)



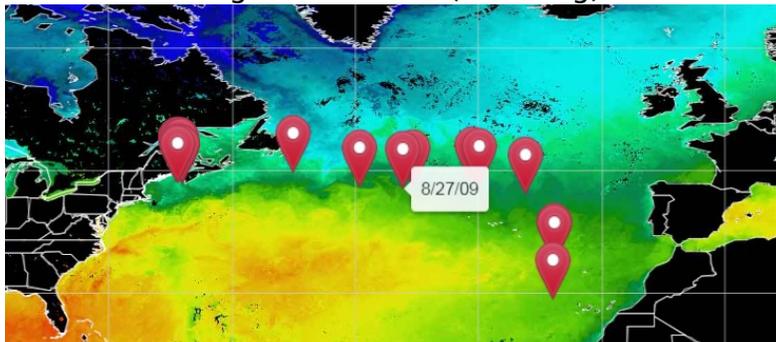
August 12<sup>th</sup> 2009 (location 1)



September 27<sup>th</sup> (traveling)



August 28<sup>th</sup> 2009 (traveling)



Location 2 and Nesting site - These maps show the SST in the Southern Hemisphere during its summer months when Atlantis, and the others, are found there. Maps are from 2009 and 2010.

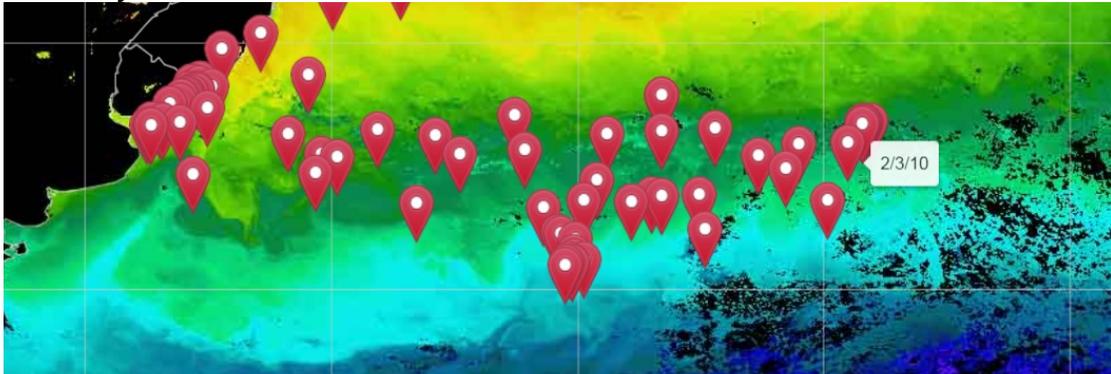
October 7<sup>th</sup> 2009



November 16<sup>th</sup> 2009



February 9<sup>th</sup> 2010



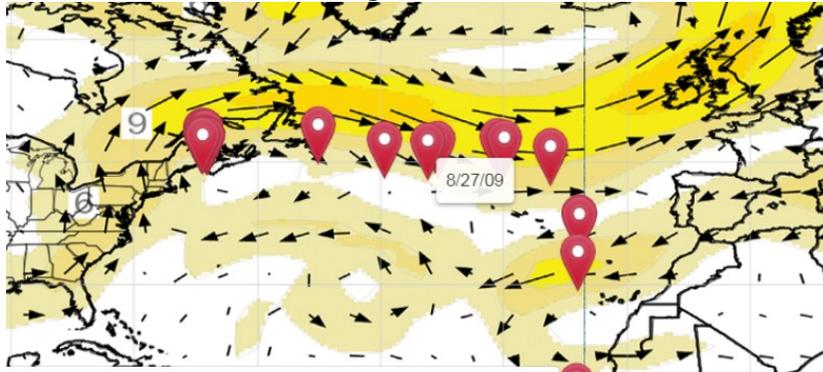
### **Summary of Sea Surface Temperature**

Atlantis was usually found to be in areas with a SST between 12-15 degrees Celsius. This could be a temperature preference or it is more likely to be directly related to the chlorophyll amounts. The conclusions that I make are that the birds prefer warmer summer weather, but since colder water is more nutrient-dense it has more plankton. The location of the birds reflects a compromise of these two. They move the hemisphere where it is summer, but instead of staying at the equator where it is always warm, they move toward areas with cooler waters and more food source.

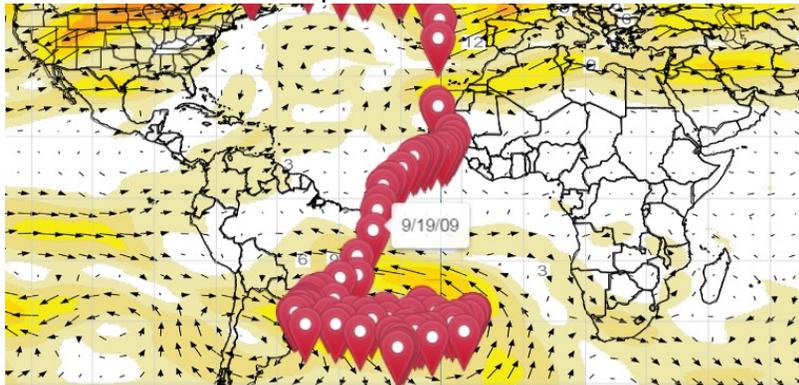
### **Wind**

Since these are birds that fly long distances, sometimes over 500 miles in a day, they are likely affected by winds, both global and seasonal. We will look at wind patterns for the times when Atlantis is actively traveling.

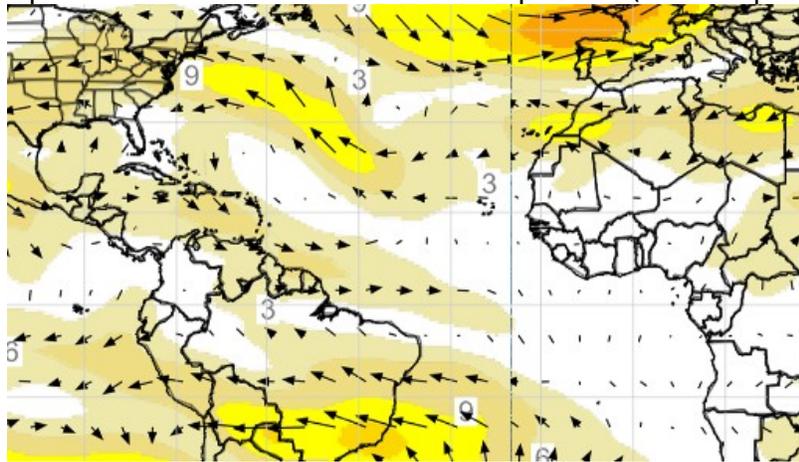
August 2009



September 2009



Winds at equator in November after Atlantis passed (for comparison data)



November 2009



## Wind Summary

The path that Atlantis took when flying south matched the direction of the winds during that time period. This would explain why Atlantis, and the other birds, would fly in the figure 8 pattern as opposed to directly south. The prevailing winds would assist in the long flights.

When directly crossing the Atlantic, the wind was in a state of doldrums. When wind is blowing in this equatorial area, it normally blows at opposite direction to Atlantis' path. I infer that even though flying during the doldrums doesn't help the ability to fly, it also doesn't hinder it. It would be worse to fly against the wind.

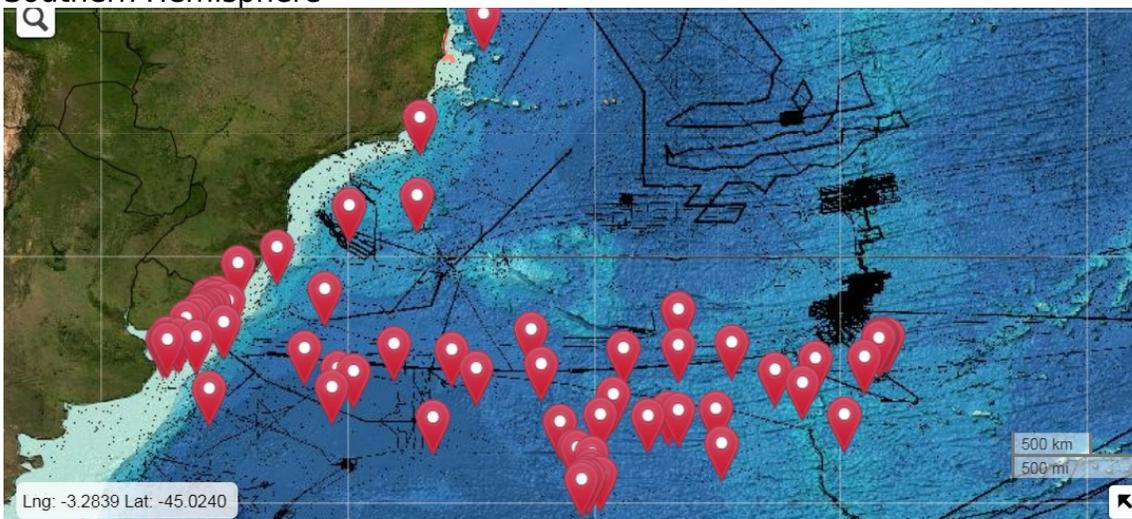
## Coral Reefs

The following maps show the locations where Atlantis spent periods of time and compares them to mapped coral reefs. This is to determine if the life surrounding a coral reef is factor in the food web that Atlantis participates.

Northern Hemisphere



Southern Hemisphere



## Coral Reef Summary

There are no coral reefs on the migratory path of Atlantis. I conclude that life on coral reefs are not a part of the motivation for the migration of Sooty Shearwaters or specifically Atlantis.

## Conclusions

After reviewing all of the known locations for Atlantis the Sooty Shearwater and comparing them to other environmental factors I conclude that my hypothesis was correct. This species obtains its food from a food web system that is directly generated from chlorophyll levels in phytoplankton. My findings also found that while chlorophyll was the main reason for the locations chosen by this species, it was likely also motivated by seasonal weather.



Figure 13 When sitting on the water it is an all dark shearwater. Photo by Scott Spangenberg. (1)

The Sooty Shearwater is all dark except for a small amount under the wings, only seen when flying. They will rest upon the water often when the weather is calm but will dive as deep as 200 ft in order to get their prey. (7) This means that when they are spending time above the continental shelf, they can often go all the way to the ocean floor.

These birds mainly eat fish, squid, and crustaceans as well as offal from fishing boats. Their prey are dependent upon a food web with phytoplankton at the base. In order to be around plenty of food, they will be found in areas with a high chlorophyll level, which means larger amounts of phytoplankton and therefore zooplankton. The upwelling that occurs in the coastal areas also contributes

to this higher nutrient level. Even though colder water has a higher nutrient content, there does come a point in winter where the lower amounts of light counteract the nutrient levels and the chlorophyll levels drop. This is one reason why the Sooty Shearwater, along with many other birds, tend to fly south in the autumn. They will follow the warmer weather and therefore go to an area with more sunlight. It was also shown that they tend to live on the edges of high plankton levels. This allows them the abundance of food while still staying in warmer weather.

The large wingspan ratio with wings up to 43 inches allows for the long distances that this bird can travel. Even though there are times when they travel long distances in short periods of time, the data shows that they often stay put for chunks of time. This is mainly in the Northwestern Atlantic from July-September and the Southwestern Atlantic from October - November. These areas are in the summer months during those times and are perfect feeding grounds. The only time they leave these coastal areas is during breeding season where they find a remote rocky island. The island where Atlantis was located during breeding season, December - June, was still in an area with high chlorophyll levels and therefore plenty of food. (1)

Atlantis did stay in the Southern Mid-Atlantic longer than would be indicated by the changing seasons, but that is likely because of the time it takes to raise the young of these birds. After nearly two months of nesting the egg, the young do not leave the nest for approximately 3 months. This takes them into the time when winter is approaching in the Southern Hemisphere. They do move north before the winter takes full effect which allows them plenty of time to take advantage of the plentiful food and warmth in the North before starting the cycle all over again.

- (1) *New England Shearwaters - Sooty Shearwater*, [www.neseabirds.com/birdsshearwatersooty.html](http://www.neseabirds.com/birdsshearwatersooty.html).
- (2) "Sooty Shearwater Bird Facts | Puffinus Griseus." *The RSPB*, [www.rspb.org.uk/birds-and-wildlife/wildlife-guides/bird-a-z/sooty-shearwater/](http://www.rspb.org.uk/birds-and-wildlife/wildlife-guides/bird-a-z/sooty-shearwater/).
- (3) "Sooty Shearwater." *Audubon*, 21 Mar. 2019, [www.audubon.org/field-guide/bird/sooty-shearwater](http://www.audubon.org/field-guide/bird/sooty-shearwater).
- (4) "Sooty Shearwater *Ardenna Grisea*." *Sooty Shearwater - Introduction | Neotropical Birds Online*, [neotropical.birds.cornell.edu/Species-Account/nb/species/sooshe/overview](http://neotropical.birds.cornell.edu/Species-Account/nb/species/sooshe/overview).

- (5) "Ardenna Grisea - Sooty Shearwater." *Department of the Environment and Energy*,  
[www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon\\_id=1024](http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1024).
- (6) "Sooty Shearwater." *Smithsonian Ocean*, 18 May 2018, [ocean.si.edu/ocean-life/seabirds/sooty-shearwater](http://ocean.si.edu/ocean-life/seabirds/sooty-shearwater).
- (7) "Sooty Shearwater." *Monterey Bay Aquarium*,  
[www.montereybayaquarium.org/animal-guide/birds/sooty-shearwater](http://www.montereybayaquarium.org/animal-guide/birds/sooty-shearwater).
- (8) "Signals of Spring." *Signals of Spring*, ACES, [www.signalsofspring.net/](http://www.signalsofspring.net/).