

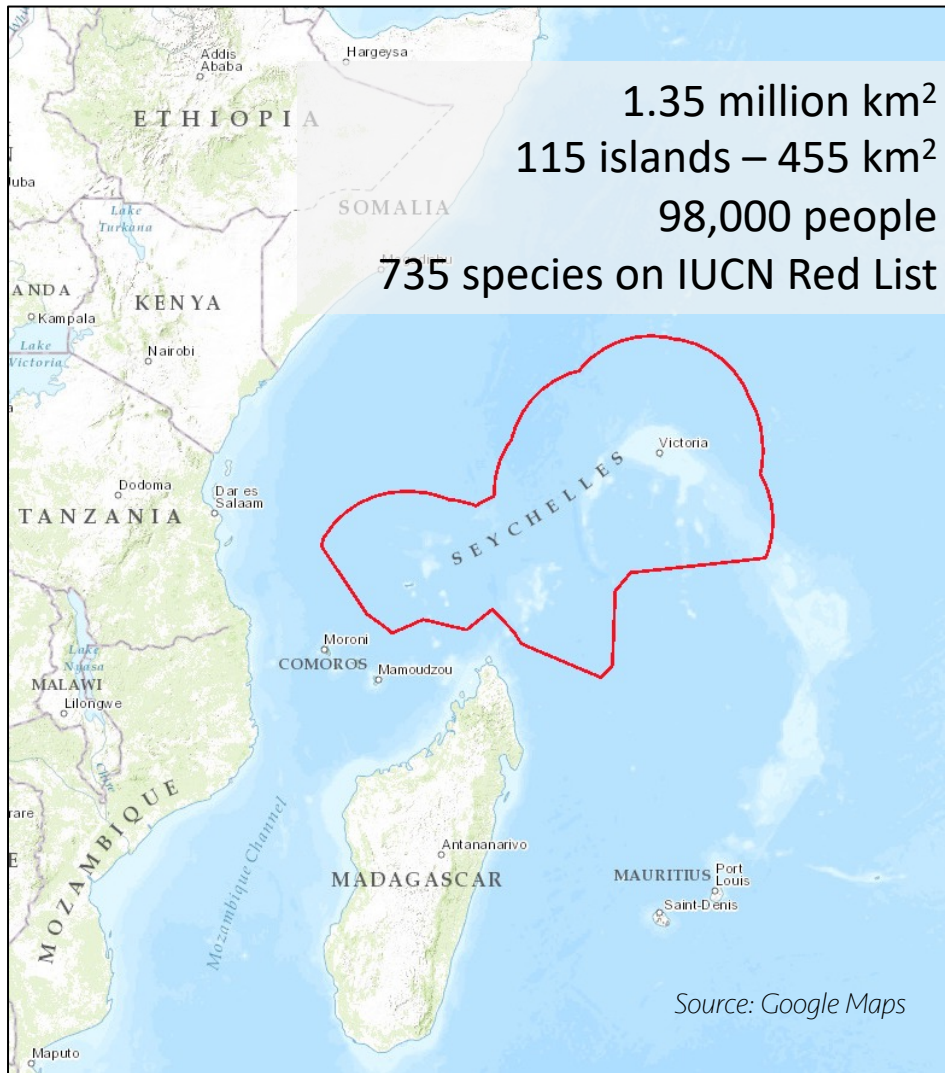
# Using climate change risk mapping to zone for marine protection goals in the in the SEYCHELLES Marine Spatial Plan

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The Nature Conservancy, Spatial Support Systems LLC, and MACCE



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MSP Symposium  
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# Seychelles Archipelago



*Inner Islands*



© Joanna Smith



*Outer Islands*

Photo Credit: - Pixabay, Pict, Seychelles  
Mauritius, Réunion, Madagascar, Comoros, Mozambique, Tanzania, Kenya, Ethiopia, Somalia, Madagascar, Mauritius, Réunion, Saint-Denis, Port Louis, Antananarivo, Mamoudzou, Moroni, Dar es Salaam, Dodoma, Nairobi, Kampala, Addis Ababa, Hargeisa, Victoria, Lake Turkana, Lake Victoria, Lake Malawi, Mozambique Channel, Maputo, Victoria

# Seychelles Marine Spatial Plan Goals

- Legislates marine protections that are 30% of Seychelles' Exclusive Economic Zone and Territorial Sea
- Promotes the Blue Economy and other national strategies to support ocean health, local economy, and economic growth.
- Addresses climate change in coastal and offshore habitats
- Is monitored and adapted over time

## SMART objective for Climate Change

### **Goal 3. Climate Change Adaptation**

*By 2020, develop climate change risk mapping for coral reefs and coastal protection to better understand the most important climate risks in Seychelles, and better understand options for adaptation measures and feasibility of implementing them.*

# Purpose of Climate Change Risk Mapping

<b>Support</b>	Support decision making for the MSP zoning design with specific climate variables.
<b>Promote</b>	Promote engagement with climate experts and advance climate change discussions.
<b>Focus on</b>	Focus on relevant measures that are meaningful to end users .
<b>Inform</b>	Inform future research and management questions.
<b>Prepare</b>	Share a “big” database product on Sea Surface Temperature to better understand options for adaptation measures

# Study Questions

Part 1: To inform the SMSP Zoning Design in Phase 2 of the Initiative, are there patterns of thermal stress or thermal refugia over time?

Part 2: Are there patterns of coral reef thermal stress not visible at using monthly mean anomalies?

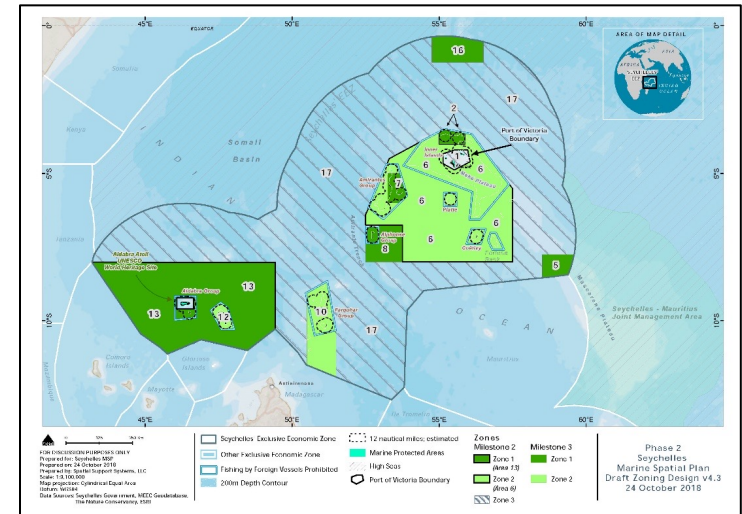
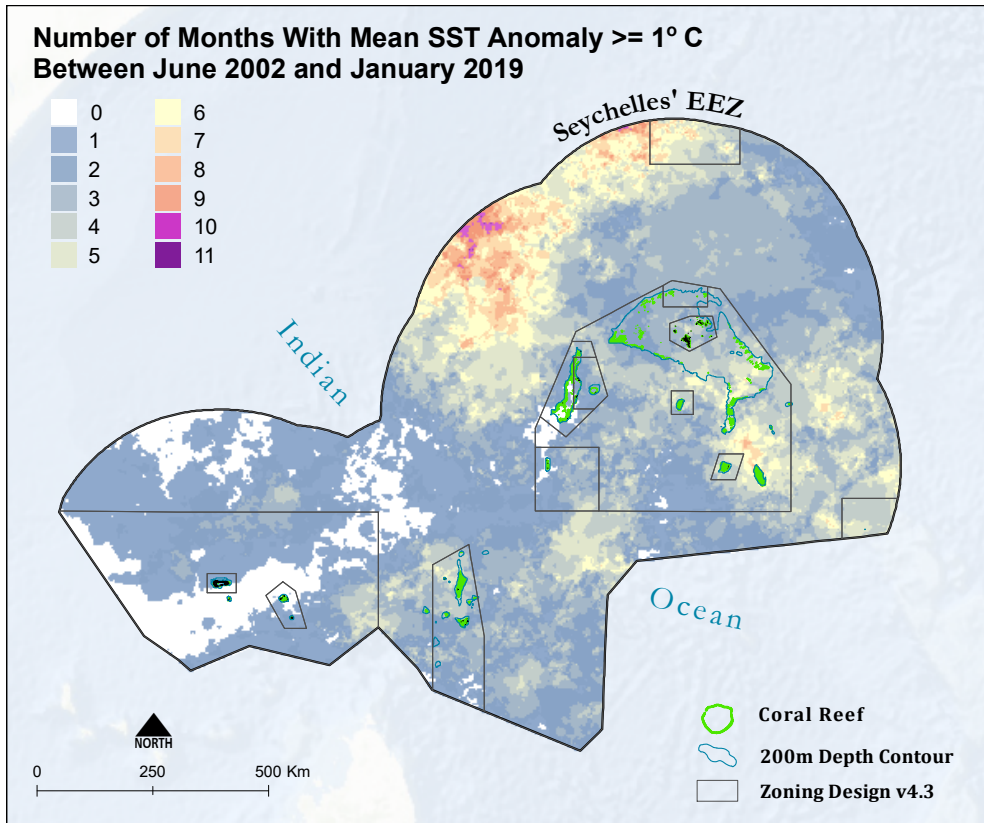


Photo: Manu San Felix/Nat Geo Pristine Seas

# Part 1 - Inform Zoning Design and Protection Areas

- To inform MSP zoning, we examined **monthly mean anomalies** greater than 1° C - not a coral reef 'hotspot' analysis.
- Used **Remotely Sensed Sea Surface Temperature (SST)** data from NOAA in the United States.
  - Long term average: global monthly means from 2003-2014
- The **finest scale SST data** available for Seychelles:
  - 'Multi-scale Ultra-high Resolution' (MUR) SST Analysis Anomaly fv04.1
  - Spatial resolution: 0.01°, or approx. 1 km
  - Monthly composites: 2002-2019

# METHODS 1: Patterns with SST anomaly $\geq 1^{\circ}\text{C}$

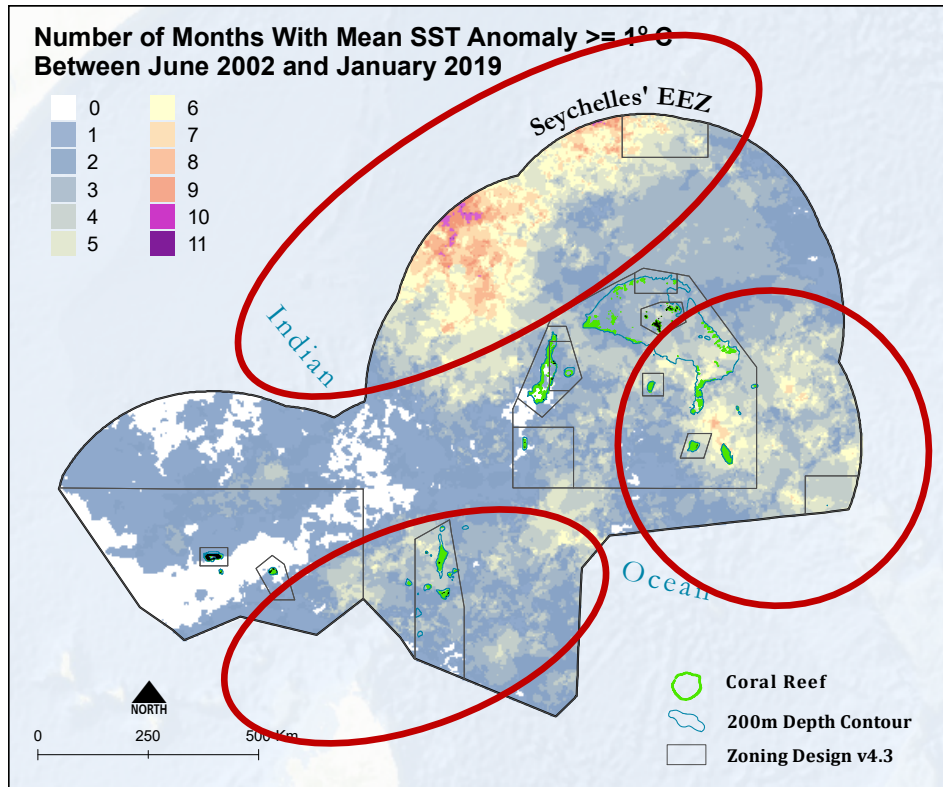


- Counted the number of months that a given location averaged  $\geq 1^{\circ}\text{C}$  over the mean temperature for that month.
- In other words, the number of times that a location experienced an extra warm month compared to the long term average.
- The purpose was to look for persistently warm and cool areas throughout the EEZ, especially associated with coral reefs.
- **Many anomalous** “SST months” represent areas that are **thermally impacted**
- **Few anomalous** “SST months” represent **thermal refugia** for sensitive species

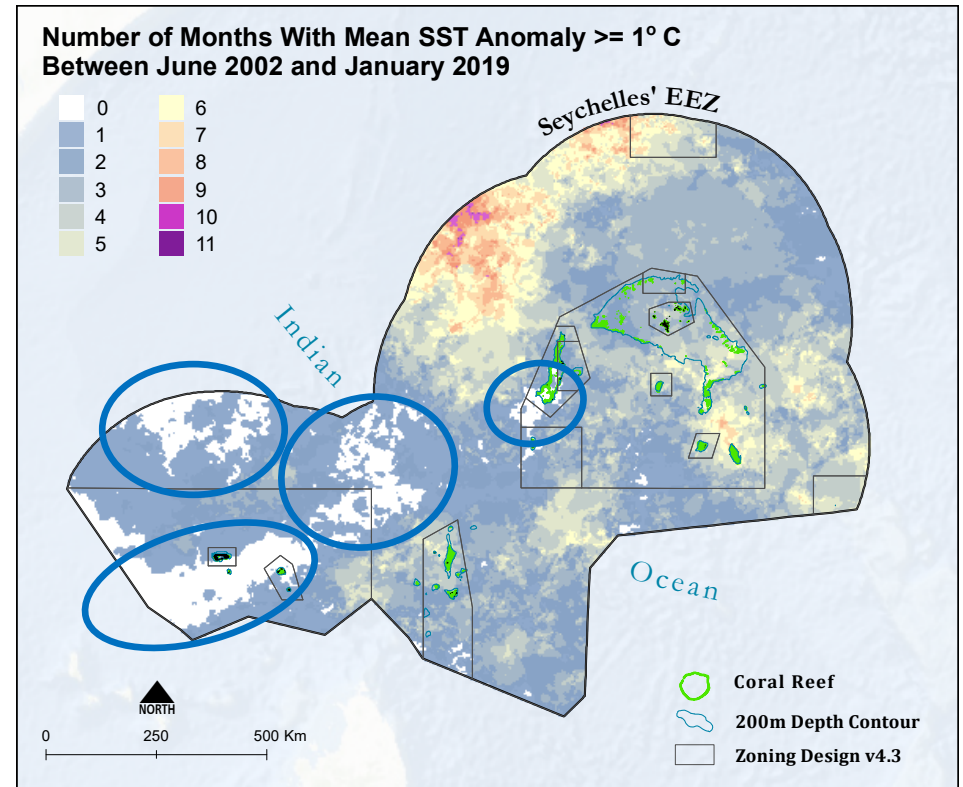


# RESULTS 1: Persistently warm and cool areas

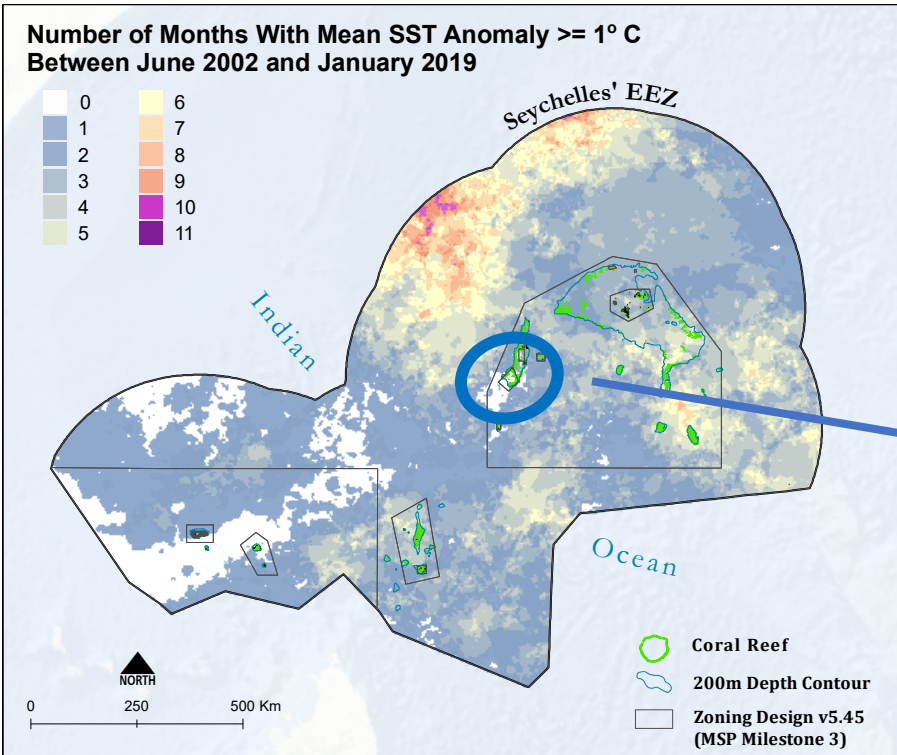
## Persistently warm areas



## Persistently cool areas



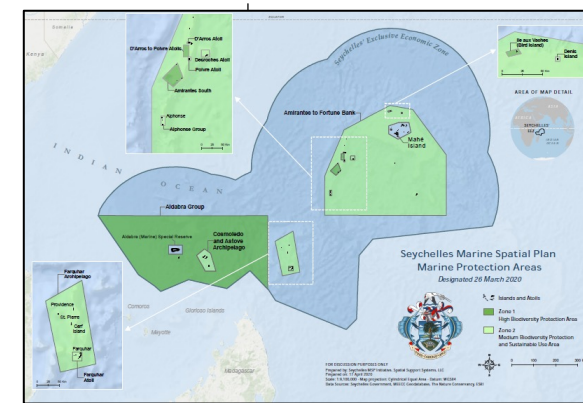
# OUTCOME: Persistent cool areas in the Amirantes informed a new Marine National Park in the Amirantes Group



The final zoning design includes several areas that represent persistent cold spots relative to a long term average (2003-2014; NOAA).

FOR DISCUSSION PURPOSES ONLY  
Prepared for: Seychelles MSP  
Prepared on: 1 May 2020  
Prepared by: Spatial Support Systems, LLC  
Scale: 1:800,000  
Map projection: UTM Zone 39s, WGS 84  
Data Sources: Seychelles Government, MEECC Geodatabase, The Nature Conservancy, ESRI

Coordinate Label Point  
Zone 1 Area Boundary (Gazetted 26 March 2020)  
200m Depth Contour



# Part 2 - Guiding management, monitoring and restoration

- We didn't find it to be very informative to use monthly mean anomalies for any finer scale, coral reef-specific investigations on climate risk.
- Little is known about coral health in Seychelles outside of the areas that have been well studied, such as Inner Islands, Aldabra. From the published literature and coral experts, thermal stress is bad for corals.
- Where are patterns of thermal stress that were not visible using the monthly mean SST anomalies in Part 1?
- For this exploration, use **Maximum Monthly Mean SST**

## QUESTIONS in Part 2:

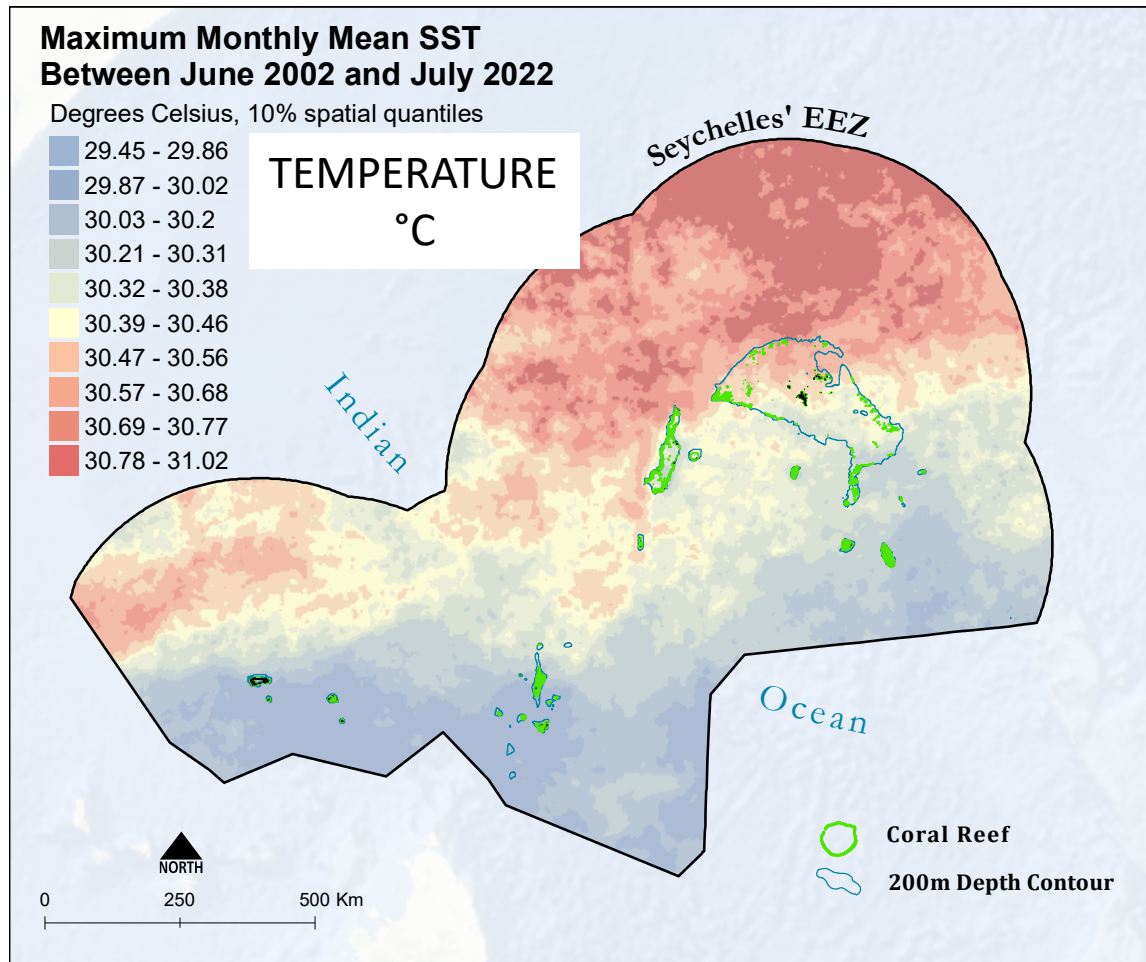
### 2A. What are patterns of the coral reef bleaching threshold?

- The accepted threshold for bleaching is  $>1^{\circ}\text{C}$  above maximum monthly mean temperatures.

### 2B. What are patterns of thermal 'hotspots'?

- The definition of a 'hotspot' is daily exceedance of the maximum monthly mean in any given location
- NOAA CoralReefWatch releases hotspot alerts - SST above maximum monthly mean - at 50x50 km resolution
- This analysis would be at **1x1 km resolution.**

# METHOD 2: Map maximum monthly mean SST



Across all months, for each location, what was the maximum monthly temperature?

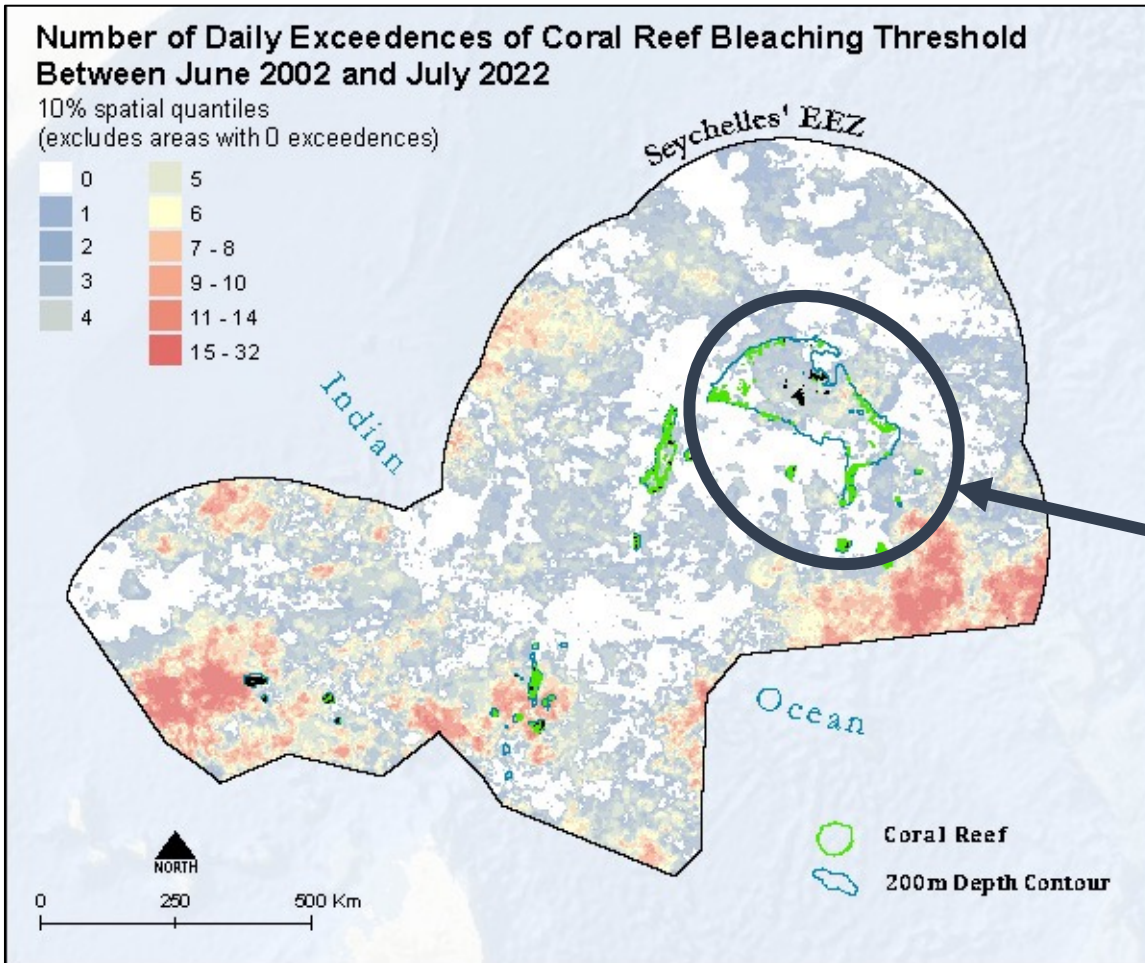
**Methods:** Analysed daily SST values from 1 June 2002 to 1 July 2022. This is the most up-to-date SST data for Seychelles.

**Results:** Max monthly mean SST was highest near the equator; reach 31°C

**Question:** How many days exceeded the max monthly mean in that location? → a 'hotspot' analysis.

**Anecdote:** To illustrate just how large this dataset is - after programming the spatial calculation for all locations in the EEZ, it took **2 weeks** to run the program on a computer and get the hotspot location map.

# RESULTS 2A: Coral bleaching thresholds 2002-2022



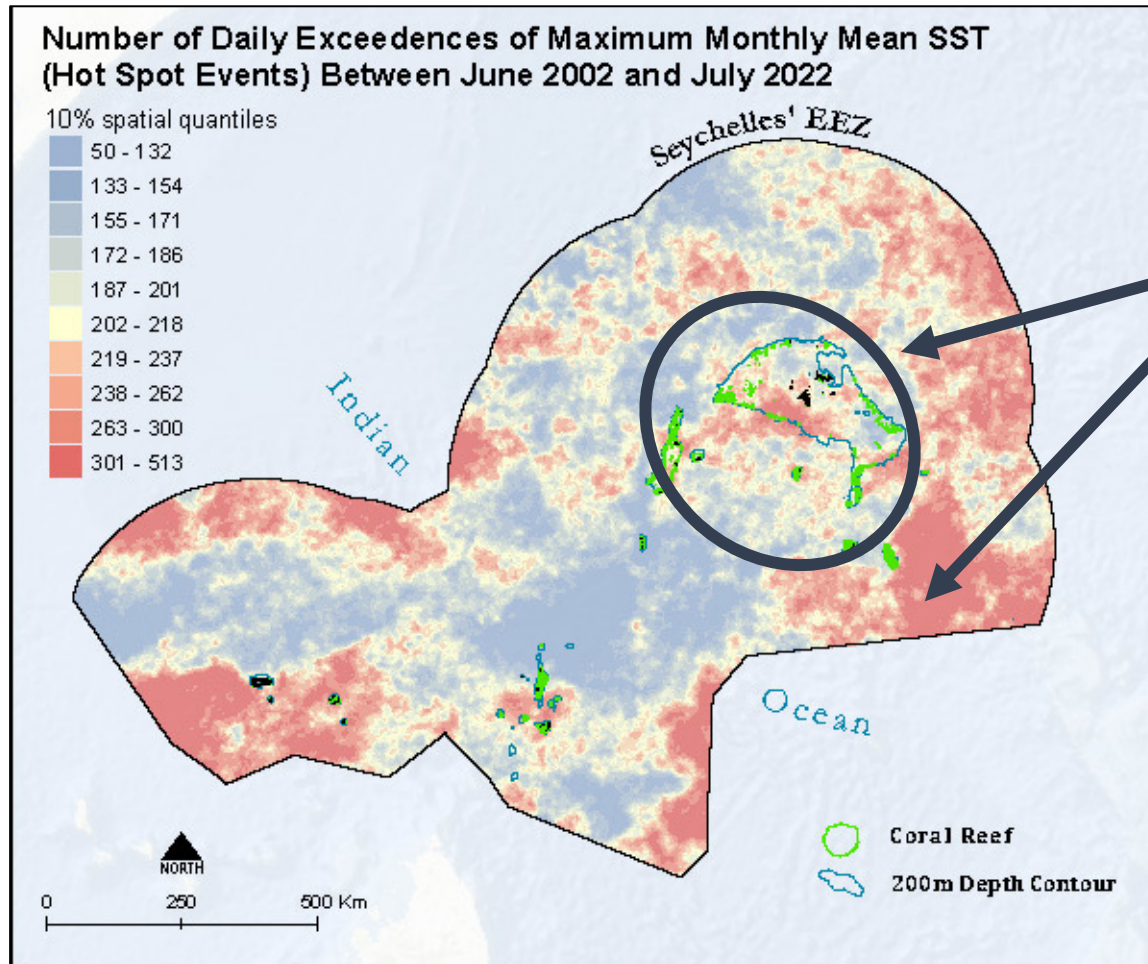
This map shows **number of days at each location that exceeded the bleaching threshold of +1C between 2002-2022**. The colour scale goes from 0 to 32 days.

Conclusion: this is not very informative. For example, according to these data, a 'bleaching threshold' was reached on the **Mahe Plateau fewer than 10 days in the last 7,336 days. This is 0.4% of days.**

Published field studies have confirmed multiple bleaching events on the Plateau in the last 20 years.

The +1°C bleaching threshold may not be a relevant measure in Seychelles?

# RESULTS 2B: Hotspot locations from 2002-2022



This map shows the number of days at each location that exceeded the maximum monthly mean SST.

Colour scale goes from 50-513 days.

In some locations, up to 513 of 7,336 days in the last 20 years have exceeded these temperatures. This is 7% of days.

More variation at this scale including on the Mahé Plateau and the other Archipelagoes and Mascarene Plateau.

The connection to the MSP SMART objective is that we might expect to see adaptation or mortality in those locations - the cumulative effects of thermal stress from 'hotspots' might be a 'tipping point'?

# Conclusions and Going Forward

- The Seychelles MSP zoning design was informed using monthly mean SST anomalies that identified persistently cool areas or thermal refugia.
- The mapping of SST values from the last 20 years also raised questions related to the relevant temperatures for a coral bleaching threshold and thermal stress, and relevant temporal and spatial scales for climate change risk mapping.
- Groundtruthing is needed in locations with known bleaching events, and evaluating other factors that contribute to bleaching.
- Acquisition of “big data” needs bandwidth and computing capacity. The databases used in this project ranged from 19 GB to 103GB. The data downloads took many hours and calculations took many days.
- Key takeaway for the project is that Seychelles MSP team will be sharing spatial data products and maps from this project that can be used to investigate other SST related questions for climate change in Seychelles. The SMSP will be preparing a report and sharing the methodology and results.
- These data can support investigations, and calibrations, at a finer scale than was previously possible.



# QUESTIONS

Photo © Warren Andre

For more information:  
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# Patterns using maximum monthly mean SST - “hotspots”

- Why not using Degree Heating Weeks? If the 1C threshold is not relevant to Seychelles, as the data suggest, then these DHW products not as relevant
- Makes sense to count the frequency of hotspot events to better understand what might be happening in that location to corals and impacts from thermal stress.