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# Coral Reef Ocean Acidification Sentinel Site at the Flower Garden Banks National Marine Sanctuary: Data Collection and Analysis

Speaker:
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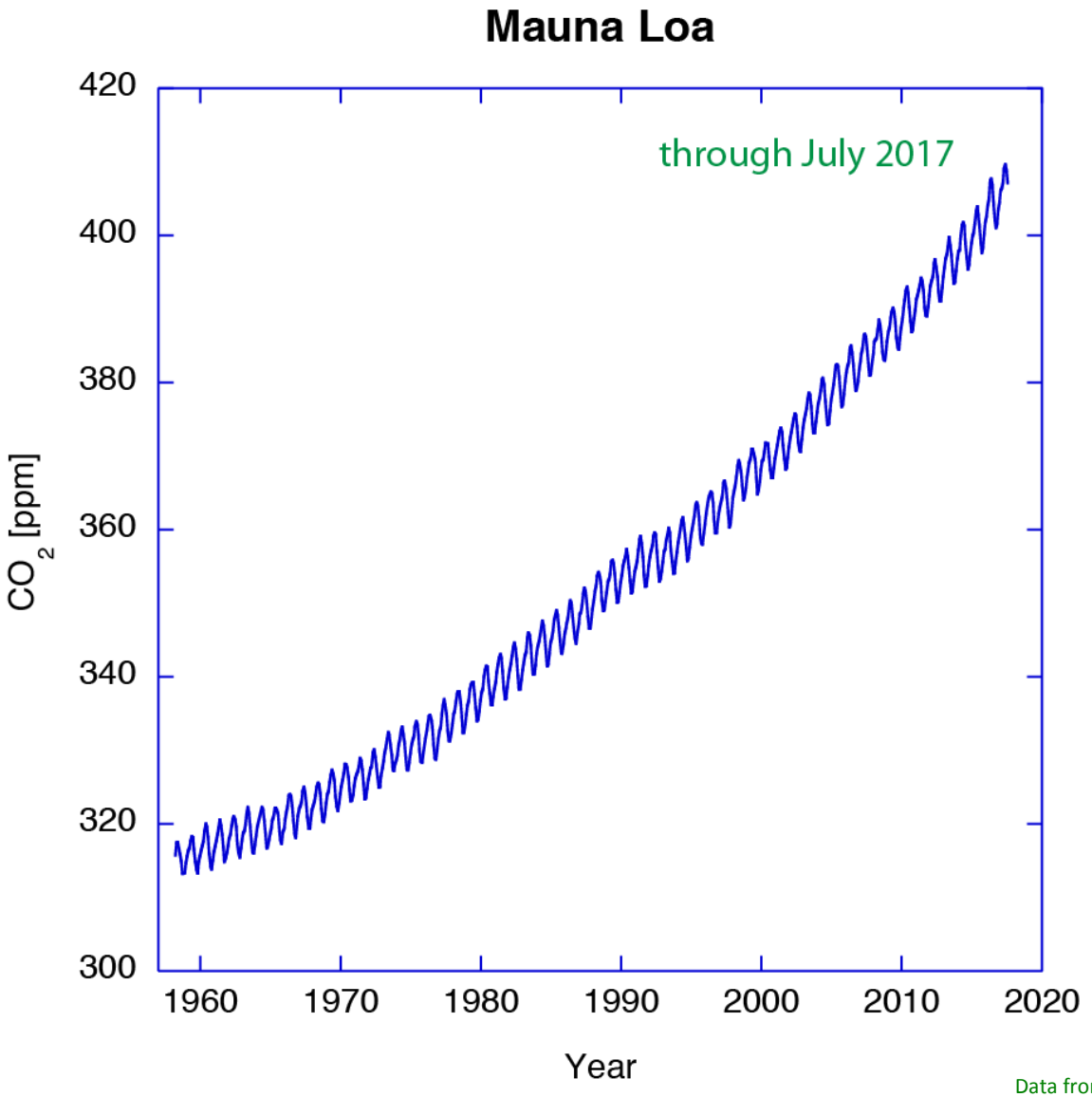
# Recognition

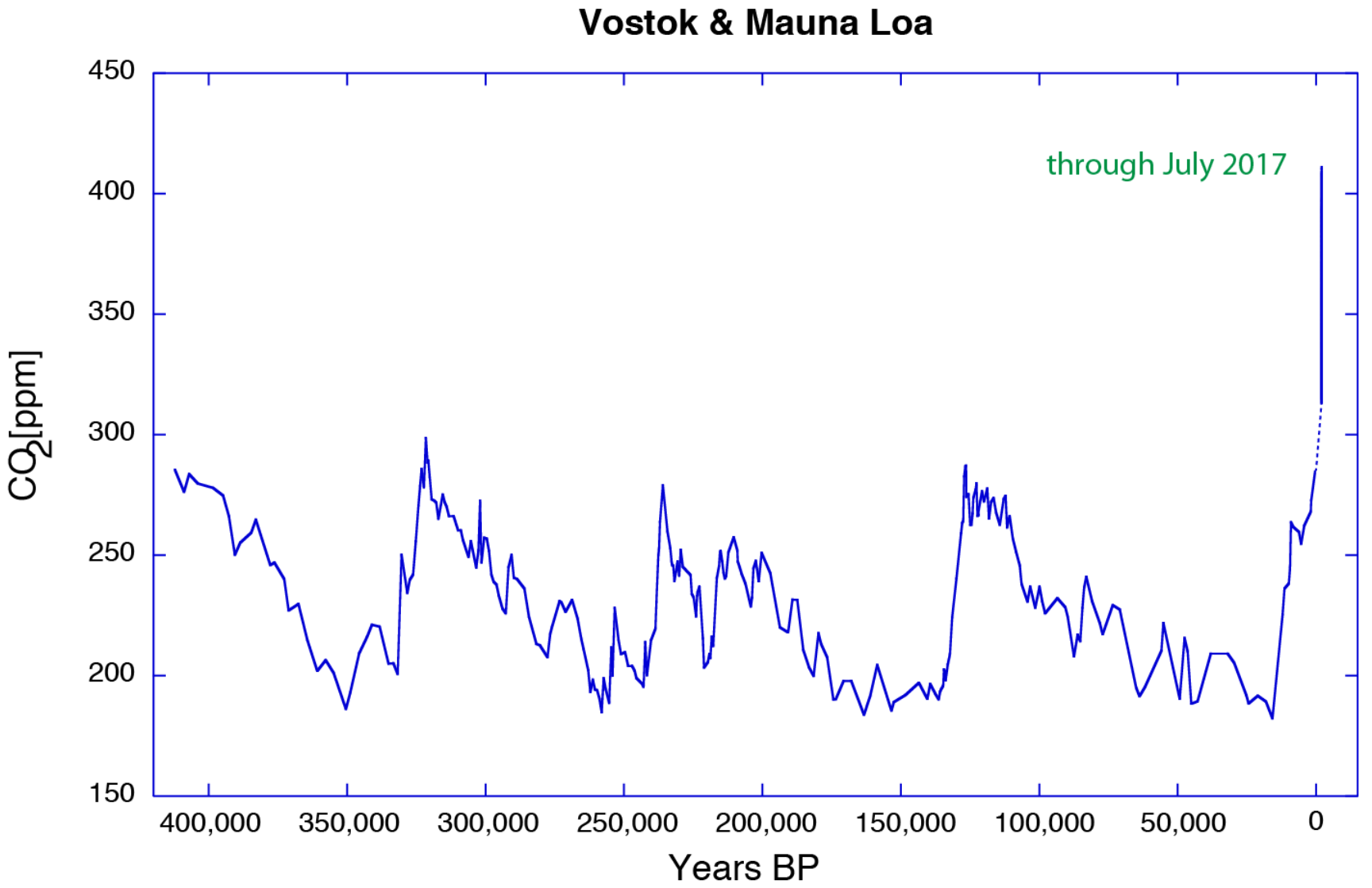
- **Vance Nygard, graduate student researcher at Texas A&M**
- Research Partners, Assistance, and Helpful Discussions
  - Rebecca Green at BOEM
  - Ruth Perry at Shell
  - GP Schmahl, Emma Hickerson, John Embesi & others at FGBNMS
  - John Walpert, Andrea Kealoha, Katie Shamberger, Shari Yvon-Lewis & others at Texas A&M
- Sponsors
  - BOEM
  - Shell
  - Texas A&M

# Rising levels of atmospheric $CO_2$




Data from: Keeling SIO & ESRL NOAA

# Rising levels of atmospheric $CO_2$




Data from: Petit et al. & Keeling SIO & ESRL NOAA

# Effects on ocean chemistry

$CO_2$ gas released into the atmosphere by human activities is taken up in dissolved form by seawater

$$CO_2(aq) + H_2O \leftrightarrows H_2CO_3 \leftrightarrows H^+ + HCO_3^- \leftrightarrows 2H^+ + CO_3^{-2}$$

Total amount of dissolved inorganic carbon ($C_T$) equals the sum of the concentrations of the carbon species

$$C_T = [HCO_3^-] + [CO_3^{-2}] + [CO_3^*]$$

$$pH_T = - \log[H^{+z}]$$

pH falls as dissolved $CO_2$ is added to seawater

Equilibrium among these relationships depends on

$$T, S, P, [HCO_3^-], [CO_3^{-2}], [CO_3(aq)], [H_2CO_3], [H^+], fCO_2$$

# Effects on ocean chemistry

Seawater has major cations and major anions

$Ca^{+2}$, $K^{+}$, $Mg^{+2}$, $Na^{+2}$, etc  $Br^{-}$, $Cl^{-}$, $SO4^{-2}$, etc

Seawater must remain electrically neutral, but the sum cation posiitve charges is a little more than the sum of anion charges

$Ca^{+2}$, $K^{+}$, $Mg^{+2}$, $Na^{+2}$, etc  $Br^{-}$, $Cl^{-}$, $SO4^{-2}$, etc

$$[\text{total Alk}] = [HCO_3^-] + 2[CO_3^{-2}] + [B(OH)_4^-] + \ldots$$

$$[\text{carbonate Alk}] = [HCO_3^-] + 2[CO_3^{-2}]$$

*Importantly*, positive charge resulting from $H^+$ addition (as would occur with the influx of atmospheric $CO_2$) would be compensated for in this fashion.

# How do we keep track of all of this?

Considering the relationships among both the relation between $C_T$, [Alk], and the carbon species

$$[HCO_3^-] = 2C_T - [Alk]$$

Four parameters of the carbonate system in seawater can be determined

$$pH,\ C_T,\ Alk,\ pCO_2$$

*With any pair of these can be used to describe the entire system*

(note: also need to know temperature, salinity, pressure, and nutrient concentrations)

# What impact do changes have?

Affects the saturation state of seawater with respect to aragonite ($\Omega_{arag}$)

$$\Omega_{arag} = ([Ca^{+2}]\,[CO_3^{-2}]) / ([Ca^{+2}]\,[CO_3^{-2}])$$

seawater  seawater saturated w/ aragonite

# What impact could changes have?

Body parts of living organisms



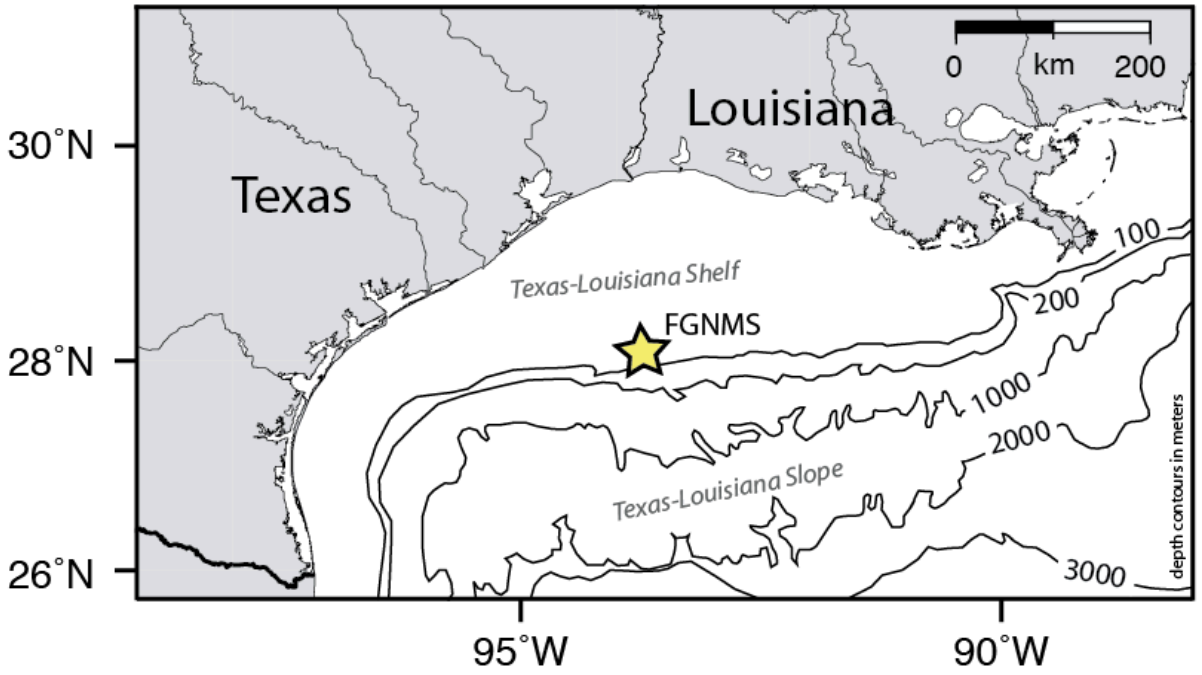
Framework and other aspects of coral reef structure

Photo source: Picture Guide to Stony Corals of the Flower Garden Banks National Marine Sanctuary

# Coral reefs are stressed!

- Coral reefs worldwide are under stress because of human activities and climate change
- Reefs in the Gulf of Mexico and Caribbean Sea region have declined markedly during the past several decades

# Study site:
# Flower Garden Banks National Marine Sanctuary

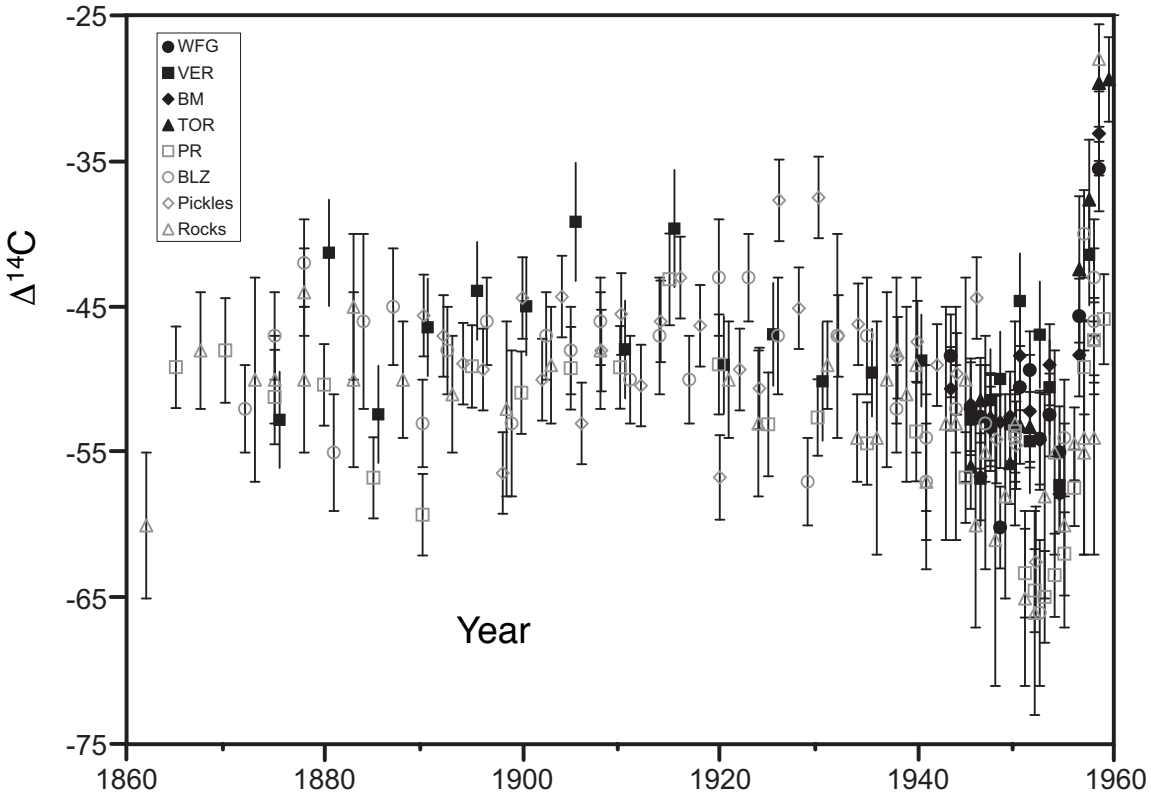



- 180 km off Louisiana/Texas Border
- Northern most U.S. Reef complex along continental shelf
- One of the healthiest reefs in the world
- Ideal location for ocean acidification, climate, and biological studies

# Evidence that atmospheric $CO_2$ enters the ocean

First ↓ [$^{14}C$] ⇒ entrance of $CO_2$ with fossil carbon

Then ↑ [$^{14}C$] ⇒ entrance of $CO_2$ with bomb carbon




Wagner, Guilderson, Slowey & Cole

# What impact do changes have?

What exactly is happening?

What will be the effects?

Must understand carbonate chemistry and physical / biological forcing!

# Objectives of our ongoing study

*We seek **baseline information** about pH and other key parameters plus a better **understanding of relevant environmental processes** because they are essential for establishing marine resource management policies and for evaluating environmental change*

*We seek to **test specific hypotheses** about **types of variations** of these parameters (magnitude, period, when occur, etc) and to determine the relative **importance of physical and biological forcing** processes*

**Must measure pH and the other key environmental parameters**

# Approach: integrated seafloor sensors obtain high-resolution time-series measurements at reef crest

- Descriptions of sensors
- Interesting elements of design
- Images of system

# Initial / test deployment May to July 2017

## Reef crest of East Flower Garden Bank

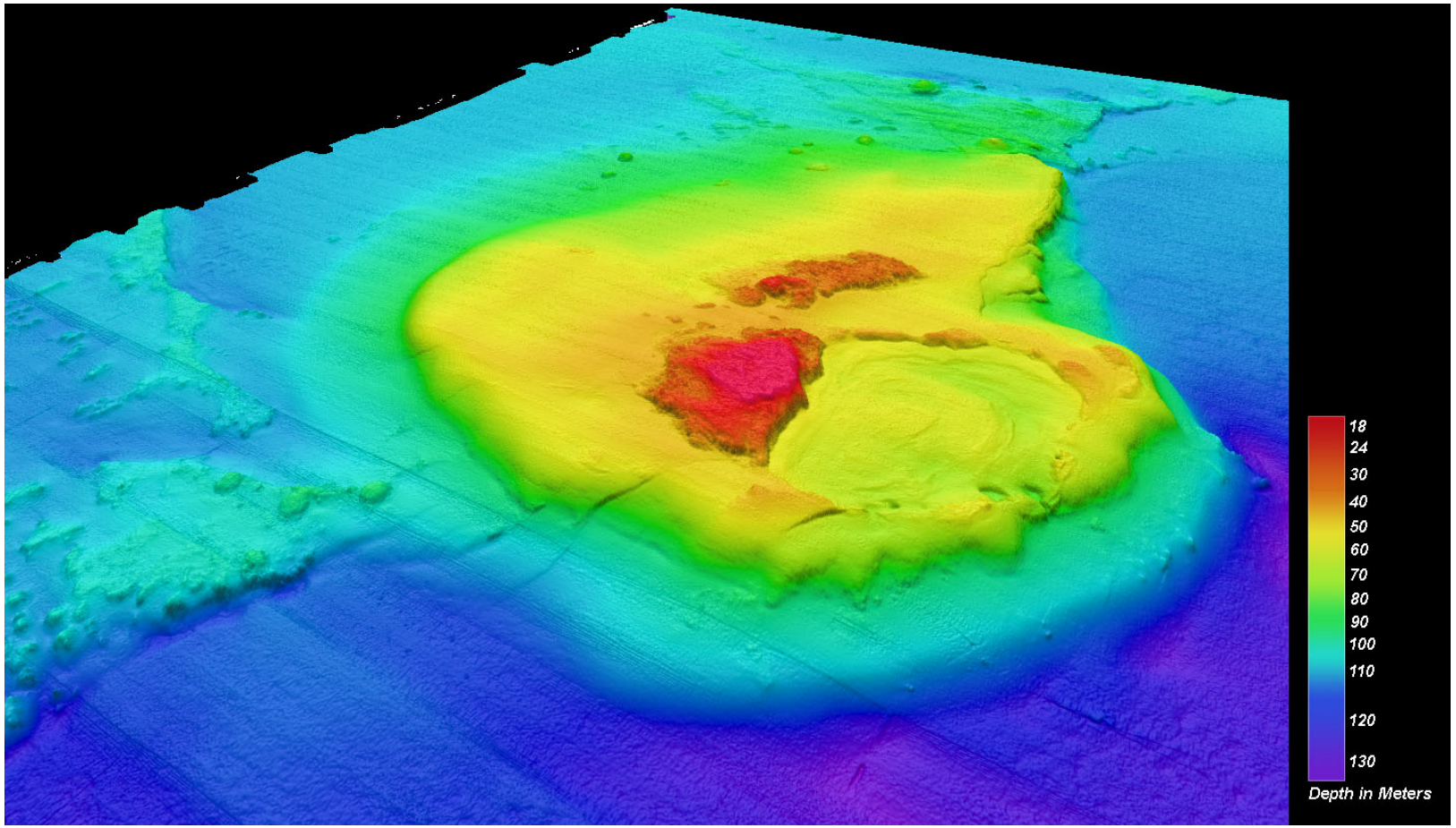



Image from: NOAA FGBNMS

# Test deployment May – July 2017

- Description of preliminary data
- Examples of aspects of data and implications

# Approach: integrated buoy sensors to obtain high-resolution time-series measurements at ocean surface

- Descriptions of sensors
- Interesting elements of design
- Images of system

# Next steps for this ongoing research project

- Logistical considerations
- Scientific objectives
- Plans for continuing investigation