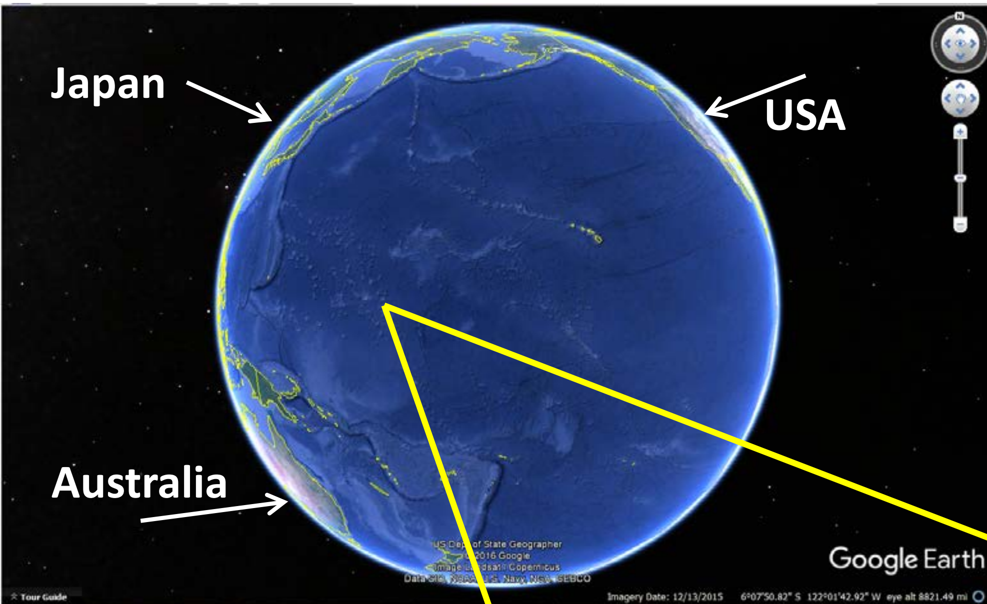
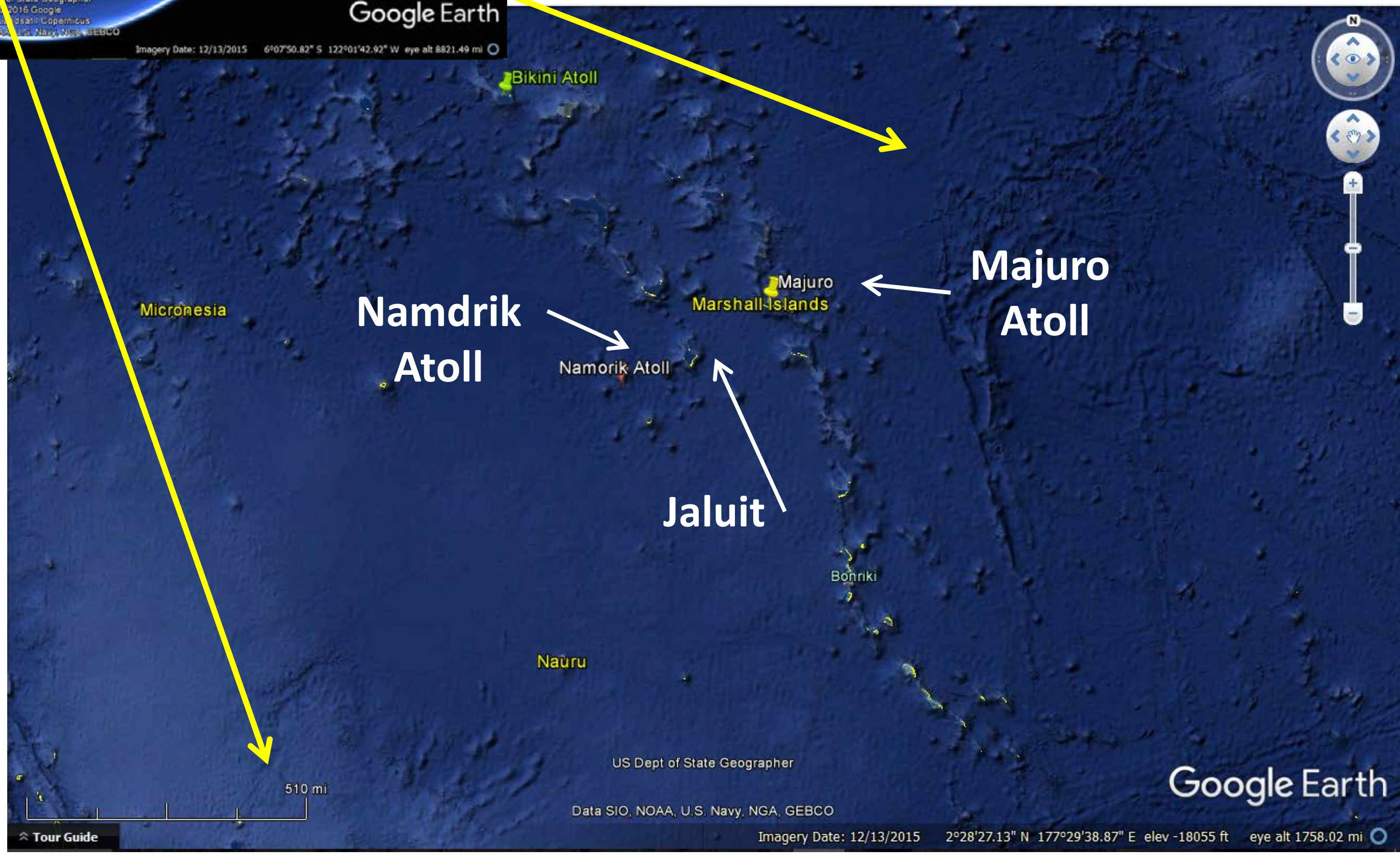
Southwestern RMI Atoll
Long Term Ecological Research Sites

Tentative Coastal Transects and Data Plots
in the Southwestern Region of the
Republic of the Marshall Islands

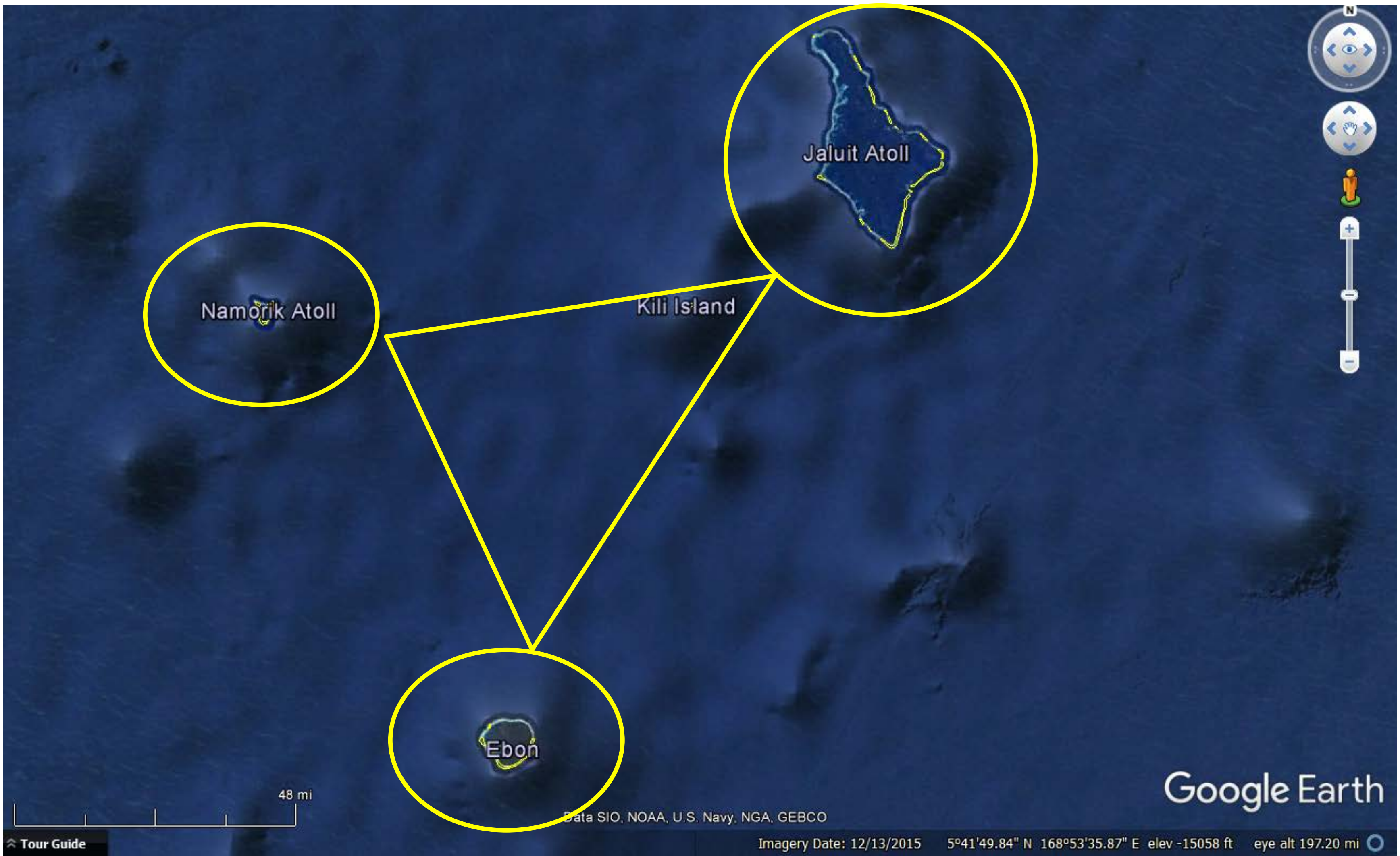
(Preliminary Sites on Namdrik, Jaluit, & Majuro)

The Republic or the Marshall Islands

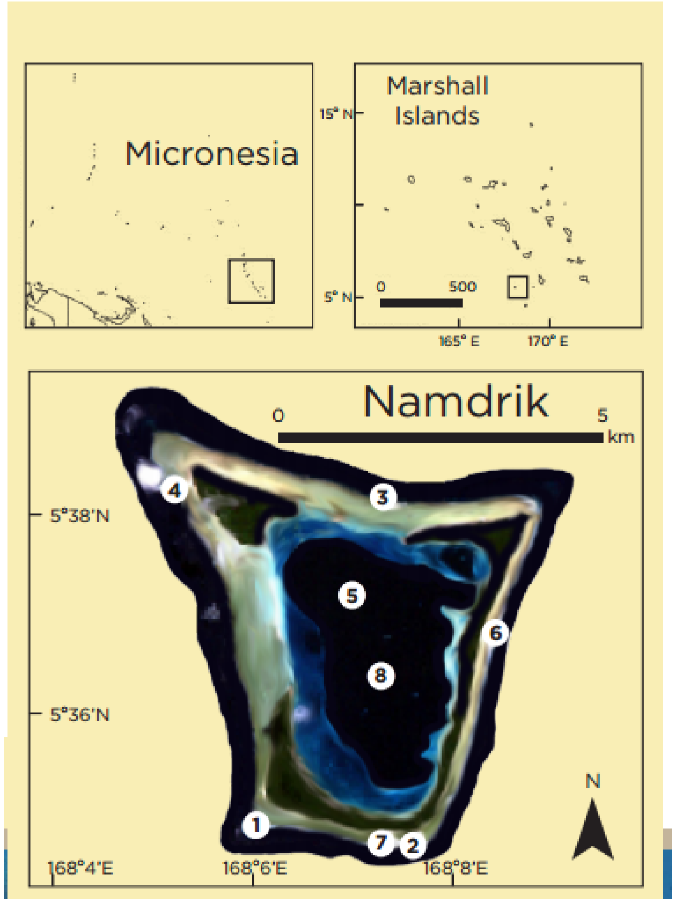




Living Islands Long-Term Ecological Research Triangle



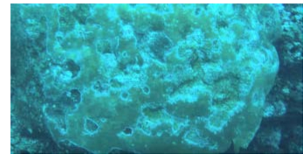
Building on Previous Research and Expanding "Citizen Scientist" Climate Change Monitoring



https://data.nodc.noaa.gov/coris/library/NOAA/CRCP/project/183/NA11NOS4820011_Namdrik_Assessment.pdf

3 Main Goals

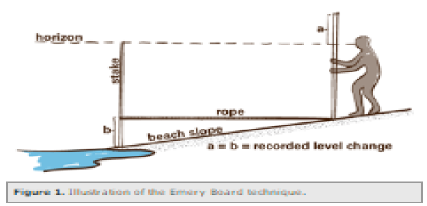
- Marine:
  - Underwater Visual Surveys assess changes to coral reef health and marine life over time following published methods for Namdrik Atoll (Coral-Reef Monitoring Assessment, 2013; MIMRA, CMI, & UOG)

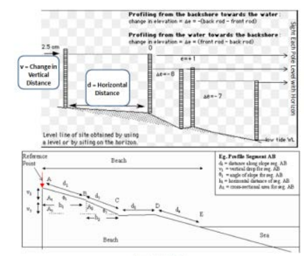


Monitoring marine life biodiversity, coral health, and Crown-of-Thorns Seastar (COTS) scars

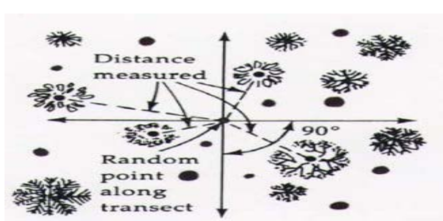
- Shoreline:

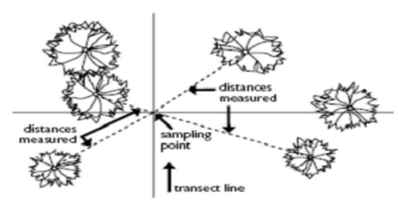
Assess changes to the physical shoreline over time following the Emery Beach Profiling method.



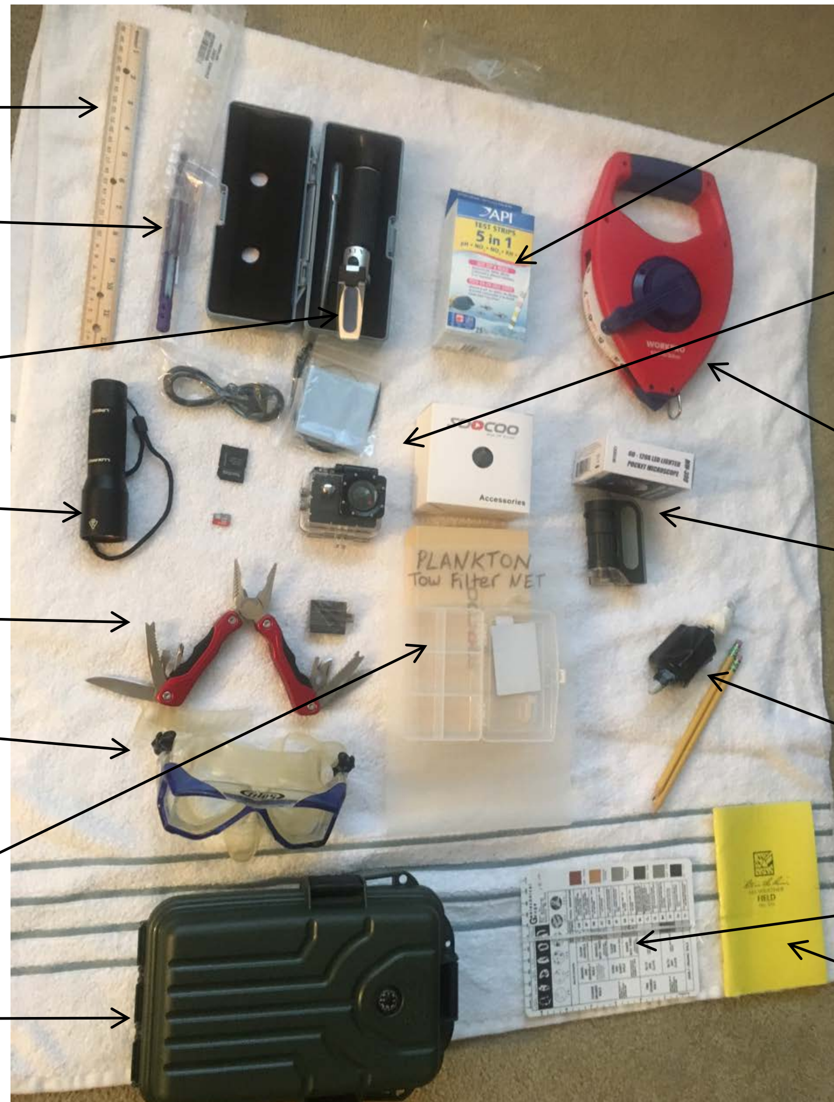


- Inland:
  - Assess changes to terrestrial vegetation cover and biota in 50 x 50 meter plots inland from Beach Profile using general and species-specific methods focusing on mangrove trees whenever present.





Living Islands Field Equipment (LIFE) Kits



Ruler/Straightedge

Thermometer

Salinity Gauge (Refractometer)

Flashlight

Multi-Tool

Mask/goggles for UVS

.75 micron Plankton Filter and Slot Tray

Dry-Box with Compass

5 Parameter Water Quality Test Strips

Underwater Camera, extra battery, SD card, and cords

Transect Tape

Handheld Microscope

Permanent Marker, Pencils, Twine, and Tape

Sand/Soil Gauge Card

Waterproof Data Notebook

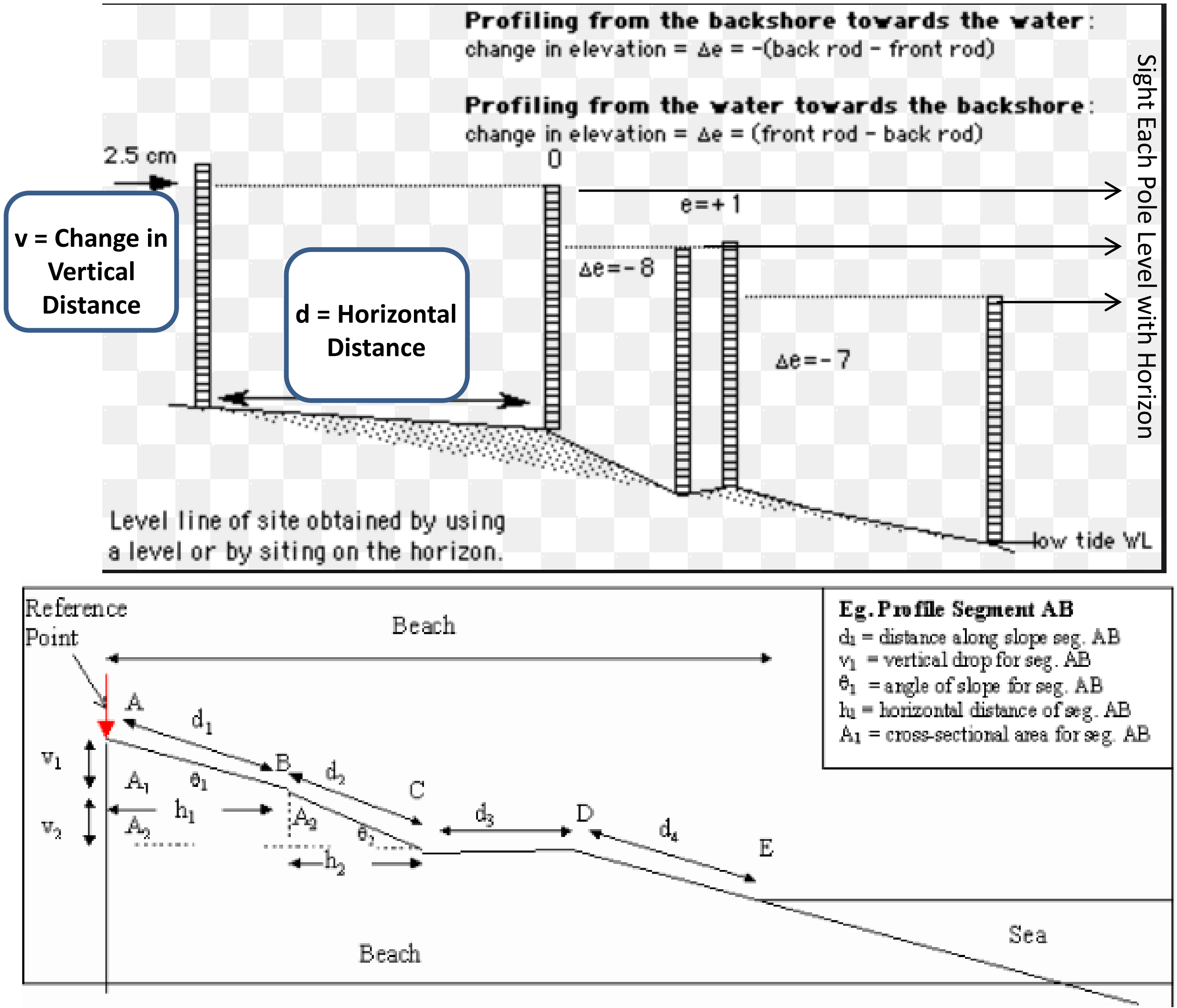
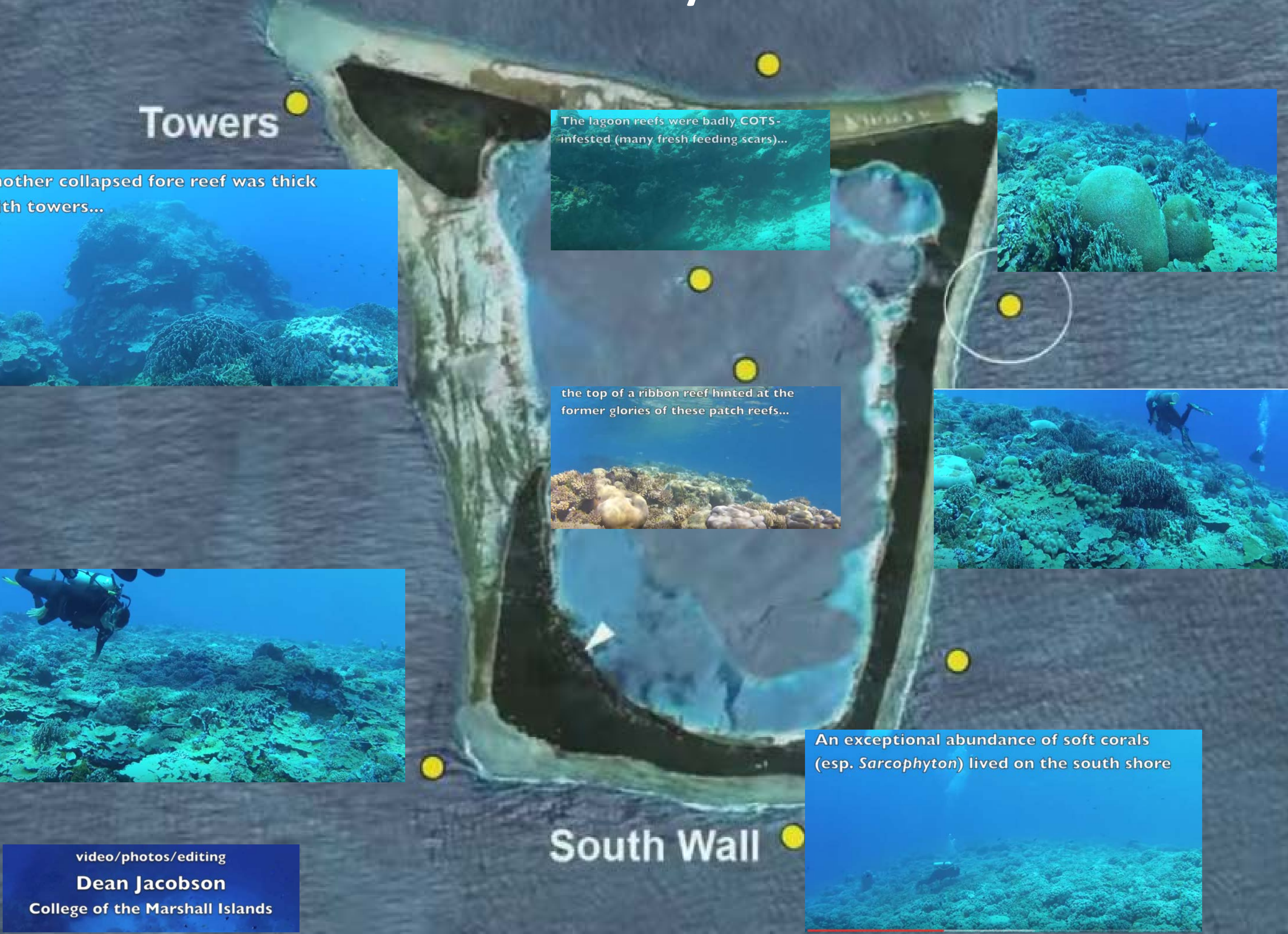
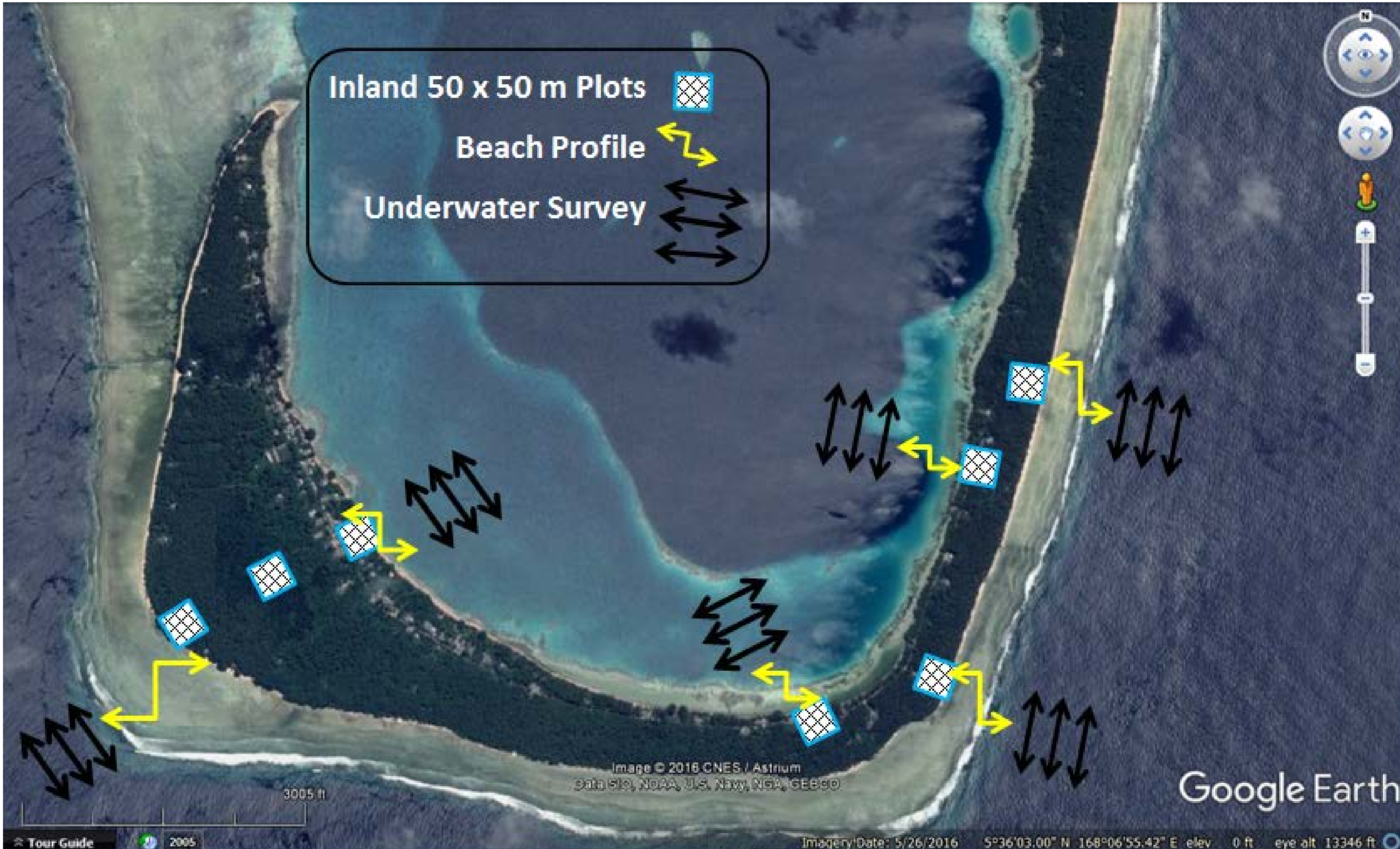


Figure 1: Beach Profile

2013 CMI Marine Surveys on Namdrik Atoll



Living Islands Coastal Monitoring Plan (Namdrik Atoll Example)




Matamat
Namorik Island
Namorik Atoll
Namorik Atoll
Image © 2016 CNE
Data SIO, NOAA, U.S. Na
6080 ft

Table 7: Traditional Sites, Navigational Markers, etc. of Namdrik

type of feature	description	Ramsar # of wetland type (see page 7 of main report)												non-wetland		explanation and/or legend	HPO no. and/or other reference
		A	B	C	D	E	I	Sp	Ss	Xp	Zk	2	7	land	sea		
Traditional	Coral in intertidal zone	X														Patch of ephermial slippery coral; associated with Lobejbejina.	MI-MM-MM-01
Traditional/ prehistoric	Swamp, marsh, former taro pit												X			Located on the interior of Namdik. House site associated with traditional story of Jedebno.	MI-MM-MM-02
Traditional/ ?prehistoric	Well										X					Said to still be in use and never goes dry.	MI-MM-MM-03
Traditional	Rock located in intertidal zone	X														Possibly associated with Lomajtamij, one of Lijobknonira's paramours.	MI-MM-MM-04
Traditional	Well										X					Supposedly located at site of Jodikwod and story on origin of the banana.	MI-MM-MM-05
Traditional	Rock in the island's interior													X		Associated with Lotepiej, a famous navigator and one of Lijobknonira's paramours.	MI-MM-MM-06
Traditional	*Intsia* tree along lagoon shore	X														Associated with the story of one of Lijobknonira's paramours.	MI-MM-MM-07
Traditional	Rocks on the table reef				X											Running from the west side of Madmad to the west side of Namdik; associated with the story of Lijobkonira's children.	MI-MM-MM-08
Historic	Building ruins													X		Japanese Trading Post	MI-MM-MM-09
Traditional	Mangrove swamp						X									Associated with the story of Lijobkonira's children.	MI-MM-MA-01
Totem	Brown Booby														X	Totem of the Erebra jowi.	Erdland pg. 343.
Navigational Marker	Green Herring			X												Lalûblok.	Erdland pg. 361.
	Stone on southern outer shore				X												
Navigational Marker	Porpoises														X	Libokja (Erdland); probably same as Linijej, Lijoñal, and Lijenmaloklok, women originally from Kosrae said to be reef rocks.	Erdland pg. 361. Knight pg. 72. Tobin pg. 136.
	Stone on weather side				X												
Navigational Marker	Wandering Tattler	X														Jelauwe	Erdland pg. 362.
	Stone on outer shore				X												
Navigational Marker	unstated						X									"Lio ilo pat in Madmad", a girl who jumped down from a tree.	Erdland pg. 362.
Navigational Marker	Large flock of birds.														X	Off of Madmad, many types of birds together.	Tobin pg 135.
Navigational Marker	Pandanus leaf at sea														X	Off of Madmad where best pandanus for weaving is said to come	Knight pg. 72. Tobin pg 135.
Navigational Marker	Rocks on Reef				X											Daij and Lilibij (Knight); Taij (with two palm trees between Madmad and Namdrik) and Lejpel (Tobin).	Knight pg. 72.
Navigational Marker	Turtle														X	Off reef of Jabar and Liltin (perhaps Namdrik or Kosrae).	Knight pg. 72.


6 ocean and 2 lagoon transects (each 5 x
50 m long) were run with 6 divers


These reefs lack the usual *Isopora* dominance typical of the RMI...


Massives on Majuro suffer nearly universal disease, unlike Namdrik...

Monitoring on Namdrik for Crown-of-Thorns Seastar

Lagoon transects had lots of COTS damage


the top of a ribbon reef hinted at the
former glories of these patch reefs...

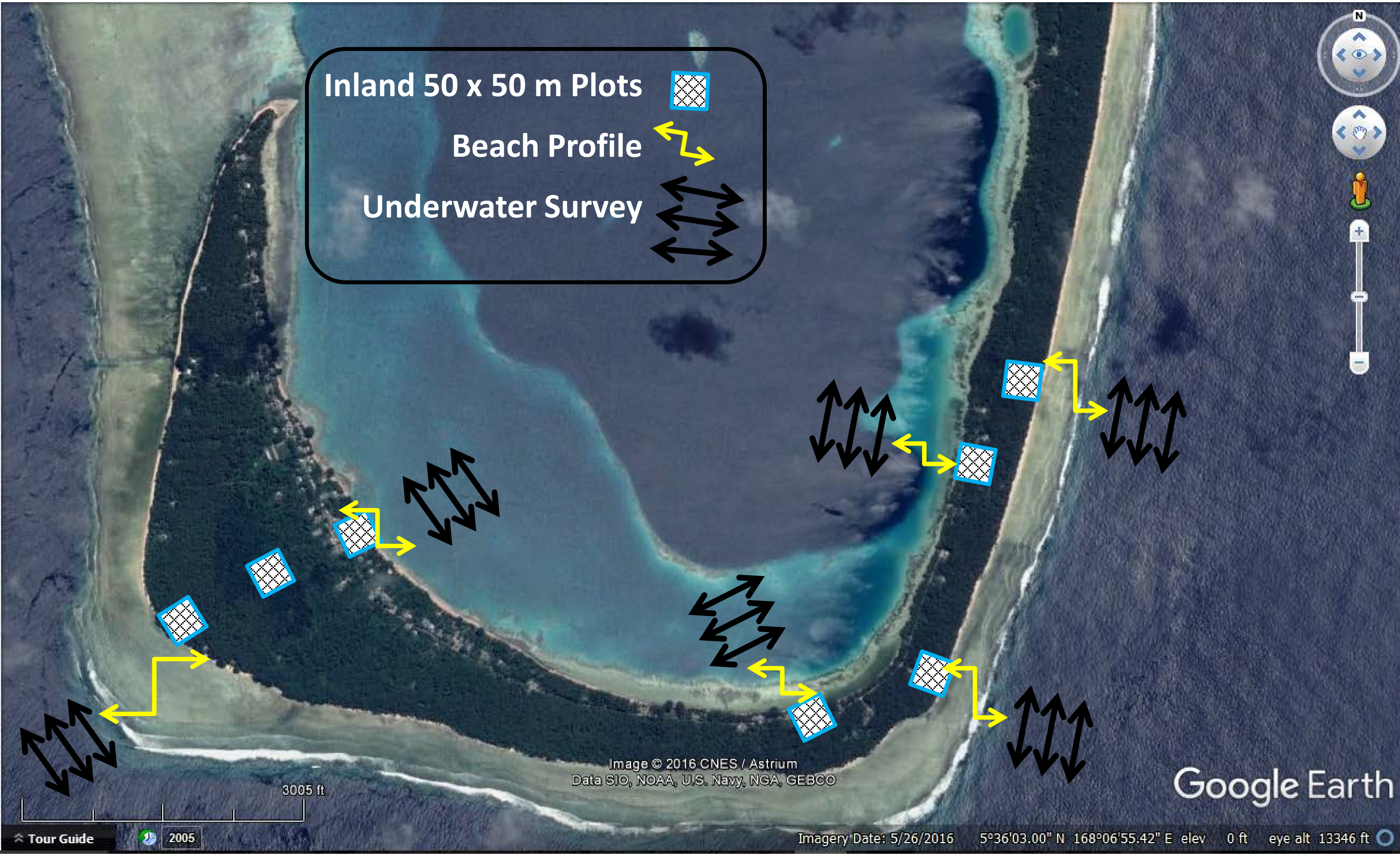

6 ocean and 2 lagoon transects (each 5 x
50 m long) were run with 6 divers


Towers
South Wall
The eastern reefs had healthy,
ancient massive coral...

Matamat
Image © 2016 CNES / Astrium
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
901 ft
Google Earth
Tour Guide
2005
Imagery Date: 5/26/2016
5°37'59.91" N 168°05'48.59" E elev 43 ft eye alt 3724 ft


Namorik Island
Image © 2016 CNES / Astrium
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
897 ft
Google Earth

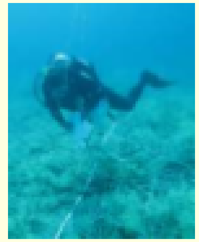
Image © 2016 CNES / Astrium
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google Earth
3005 ft
Tour Guide
2005
Imagery Date: 5/26/2016
5°36'03.00" N 168°06'55.42" E elev 0 ft eye alt 13346 ft


Inland 50 x 50 m Plots
Beach Profile
Underwater Survey
Image © 2016 CNES / Astrium
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
3005 ft
Tour Guide
2005
Imagery Date: 5/26/2016
5°36'03.00" N 168°06'55.42" E elev 0 ft eye alt 13346 ft
Google Earth

Ralik Ridge
Namu Atoll
Ailinglaplap Atoll
Majuro
Marshall Islands
Arno Atoll
Mili Atoll
Jaluit Atoll
Harrie Guyot
Namorik Atoll
Ebon
99 mi
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google Earth
Tour Guide
Imagery Date: 12/13/2015
7°20'12.61" N 166°33'28.58" E elev -16309 ft
eye alt 400.99 mi

Survey Methods

2 depths @ each site
3-5m & 8-10m



Reef FISH
3 x 50m (2m wide belts – small reef fish)
3 x 50m (5m wide belts – large reef fish)

CORAL & RUBBISH Diversity
3 x 50m (2m wide belts)
*** Includes inventory of rubbish within belts**

Large reef FISH
3 x 250m (5m wide belts)

BENTHIC Cover
3 x 50m Point-intercept transects
(100 points, record every 50cm)
***includes counts of rubbish**

MacroINVERTebrates
3 x 250m (5m wide belt)

4

***** Remember 2 depths surveyed at each site = 6 transects per site for all taxa.***

Ref: zoe.richards@austmus.gov.au

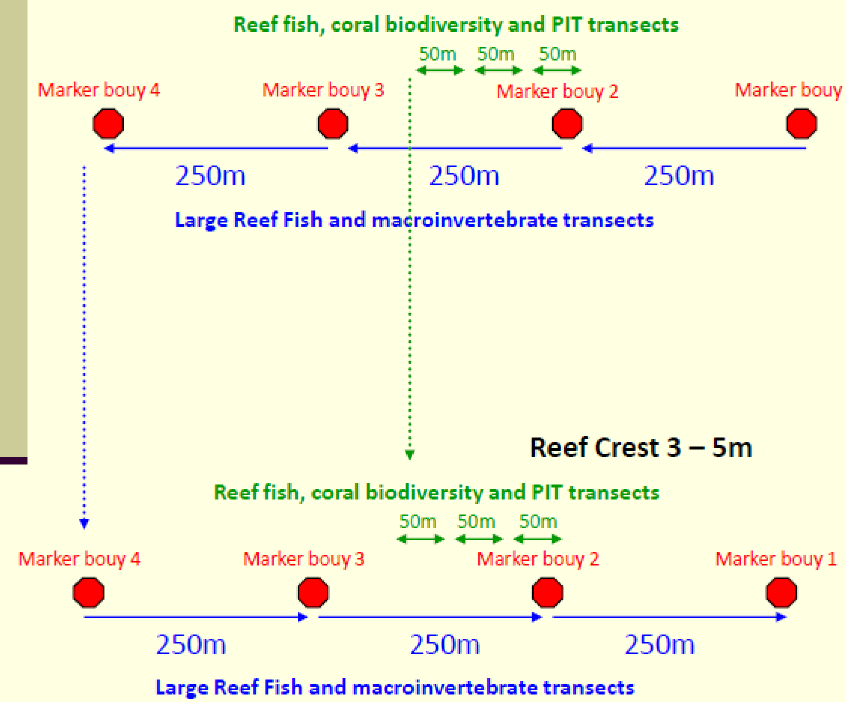
Sample Design Following Majuro's LTER Model

https://data.nodc.noaa.gov/coris/library/NOAA/CRCP/other/grants/MonitoringGrants_FY09_Products/Majuro_Monit_Guide_NA09NOS4260098.pdf

Survey Design Illustrated

Reef Slope 8 – 10m

The deep sites are always surveyed first to ensure dive safety. **Four weighted marker bouys** are deployed every 250m using a GPS to measure the distance. The coral and fish surveyor begin surveying first starting at the second marker bouy and the large fish and invertebrate surveyor then being their surveys at the first marker bouy. This strategy minimizes the disturbance of sharks and large reef fish.



5

NOTE: The reef fish biodiversity surveyor swims first while deploying the 50m transect tapes and is followedby the coral biodiversity surveyor. After 3 transects, the coral surveyor swims first back along the transect conducting point-intercept transects and the fish surveyor follows winding up the tape.

Counting Fish

Reef Fish Biodiversity

The abundance and size of all non-cryptic fish species is documented on 3 replicate 50m transects per habitat. Larger mobile fishes such as Wrasses, Parrotfishes, Emperors, Snappers, Surgeonfishes, Groupers, Butterflyfishes, Angelfishes are recorded on a 5m wide, and smaller site attached fishes (damselfish, small wrasses, etc.) on a 2m belt. This approach will ensure very rigorous assessments of fish biomass and density, which is crucial for temporal and spatial comparisons.

Large Reef Fishes and Sharks

The biomass and abundance of larger, wide-ranging fish species with larger territories can be more accurately assessed on long swim transects. Large fishes are recorded at each site and depth on 3x250 m belt transect of 5 m width. Many of the species recorded in these counts occur at such low densities that estimates based on smaller transects are imprecise and unreliable for on-going monitoring.

GPS co-ordinates of long-term monitoring dive sites at Majuro

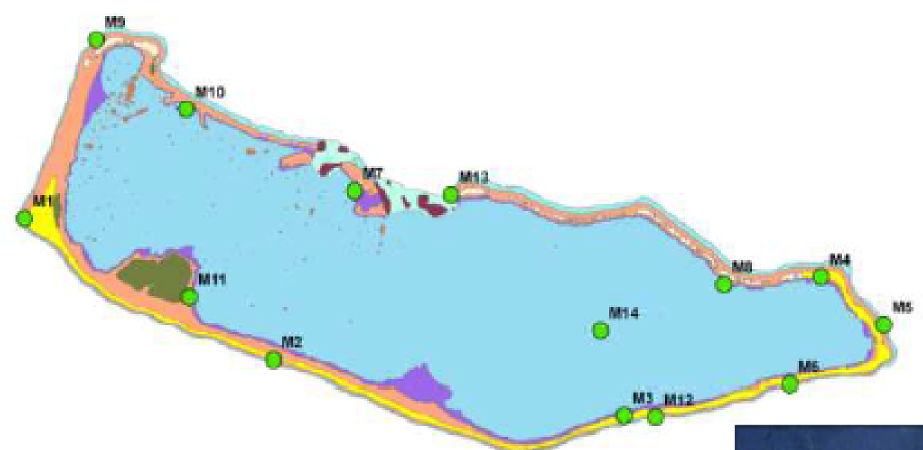
ID	LAT: N	LON: E
M1	7.147326	171.026506
M2	7.089044	171.129486
M3	7.066964	171.274774
M4	7.123253	171.35631
M5	7.103624	171.38224
M6	7.079354	171.343472
M7	7.158668	171.163085
M8	7.123253	171.35629
M9	7.221025	171.056227
M10	7.192273	171.093613
M11	7.114926	171.094738
M12	7.066318	171.28767
M13	7.157113	171.203093
M14	7.101144	171.265011

GPS co-ordinates of rubbish snorkel sites in Majuro Lagoon

ID	LAT: N	LON: E
RU1	7.086766	171.373531
RU2	7.088113	171.378002
RU3	7.092751	171.379386
RU4	7.113357	171.366963
RU5	7.111748	171.367668
RU6	7.10811	171.371193
RU7	7.101758	171.377096
RU8	7.078722	171.33149
RU9	7.076408	171.322287
RU10	7.074649	171.318014
RU11	7.074649	171.318

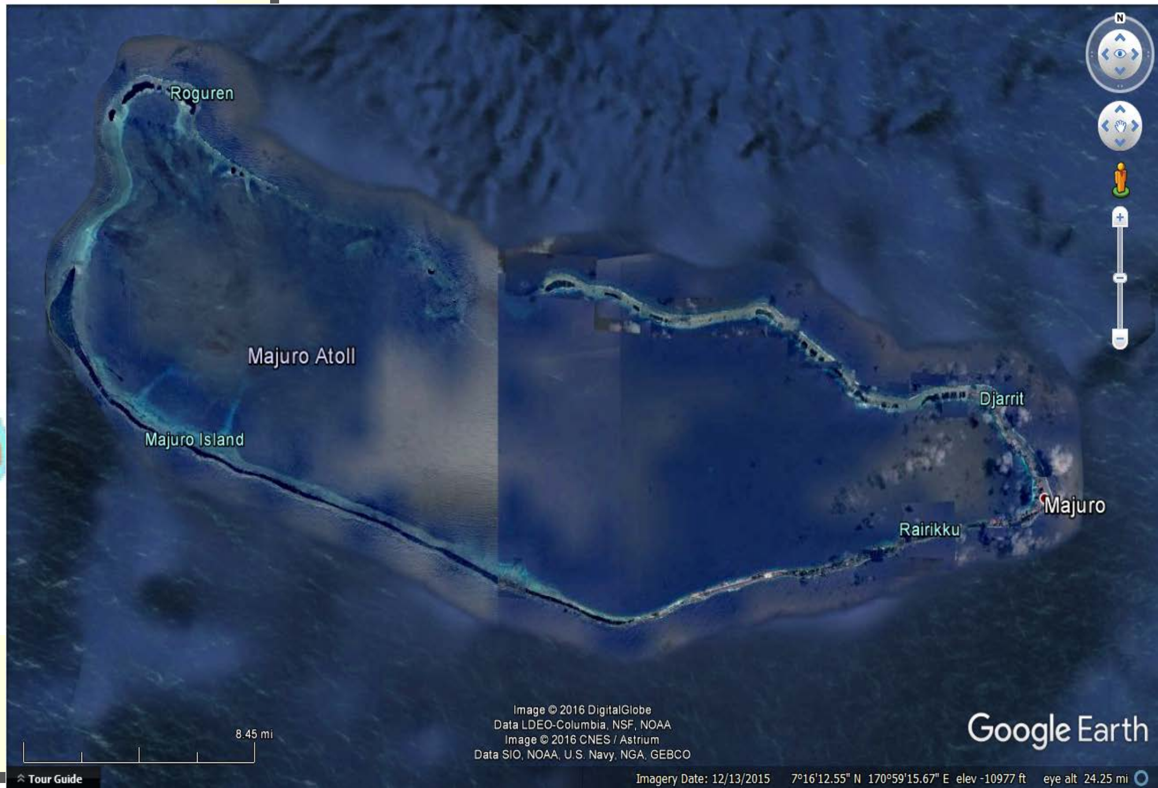
Majuro's Established LTER Locations

Long-term monitoring sites in Majuro Atoll

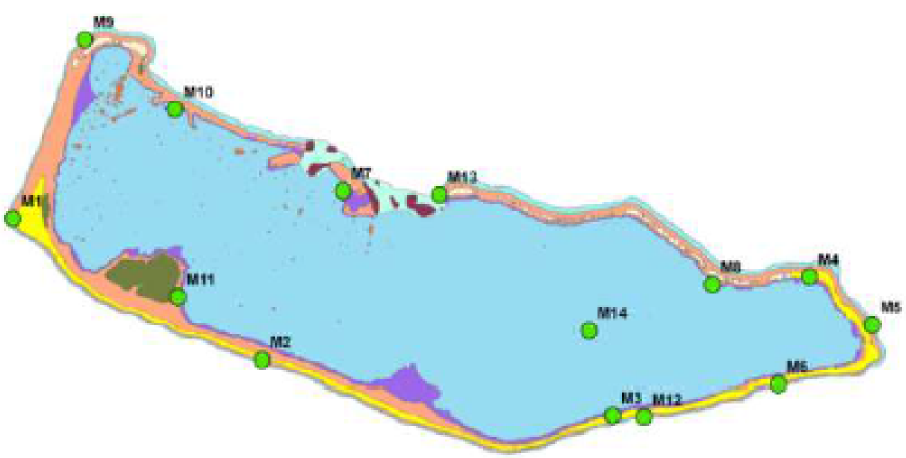


a). SCUBA sites on the reef crest and reef slope.

b). SNORKEL sites from shallow lagoon sites.
Specifically conducted to record marine debris.



Long-term monitoring sites in Majuro Atoll



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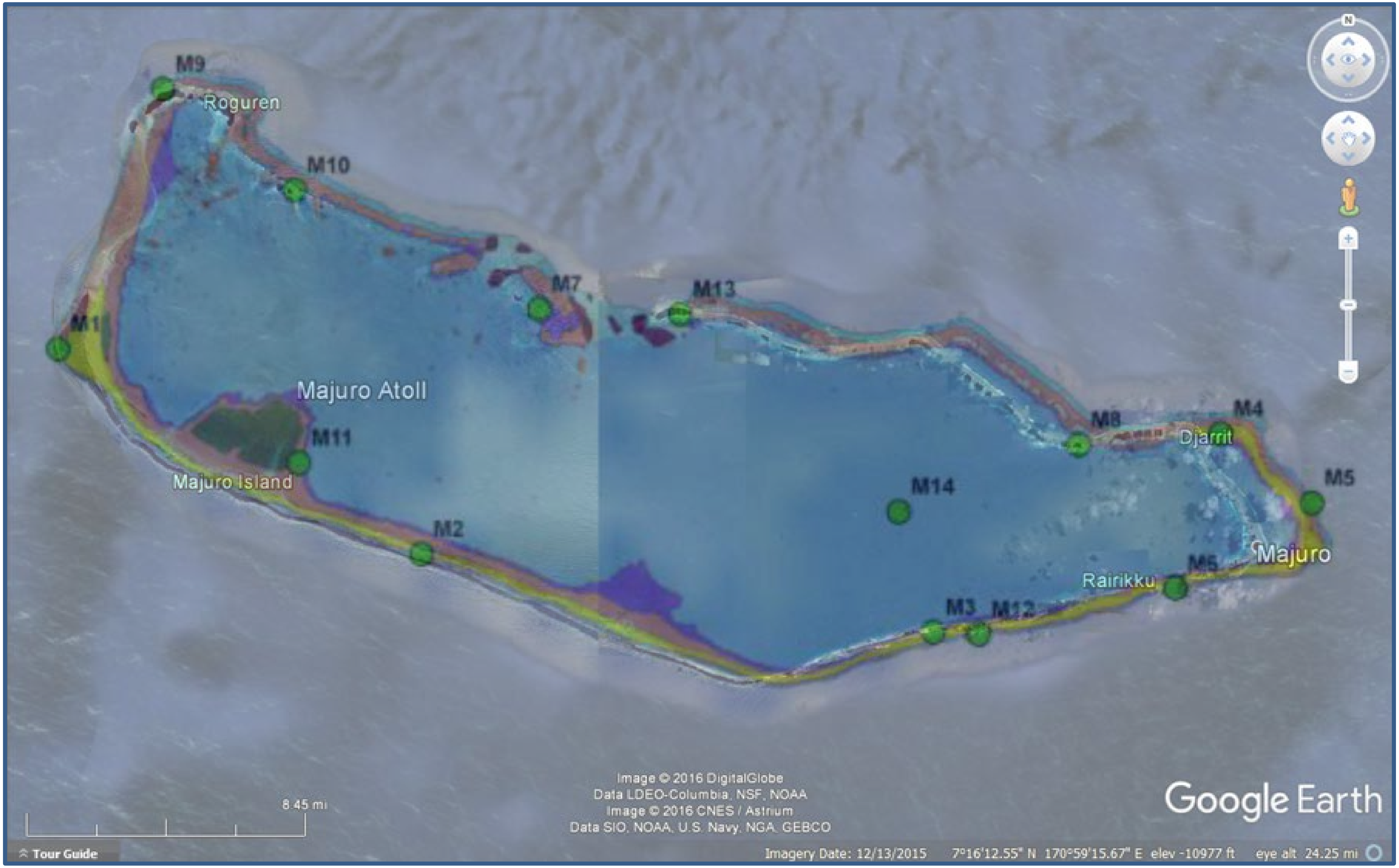

M9
Roguren
M10
M7
M13
M1
Majuro Atoll
M11
Majuro Island
M8
M4
Djarrit
M5
M14
M2
Majuro
M6
Rairikku
M3
M12
Image © 2016 DigitalGlobe
Data LDEO-Columbia, NSF, NOAA
Image © 2016 CNES / Astrium
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
8.45 mi
Google Earth
Tour Guide
Imagery Date: 12/13/2015 7°16'12.55" N 170°59'15.67" E elev -10977 ft eye alt 24.25 mi


M9
Roguren
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M13
M1
Majuro Atoll
M11
Majuro Island
M2
M8
M4
M5
M14
Majuro
M6
M3
M12
Image © 2016 DigitalGlobe
Data LDEO-Columbia, NSF, NOAA
Image © 2016 CNES / Astrium
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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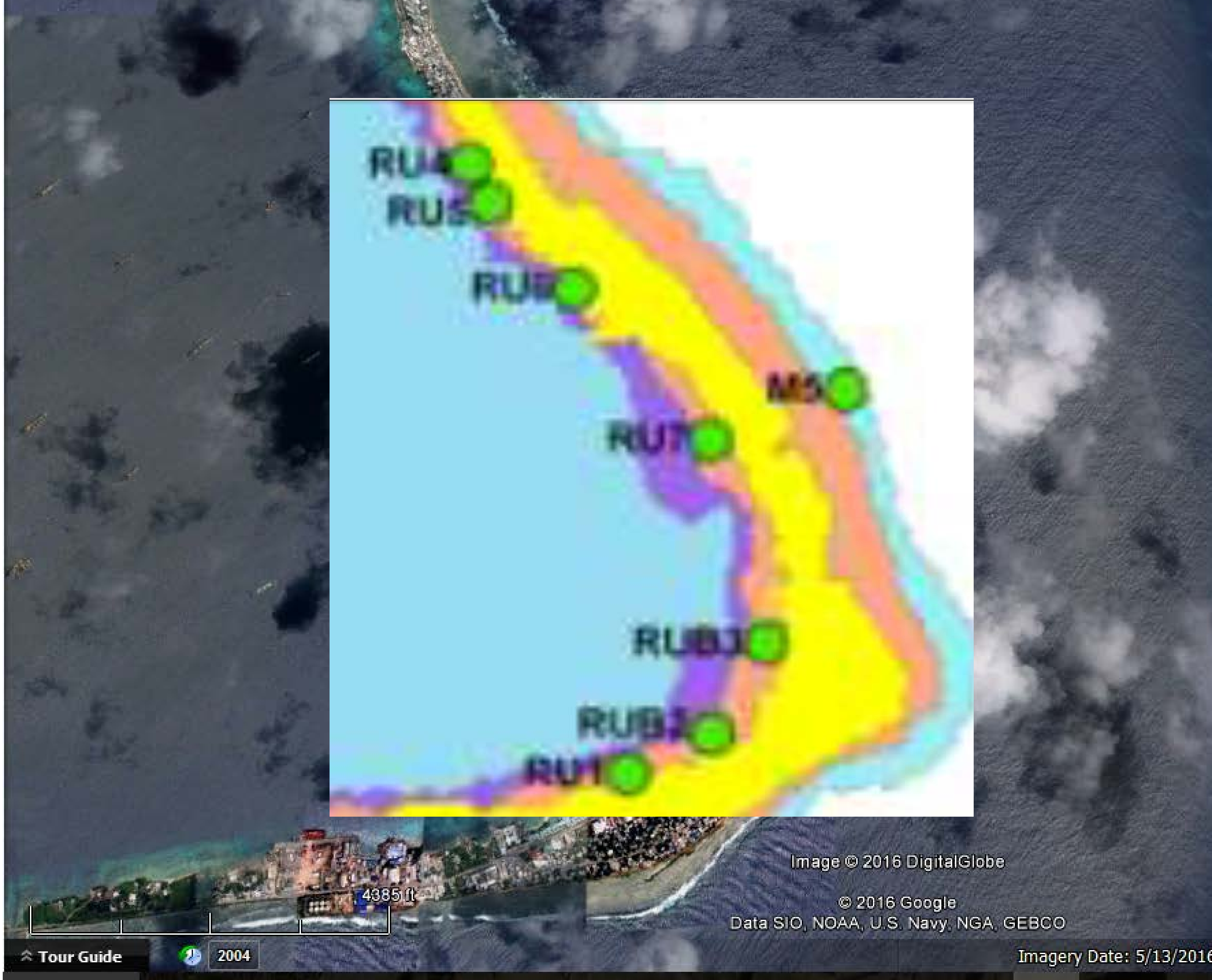
Google Earth
Tour Guide
Imagery Date: 12/13/2015 7°16'12.55" N 170°59'15.67" E elev -10977 ft eye alt 24.25 mi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© 2016 Google
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4385 ft
Tour Guide
2004
Imagery Date: 5/13/2016

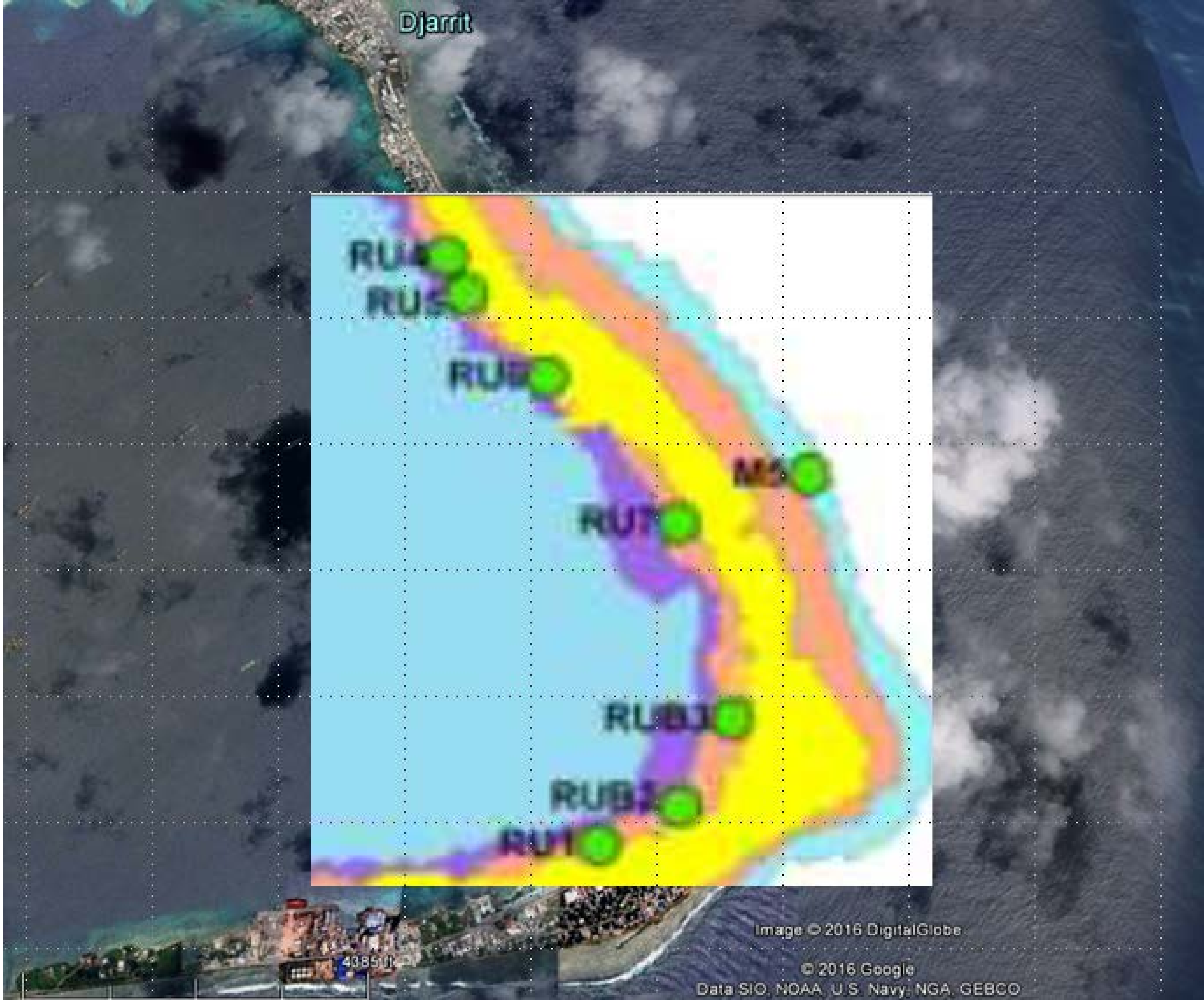
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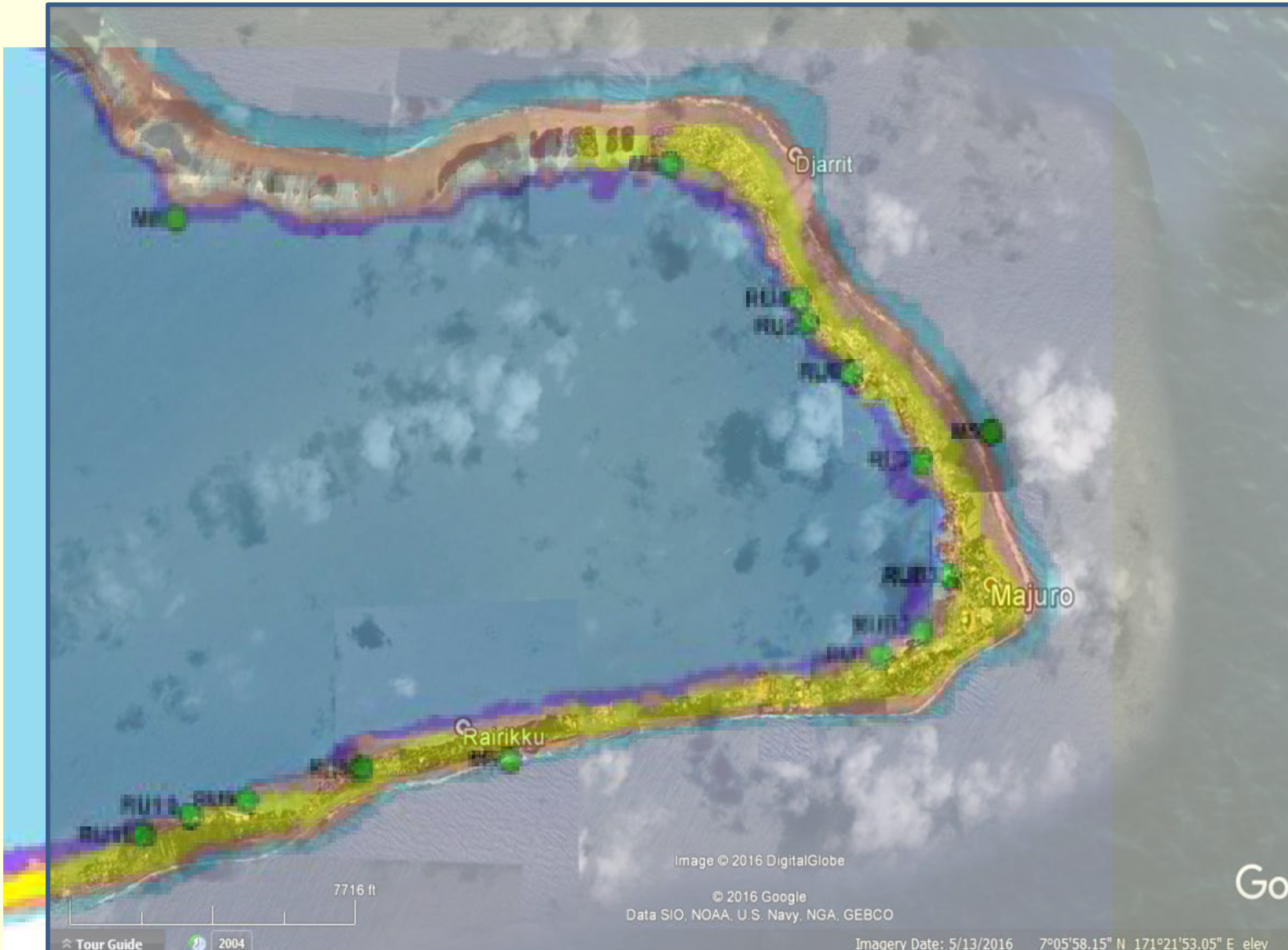
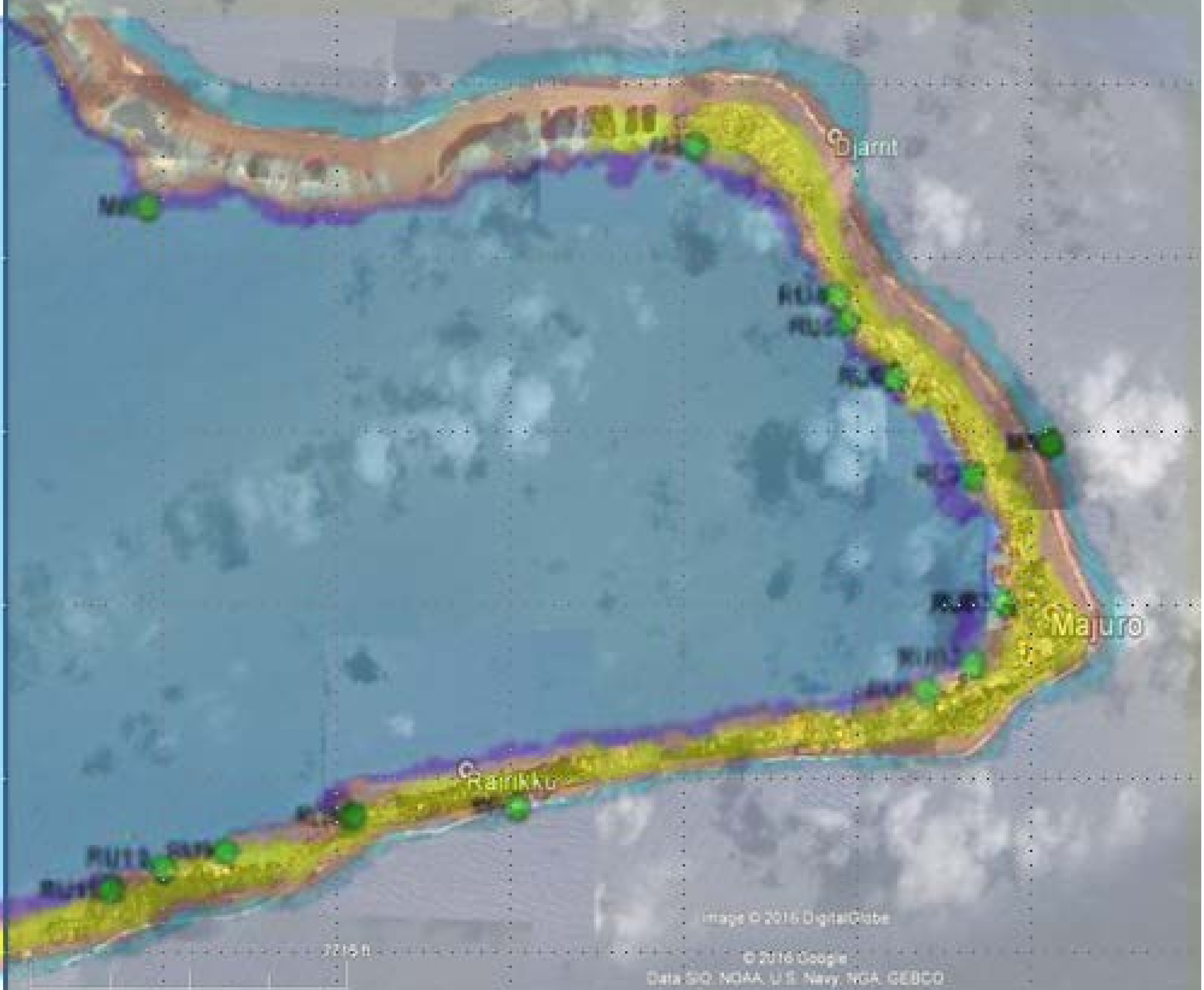
Image © 2016 DigitalGlobe
© 2016 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO



b). SNORKEL sites from shallow lagoon sites.

Specifically conducted to record marine debris.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Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Beach Profiling with "Emery Boards" and Measuring Sand Grain Size

Abstract

Using only a rope and two boards, students can measure the profile (shape) of a beach and examine the relationship between the beach profile and sand grain size. The beach profile is constructed from a series of measurements of beach elevations taken perpendicular to the shoreline, with the measurements being taken at intervals parallel to the shoreline. This is an excellent activity for a class field trip.

Introduction

Lots of people enjoy going to the beach. Some people like to play volleyball in the dry sand, some people like to surf on the breaking waves, and some people like to just lie down on a blanket and catch some rays. For whatever reason people like to go to the beach, it's worthwhile to know something about why the beach is shaped the way it is.

The shape of the beach is determined by two main factors:

1. the waves approaching and breaking in the surf zone and
2. the size of the individual sand grains on the beach.

Method

Figure 1. Illustration of the Emery Board technique.

Perhaps the simplest technique to measuring a beach profile is known as the **"Emery board"** method, developed by a famous coastal scientist named K.O. Emery. As depicted in Figure 1 the apparatus consists of two stakes connected by a rope of known length (5m or 10m). This length sets the measurement interval for individual data points along the profile. Each stake has a measurement scale which runs from 0 at the top, down to the bottom of the stake. Either English or Metric units can be used, although the scientific community is nearly completely converted to the metric system. If the beach is sloping downward toward the sea, the observer sights across the top of the seaward board to the level of the horizon, and determines the distance **(a)** from the top of the landward board to the sightline. If the beach is locally sloping upward in the offshore direction, then **(a)** is measured on the seaward board and the sighting is with the horizon over the top of the landward board. In either case, the measured distance **(a)** is equal to the distance **(b)** that the beach has either dropped or risen within the horizontal distance between the boards (the rope length). (Komar, 1998) This approach may seem simple, but it provides reasonably accurate measurements of beach profiles. It also has the advantages of light, inexpensive, equipment, which can be easily carried to distant survey sites, for very rapid surveys.

The technique of measuring sand size will be conducted in the field with the use of **sand gauge charts**. These are small, credit-card sized, plastic charts with calibrated samples of sieved sand mounted on the face. By using a hand-lens and sand gague chart, students may compare samples from the beach with calibrated samples on the chart for an estimate of size range.

Materials

To build a set of "Emery boards", the materials needed are two pieces of wood of equal length and a rope of known length. (Boards of 6-8 feet length will work well.) Tie a loop in each end of the rope, which can easily slide up and down the two boards. Measuring down from the top of each board, use a marker and a ruler to draw and label the "graduations" (marks of equal length). It is recommended that SI (system international) units are used for the exercise – an appropriate graduation interval is every two centimeters.

Sand gauge charts are available for a nominal fee ($10 - $12 each) from a number of vendors. One such distributor is **ASC Scientific: (http://www.ascscientific.com/books.html).**

Hand lenses are available, for a nominal fee ($10 - $100 each, depending on quality) from a number of vendors. One such distributor is Miners, from Riggins, Idaho (**https://minerox.com**).

Paper and pen or pencil are needed for recording data.

Activity - Fieldwork

Much of the enjoyment that comes along with a career in the geological sciences is the process of data collection in the field. For this exercise, the fieldwork takes place at a local beach.

1. After arriving at the beach and selecting the site for beach profile measurement, students should split into groups of fours. The first task is to mark a line in the sand parallel to the shoreline. Call this line the **baseline**. The beach profile (i.e. elevations) will be measured along this baseline at specific intervals. These intervals will be designated the horizontal (along-the-coastline) distance (x).
2. Each team of four students will have a "**seaward surveyor**", a "**landward surveyor**", a "**geotechnical engineer**" and a "**data recorder**". The "seaward surveyor" is responsible for holding the seaward board and ensuring that the rope is level between the two boards (by sliding the loop up or down) when fully extended. The "landward surveyor" is responsible for holding the landward board, sighting over the seaward board to the horizon (as described in the Methods section), and shouting out the measurement (cm down from the top of the landward board) to the "data recorder". The "geotechnical engineer" is responsible for moving with the "seaward surveyor" to collect a sand sample, and identify it using the hand lens on the basis of its size comparison to the sand gage chart. The "data recorder" should keep organized notes of each measurement including **horizontal distance (x), measurement of change in elevation (a), cumulative change in elevation of all measurements, and sand size at each location**. Students are encouraged to rotate positions within the team so everyone has experience with each task.
3. Starting at the landward extent of the survey region (baseline), cross-shore data points of elevation and sand size are collected at the sampling interval determined by the length of the rope (distance between the two boards at full extension). Collect at least 5 cross shore data points. Collect more than 5 cross shore data points if the beach is wide.
4. This process should be repeated at 4 locations (at least) to ensure that each student rotates through each task. The alongshore spacing of each profile should be uniform to cover a consistent reach of beach.
5. Depending on how many students participate in the exercise, the class should be able to cover a significant alongshore portion of the beach.

Results - Data Analysis

Back in the classroom, students can participate in **data analysis**. This is often the first look that a scientist has at his/her data, and therefore the first opportunity they have to verify or reject some of their initial hypotheses.

Using the data of the beach profiles recorded by the class, the first step is to plot the cumulative vertical elevations (y-axis) as a function of horizontal position (x-axis). This will reveal the actual beach profile. It will also be valuable to plot slope against horizontal position as a measure of steepness. Slope is calculated by dividing the difference in elevation between any two adjacent points by the difference in horizontal distance between those two points. Remember, the units of elevation and distance must be consistent, so you'll likely have to convert cm to meters. Lastly, a corresponding plot of grain size vs. horizontal position will help to illustrate the correspondence of material properties and beach shape. See the sample spreadsheet and plots for clarification of the analysis.

At first, the beach profile data may not appear to be very exciting – about like a horizontal line, if the horizontal and vertical scales are equal. This provides an opportunity to employ a common technique of geologists, geographers, and cartographers (map makers) called "**vertical exaggeration** ". To employ vertical exaggeration, simply alter the vertical scale by a chosen factor (for example, a factor of 10) to accentuate subtle topographic features.

Click **here** to download the sample spreadsheet for this activity.

Interpretation of Results

The final step in the scientific process is the interpretation of the results. During this stage, students will be able to place their results in the context of the greater body of knowledge amassed by previous scientific investigations. The results plotted in the graphs are better interpreted if we compare them to some of the work done by other scientists. Figure 2 shows a compilation of a significant amount of data on beach slopes and corresponding grain sizes. Can you identify where your beach would plot on such a diagram? Remember, "slope ratio" is simply the rise over the run, so if your beach slope is 0.05, that's the same as a slope ratio of 1 to 20, or 1:20.

Figure 2. shows data from other scientists who measured beach slopes and sand grain sizes. Graph from Wiegel, R.L., 1965. *Oceanographical Engineering*, Prentice-Hall, 531 pages.
Reference: Komar, P.D., 1998. *Beach Processes and Sedimentation*. Prentice-Hall, Inc. 544 pages.

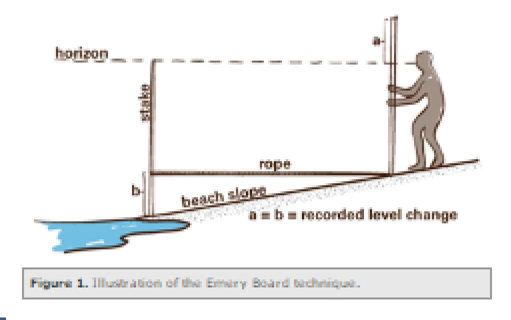
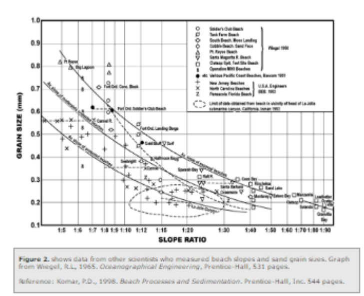
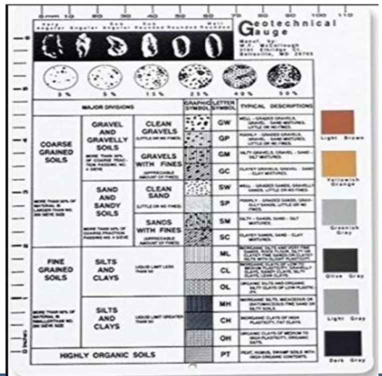


Figure 1. Illustration of the Emery Board technique.





Jaluit

Jaluit Atoll Conservation Area
Environmental Resource Management Plan – Background Report *December 2002*

Table 1: Summary of Resource Specific Threats.

Resource	Fishing Demand	Present Population Status	Existing & Potential Threats	Current Threat Level
Giant Clams	Subsistence Off-Island Demand Special Occasion	Depleted	▪ Over-harvesting	Extreme
Reef Fish	Subsistence Off-Island Demand Special Occasion Commercial	Reported reduction in quantities & sizes caught	▪ Overfishing	Moderate/high
			▪ Fishing at aggregation sites	High
			▪ Chlorine fishing	Low
			▪ Live fish collecting	None
			▪ Aquarium collecting	None
Sharks	None	Stable	▪ Over-harvesting	None
Pearl Shell	Commercial	Depleted	▪ Over-harvesting	High
Sea Cucumber	Commercial	Commercial species depleted	▪ Over-harvesting	Extreme
Trochus	Subsistence Commercial	Depleted	▪ Over-harvesting	Extreme
Mangrove Crabs	Subsistence	Depleted	▪ Over-harvesting	Extreme
			▪ Habitat destruction	Moderate
Coconut Crabs	Subsistence	Unknown	▪ Over harvesting	Unknown
Birds	Subsistence	Stable Nesting populations restricted to only a few small islands	▪ Shooting of adults	Moderate
			▪ Collecting eggs from nests	Moderate
Turtles	Subsistence	Reports of reductions in the numbers seen and caught	▪ Killing of adults	Low/Moderate
			▪ Collecting of eggs from nests	Low/Moderate
Mangroves	Subsistence	Stable – recent clearing has occurred in areas made more accessible by as construction of paths for ecotourism	▪ Tree clearing	Moderate
			▪ Land filling in mangrove areas	Low
			▪ Habitat destruction through tidal flush restriction	Moderate