THE DISTRIBUTION OF SHALLOW-WATER BENTHIC FORAMINIFERA IN THE GULF OF AQABA AND NORTHEASTERN RED SEA

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Introduction

What are Foraminifera (Forams)?
- Forams are small, aquatic amoeboid protists that secrete calcium carbonate tests.

- Why are Foraminifera Significant?
  - Foram tests contribute to sediment formation and can accrete onto reef substrate
  - They serve as important bio-indicators (temperature, nutrient levels, heavy metal pollution) (Hallock et al. 2003)
  - Studying foram tests in sediments can provide insight on a region's oceanographic history
  - Can be used as an indirect way to study coral health (Hallock et al. 2003)
- The 3 foram functional groups are: Symbiont-bearing/large benthic forams (LBF), stress-tolerant/opportunistic forams (OPP), and heterotrophic forams (HF) (Hallock et al. 2003).

Why the Red Sea?
- The Red Sea is home to some of the highest latitude coral reefs in the world.
- The Red Sea has high temperature and salinity- endemic species there have since evolved to be more tolerant of these stressors (Fine et al 2013).
  - Studying Red Sea species can reveal how similar organisms worldwide may respond to increasing climate change
  - Red Sea reef ecosystems may serve as key marine refugia as oceans warm

Study Purpose:
- Determine the distribution and abundance of the foram genera present in the Gulf of Aqaba and northeastern Red Sea

Fig. 1: Image of master slide. The master slide showcases the various genera present across all samples in the study.

Fig 2: Close-up of *Amphistegina lessonii*

Methods

- Samples collected during 2020 OceanX-Neom 'Deep Blue' Expedition
- Study used 16 samples from sites 3, 14, 32, 33, 34, 35, 36, 40, 42, 48, 49, 50, 54, 55, 59, and 62.
- For each sample, 300 foram specimens were picked out with a paintbrush
- Specimens were mounted to micropaleontology slides
- Specimens were identified to genus-level and a master slide was made representing all the genera present across all samples
- The number of individuals of each genus in each sample were counted
- Data was run through a Hellinger-transformation to account for any double-zero problems (Legendre and Legendre 1998)

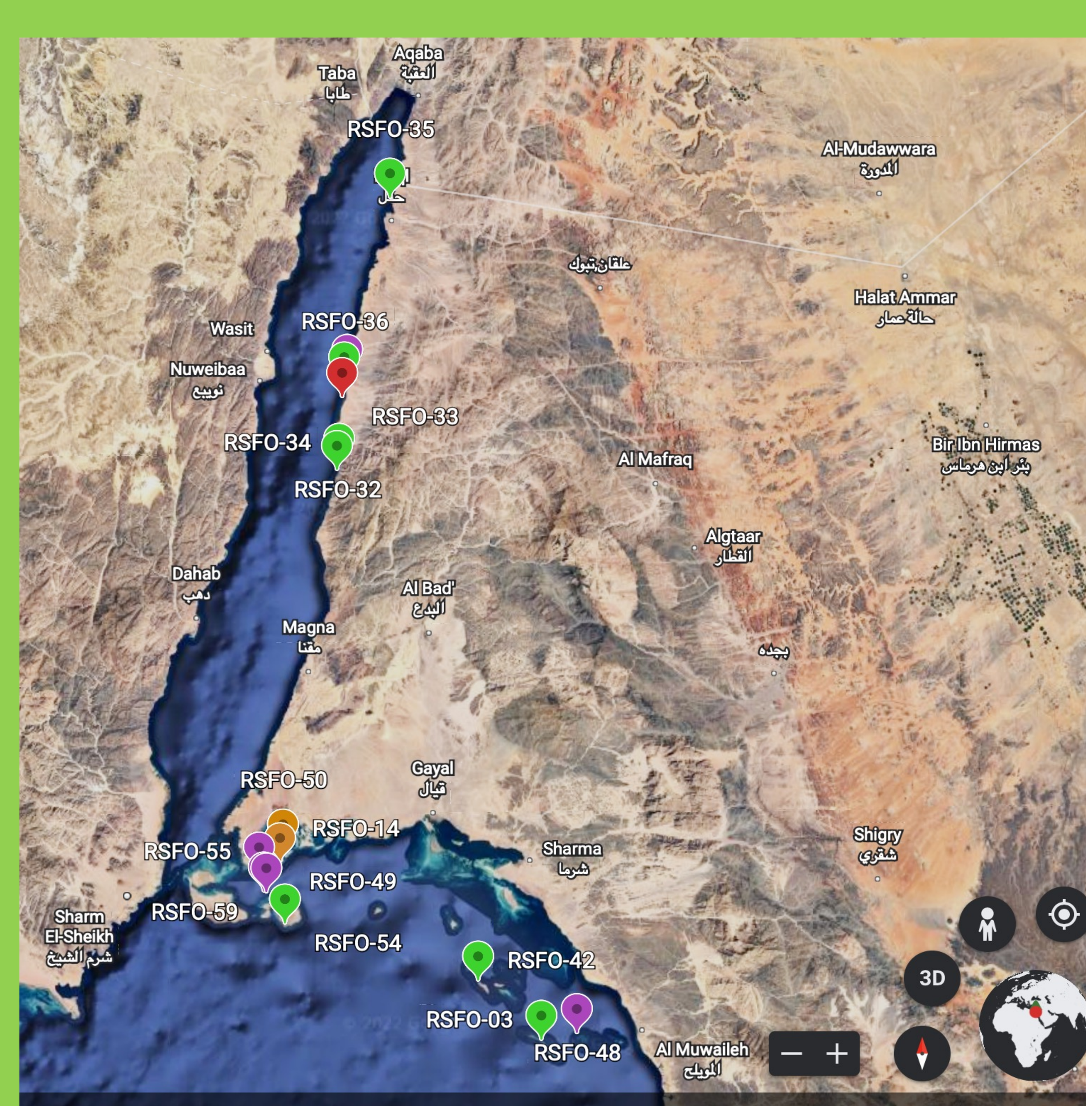

Fig 3: Sample Site Map. Marker colors align with sample's corresponding cluster. The red marker is site 33, the outlier.

Results

Table 1: Sample IDs, Locations, and Functional Group Percentages

Sample ID	Latitude	Longitude	Depth (m)	Total % LBF	Total % OPP	Total% HF
RS-FO-03	27.6689722	35.2642500	10.00	0.28	0.01	0.71
RS-FO-14	28.0486167	34.7027167	10.00	0.72	0.01	0.27
RS-FO-32	28.7896280	34.8233080	8.00	0.48	0.00	0.52
RS-FO-33	28.9325420	34.8359050	7.00	0.53	0.04	0.43
RS-FO-34	28.8038350	34.8282870	7.00	0.47	0.01	0.52
RS-FO-35	29.3230833	34.9438500	8.00	0.62	0.00	0.38
RS-FO-36	28.9630300	34.8401830	9.00	0.59	0.09	0.32
RS-FO-40	28.9776667	34.8469444	15.00	0.57	0.00	0.43
RS-FO-42	27.7871167	35.1267333	8.00	0.16	0.01	0.84
RS-FO-48	27.6813500	35.3417000	7.50	0.41	0.00	0.59
RS-FO-49	28.0222500	34.6963500	8.00	0.34	0.06	0.61
RS-FO-50	28.0491000	34.7029000	8.00	0.51	0.03	0.46
RS-FO-54	27.9019833	34.7067333	8.00	0.08	0.04	0.87
RS-FO-55	28.0041500	34.6507167	8.00	0.50	0.07	0.43
RS-FO-59	27.9631000	34.6664667	8.00	0.67	0.00	0.33
RS-FO-62	27.9649523	34.6609387	8.00	0.51	0.02	0.47

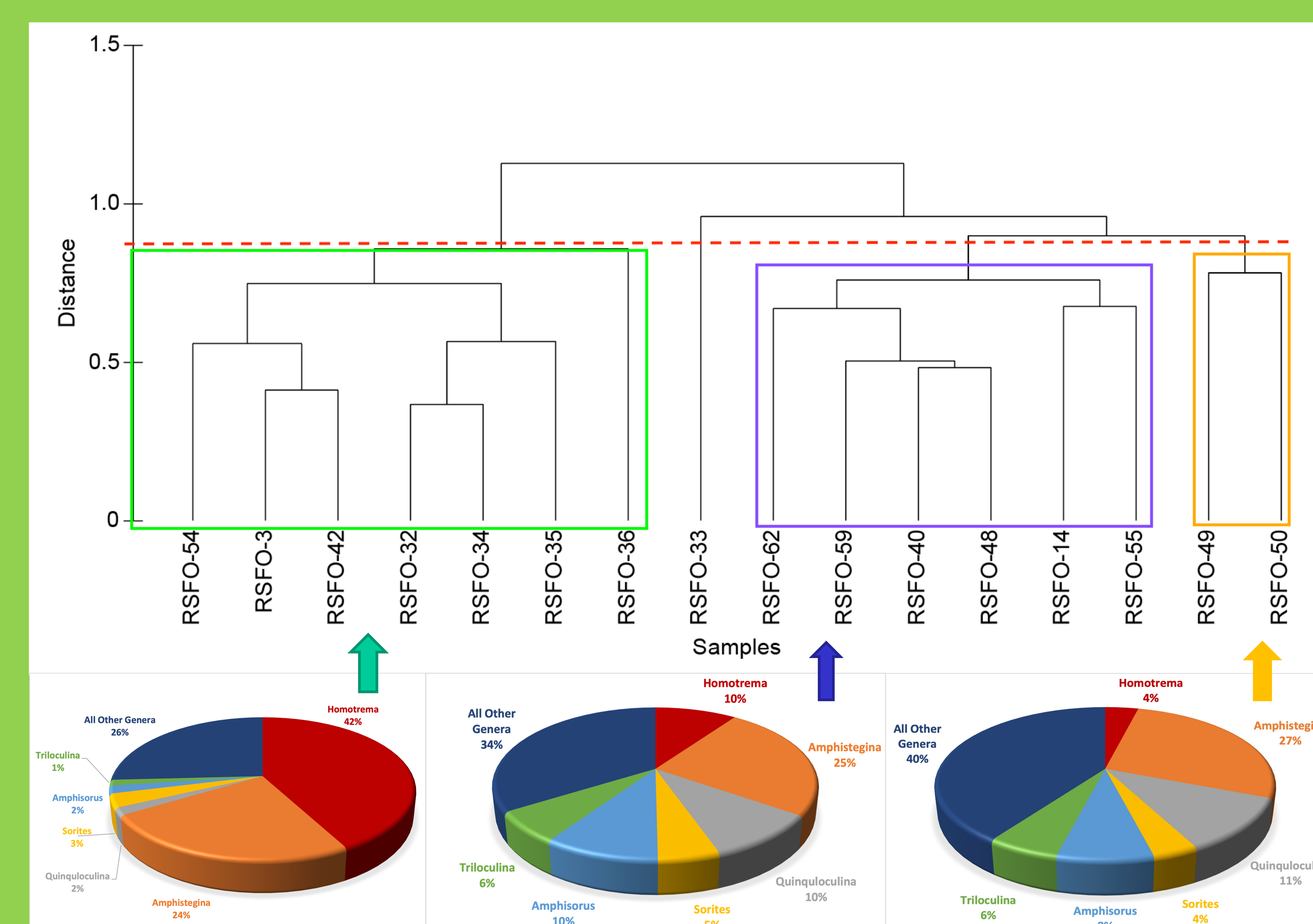

Fig 4: Linkage tree of similarities between samples based of their Hellinger-transformed percent abundance data with attached pie charts of contributions of average most abundant genera for each cluster

- Three major clusters were found:
  1. The Gulf of Aqaba-dominant cluster (Green)
     - *Homotrema-dominant*
  2. The Northwestern Saudi Arabian Cluster (Purple)
     - Highest levels of *Amphisorus/Sorites*
  3. Sand Shoal Cluster (Orange)
     - *Amphistegina* dominant, lowest avg *Homotrema abundance*
- Sample 33 was an outlier to all 3 clusters
- The most abundant genera across all samples were *Homotrema* and *Amphistegina.* These 2 genera alone comprised 46% of all specimens in this study

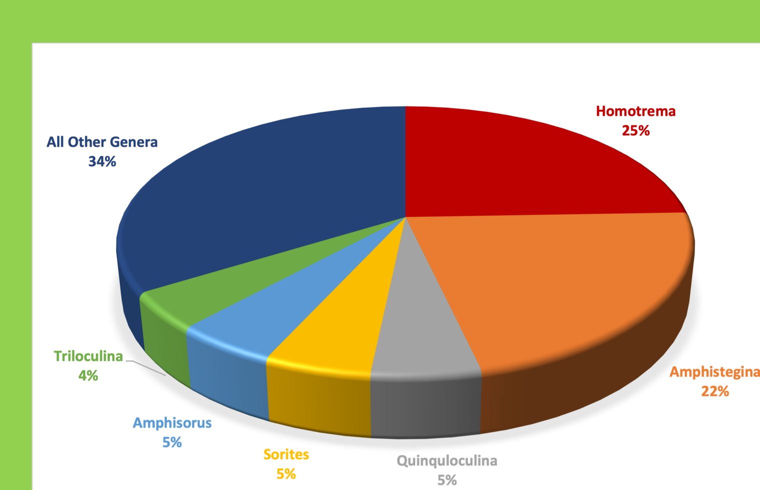

Fig. 5: Pie graph of contributions of most abundant genera to total counts across all samples

Discussion

- These samples show a clear dominance of *Amphistegina*. This genus is abundant across all clusters, regardless of geographic location. This is expected as the Gulf of Aqaba and the northern Red Sea are known to be inhabited by two abundant species *of Amphistegina— A. lobifera* and *A. lessonii (*Titelboim et al. 2019).

- The decline of *Homotrema* is notable between clusters. *Homotrema* is a tropical and subtropical, sessile foraminifera that supports the reef skeletal framework by calcifying in cracks and on the cryptic undersides of coral colonies and other reef structures (Phalen et al, 2016). Thus, its presence or absence is heavily impacted by substrate type.
- *Homotrema* appears to decline with increases in the abundance of the heterotrophic genera *Quinqueloculina* and *Triloculina.*
  - This may indicate changes in the oceanographic condition.
  - Future research should model local oceanographic parameters against these samples to shed light on the complex oceanographic controls of the forams collected among these high latitude reef environments.

- Sample 36 is an outlier within the cluster in the Gulf.
  - It had higher levels of stress-tolerant forams and lower levels of some LBF genera (*Amphisorus* and *Sorites)* than neighboring sites.
  - This could be a sign of ecological disturbance in the area, suggested by studies such as Madkour and Ali 2008.
- While site 14 lies close to and between sites 49 and 50, it may have different abundances due to current flows/temperature shifts from the island topography in the area that influence foram movement

- Future Research Directions:
  - Sample the same locations over time to see if abundances are shifting
  - More sites should be sampled from the region
  - Look into forces, like hydrology, that may be moving forams around or blocking their movement
  - Continue to document the role of pollution, like heavy metals, on the abundances of opportunistic forams in the Gulf of Aqaba and coastal urban settings of the Red Sea.

References:

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Acknowledgements: Thank you to RSMAS and UM for providing me with such amazing opportunities and experiences over the past four years. Thank you so much to Dr. Alex Humphreys for putting up with my endless questions and for the countless thesis meetings and late-night correspondence with me as I completed this project. Thank you to Dr. Sam Purkis for introducing me to the world of forams and for taking me on as his first ever undergraduate thesis student. A hearty thanks to Dr. John McManus for being my third panel member and for all the encouragement and support for my project over the past year. Lastly, thank you to my family for nurturing my love of marine sciences and for allowing me to attend this university.