

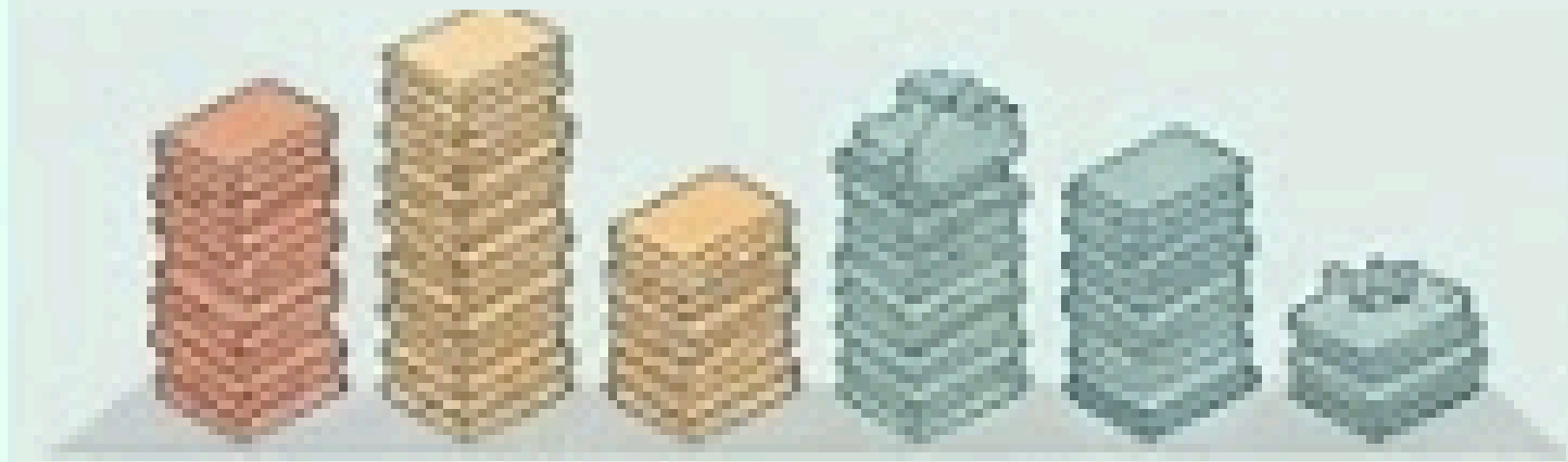
IMPACT OF CYCLONIC EVENTS ON COASTAL MARINE DEBRIS & CORAL REEF ECOSYSTEMS: ROBOTIC RESTORATION STRATEGIES

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IMPACT & DATA: MARINE DEBRIS

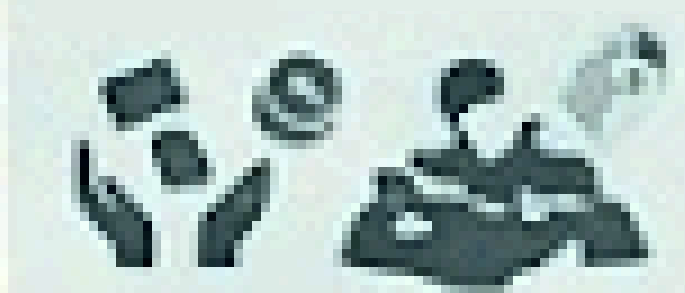
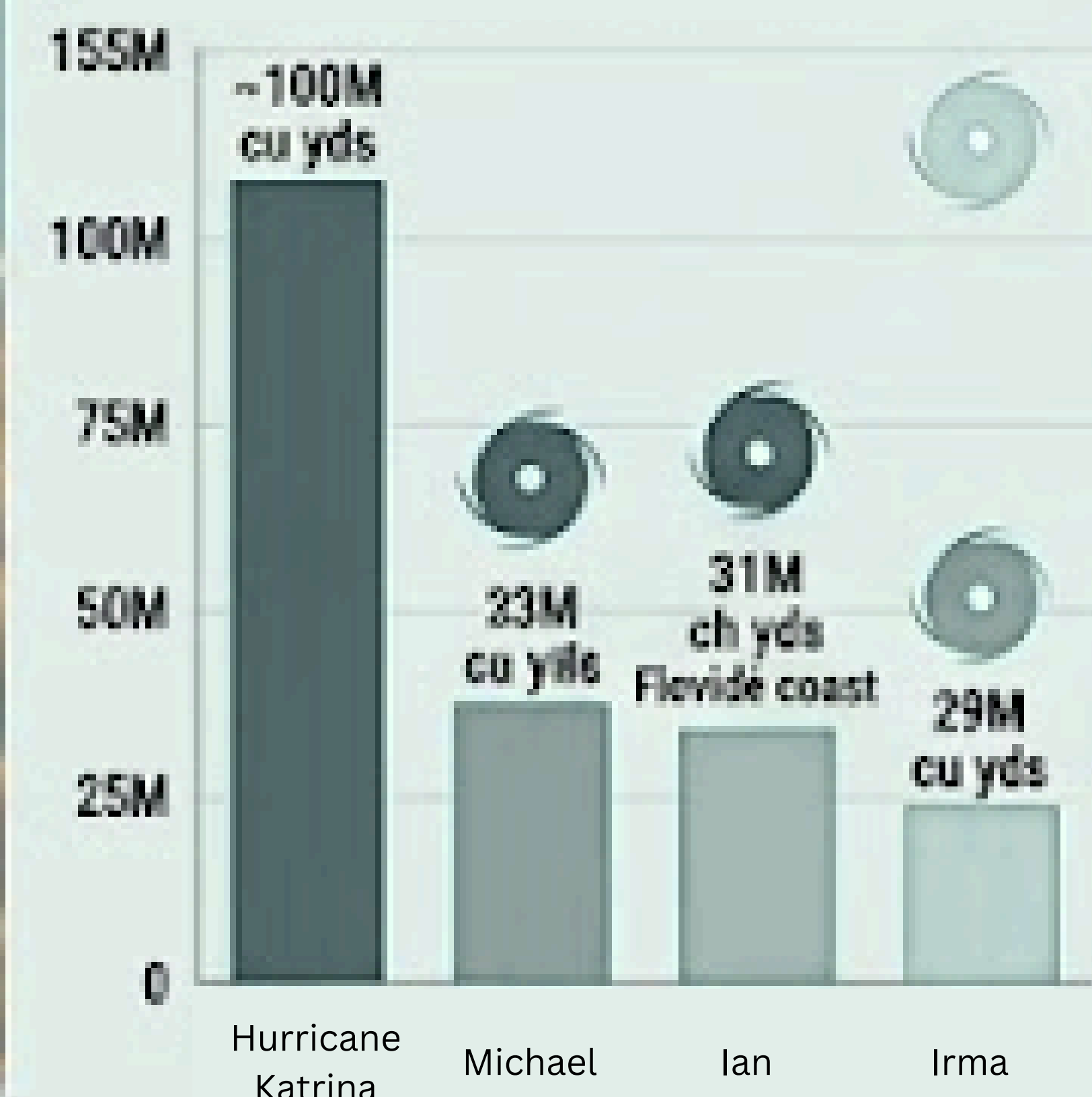
Severe cyclonic events, such as hurricanes, deposit millions of cubic yards of human caused and natural waste into coastal ecosystems. This accumulation, known as marine debris, poses significant threats to navigational safety, local economies, and benthic habitats.

DEBRIS ACCUMULATION OVERVIEW



According to NOAA, there are approximately 1.8 billion items of debris along U.S. shorelines at any given time, a figure that surges following major landfalls.

Historical Debris Accumulation Data



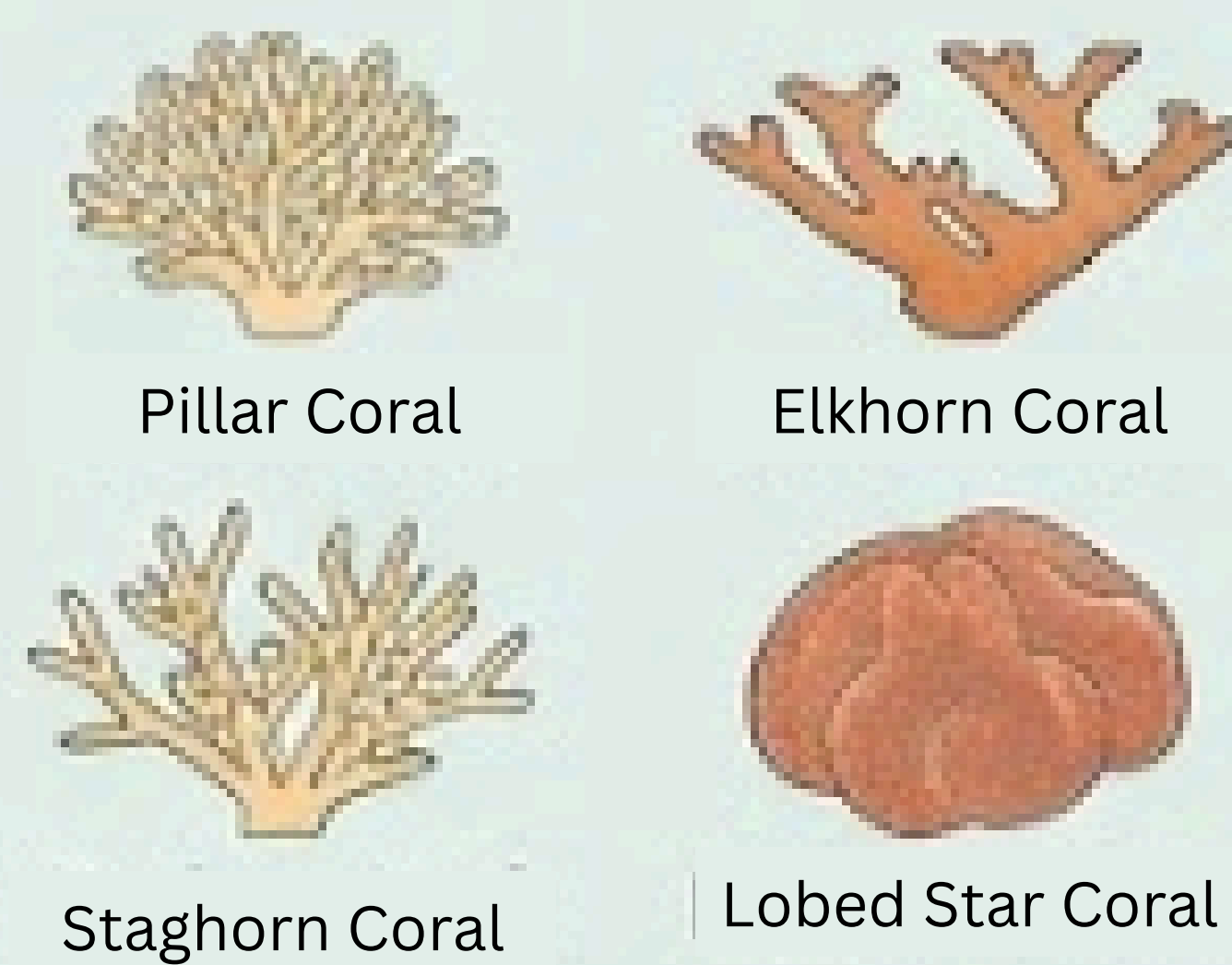
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items of debris along U.S. shorelines at any given time.

ECOLOGICAL IMPACT & CORAL REEFS

ECOLOGICAL ASSESSMENT: HURRICANE IRMA (2017)

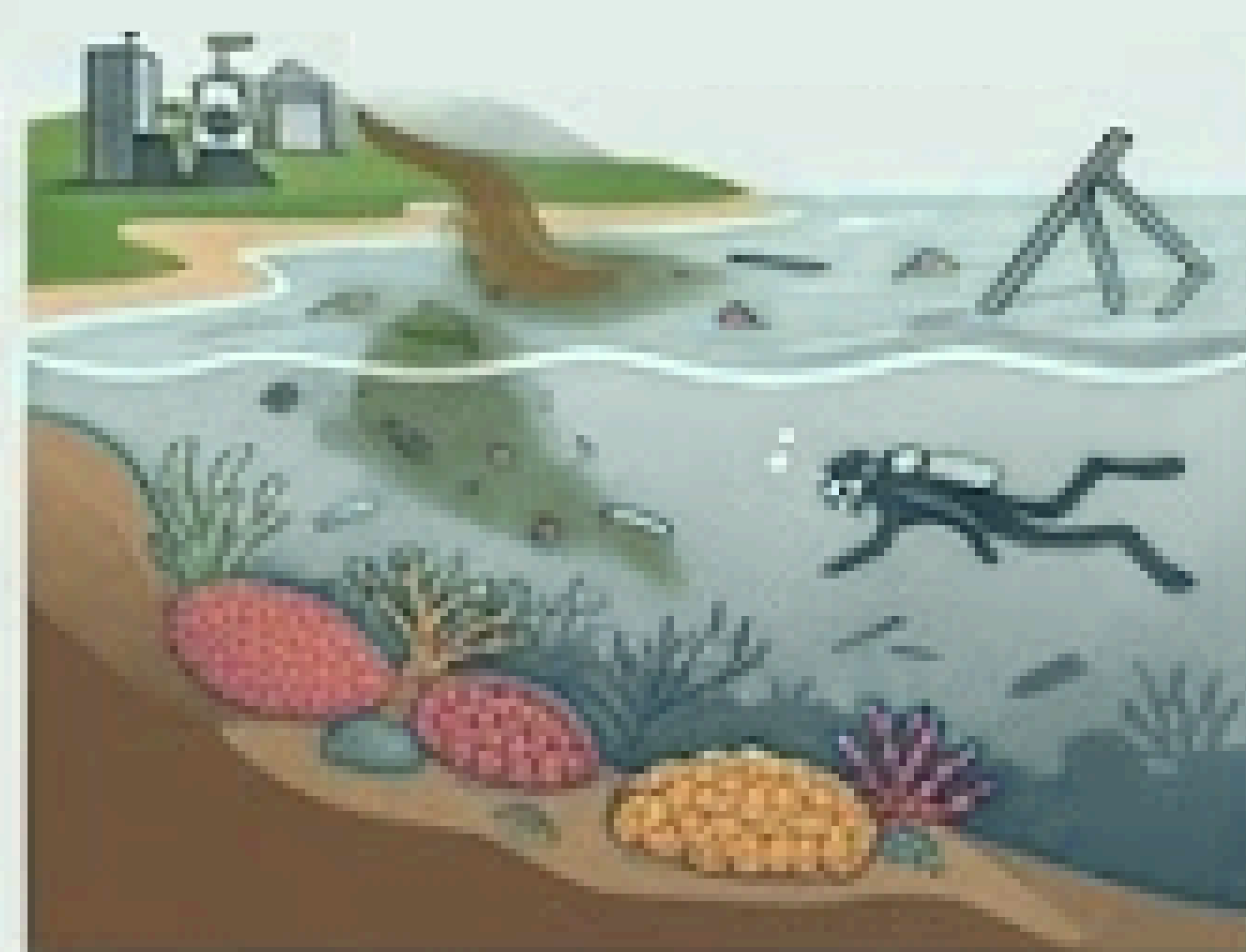
Tropical cyclones represent a primary source of acute mechanical stress for marine ecosystems. In 2017, Hurricane Irma caused catastrophic damage to coral reef tracts throughout the Caribbean and the Florida Keys. High-energy wave action resulted in widespread fragmentation, colony inversion, and sediment burial. The impact was particularly severe for four key species currently listed.



EMERGENCY RESPONSE SUCCESS

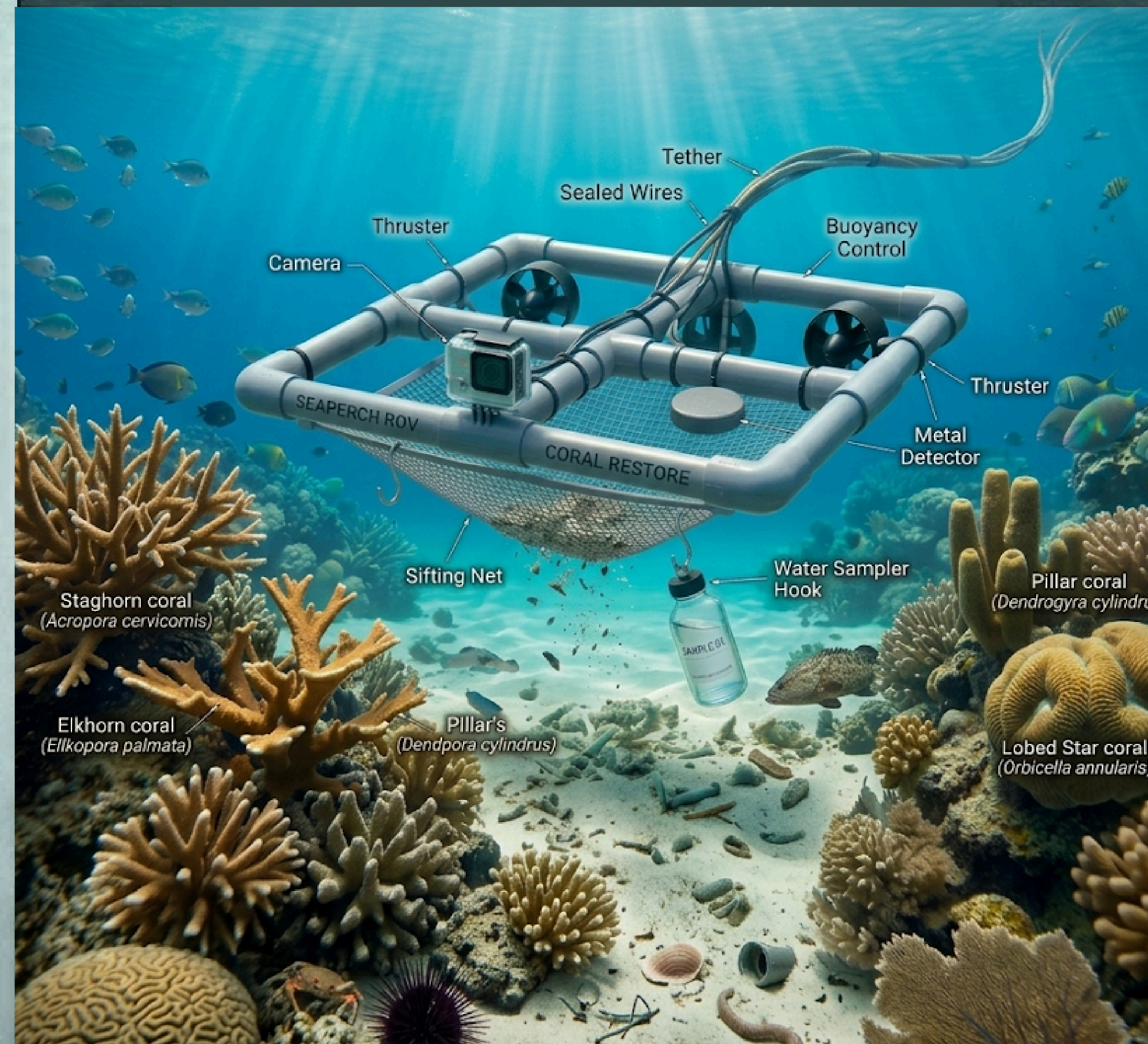
NOAA emergency response teams successfully stabilized and reattached approximately 16,000 fragments from 18,700 colonies surveyed.

ECOSYSTEM SERVICES



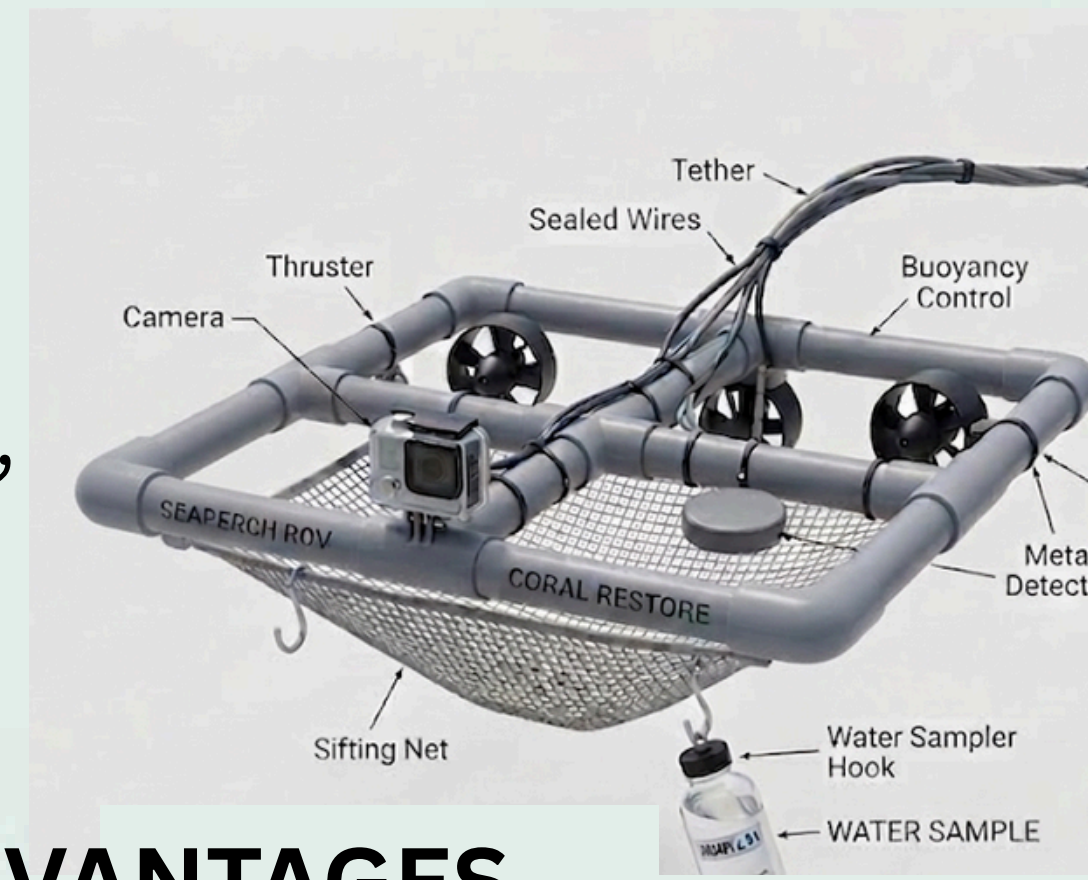
Reefs function as biological breakwaters attenuating up to 97% of wave energy. Reduces coastal erosion and protects inland infrastructure from storm surges.

SEA PERCH ROV: MODULAR DESIGN FOR REMEDIATION



DESIGN APPROACH & CAPABILITIES

The SeaPerch is a highly adaptable, PVC-based underwater robot capable of reaching areas inaccessible to humans. For shallow-water operations, a low profile planar (square) frame is ideal.



MODULAR DESIGN ADVANTAGES

- **STABILITY AND MANEUVERABILITY:** A horizontal, square configuration lowers the vehicle's center of gravity, preventing flipping in turbulent currents
- **SENSOR INTEGRATION:** Flat frame allows for easy attachment of optical sensors (cameras) and electromagnetic sensors (metal detectors) to locate the submerged hazards.
- **MODULAR PAYLOAD SYSTEMS:**
- **Remediation Tools:** 3D-printed sifting nets can filter micro-debris from the sand.
- **Sampling:** Mesh attachments carry water samplers to test for post storm toxicity or carry ballast weights to fine-tune neutral buoyancy.

UTILIZING MODULAR ROVs: Safe survey, data collection targeted removal for students and researchers.

Sources

Florida grapples with mountain of debris from Hurricane Ian - The Washington Post. (n.d.). <https://www.washingtonpost.com/climate-environment/2022/11/25/florida-hurricane-ian-debris/>
Coral Assessment and restoration results released for U.S. Caribbean after 2017 hurricanes. NCCOS - National Centers for Coastal Ocean Science. (2026, March 20). <https://coastalscience.noaa.gov/news/coral-assessment-and-restoration-results-released-for-u-s-caribbean-after-2017-hurricanes/>

TECHNICAL PROPOSAL: NON-INVASIVE RESTORATION & CORAL GUIDE

Design Justification

Traditional restoration requires human diver interaction, which can stress fragile reef environments. Planar SeaPerch ROV facilitates 'hands-off restoration and navigates interstitial spaces.

PROPOSED MODIFICATION (THE HOOK) FOR CORAL RECOVERY

• Precision End Effector



A specialized hook attachment designed for the delicate manipulation of coral fragments (nubbins). This allows for the precise placement of fragments into "coral nurseries" or onto substrate for

• planar stability:

The 2D frame ensures a low center of gravity, which is essential for maintaining a steady "hover" during the delicate process of picking up and depositing biological samples.

• Efficiency

Modular ROV platform rapidly shifts from debris removal to biological restoration, maximizing post-storm utility.

ENDANGERED CORAL ID GUIDE: CARIBBEAN & FLORIDA

1. Elkhorn

Acropora palmata
Appearance: Features thick, sturdy, flattened branches that resemble elk antlers.
Color: Typically brownish-yellow to golden-tan with white tips.
Habitat: Found in shallow, high-wave energy zones (0-20 feet deep).
Fun Fact: a fast-growing "foundation" coral that forms the main structure of the reef crest.
ROV Challenge: Fragments are heavy and broad; requires a strong, wide hook grip.

2. Staghorn

Acropora cervicornis
Appearance: Thin, cylindrical, "antler-like" branches that are narrower than Elkhorn.
Color: Golden brown & white, pointed tips.
Habitat: Prefers slightly deeper, calmer water (15-60 feet) than Elkhorn.
Fun Fact: Staghorn form dense "thickets" that provide essential hiding spots for juvenile fish.
ROV Challenge: Highly fragile; the hook must exert minimal pressure to avoid snapping the thin branches.

3. Lobed Star Coral

Orbicella annularis
Appearance: Forms large mounds or boulder-like structures composed of separate lobes or "heads."
Color: Usually shades of brown, green, or gray.
Habitat: Found across a wide range of depths, often forming the massive backbone of the reef.
Growth Rate: Very slow (only a few millimeters per year).
ROV Challenge: The smooth, rounded surface of a "star" colony makes it difficult to hook or grip; restoration usually involves placing small "nubbins" (fragments) back into crevices.

Future Directions

- Field testing for ROV prototypes.
- Developing more advanced sensory systems (e.g., more cameras, stronger detectors).
- Creating larger/modifying sifting tools based on results.

MODULAR VISUALIZATION & PROJECT IMPACT

