GUAM YEAR OF THE REEF NEWSELTTER

REEF INVADERS

While the invasive brown tree snake and the coconut rhinoceros beetle are common topics of discussion on Guam, this issue of the GYOR2018 newsletter focuses on invasive and nuisance species in our marine environment. We'll take a look at two "invaders" that have recently generated buzz on Guam, the crown-of-thorns sea star *(Acanthaster planci)* and brown and red algae.

We're also excited to announce the **Guam Year of the Reef finale celebration**! We're partnering with Underwater World to host an evening event at Splash Bar and Café on Thursday, December 6 from 6:30 – 9:00 PM. Hope to see you there!

Don't forget to check out our website at www.guamcoralreefs.com and like us on Facebook at @GuamYearoftheReef2018

At the end of the year, we will be updating the website and transitioning the GYOR Facebook page to the Guam Coral Reef Initiative Facebook page. Please send any reef-related content you'd like others to know about!

#GYOR18

There are approximately 100 known nonnative marine species in Guam's nearshore waters, and most are confined to Apra Harbor, introduced by heavy commercial activities (Paulay et al., 2002). However, outbreaks of other "invaders" such as the crown-of-thorns sea star or COTS *(Acanthaster planci)* and angel hair algae *(Chaetomorpha vieillardi)* are observed around the island.

Nonnative marine species are introduced to new marine environments in many ways, such as shipping and boating activity, mariculture, the aquarium trade, tourism, and marine debris. The most common source on Guam is through ballast water or attachment to vessel hulls. As one of the largest US military bases in the Pacific, and the busiest commercial port in Micronesia, Guam may be particularly vulnerable to nonnative species. Proposed future military build-up and cruise ship tourism may also increase the risk of reef invaders to the island.

However, highly diverse ecosystems are more resilient to invasive species than less diverse systems (Stachowicz et al.1999). This is good news for Guam which has high marine diversity relative to other regions such as the Caribbean. Moreso, researchers found invasive species in Apra Harbor are more likely to remain on artificial substrate as opposed to finding their way to disturb nearby reefs (Paulay et al., 2002).

Invasive species lingo - What does it all mean?

Native and indigenous species *are interchangeable terms. Native species occur naturally in an area without human interference.*

Endemic species *are native species found only in a particular area, highly adapted to a particular niche.*

Nonnative species *are introduced to a new habitat, typically through human activity, but do not displace existing native species or disrupt ecological balances.*

Invasive species *are not native to the region and causes, or are likely to cause economic or environmental harm or harm to human health [defined by Executive Order 13112].*

Nuisance species *are native species that can cause problems when their populations become too large. For example, COTS are native to Guam, but COTS outbreaks can cause severe reef damage.*

PROTECTING GUAM'S REEFS FROM THE CORAL-EATING CROWN-OF-THORNS-SEASTAR

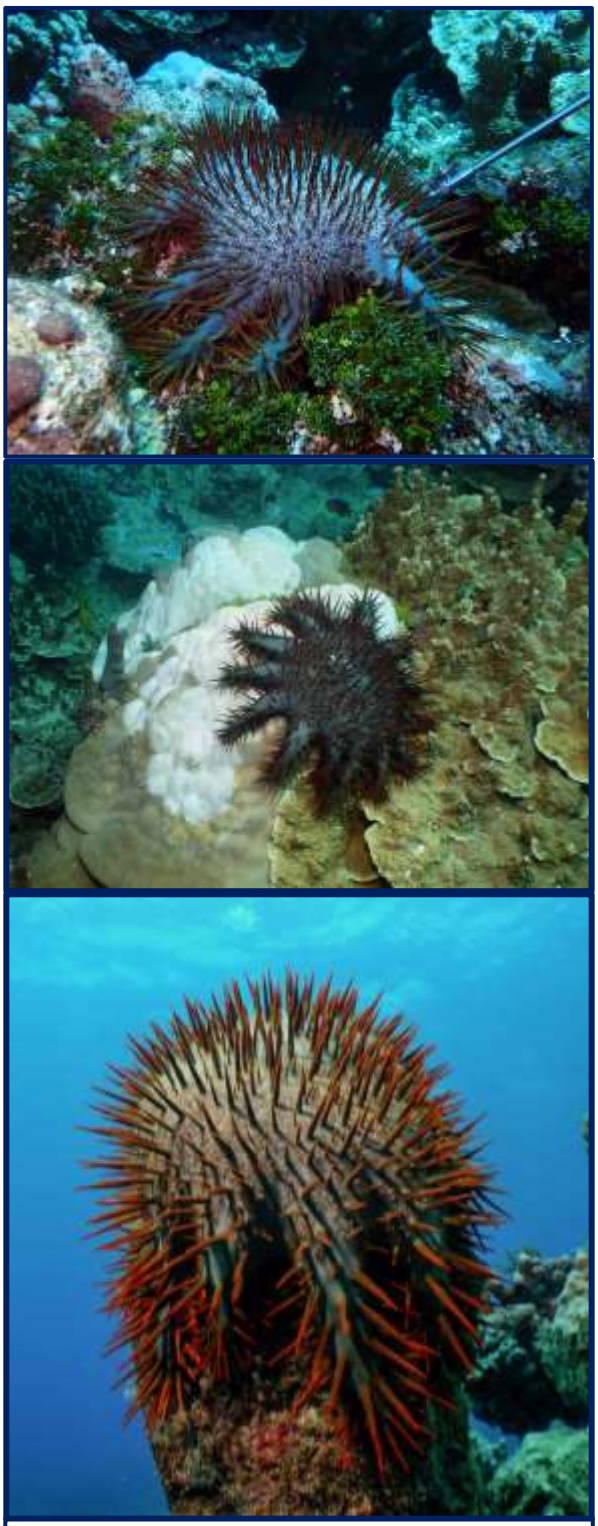

Photo credit top to bottom: Whitney Hoot (BSP), David Burdick (UOG), David Burdick (UOG)

The crown-of-thorns sea star (scientific name: *Acanthaster planci*) is found on coral reefs throughout the Indo-Pacific region. Although these sea stars – often called COTS – are native on Guam's reefs, they can cause severe damage when their population size increases and an outbreak occurs. An adult COTS can grow to over 0.5 m diameter (1.6 ft) and consume 5-13 m^2 (54-140 ft^2) of live coral each year (Dixon 1996, Pan et al. 2010). When a COTS feeds, it is able to expand its stomach outside of its body, covering the coral and digesting all live tissue (Brauer et al. 1970). Generally, COTS prefer to eat branching corals, such as *Acropora* spp. and *Pocillopora* spp (Pratchett et al. 2017). COTS actually play an important role in the reef ecosystem: by eating fast-growing branching species, they create space for slower-growing corals on the reef, such as massive or boulder corals. However, when a COTS outbreak occurs, the sea stars consume coral at a faster rate than it can grow, resulting in reduced live coral cover, habitat loss, and decreased reef health.

Scientists still do not fully understand what causes COTS outbreaks. One theory is that outbreaks occur when there is high survival of COTS larvae, thus more sea stars become adults, consuming more coral as they grow larger. COTS larvae eat phytoplankton – microscopic plants that float in the ocean – which are normally found in limited quantities in the clear nutrient-poor waters that surround coral reefs. However, increased nutrients in the water – which may come from run off from farming, erosion, and poor stormwater management – can feed the phytoplankton, increasing their abundance, and in turn providing more food for COTS larvae (Birkeland 1982, Pratchett et al. 2017). Another possible factor contributing to COTS outbreaks is overharvesting of their predators. Only a few species will eat adult COTS, such as triton snails, Napoleon wrasse, and titan triggerfish (Harriott et al. 2003, Prakash and Kumar 2013). Decreased abundance of these species may result in increased COTS populations and thus lead to outbreaks. Additionally, climate change may cause more frequent COTS outbreaks as increased temperature stimulates spawning and speeds up larval development (Hoegh-Guldberg and Pearse 1995, Pratchett et al. 2014). Researchers are focused on studying COTS reproduction and ecology and the effects of anthropogenic impacts (such as nutrient pollution and ocean warming) to better understand the drivers of outbreaks.

COTS outbreaks have been a feature of Guam's reefs for decades. In the late 1960s, COTS outbreaks killed up to 90% of coral between Ritidian Point and Orote Point (Chesher 1969). Throughout the 2000s, widespread COTS outbreaks were detected on Guam's coral reefs, causing extensive coral loss (Burdick et al. 2008). At Tanguission Point, a density of almost 1,500 COTS per hectare (about the size of two US football fields) was recorded in 2006, which well exceeds the outbreak definition of >30 adult COTS per hectare (Dixon 1996, Burdick et al. 2008). Although Guam's coral reefs have recovered from COTS outbreaks in the past, local natural resource managers and scientists are

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now much more concerned about the potential impacts of COTS due to the loss of coral caused by other stressors, especially coral bleaching, which has severely impacted Guam's reefs in recent years. After the devastating outbreaks at Tanguission in the late '60s, the coral community recovered after twelve years – a very speedy recuperation for such slow growing organisms! However, given that Guam's reefs are less resilient today due to stressors such as ocean warming, pollution, and overfishing, coral reef communities are less likely to recover quickly after a COTS outbreak.

In order to better protect Guam's reefs and increase reef resilience, the Guam Coral Reef Response Team is working to reduce acute impacts, including COTS outbreaks. The Response Team includes representatives from the Government of Guam (Bureau of Statistics and Plans, Guam Coastal Management Program, Department of Agriculture's Division of Aquatic and Wildlife Resources, and Guam Environmental Protection Agency), federal agencies (National Oceanic and Atmospheric Administration, US Navy, US Coast Guard, US Fish and Wildlife Service, and Army Corps of Engineers), and the University of Guam. In 2017, the Response Team developed the Guam Crown-of-thorns Outbreak Response Plan, which describes protocols for documenting and mitigating COTS outbreaks on Guam's reefs. One important aspect of the response plan is the early warning system, which includes Eyes of the Reef Marianas (EOR) – a community-based reporting program that trains local residents to identify and report reef impacts, including COTS. The next EOR training will be held on November 14th from 6-8 PM at the Piti Church Social Hall; visit the EOR website or Facebook page for more information. This year, over 50 COTS sightings have been reported by EOR participants. This program helps local managers and scientists detect reef impacts before they become very severe.

As COTS reports continue to come in, the Response Team is focusing on mitigation. The team is equipped with special COTS injectors, which have long needles that keep divers away from the COTS's venomous spines. Injecting COTS with a solution of ox bile – a byproduct from the cattle industry – is fatal to the COTS but does not harm any other coral reef organisms (Rivera-Posada et al. 2013). In the past, early culling methods included cutting up the sea stars into small species; this approach is no longer practiced because even small fragments of COTS can regenerate, creating new individuals. Physical removal from the reef – usually using long tongs – is another removal option, but this method may cause coral damage when the sea stars are pulled out of crevices and can also be hazardous for the divers who have to dispose of them. Ox bile has become a popular method because it is relatively fast, safe, and effective for COTS mitigation. This year, the Response Team has used ox bile injections at five reef sites around Guam to address COTS outbreaks.

Whitney Hoot (BSP) from the Guam Coral Reef Response Team injects a COTS at Gun Beach [Photo credit: Val Brown (NOAA)].

This is a challenging time for coral reef management on Guam, where reefs were severely damaged by coral bleaching events in 2013, 2014, 2016, and 2017 and are now being impacted by widespread COTS outbreaks. However, COTS mitigation has been successful in other places affected by outbreaks, such as Australia and American Samoa. With an effective early warning system based on community participation in programs such as EOR, local managers and scientists can mitigate COTS outbreaks before severe damage occurs. By keeping COTS numbers down and preventing additional coral loss, we can restore reef resilience and help our reefs withstand other stressors such as climate change.

NEW ALGAE REMOVAL TECHNIQUES EXPLORED BY FOR GUAM

FOR Guam 2018 interns - Marilyn, Brittany, and Alicia – ready for field work.

What do you see when you think of "coral reefs?" Colorful corals, plenty of fish, turtles, the list goes on. But sometimes, we forget that algae is part of our reefs too. Algae provide food for fish and homes for small ocean critters. But in some conditions algae can overgrow corals, which affects habitat availability for fish and other animals. The key to the health of our coral reef ecosystems is balance. This means the right balance between corals and algae that provide inhabitants what they need to keep the system running.

This summer, Friends of Reefs Guam (FOR Guam) interns focused their project on algae – specifically, algal removal. Why remove algae from the reef? In this case, algae had grown on top of corals that were damaged by coral bleaching and was preventing the corals from fully recovering. The fish at the site were too small to eat the large algae. The interns wanted to see if removing algae could help the corals recover.

Before algal removal, FOR Guam interns completed coral reef monitoring surveys to see what animals, corals, and algae were at the Merizo monitoring site. Next, interns removed brown and some red algae at three monitoring stations, while three stations were left alone. In total, they removed 61 pounds of algae. The interns noticed small fish immediately swarmed the coral colonies where algae was removed and began eating the small bits of algae left behind.

Algal removal proved a challenge – stirring up sediment during removal was common.

The interns re-surveyed the site one month later to see how algal removal affected their site. What did they find? More fish and more types of fish were counted in stations where algae was removed and some fish were eating algae on the cleared coral heads.

So what does all this mean? FOR Guam interns successfully tested a simple algal removal method that may help corals recover from damage and improve fish habitat. FOR Guam hopes to try this at more sites with community members in the future. Algal removal paired with coral reef monitoring surveys will help us assess the balance on our coral reefs over time. Stay tuned for algal removal activities in 2019. For more information, visit us at http://guamreefmonitoring.wordpress.com.

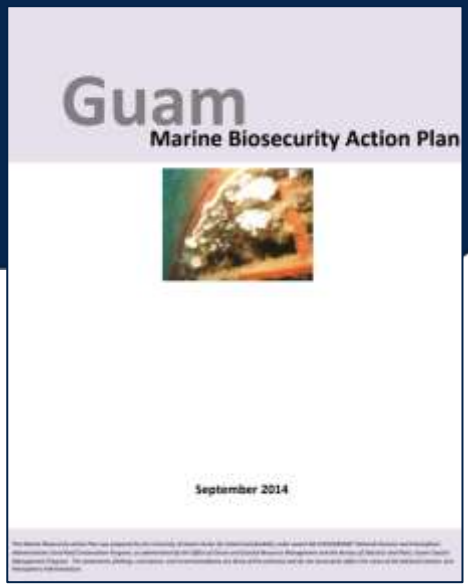
[Left] Historic photograph of a diver removing COTS at 65 ft depth on Catalina Island, California 1971.

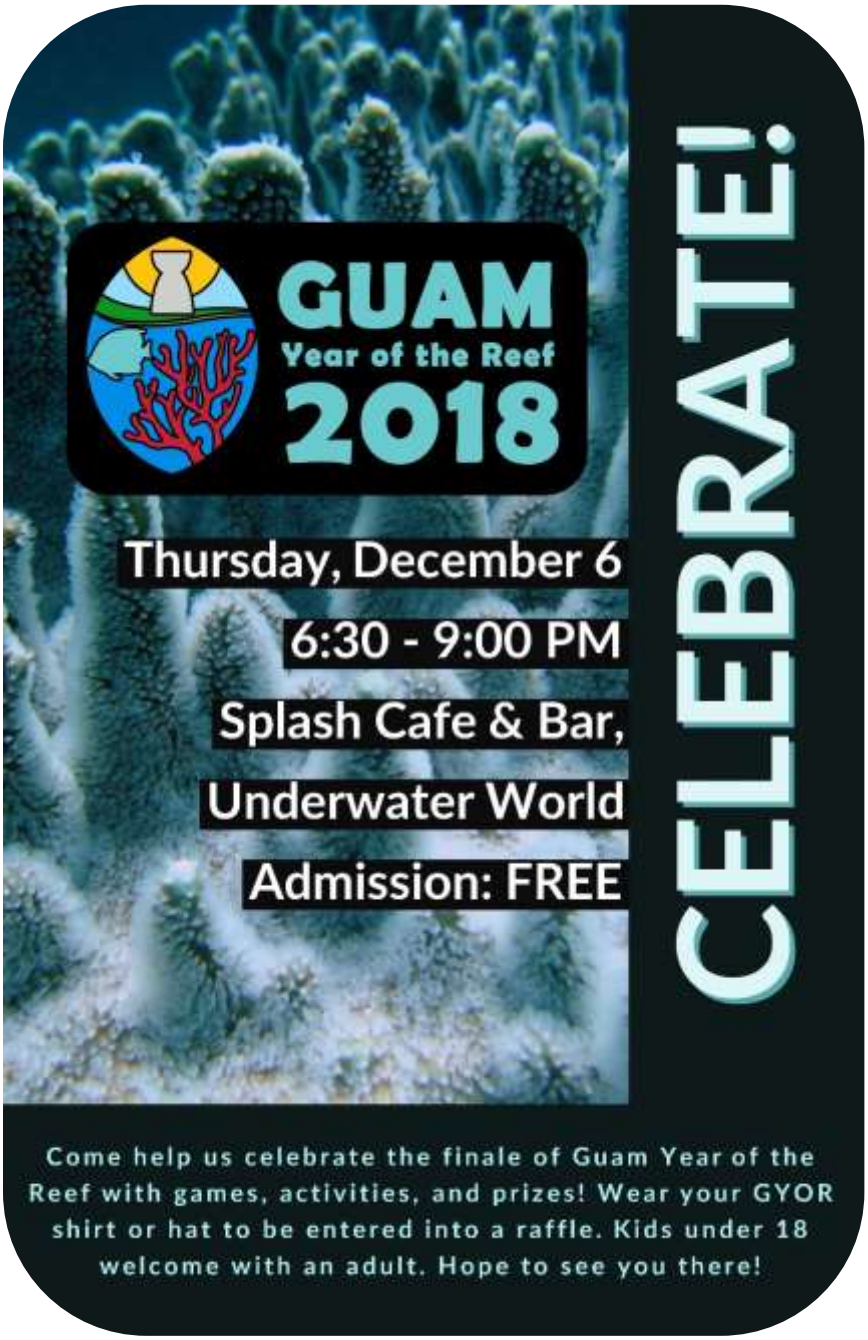
According to the Guam Marine Biosecurity Action Plan, an organism must meet all of the following criteria to be considered an invasive species:

- non-native
- able to establish in a new location (start an incipient population) (or at least seems likely to be able to do this based on life history traits and/or examples of establishment in similar locations)
- cause harm (to environment and/or directly to humans and/or their endeavors) (or at least seems likely that it would cause harm if permitted to establish based on life history traits and/or examples from other locations)

Contributing factors to a species' ability to invade:

- ability to tolerate a variety of habitat conditions
- ability to grow and reproduce rapidly
- ability to outcompete natives for resources
- lack of natural enemies or pests in the new ecosystem





NOVEMBER EVENTS

- **Nov. 6**: VOTING DAY!
- **Nov. 10**: Tree plantings at Asgadao, Merizo, 8:30 AM – 12:00 PM, meet at Blue Bus Stop in Asgadao
- **Nov. 14**: Eyes of the Reef Training, 6:00-8:00 PM, Piti Church Social Hall
- **Nov. 17:** HITA Talk: The Future of Guam's Reefs, 2:00 – 4:00 PM, Guam Museum
- **Nov. 18:** Science Sunday featuring Dr. Sarah Lemer, 2:00 PM, T. Stell Newman Visitor Center
- **Nov. 22:** Thanksgiving Day

December's GYOR theme: Our reefs, our future

Let Mallory know @ Dec. 6 celebration you saw this hidden message, and receive a special prize!