COTS

Nutrient Loading, and CoralWatch

An innovative project
to save the corals in
KOSRAE

COTS, Nutrient Loading, and CoralWatch

KATO - Kosrae Association of Tourism Operators

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Pictures credit: Masa Michishiro, Maria G. Fanelli Stephens

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Kosrae, 30th September 2020

Abstract

The project “COTS, Nutrient Loading, CoralWatch” was conducted by a group of divers in Kosrae who witnessed coral distress caused by the voracity of crown-of-thorns starfish (COTS). In 2018, the Kosraean team (KATO) came up with this experimental project with the aim to control COTS outbreaks using vinegar. Vinegar changes the starfish's pH, causing them to dissolve within one or two days. The team investigated this further, looking for any relationships between coral loss, COTS outbreaks, ocean acidification, and nutrient loading. From initial observation, the areas affected by the outbreak seemed to have higher phosphate concentrations. While intensive coral predation may be linked to increased nutrient concentrations, rising water temperature and changing pH affect the reef-building corals' ability to produce their skeletons and also impact mollusk shell growth. The triton snail, an important COTS predator, has nearly disappeared in recent years in Kosrae.
Research on how these changes might be related to human activity and climate change is in progress, with findings already providing information to efficiently restore the balance of the reef ecosystem.

"This project aimed to control the number of Crown-of-Thorns Starfish (COTS), Acanthaster solaris, around Kosrae Reef, and collect data related to the outbreak."

Crown-of thorns starfish (COTS) are corallivorous. In other words, they feed on reef building corals. COTS were previously thought to belong to a single species, Acanthaster planci. It is now recognized that there are at least four species in the Indo-Pacific, and the Acanthaster solaris have been identified in Kosrae[1].

"In 2017, KATO divers reported that there was an outbreak of COTS in Kosrae"

COTS are a natural part of the ecosystem and an over-abundance only occurs when the reef is out of balance and unhealthy. In healthy reef conditions, COTS can play a productive role by eating some of the faster-growing corals and giving the slower-growing corals a chance to catch up and regenerate (Crown of Thorn Starfish, The Nature Conservancy)·

Coral reefs are essential to millions of island inhabitants. Yet, coral reefs are threatened by thermal anomalies associated with climate change and by local disturbances that include land-use change, pollution, and the coral-eating seastar Acanthaster solaris. In combination, these disturbances cause coral mortality that reduce the capacity of reefs to produce enough carbonate to keep up with sea-level rise (van Woesik, Cacciapaglia, 2019).

[1] *The Acanthaster solaris species were studied by Prof. van Woesik in his article "Carbonate production of Micronesian reefs suppressed by thermal anomalies and Acanthaster as sea-level rises."*

After the 2017 COTS outbreak, there was a growing concern on the presence of COTS in such high densities. This has driven KATO divers to research for innovative methodologies that allow for safe control of COTS numbers with minimum impact on the surrounding coral reef environment. KATO found out that an Australian group was in the early experimental stages of using vinegar to reduce COTS densities on the Great Barrier Reef.

After getting approval from the Kosrae Island Management Authority (KIRMA), KATO decided to test the process for themselves. In February 2018, KATO acquired one modified drench gun able to deliver the dose of the vinegar into the COTS.

In March 2018, with only one gun, KATO started the experimental project for the first time in Micronesia. The experimental project consisted of two parts:

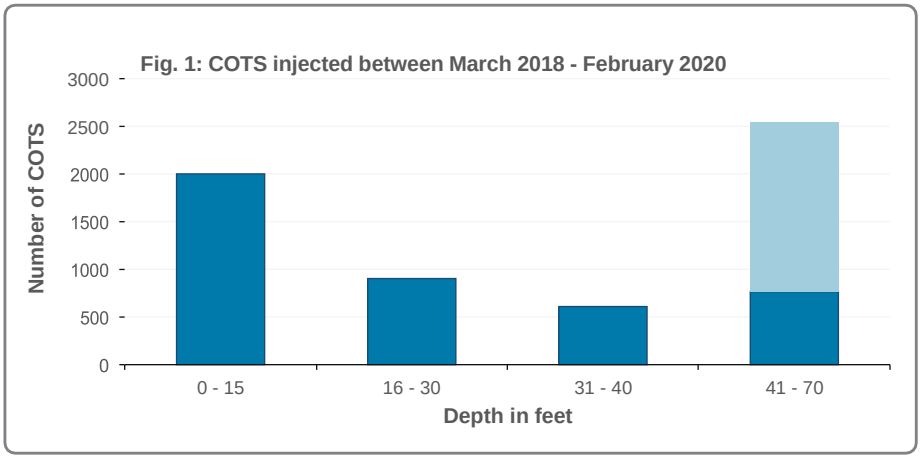
- COTS Control Project in lab
- COTS Control Project in open_water

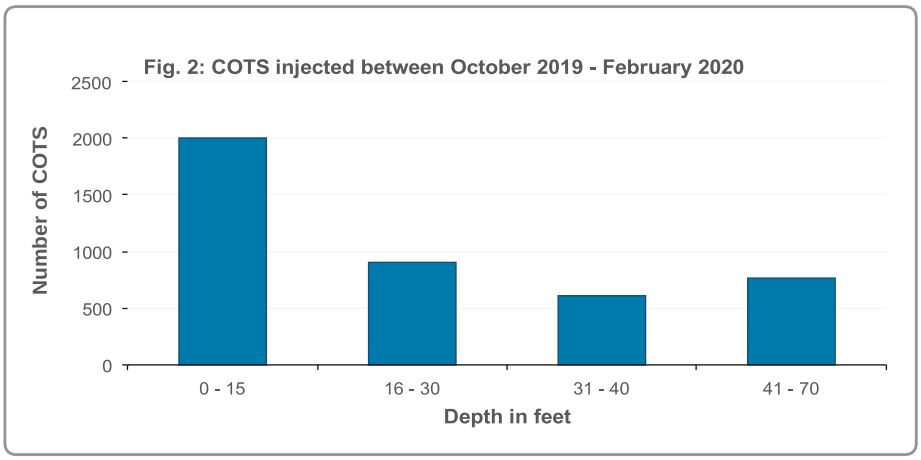
When injecting 20 ml of white vinegar, containing acetic acid, into the base of the starfish arm, the organism disintegrates within 48 hours. This reaction is due to the inability of the starfish to regulate internal pH levels. From there on, KATO purchased twenty guns. After a two year project, we can say that the use of the modified drench gun and vinegar was the best approach to kill the starfishes, since there was no detrimental damage to the ecosystem and risk for the divers was minimal.

Two specimens after 48 hours injection

Battling the Crown-of-Thorns, the coral carnivorous summarizes the COTS Control Project.

From March 2018 to September 2019 (FIRST part), the volunteers have been scuba diving mainly in the popular dive sites, at a depth of 40-70 feet. In October 2019, thanks to the partnership with KIRMA and Fisheries (a division from DREA), larger groups of divers (skin and scuba) were able to cover a more extensive area from 0 to 70 feet depth, from Okat to Hiroshi (SECOND part). Throughout the implementation of the project, it was alarming to see the large amount of COTS on Kosrae's inner reefs.



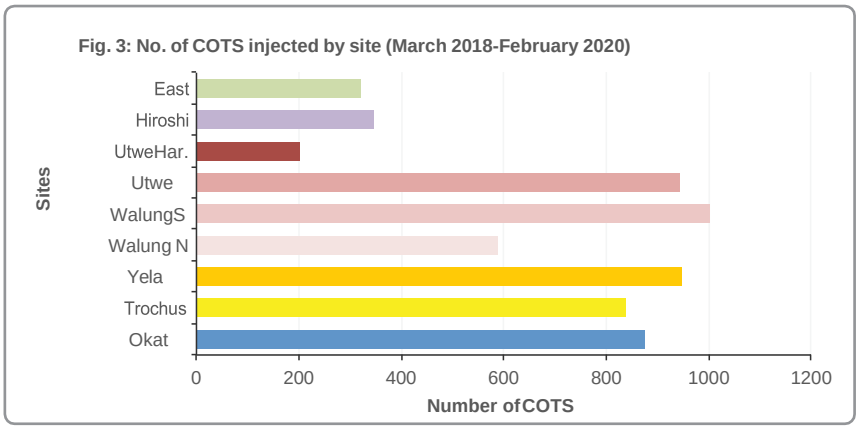


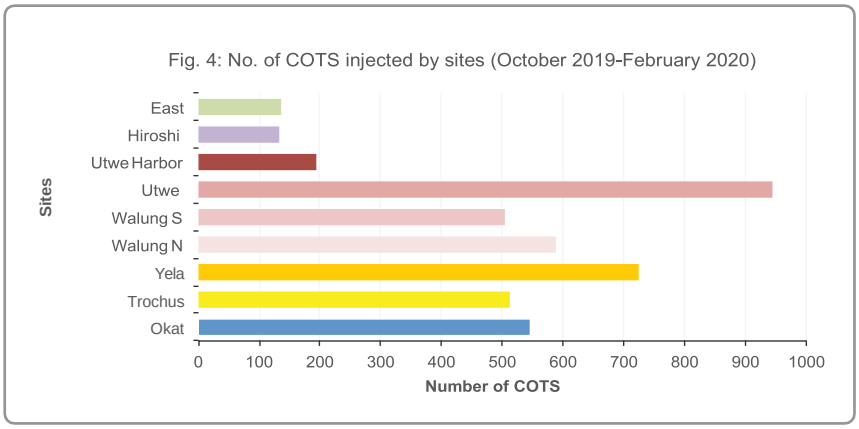
In two years of project implementation, KATO divers have shot with vinegar 6,065 COTS.

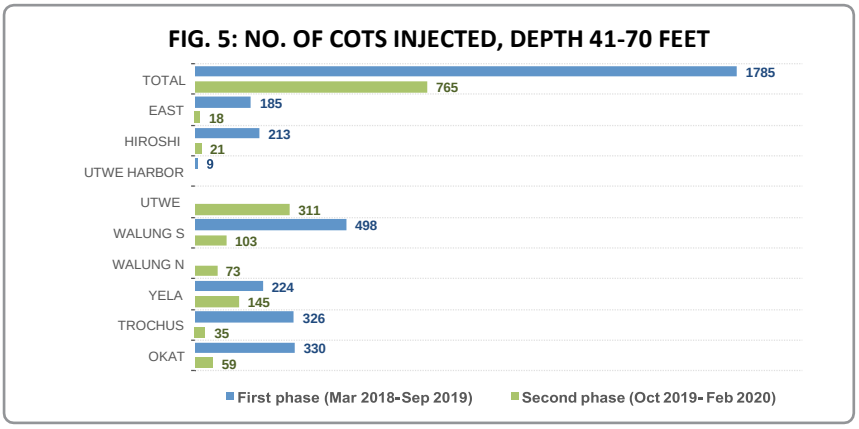
Why are there so many COTS at shallow? Young crown-of-thorns starfish eat encrusting (coralline) algae, which are common among rocks at deep. At about six months of age, they start to eat coral, which are more prolific in the shallows. COTS aggregate to spawn in shallow reefs too, usually two months before the highest water temperatures (September in Kosrae), therefore COTS spawning would likely occur in late July-early August.

With these graphics, we wanted to compare the number of COTS shot the FIRST part to the SECOND part.

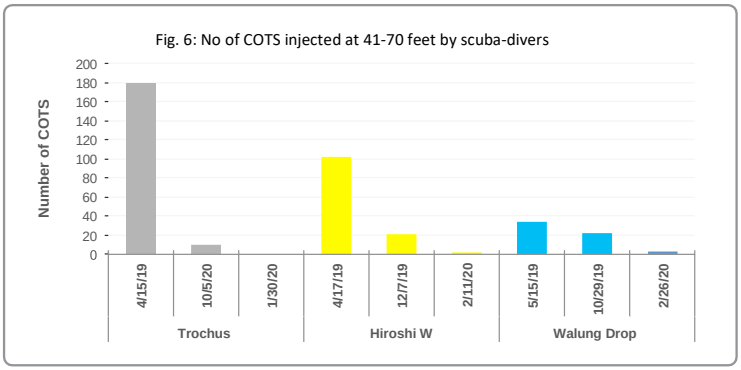
Note: During the FIRST part of the project, we did not cover Utwe. First part includes data collected only at 40-70 feet, with a limited number of divers. Second part includes data collected at 0-70 feet.

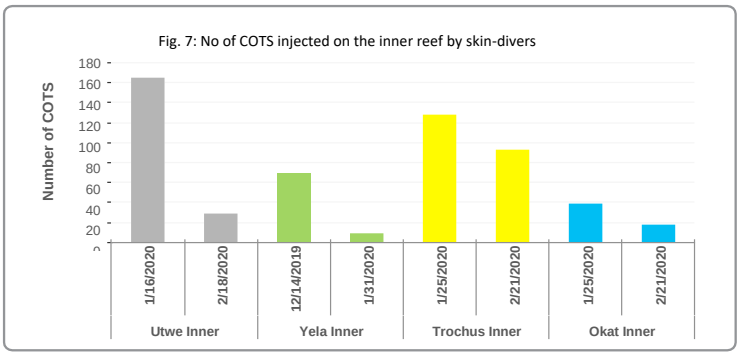






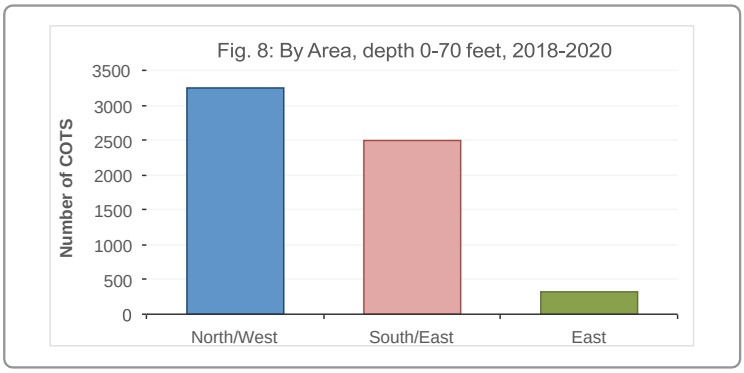
With the Number of COTS shot at a marked Waypoint, the data can confirm that the project was working.





During the two years project, higher densities of COTS were found on the West side of the island with an alarming spread over the South.

Because of the high numbers of COTS over a vast area, we would need to continue the project for several more months. KATO volunteers alone could not complete all, so work was then conducted in collaboration with KIRMA and the Kosrae Fisheries. In the meantime, data were collected on nutrient loading, pH and coral reef status to better understand the reasons behind the outbreak on the west coast.



Nutrient Loading

Nutrient loading is the influx of nutrients (nitrogen, phosphorus, etc.) into the water surrounding reefs that negatively affects the overall health of the reefs. Excess nutrients from runoff, wastewater treatment plants/ships, coastal development, marinas, and other sources can encourage the growth of fast-growing macroalgae, which can smother a reef. The macroalgae block out the sunlight, preventing the zooxanthellae that grow on the coral from conducting photosynthesis. Then, the symbiotic relationship between the algae and the coral is compromised, resulting in death of the coral. Sea water quality analyses were conducted to provide information on the concentration and distribution of nutrients along the coast of Kosrae. It seems likely the existence of a connection with the COTS outbreak in the North-North West area and the amount of nutrients in seawater. Another important parameter assessed during this project, due to its impact on seawater pH and nutrients in the selected area, was seawater temperature. Although in 2019, seawater temperature did not increase as predicted, monitoring was continuous throughout the project. A total of 65 seawater samples were analyzed (within two hours from the collections) using the photometer model HI83300. In the table no. 1, we considered the samples collected around the island at an average depth of 10 m next to the reef. The water was stored in dark bottles and transported in a cooler with ice.

At first glance, we noticed a high concentration of nutrients in the North-West reef (From Soar to Yela), an uninhabited area with limited human activities (apart from Okat harbor activities). In 2017, we first reported the COTS outbreak in the same area. As nutrient loading can result in algal blooms and sometimes dead zones, we will keep monitoring for those data. If we compare these data with the ones analyzed in our June 2019 report, we can notice an increase in the numbers of Nutrients in Walung together with an increase in the number of COTS.

Table 1: Data Collection by area from April 2019 to February 2020

Area	Site	mg/L NH4(+) Ammonia	mg/L NH3-N Ammonia	mg/L NH3 Ammonia	µg/L P Phosphate	µg/L PO4(3-) Phosphate	µg/L P2O5 Phosphate	pH	µg/L NO2(-)-N Nitrite	µg/L NaNO2 Nitrite	µg/L NO2(-) Nitrite
Saolung	EAGLE RAY	9.23	7.16	8.71	34	105	79	8.1	5	26	17
Pinglap to Sarar	HIROSHI	9.95	7.89	9.33	71.7	220.6	164.7	8.31	6.89	25.22	15.11
Teyac	KVR	9.92	7.72	9.39	27.33	83.33	62.33	8.17	22	50.67	22
Kwesrom to Molsron	MALEM	9.27	7.2	8.75	51.53	158.08	118.06	8.28	6.67	33.67	22.33
Metais to Nao	RABBIT (left Lelu Harb)	9.19	7.07	8.61	72	219.75	164.5	8.18	7.25	35.75	23.75
Pihkuhsrihk to inkoeyac	SENNY/SANDY BEACH	8.78	6.76	8.22	46.25	142	106.5	8.16	8	40	26.5
Kiyuhl to Insrac	SHARKI	6.83	5.35	6.56	119.25	365.25	284.6	8.08	10.75	36.67	24.33
Soar	SPLITRO	9.15	7.1	8.64	83.67	246.33	167.5	8.07	8	21.5	14
Trochus to Yela	TROCHUS/YELA	9.63	7.47	9.09	77.14	236.71	142.29	8.13	11.14	54	41.67
Walung	WALUNG	10.16	7.85	9.54	87.82	269.37	163.73	8.04	4.14	20.43	13.71
Lelu Harbor	LELU HARBOR	6.13	4.76	5.79	127.5	391.5	292.5	8.3	5	25	17
Okat Harbor	OKAT HARBOR	8.02	6.23	7.57	41.5	128	95.5	8.2	4	19.5	13
Utwa Harbor	UTWA HARBOR	7.98	6.2	7.53	81	248	185	8.25	29	144	96

The analysis of phosphates in water is one of the most common to evaluate water quality, pollution. Phosphates (PO4(3-)), classified as ortho-phosphates, are generally found combined or linked to organic compounds and are present in numerous products used daily by man. For example, they are used in agriculture like fertilizers and in laundry products. Fish processing wastewater has a high organic content, and subsequently high content of phosphorus. High concentrations of phosphates in water stimulate the growth of photosynthetic organisms that can contribute to the eutrophication of the ocean. For this reason, environmental monitoring of phosphates is of fundamental importance.

Ammonia is very soluble in water, in which it takes a proton and turns into ammonium ion (NH3) called Ammonium hydroxide. Ammonium hydroxide (NH3) is also used as an antimicrobial agent in meat products. It is also used for many other applications, such as a base for fertilizers, detergent, bleaching in the paper industry, and hair dyes. The level of ammonia in the water can vary from case to case. Typically, in groundwater it comes from the bacterial degradation of plants and animals (pig houses are sources of ammonia (NH3) emissions). While in surface waters, it can be indicative of pollution due to landfills or natural causes.

Nitrite is an intermediate product in the nitrogen cycle and is found in water, as it is produced by the oxidation of ammonia with water. Nitrites come from fertilizers through run-off water, sewage, and mineral deposits. Nitrite is used in food production to cure meat products due to its inhibiting the growth of bacteria.

The term pH describes the acidity or alkalinity of any liquid. Globally the oceans have a pH of 8.2. This value varies across the globe, with regional variations linked to different rates of carbon dioxide (CO2) absorption from the atmosphere. The rate of absorption is also linked to the ocean's temperature, currents, and biological activity level. Changes in both pH and temperature reduce the ability of coral reefs to calcify and grow.

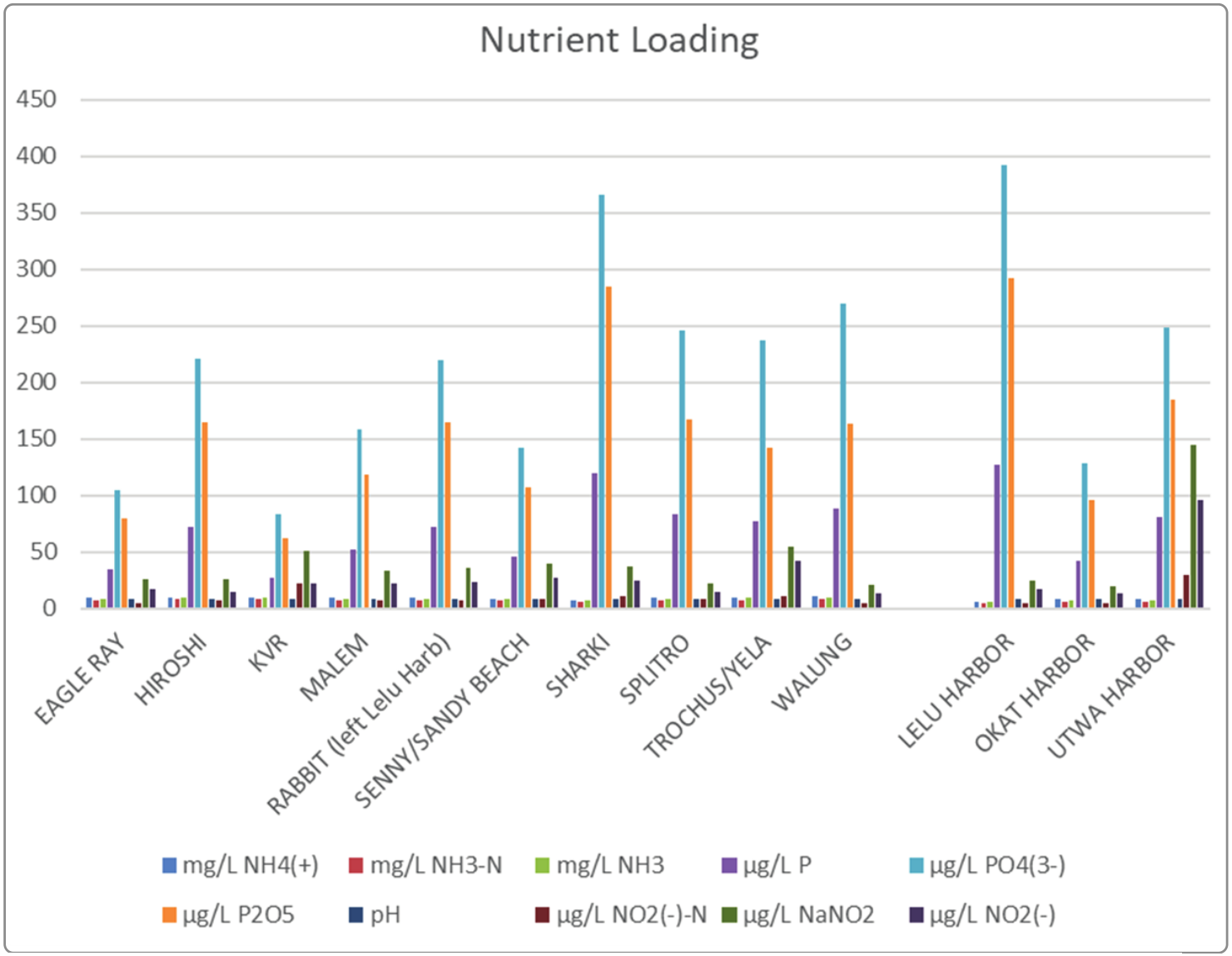
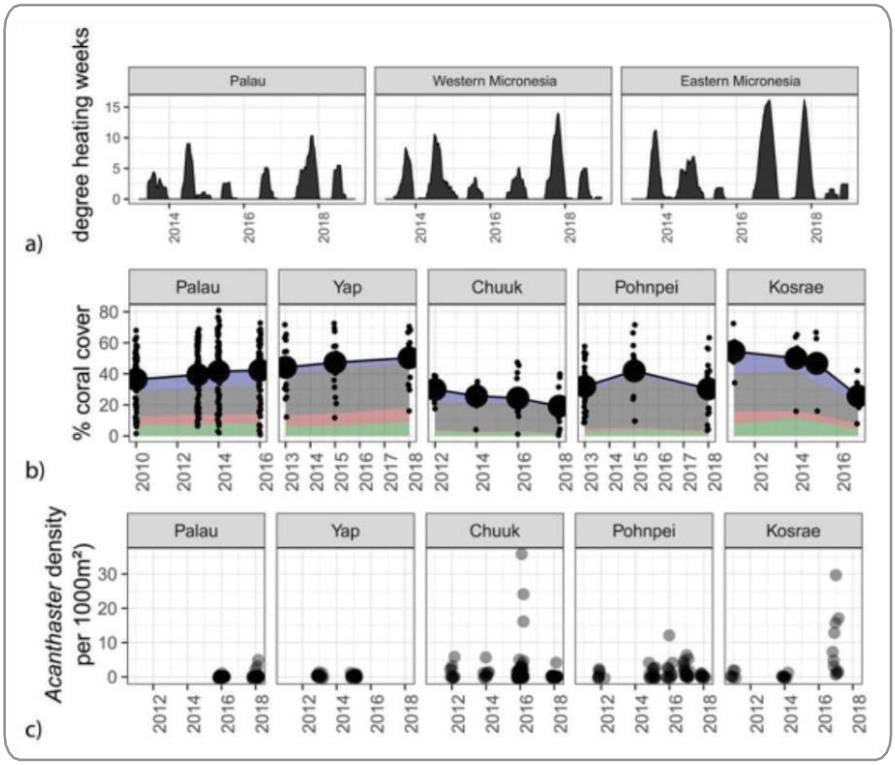


Figure 9. Nutrients concentrations and pH from samples collected at 10m depth from across Kosrae's island

While we will ask experienced chemical oceanographers for their interpretations of complete seawater analysis, we are glad to report that Houk et al. (2020)[2] supported the theory that a relationship among water temperature, nutrients, and COTS may be possible. Here following a graphic from Prof. Peter Houk showing how maximum sea-surface temperatures were associated with coral bleaching and declines in coral cover, which were associated with high densities of coral-predatory Acanthaster starfish. These episodes of intensive coral predation have been linked to high nutrient concentrations for brachiolaria larvae of Acanthaster. Such high nutrient concentrations are associated with river discharge or anomalous oceanographic conditions generating high coastal productivity, frequently detected as high chlorophyll-a concentrations (Houk et al., 2020). It is alarming that Kosrae lost such high percentage of coral cover in less than 10 years.



a) provide an indication of heat stress

b) Biological data show the dynamics of coral cover

c) Small black circles for *Acanthaster* densities represent numbers per site, or 1000 square meters

Acroporidae

other corals

Merulinidae

Poritidae

[2] Predicting coral-reef futures from El Niño and Pacific Decadal Oscillation events, Nature, 8th May 2020

Coral-Watch

We have been collecting data on coral bleaching using the Coral Health Chart from

Coral Watch (using Coral Watch methodology after Siebeck et al., 2006). The Coral Health Chart allows for recording changes in coral color and provides a simple tool for monitoring coral color as an indicator of coral health. According to the data collected, Kosrae reef did not suffer from significant bleaching in 2019. Here we reported the chart of four of the sites selected for the monitoring.

Fig. 10: Hiroshi point

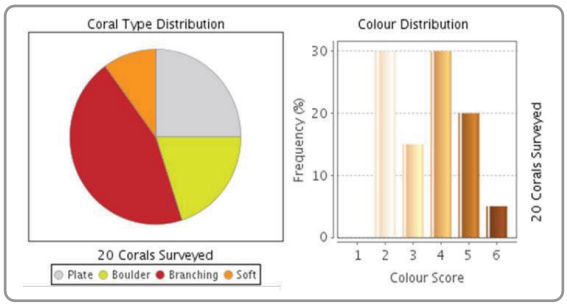


Fig. 11: Walung wot

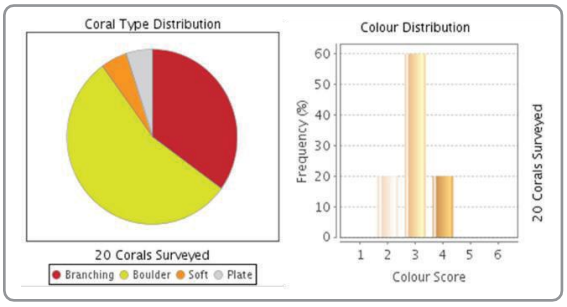


Fig. 12: Malem

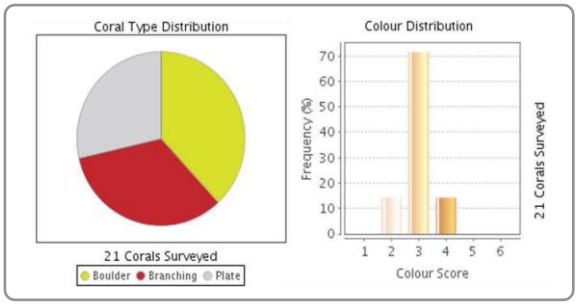
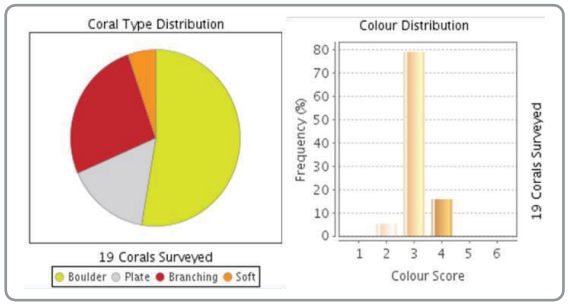


Fig. 13: Trochus



COTS-Coral Awareness

As part of this project, KATO conducted an Awareness Program that aimed to explain to students from 7th grade to high-school the importance of reef-building corals and the damage caused by climate-change and COTS. We organized Coral-Workshops in Malem, Lelu, Walung, Utwe, and Tafunsak elementary schools and Tofol High-school during the project.

We noticed much interest among the students and the willingness to be part of our conservation projects.

Carlos Cianchini "Coral, Reef, COTS, and Climate Change" Awareness Program with Kosrae High School's students

Conclusion and Recommendation

According to the mentioned study by Houk et al. (2020), in eastern Micronesia, where degree heating weeks were highest, coral cover declined by 20–50% between 2010 and 2017. Acanthaster densities were highest between 2015 and 2017. The Kosraean team observed COTS outbreaks and started the control and analysis project during this same period.

The consequences of COTS outbreaks are harmful to diving and fishing businesses. Unfortunately, the damage caused by outbreaks on the Kosrae reef is visible to scuba divers. The outbreaks also threaten the reefs' ability to keep up with sea-level rise and to protect the island against storms and other natural events. We strongly recommend continuing the COTS control project for at least 12 months, or until a balance is achieved with the ecosystem.

In the article "Defending the Kingdom," published in Oceanographic magazine, author David Krzesni compares the COTS outbreaks in Kosrae to forest fires, which are becoming more frequent and severe because of climate change and human activity. Just as good environmental policy helps prevent forest fires, implementing the control project and finding the reasons behind the COTS outbreaks will help maintain the balance of the reef ecosystem. The observations and data related to nutrient concentrations and changing pH levels in water may help accomplish this goal. If harbor activities are the cause of the considerable increase of nutrients in the northwest sites, the results indicating this should be provided to leadership to assist them in making future environmental decisions. Enforcing compliance with the MARPOL Convention, monitoring of the Garbage Record Book, and controlling the ballast and sewage water from ships entering Kosrae should help. In the meantime, we will continue collecting data. After consulting with a coral expert, we plan to evaluate the reef's reseeding (Porites) to mitigate the damage and help the reef regenerate faster.

We should never forget that a healthy reef is vital to protect Kosrae from climate change.