PAPAHĀNAUMOKUĀKEA
Marine National Monument

A World Heritage Site

An overview of *Chondria tumulosa* in Papahānaumokuākea and the development of preliminary biosecurity protocols

S10: East meets West and West meets East: Past, current and future implications of Non-Indigenous Species (NIS) in the North Pacific October 29, 2024

Brian B. Hauk, Heather L. Spalding, Taylor M. Williams, Randy K. Kosaki

OFFICE OF HAWAIIAN AFFAIRS

Group Effort!

Effort measured in Days at Sea (DAS) on Research expeditions focusing on *Chondria*:

- 2019: NOAA/ONMS Rainier Cruise: 8 (on accident)
- 2020: Oct FWS Imua re-supply Cruise: 1
- 2021: NOAA/ONMS Imua Cruise: 10
  - PMND/Marine Debris Cruise: 1
- 2022: USFWS Survey: 2
  - Midway NFWF Expedition: 14
- 2023: NOAA/ONMS Kahana II Cruise: 11
- 2024: NOAA/ONMS Sette Cruise: 7

Total: ~54 DAS

Combined efforts consist of 6+ months at sea and 5 years of additional research

Acknowledgements

- National Fish & Wildlife Foundation (NFWF)
- College of Charleston
- University of Hawaii
- University of Alabama at Birmingham
- Virginia Institute of Marine Science
- US Fish & Wildlife Service (Refuges/ES)
- Hawaii Division of Aquatic Resources (DLNR/DAR)
- Cooperative Institute of Marine & Atmospheric Research (CIMAR)
- The Papahānaumokuākea Marine Debris Project (PMDP)
- NOAA
  - Office of National Marine Sanctuaries (ONMS)
  - National Marine Fisheries Service (PIFSC/PIRO)

Outline

- **Introduction to PMNM**
- What is *Chondria tumulosa*?
  - Why should we care?
  - Where is it?
- Ecology of *C. tumulosa*
- Theorized Vectors
- BMPs Development & Management Actions

PAPAHĀNAUMOKUĀKEA

Marine National Monument

Photo by Na'alehu Anthony

A Living Hawaiian Culture

Traditional Hawaiian accounts describe Papahānaumokuākea as a sacred area from which life first emerged and to which spirits return after death.

Photo by Mark Sullivan/NOAA

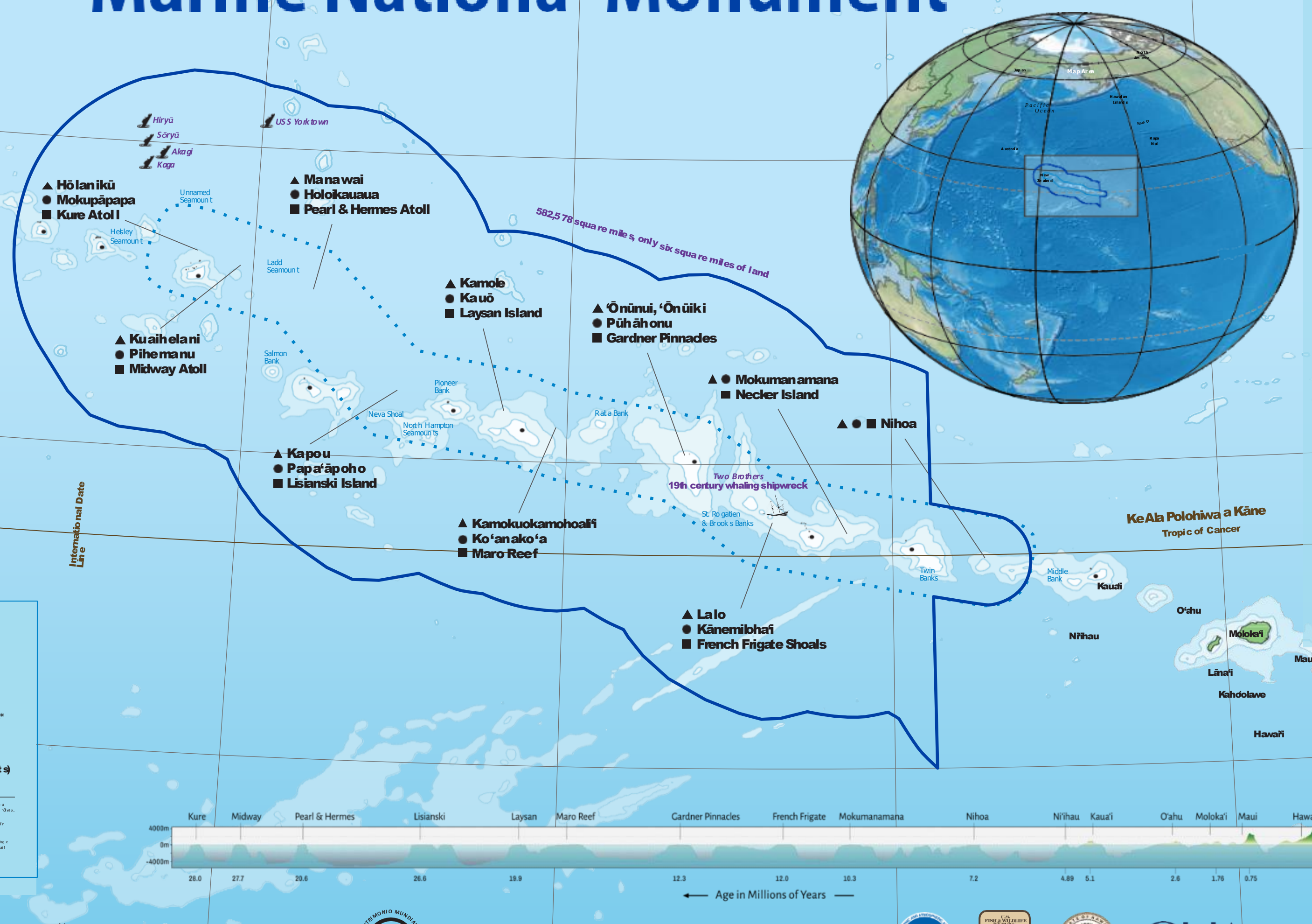
Endemic Sanctuary

The monument is home to many species found nowhere else on Earth and is a critically important nesting ground for green sea turtles and breeding ground for Hawaiian monk seals.

Photo by Greg McFall/NOAA

Predator-Dominated Coral Reefs

The monument protects 3.5 million acres of coral reef where sharks and large fish like ulua (trevally, pictured here) still dominate



Original boundary

Expanded boundary

▲ Kaʻaikawaha genealogy names* (Ancient Hawaiian names)

● Hawaiian Lexicon Committee names* (Contemporary Hawaiian names)

■ Common names† (Derived from modern nautical charts)

References

*Nogelmeier, P. (1995, December). He mau inoa kahiko paha i nalo a hoea hou mai? [Ancient names that have disappeared and been recovered?]. Ka ʻĀhaʻi ʻŌlelo, Puke VIII: II.

Kikiloi, Kekuewa. "Rebirth of an Archipelago: Sustaining a Hawaiian Cultural Identity for People and Homeland." Honolulu: Kamehameha Schools, 2010. Print.

*Kimura, L.L. 1998. Hawaiian names for the Northwestern Hawaiian Islands. Page 27 in S.P. Juvik and J.O. Juvik (eds.), Atlas of Hawaii, 3rd ed. University of Hawaii Press, Honolulu.

†Rauzon, Mark J. 2001. Isles of Refuge: Wildlife and History of the Northwestern Hawaiian Islands. University of Hawaiʻi Press, Honolulu.

Kilometers 0 100 200
Miles 0 100 200

N

A World Heritage Site

www.papahanaumokuakea.gov

Photo by Dan Clark/USFWS

Seabird Refuge

The monument is home to over 14 million seabirds representing 23 species. This includes the world's largest colonies of Laysan and black-footed albatross. Pictured above is the world's oldest known bird in the wild – a Laysan albatross named Wisdom! Banded in 1956 when she was at least five years old, Wisdom may have hatched more than 36 chicks in her lifetime.

Photo by NOAA/OER

New Discoveries

The majority of the seafloor in the Northwestern Hawaiian Islands lies at depths below 10,000 feet (3,000 meters). Using advanced technologies like remotely operated vehicles, researchers are discovering high-density biological communities and unique species at these depths.

Photo by Tane Casserley/NOAA

Traces of our Seafaring Past

Archival research indicates there may be as many as 67 shipwreck sites, the earliest of which dates back to 1818, within monument waters. There are also at least 503 aircraft sites, many lost during the Battle of Midway. These sites represent the legacy of our nation's maritime heritage in this region, providing a window through which we can better understand our seafaring past.

Pō

Ao

United Nations Educational, Scientific and Cultural Organization

World Heritage Centre

These island, atolls, and waters are also considered to be a sacred realm, where the boundary between *Ao*, the world of light and the living, and *Pō*, the world of gods and spirits, can be found. It is a place where life originates and where ancestors return after death.









Size, Scale, Location

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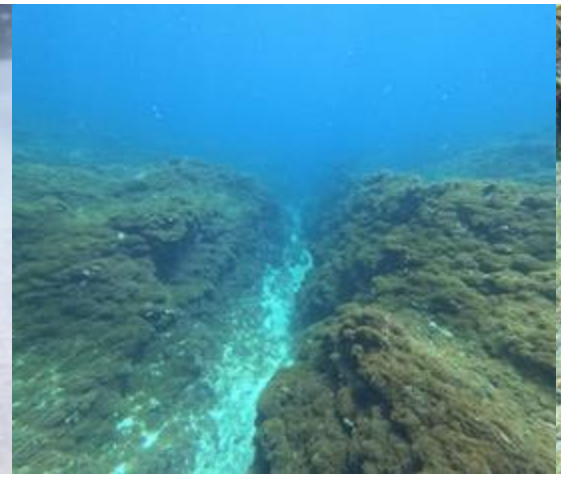
Alien Algae in Papahānaumokuākea Marine National Monument (PMNM)*

- NOAA staff and partners continue to monitor the spread of two algal species of concern in PMNM:

1. *Chondria tumulosa:* This alga forms large, thick mats and smothers sessile benthic organisms, including coral

2. *Acanthophora spicifera*: The most prevalent alien algae species in the Main Hawaiian Islands which was recently discovered at Midway Atoll (Kuaihelani) in 2022






*title is a link to more info

Terminology & Assumptions

INVASIVE

NONINDIGINOUS

CRYPTOGENIC

ALIEN

NUISANCE

ENDEMIC?

The “Re”-Discovery of the Nuisance Alga *Chondria tumulosa* at Manawai (Pearl and Hermes Atoll)

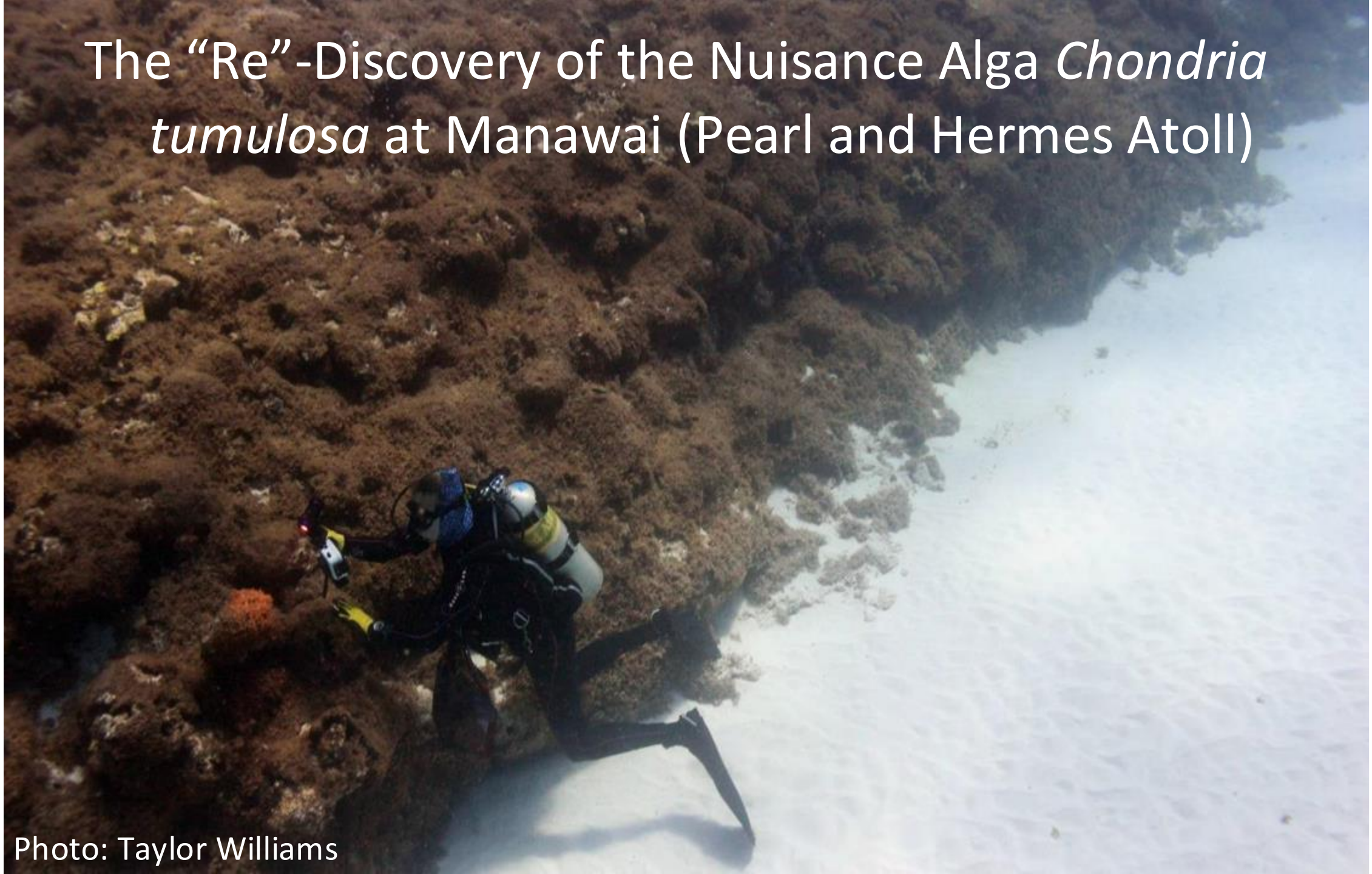


Photo: Taylor Williams

Excerpt from 2016 PIFSC Cruise Report

- Dense algal cover (primarily *Microdictyon* sp.) was observed in many areas around the atoll.
- Dense mats and floating "rafts" of a red alga (tentatively identified as a *Laurencia* sp.) were observed on the reef on the north-northeast side of the atoll and at the ARMS site on the southwest corner (PHR-54). This alga was not observed in other areas. Samples were collected for positive ID and further study.

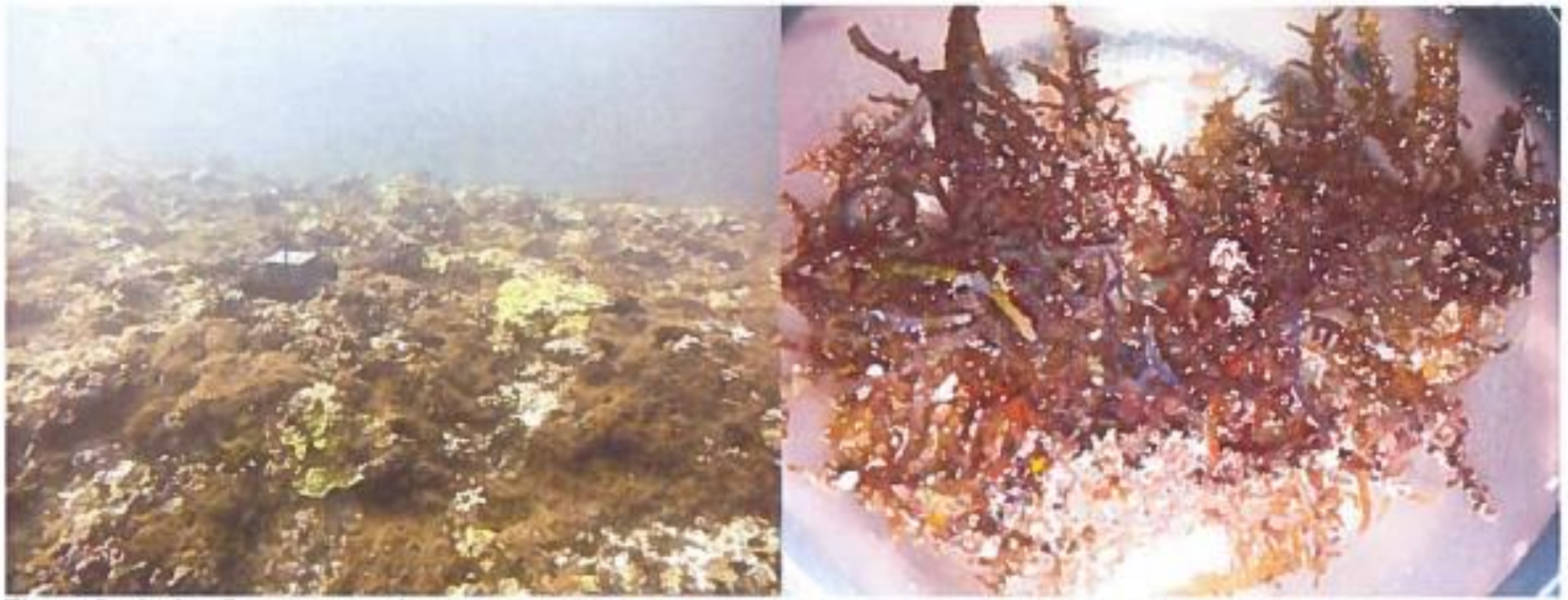


Figure 3.--Left – Dense mats of red algae at the ARMS site (PHR-54) on southwest side of Pearl and Hermes Atoll *Photo by Kerry Reardon*. Right – Close up view of algae in the lab. *Photo by Louise Giuseffi (right).*


Photo credit: NOAA/PIFSC

PLOS ONE

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Taxonomic determination of the cryptogenic red alga, *Chondria tumulosa* sp. nov., (Rhodomelaceae, Rhodophyta) from Papahānaumokuākea Marine National Monument, Hawai'i, USA: A new species displaying invasive characteristics

Alison R. Sherwood, John M. Huisman, Monica O. Paiano, Taylor M. Williams, Randall K. Kosaki, Celia M. Smith, Louise Giuseffi, Heather L. Spalding

Published: July 7, 2020 • https://doi.org/10.1371/journal.pone.0234358

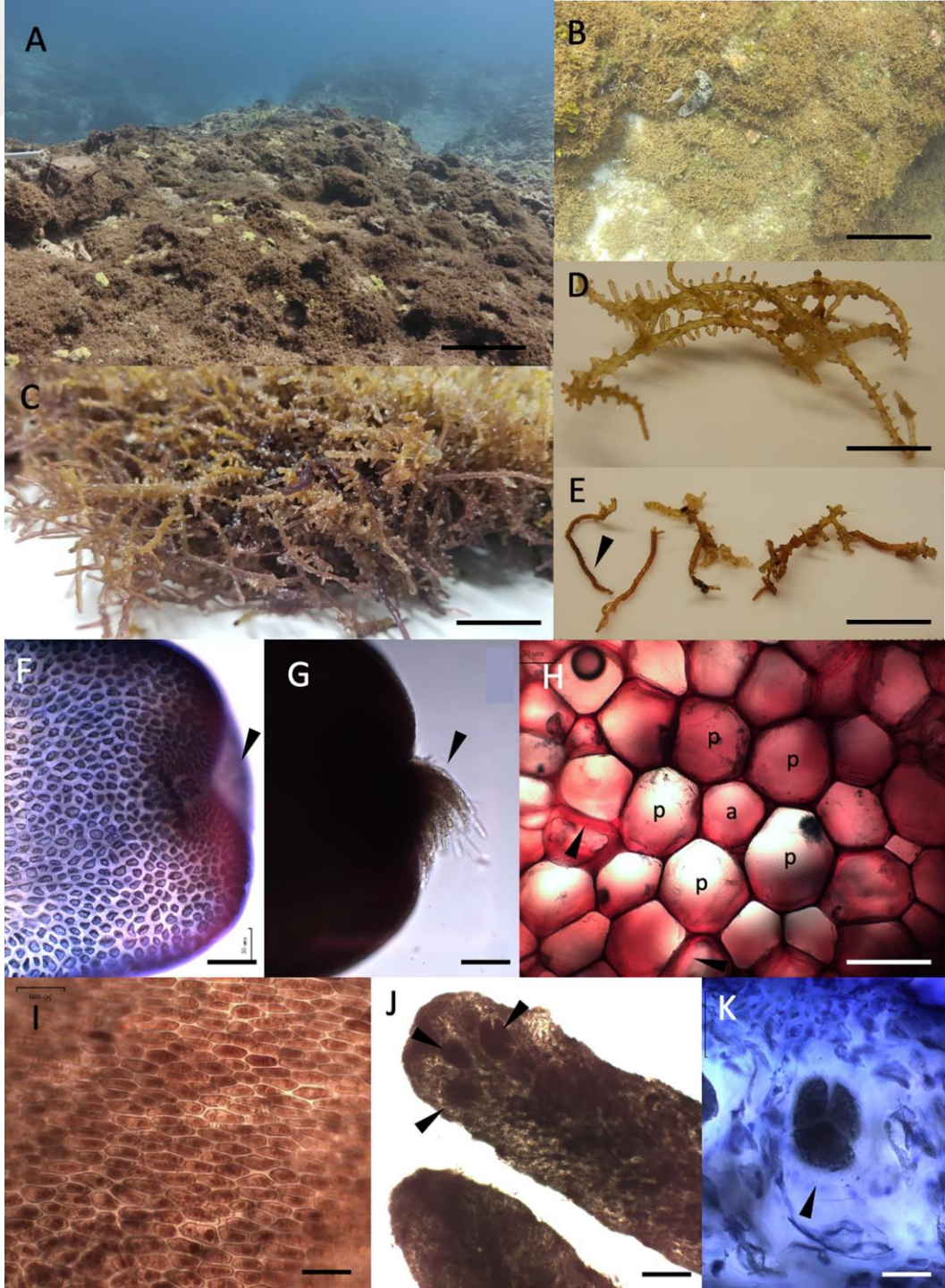


Fig 4. Morphological features of *Chondria tumulosa* sp.nov.
A. View of *Chondria* overgrowing the coral reef at Pearl and Hermes Atoll (PHA) at 12 m depth, Papahānaumokuākea Marine National Monument, Hawai'i, USA. Scale bar = 30 cm. B. Close view of *Chondria tumulosa* at PHA. Scale bar = 10 cm. C. Macroscopic view of the edge of a mat of *Chondria tumulosa*, illustrating the intertwined and mat-like growth of the alga, and the color variations from yellowish to purple. Scale bar = 2 cm. D. Close up view of several main axes that were separated from the upper surface of a mat, illustrating the numerous secondary and tertiary branches from the main axis. Scale bar = 5 mm. E. Close up view of several main axes that were separated from the lower surface of a mat, illustrating the darker color and slender haptera (arrow) used for attachment of the mat to the substratum. Scale bar = 5 mm. F. A branch apex, focused internally to illustrate the apical depression, or pit. Scale bar = 50 μm. G. A branch tip, focused to illustrate trichoblasts emerging from the pit. Scale bar = 50 μm. H. Cross section of *Chondria tumulosa* stained with ruthenium red, demonstrating the typical rhodomelacean structure, with a central axial cell (a) surrounded by five pericentral cells (p). Cell wall thickenings are indicated in some cells (arrows) outside of this central structure. Scale bar = 50 μm. I. Surface view of cortical cells in the epidermal layer. Scale bar = 50 μm. J. Tetrasporangia developing towards the apices of secondary and tertiary axes. Scale bar = 200 μm. K. Close-up of a tetrahedrally divided tetrasporangium, stained with aniline blue. Scale bar = 100 μm.
https://doi.org/10.1371/journal.pone.0234358.g004

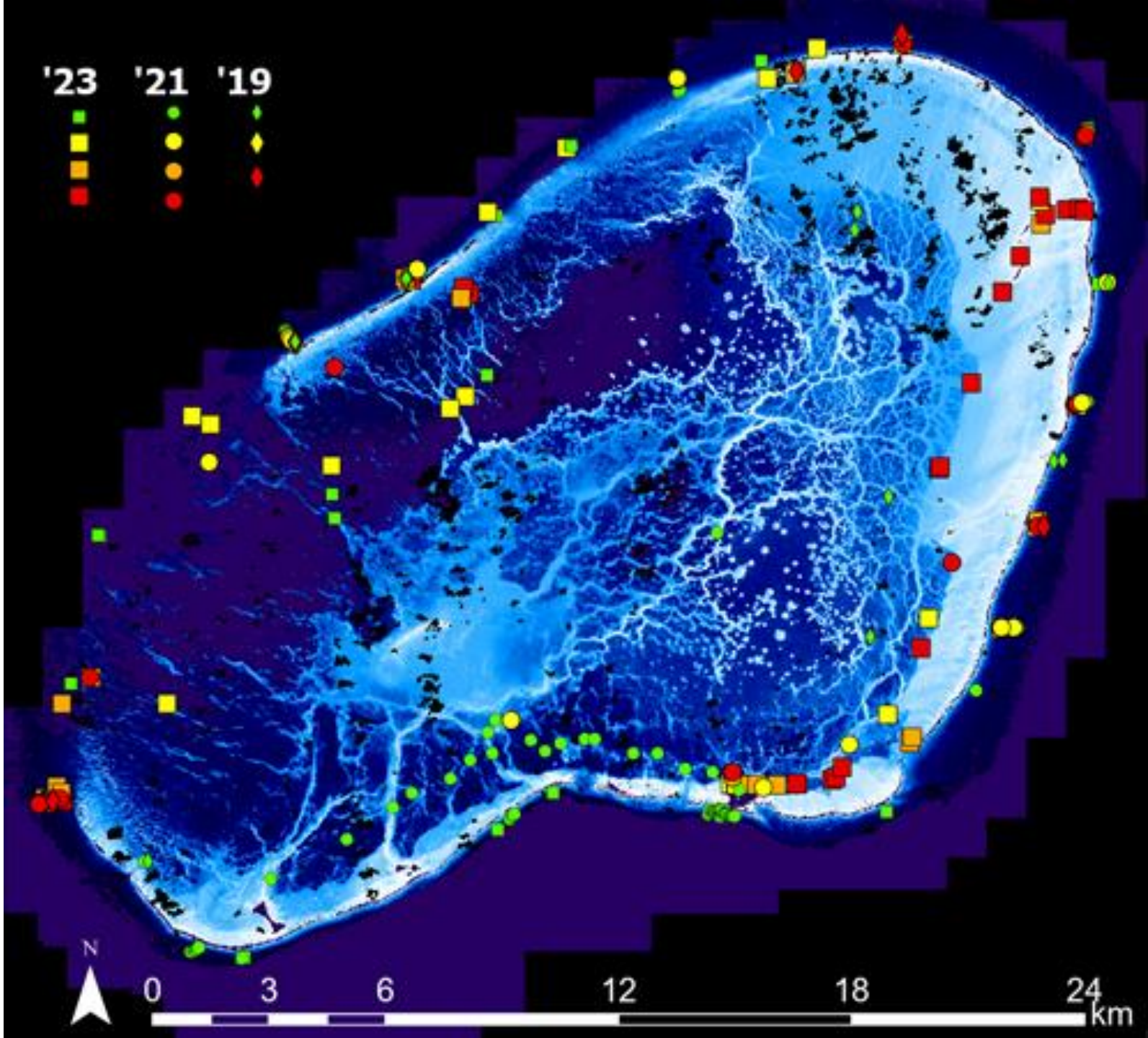
Manawai

(Pearl and Hermes Atoll)

0% **1-10%** **>10-40%** ***>40%***

***Chondria tumulosa* cover** from in water surveys conducted by trained scientists on SCUBA & snorkel.

Present since at least 2015



Maps produced in ArcGIS Pro (on 4m bathymetry USGS base maps) by Chelsie Counsel, PhD.

Kuaihelani

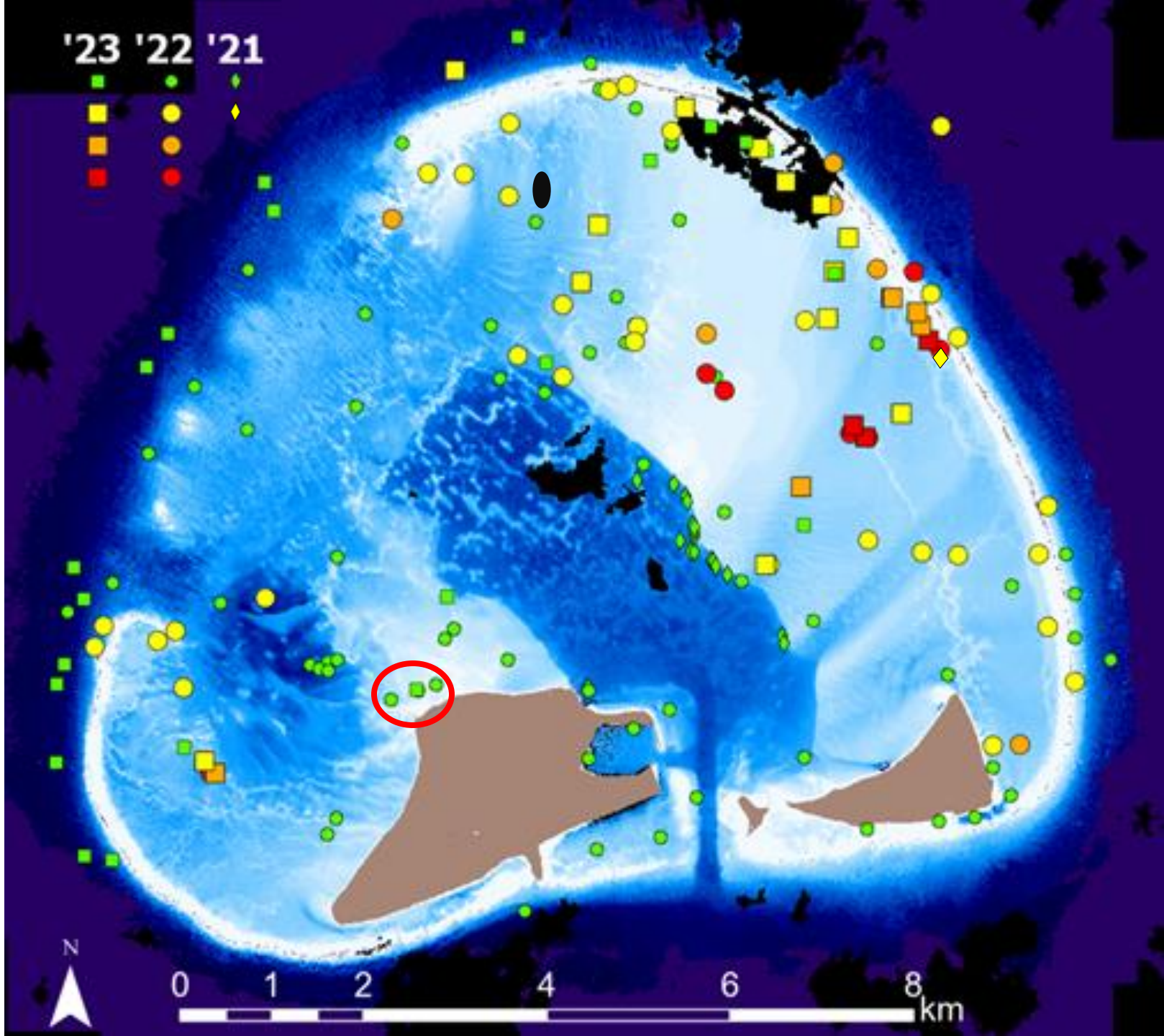
(Midway Atoll)

0% 1-10% >10-40% >40%

***Chondria tumulosa* cover** from in water surveys conducted by trained scientists on SCUBA & snorkel.

Present since at least 2021

Maps produced in ArcGIS Pro (on 4m bathymetry USGS base maps) by Chelsie Counsel, PhD.



Hōlanikū

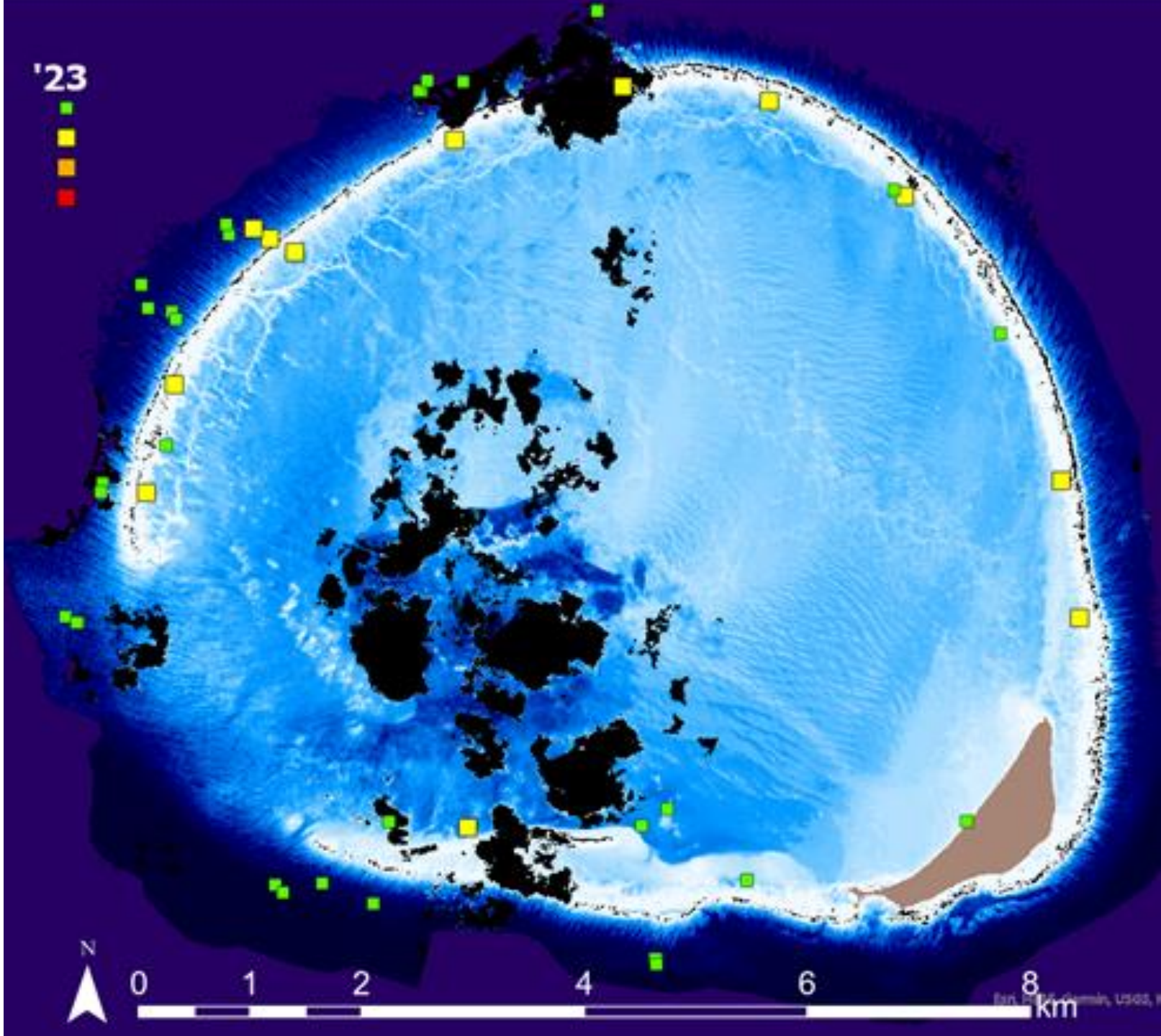
(Kure Atoll)

0% 1-10% >10-40% >40%

***Chondria tumulosa* cover** from in water surveys conducted by trained scientists on SCUBA & snorkel.

Present since at least 2023

Maps produced in ArcGIS Pro (on 4m bathymetry USGS base maps) by Chelsie Counsel, PhD.



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PHYCOLOGIA
2024, VOL. 63, NO. 1, 36–44
https://doi.org/10.1080/00318884.2023.2284074

International Phycological Society

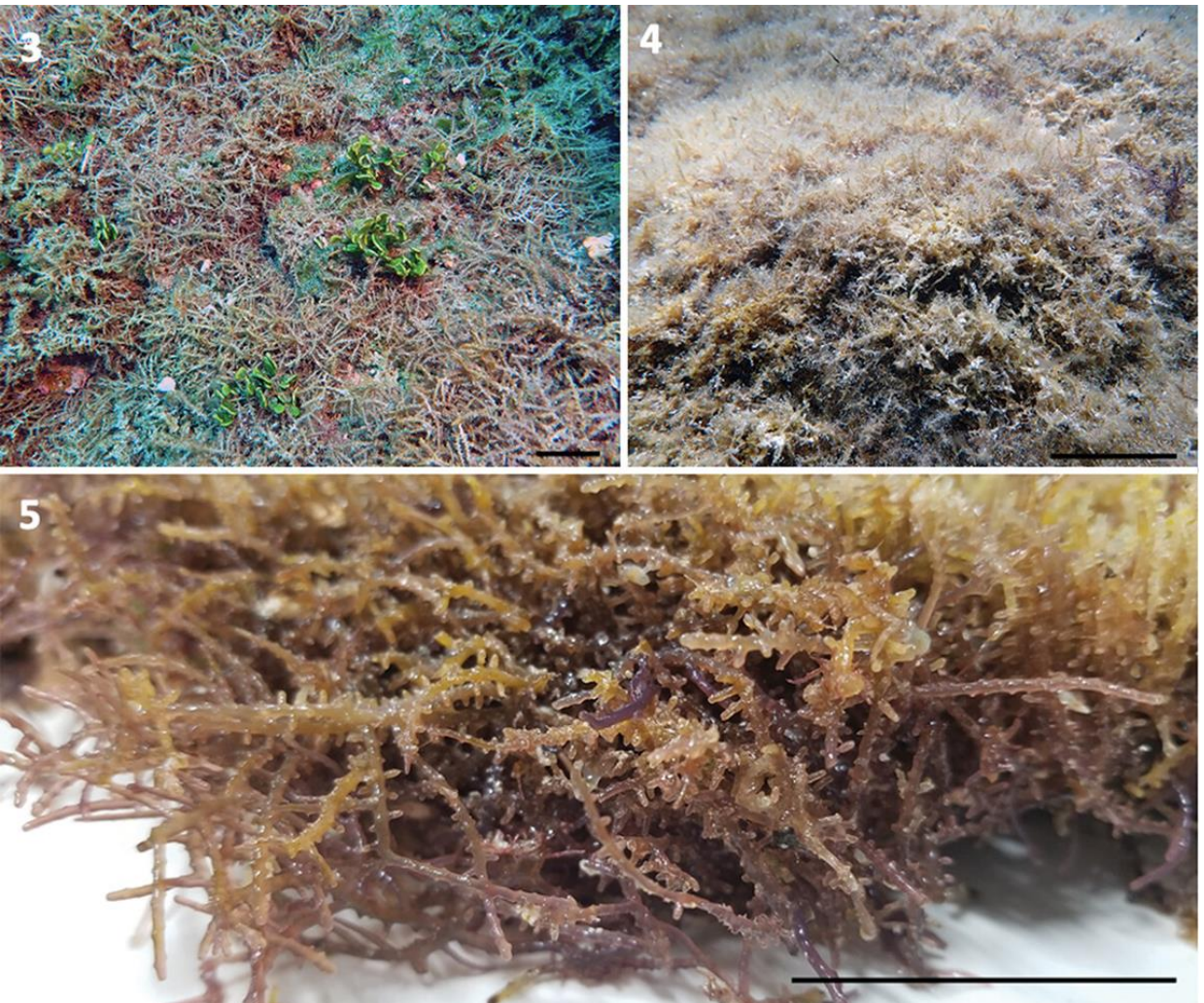
Taylor & Francis
Taylor & Francis Group

https://doi.org/10.1080/00318884.2023.2284074

OPEN ACCESS Check for updates

The reproductive system of the cryptogenic alga *Chondria tumulosa* (Florideophyceae) at Manawai, Papahānaumokuākea Marine National Monument

Taylor M. Williams[1,2], Stacy A. Krueger-Hadfield[2,3], Kristina M. Hill-Spanik[1], Randall K. Kosaki[4], Solenn Stoeckel[5] and Heather L. Spalding[1]



Figs 3–5.:
Chondria tumulosa in situ at Manawai.
Scale bars = 3 cm.

Figs 3, 4.
Chondria tumulosa displaying mat-forming morphology.

Fig. 5.
Close-up view of intertwined thalli.

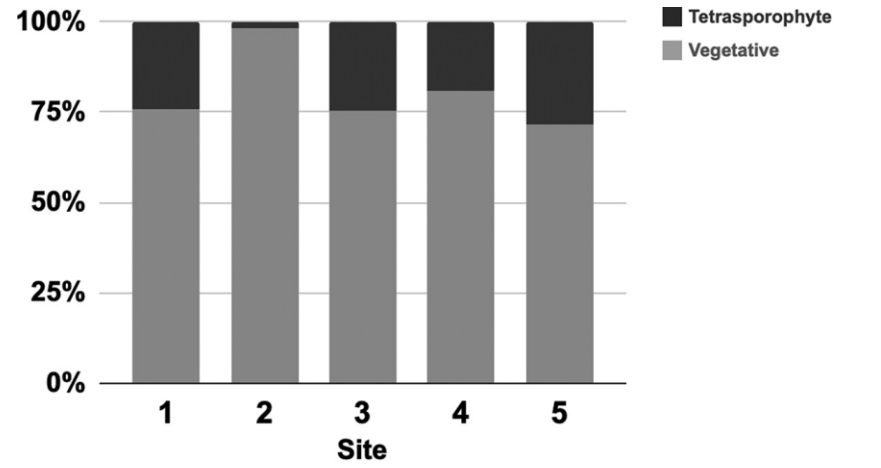


Fig. 6.
Proportion of *Chondria tumulosa* tetrasporophytic to vegetative thalli by site across Manawai
(N_{TOTAL} = 372 samples, 74–75 thalli per site).

Phase Shifts

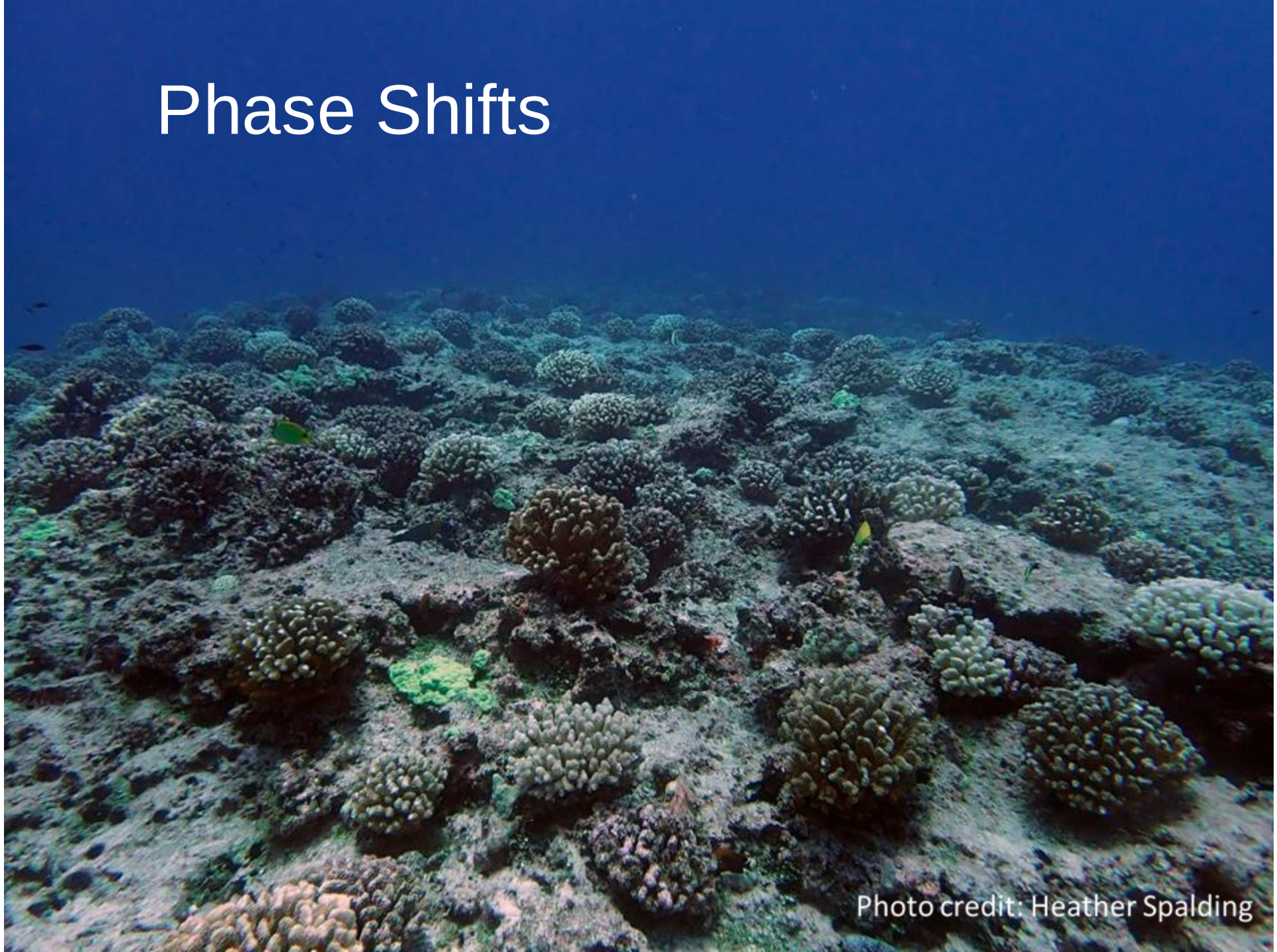
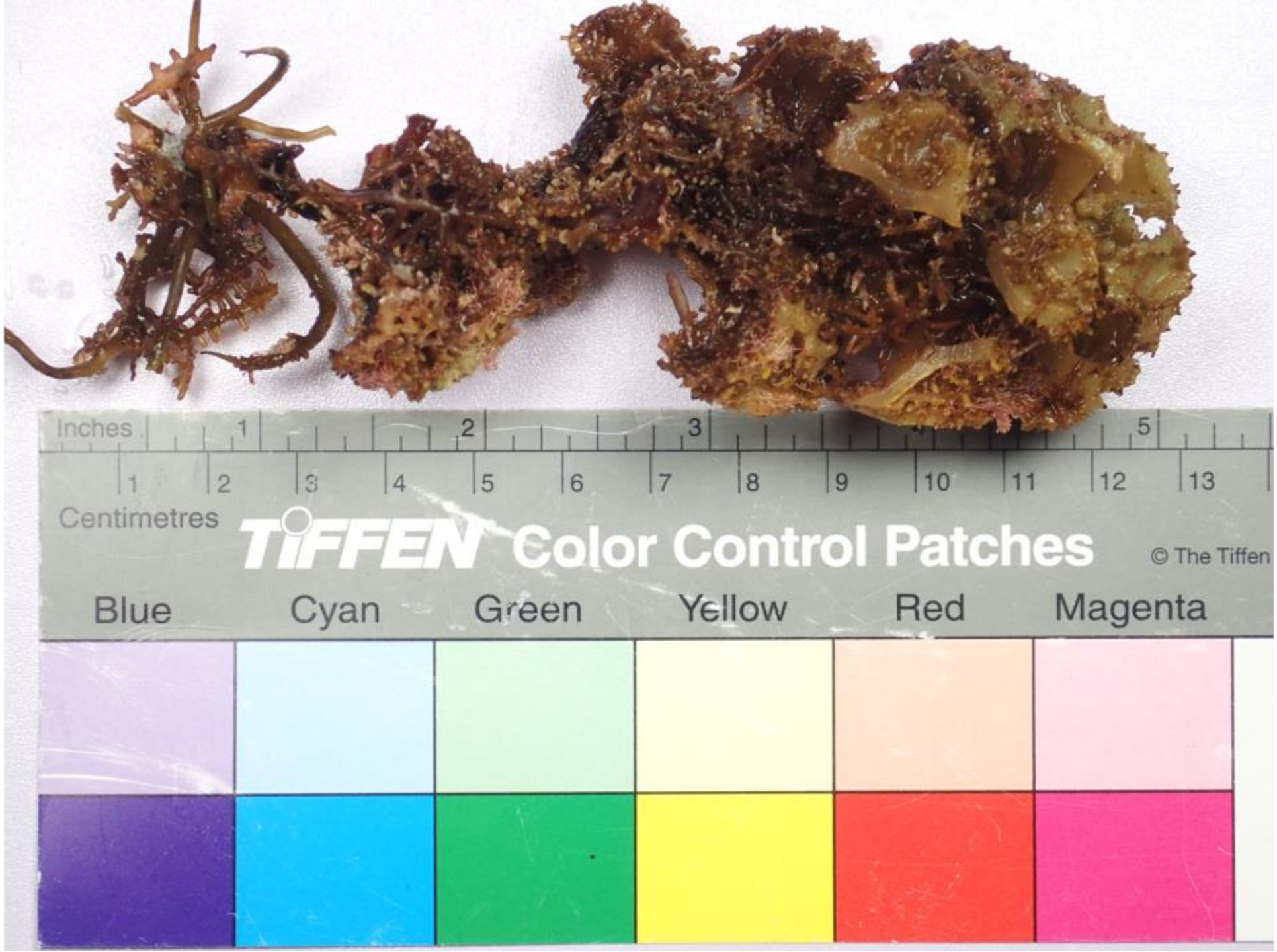



Photo credit: Heather Spalding


Photo credit: Heather Spalding

Photo credit: Brian Hauk


Inches
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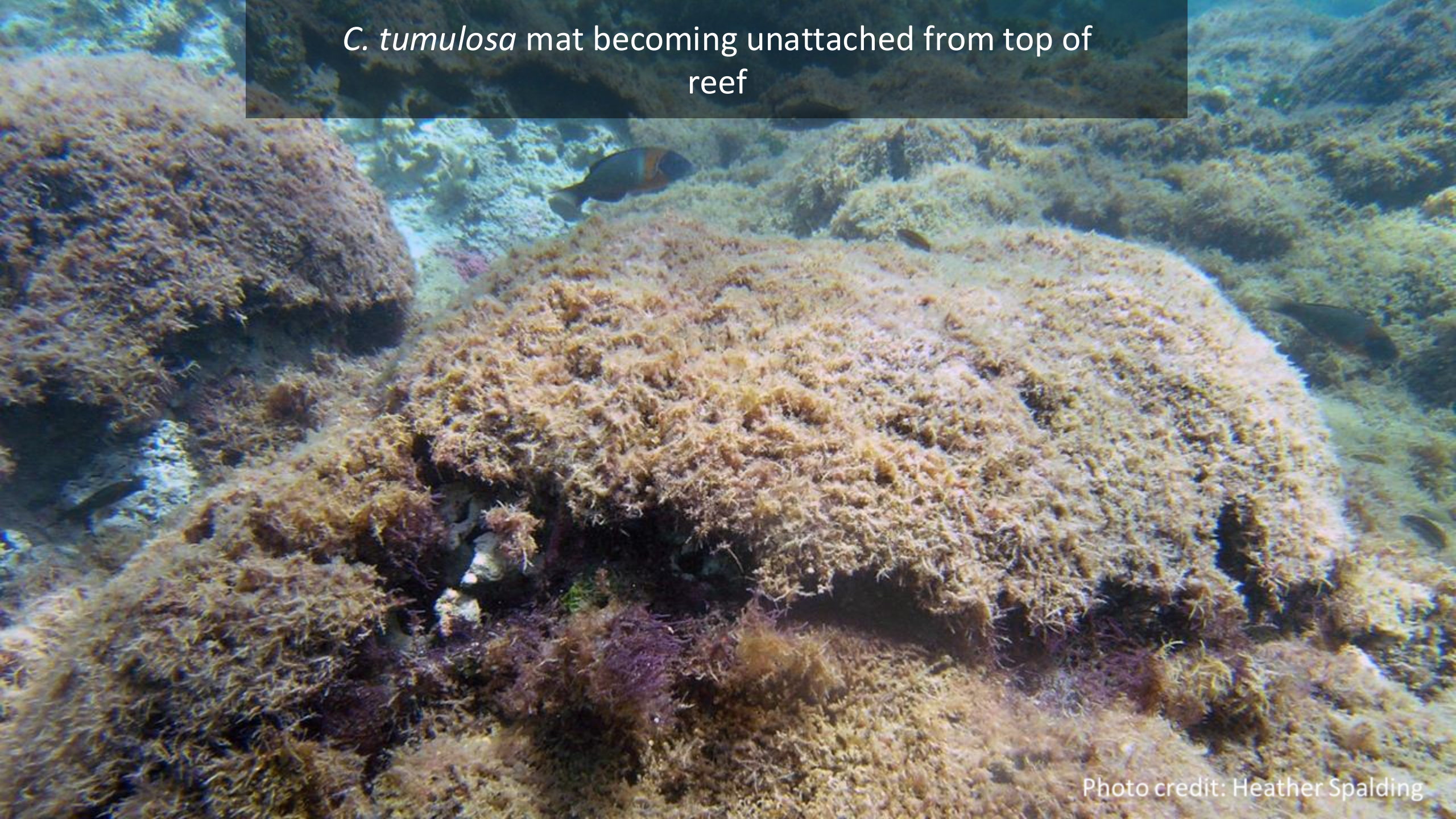
Centimetres
TIFFEN Color Control Patches
© The Tiffen
Blue
Cyan
Green
Yellow
Red
Magenta

Photo credit: Taylor Williams

Photo credit: Taylor Williams


C. tumulosa mat becoming unattached from top of reef
Photo credit: Heather Spalding


Reef with mat removed from the top
Photo credit: Heather Spalding

Close-up of previous picture, showing attached algal fragments and dead reef

Photo credit: Heather Spalding

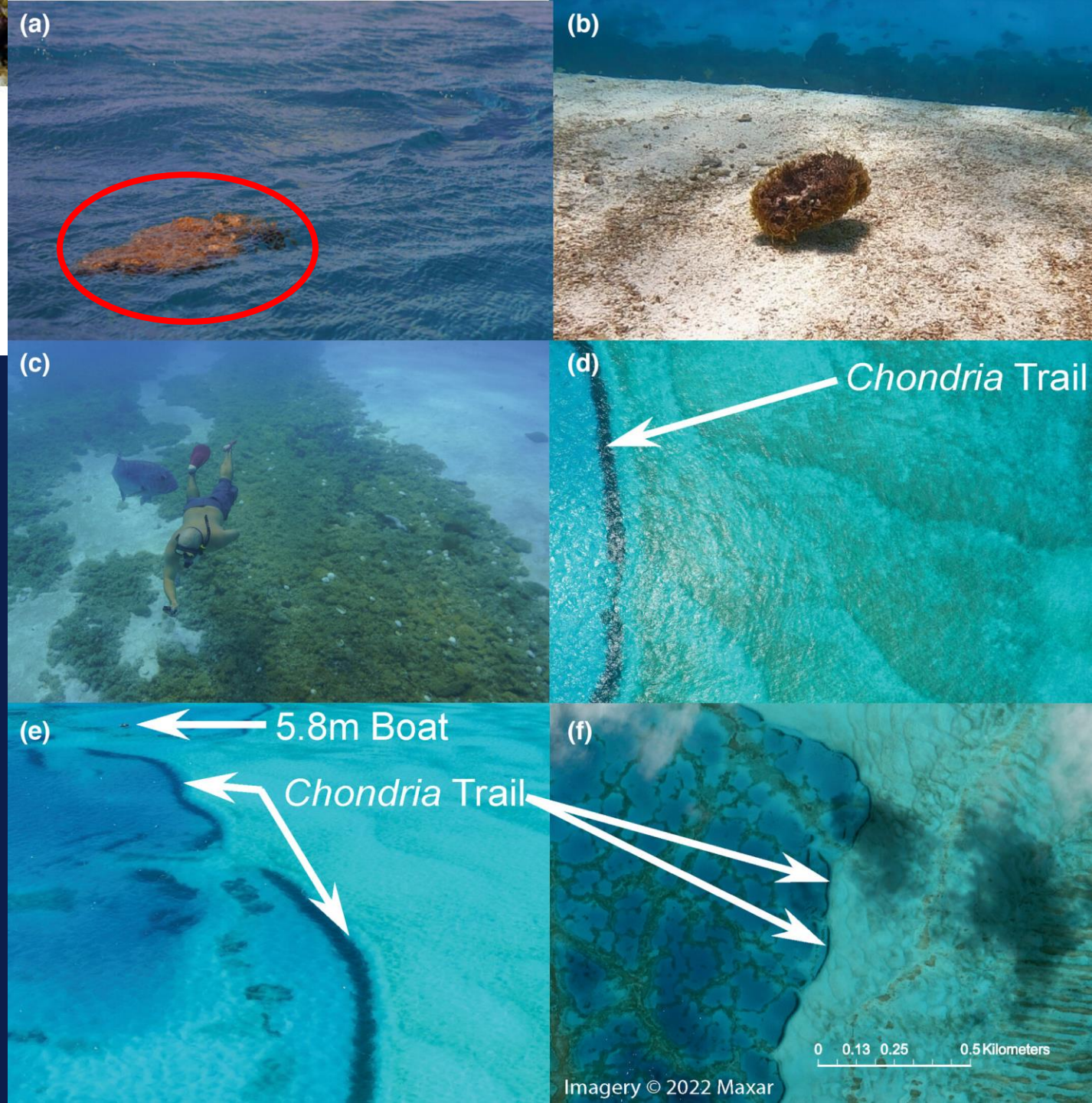
Journal of Phycology

NOTE | Open Access

Rapid expansion of the invasive-like red macroalga, *Chondria tumulosa* (Rhodophyta), on the coral reefs of the Papahānaumokuākea Marine National Monument

Keolohilani H. Lopes Jr, Tomoaki Miura, Brian Hauk, Randall Kosaki, Jason Leonard, Cynthia Hunter

First published: 14 August 2023 | https://doi.org/10.1111/jpy.13369



(a) Dislodged *Chondria tumulosa* rafting, (b) drifting along the lagoon floor, (c) accumulated at the foot of sandy slopes, (d, e) drone images collected on July 7, 2021, and (f) the satellite image of the study site (acquisition date, Sept. 5, 2021).

https://doi.org/10.1111/jpy.13369


NMFS ESA MMPA Permit No. 22677_Paige Mino NOAA


Paige Mino-NMFS permit #PMNM-2022-002


Paige Mino-NMFS permit #PMNM-2022-002

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- BMPs Development & Management Actions

Where did it come from?

Source: http://www.davegranlund.com/cartoons/

REPORT

Tsunami-driven rafting: Transoceanic species dispersal and implications for marine biogeography

JAMES T. CARLTON, JOHN W. CHAPMAN, JONATHAN B. GELLER, JESSICA A. MILLER, DEBORAH A. CARLTON, MEGAN I. MCCULLER, NANCY C. TRENEMAN, BRIAN P. STEVES, AND GREGORY M. RUIZ Authors Info & Affiliations

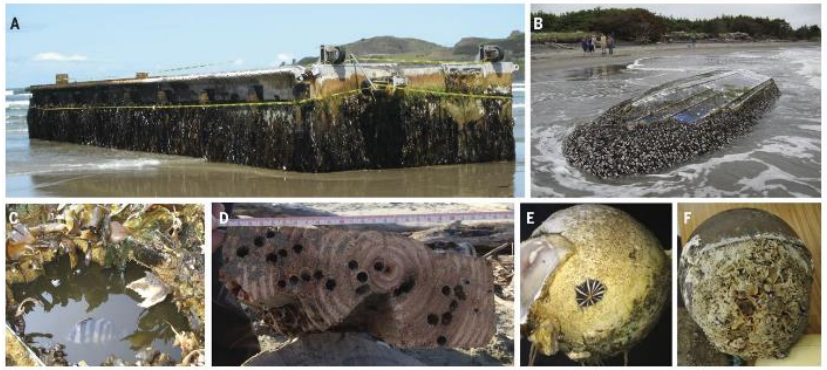
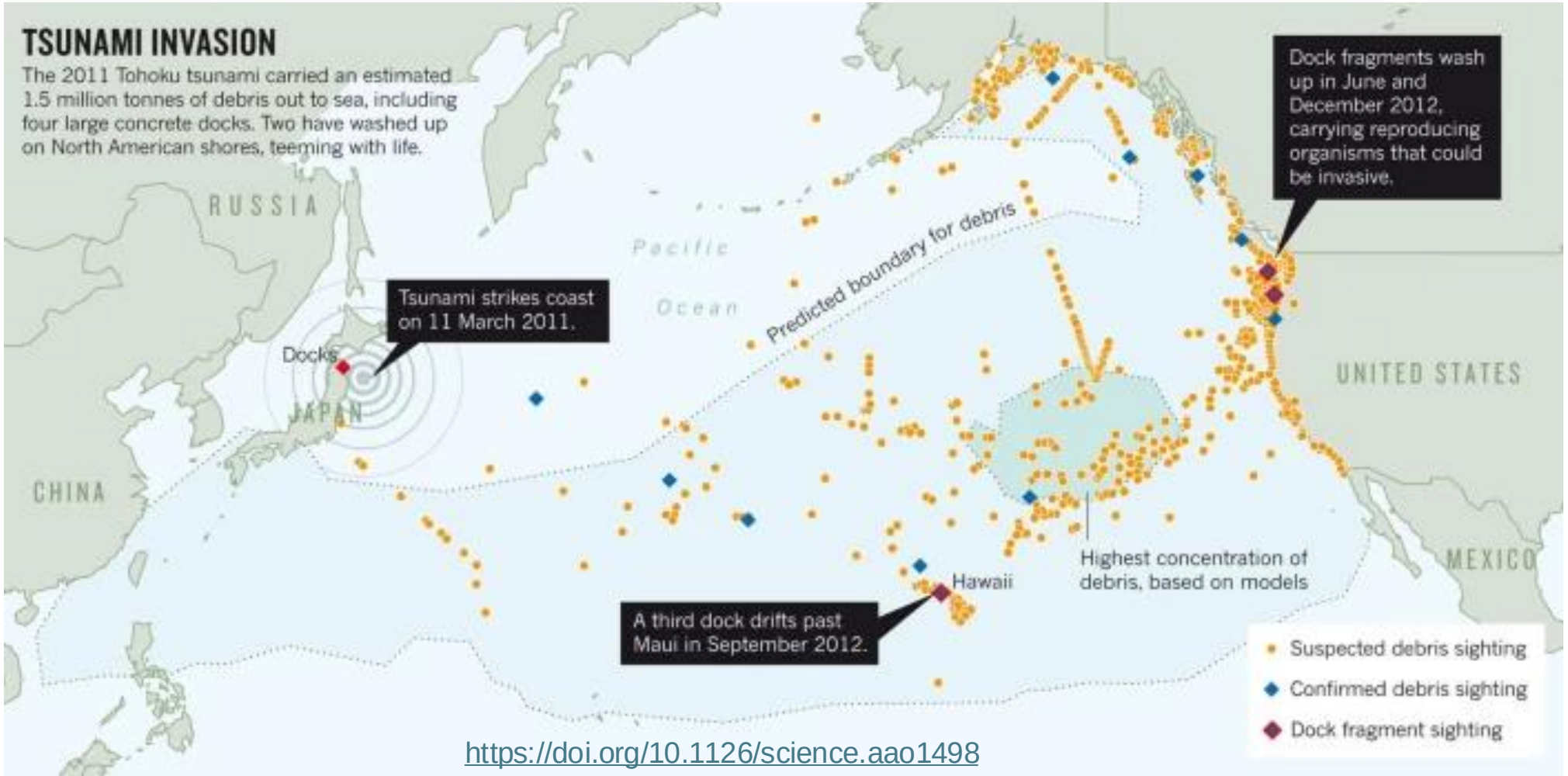


Fig. 1 Japanese tsunami marine debris rafts and associated biota.



https://doi.org/10.1126/science.aao1498

Aquatic Invasions (2018) Volume 13, Issue 1: 1–9
DOI: https://doi.org/10.3391/ai.2018.13.1.01

Special Issue: *Transoceanic Dispersal of Marine Life from Japan to North America and the Hawaiian Islands as a Result of the Japanese Earthquake and Tsunami of 2011*

Introduction to Special Issue

Ecological and biological studies of ocean rafting: Japanese tsunami marine debris in North America and the Hawaiian Islands

James T. Carlton[1,2,*], John W. Chapman[3], Jonathan B. Geller[4], Jessica A. Miller[3], Gregory M. Ruiz[5], Deborah A. Carlton[2], Megan I. McCuller[2], Nancy C. Treneman[6], Brian P. Steves[5], Ralph A. Breitenstein[7], Russell Lewis[8], David Bilderback[9], Diane Bilderback[9], Takuma Haga[10] and Leslie H. Harris[11]

Figure 1. Upper photo, "Misawa 1", a fisheries dock from the Port of Misawa, Aomori Prefecture, washed away March 11, 2011, and landing on Agate Beach, Newport, Oregon, June 5, 2012. Lower left, sea anemones (*Metridium dianthus*) from Japan, along with barnacles (*Semibalanus cariosus*) and mussels (*Mytilus galloprovincialis)* on Misawa 1; lower right, *S. cariosus*, *M. galloprovincialis*, and the barnacle *Megabalanus rosa*. Photographs by Jessica A. Miller.

https://doi.org/10.3391/ai.2018.13.1.01

Movement and retention of derelict fishing nets in Northwestern Hawaiian Island reefs

Kaylyn S. McCoy [a], Brittany Huntington [b], Tye L. Kindinger [a], James Morioka [b], Kevin O'Brien [c]

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Photo credits: Kim Fuller

Research Article
Aquatic Invasions 19(3): 259-273
https://doi.org/10.3391/ai.2024.19.3.135377 (20 Sep 2024)

Modeling the dispersal of the cryptogenic alga *Chondria tumulosa* (Rhodophyta, Ceramiales) in the Papahānaumokuākea Marine National Monument

James T. Fumo, Brian S. Powell, Randall K. Kosaki, Alison R. Sherwood

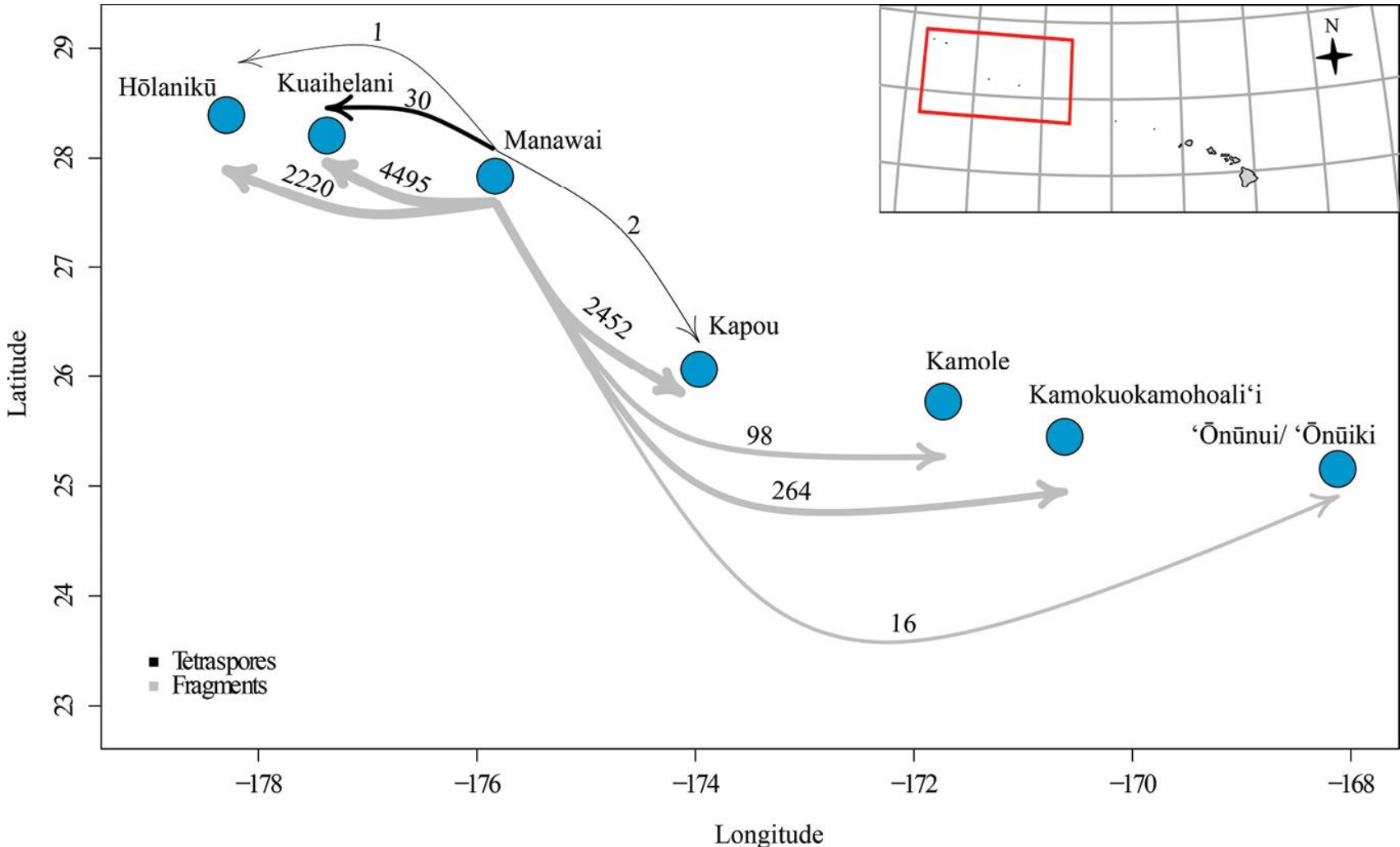

Figure 2. Total number of successfully settled particles released from Manawai. Islands are represented as blue dots with tetraspores shown above in black and fragments below in gray. Arrow width and associated numbers correspond to the number of successful settlements from Manawai to the settlement location of interest. The red box in the inset map in the top right corner shows the location of the study region with respect to the remainder of the Hawaiian Archipelago.

https://doi.org/10.3391/ai.2024.19.3.135377

Japan, Johnston, Palmyra & Line Islands, Galápagos??

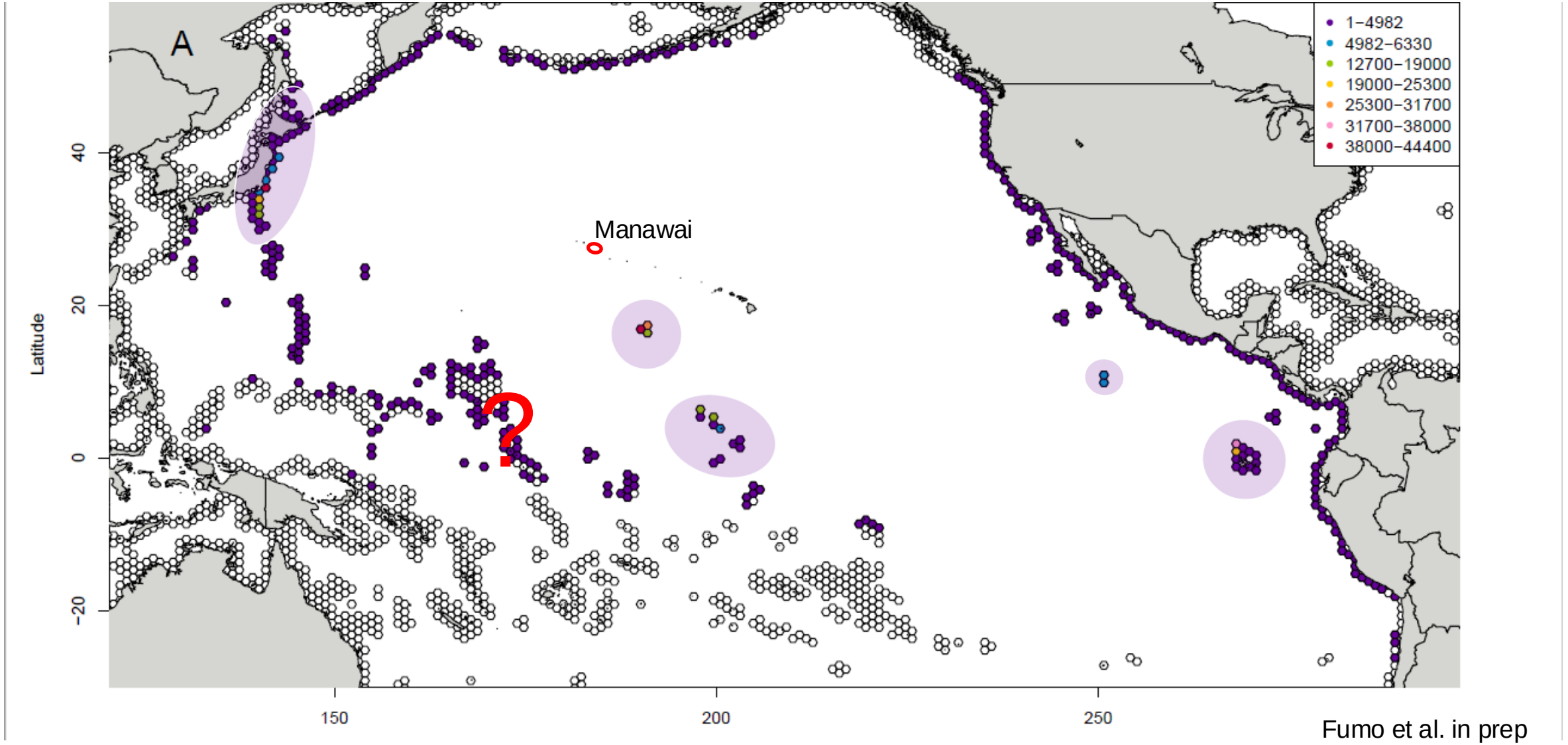

Fig 1 Modeled source locations for the *C. tumulosa* outbreak at Manawai. From December 30, 2015 to January 1, 2000, 100 particles per day originating at Manawai (Pearl and Hermes Atoll) were traced backward until settling in a source location. Hexagonal polygons were the regions designated as source areas in the Connectivity Modeling System. Each hexagon is colored by the number of landings in that settlement polygon with colorless locations receiving zero throughout the modeled period. All landings throughout are shown in panel A. The regions of highest likelihood are Japan (B), the central Pacific islands of Johnston Atoll, Palmyra Atoll, and the Line Islands (C), and the eastern Pacific islands of Clipperton and the Galápagos archipelago (D). The legend in panel A applies to all panels.

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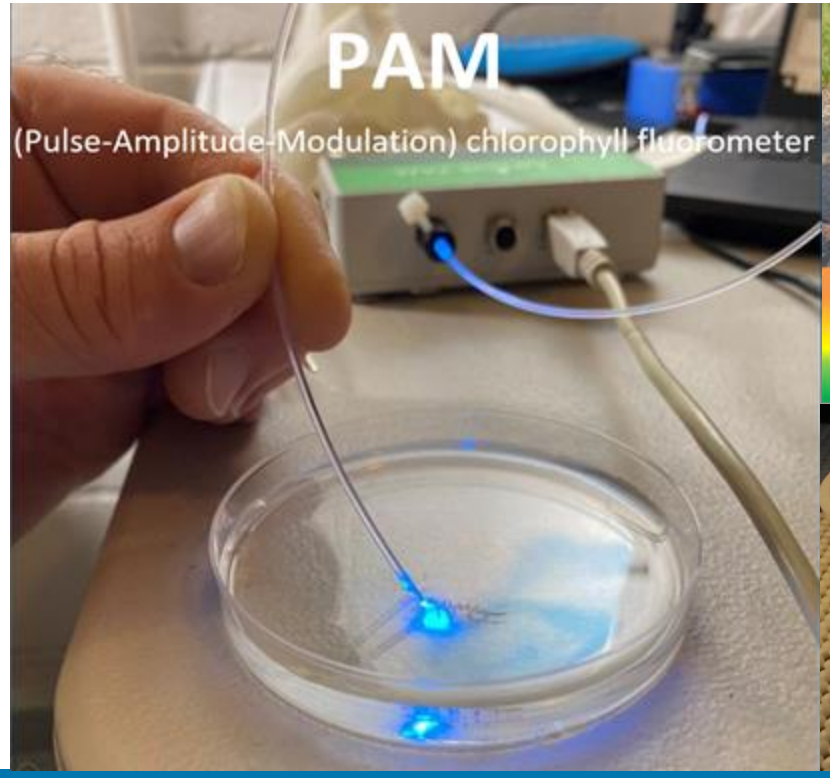
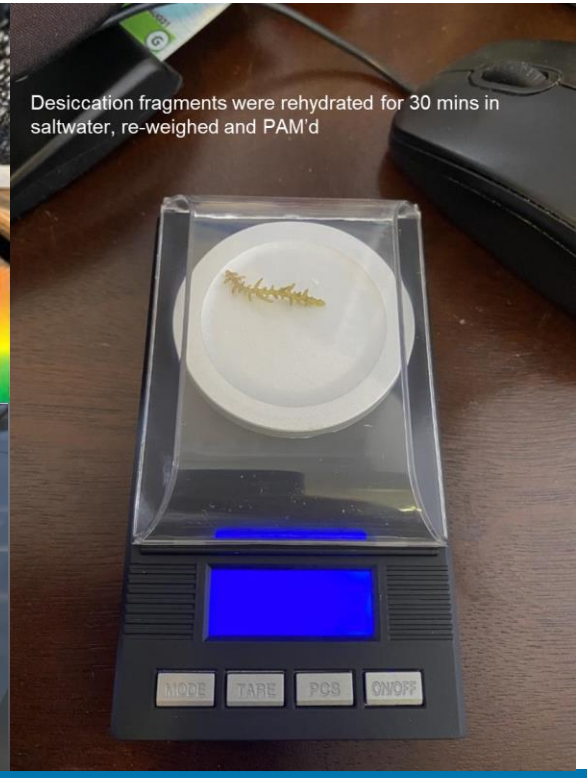
- **BMPs Development & Management Actions**

BMPs & Management Research

- NOAA is working with other Co-Trustee agencies to develop best management practices for permitted activities which compliment existing pre-access vessel biosecurity requirements for entry and work within the Monument.
  - Lethality trials have informed BMPs to mitigate risk from anthropogenic activities
  - NOAA is collaborating with several Universities and Phycologist to make science informed decisions
  - No known predators





Current Recommendations Per BMP020

1. Remove all fragments via a visual inspection in daylight of all dive gear
2. Soak gear/equipment in 6% commercial-grade bleach for 10 minutes followed by a freshwater rinse
3. Fully dry dive gear/equipment/boats for 14-30 days before use in a different island or atoll depending on usage.

NOTE: Particular caution should be paid to dive gear containing mesh, such as goody bags, or Velcro that easily catch and retain algal fragments.

Finding the Source/EDRR = eDNA Tools

Nichols PK, Fraiola KMS, Sherwood AR, Hauk BB, Lopes Jr. KH, Davis CA, Fumo JT, Counsell CWW, Williams TM, Spalding HL, and Marko PB. *(in review) Navigating uncertainty in environmental DNA detection of a nuisance marine macroalga.* PLoS ONE.

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Early detection system for nuisance alga infesting Papahānaumokuākea reefs

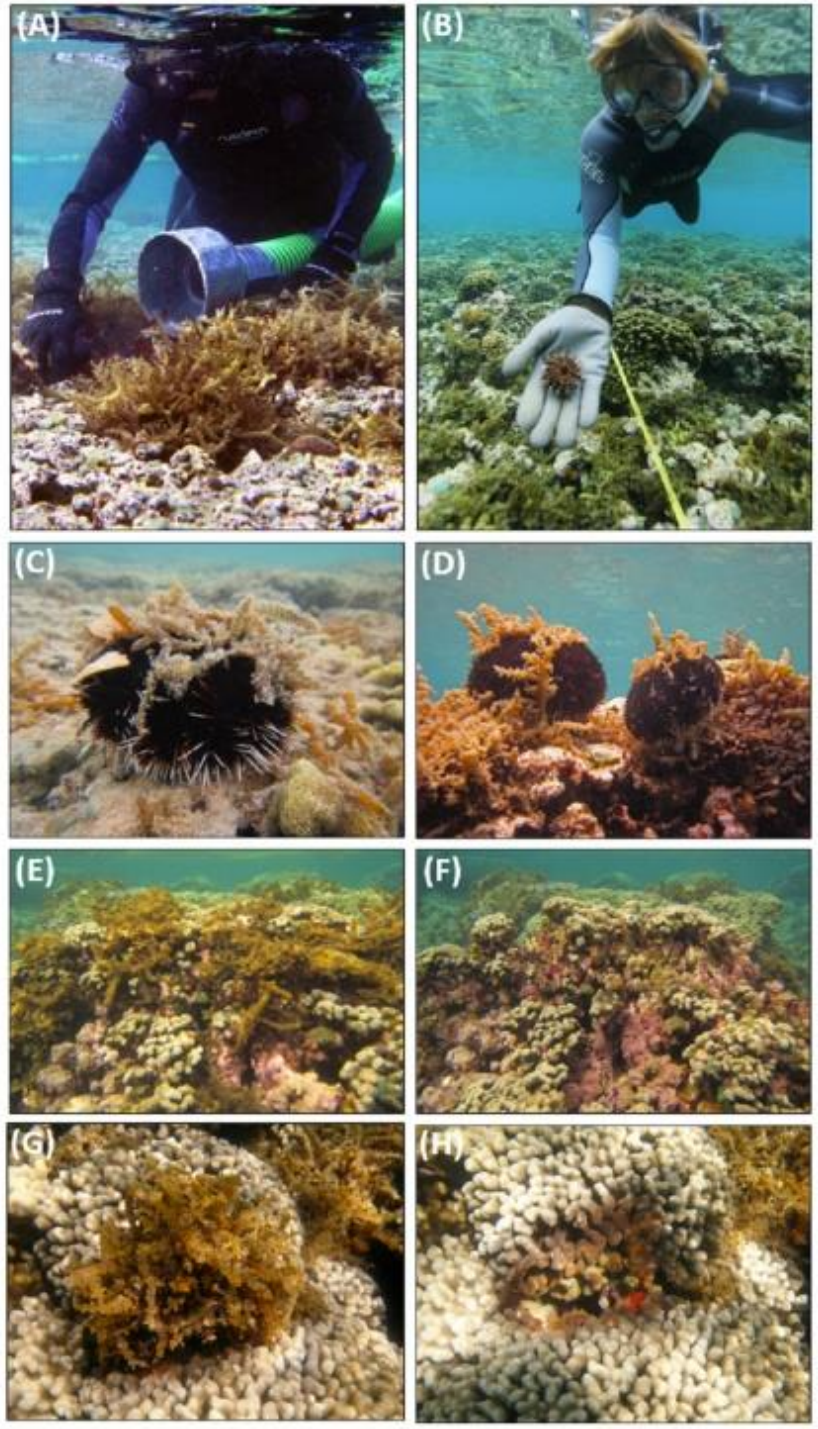
UH News » Research » Early detection system for...

UNIVERSITY of HAWAI'I® MĀNOA

School of Life Sciences PhD candidate Patrick Nichols developed a test to detect the presence of *Chondria tumuloso* DNA in the water.

https://www.hawaii.edu/news/2022/09/25/early-algae-species-detection-system/

Management Options-Control Strategies



PeerJ

Herbivore biocontrol and manual removal successfully reduce invasive macroalgae on coral reefs

Brian J. Neilson[1], Christopher B. Wall[2], Frank T. Mancini[2] and Catherine A. Gewecke[1]

[1] State of Hawai'i Division of Aquatic Resources, Honolulu, Hawai'i, United States of America
[2] Hawai'i Institute of Marine Biology, University of Hawai'i at Mānoa, Kāne'ohe, Hawai'i, United States of America

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Outline

- ~~Introduction to PMNM~~
- ~~What is *Chondria tumulosa*?~~
  - ~~Why should we care?~~
  - ~~Where is it?~~
- ~~Ecology of *C. tumulosa*~~
- ~~Theorized Vectors~~
- ~~BMPs Development & Management Actions~~

Thank You

QUESTIONS?

Brian.hauk@noaa.gov

https://sanctuaries.noaa.gov/news/sep23/nuisance-alga-new-locations.html