# Contemporary assessment of forestomach contents from Hawaiian green sea turtles (*Chelonia mydas*) in Kane'ohe Bay, Oahu

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# Hawaiian Turtles

**Green turtle**

*Chelonia mydas*

*Honu*

*Herbivorous*

*Diet: Algae and Seagrass*

**Hawksbill turtle**

*Eretmochelys imbricata*

*Honu 'ea or 'ea*

*Omnivorous*

*Diet: Sponges, algae, jellyfish, crustaceans*

**NOAA Technical Memorandum NMFS**
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**JUNE 2000**

# IDENTIFICATION MANUAL FOR DIETARY VEGETATION OF THE HAWAIIAN GREEN TURTLE *Chelonia mydas*

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## Rhodophyta (red algae)

## *Gracilaria salicornia* (C. Ag.) Dawson

**Distinguishing characteristics:** *G. salicornia* is a yellow to red alga, 2-3 mm diameter, translucent, cylindrical, and constricted at regular intervals. Tips are inflated at the uppermost end with a dent on the top, sometimes containing a small terminal section.

*G. salicornia* occurs in green turtle samples as fragments that for certain identification include typical pear-shaped sections. In cross-section there are large (100 µm) colorless medullary cells with thick cell walls (2-6 µm) that typically blend into a tangled mass. Cells are smaller toward the cortex, and large gland cells are just beneath the surface.

**Ecology:** *G. salicornia* was introduced from an unknown source location to Hilo and then to Waikiki in 1972 and to Kaneohe Bay in 1978. It grows well in the shallow, calmer parts of reef flats.

**Related species:** *Gracilaria coronopifolia* and *Gracilaria parvispora* look similar but do not have a constricted thallus, fragile branches, or prostrate growth habit.

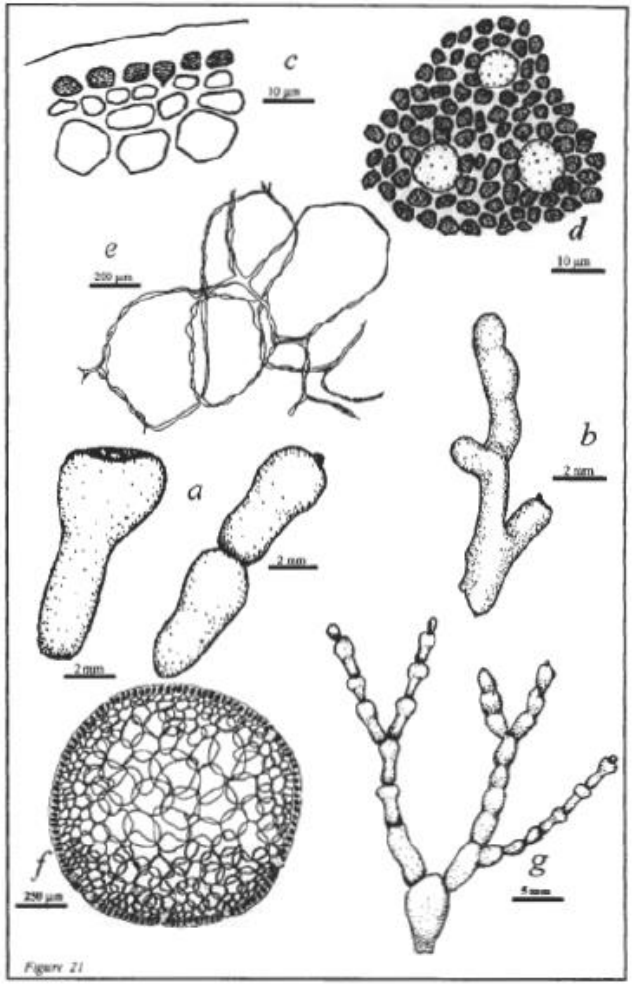



Figure 21

**Key to figure 21:** *a.* branch tip form, with small apex and indented tip *b.* branch tip variation *c.* detail of cells near the cortex *d.* surface view with larger, clear gland cells *e.* medullary cells *f.* cross-section of the thallus *g.* branching pattern

Russell, D. J., Balazs, G. H., 2009. Dietary shifts by Green Turtles (Chelonia mydas) in the Kane'ohe Bay region of the Hawaiian Islands: a 28-year study. Pac. Sci. 63 (2), 183–194.

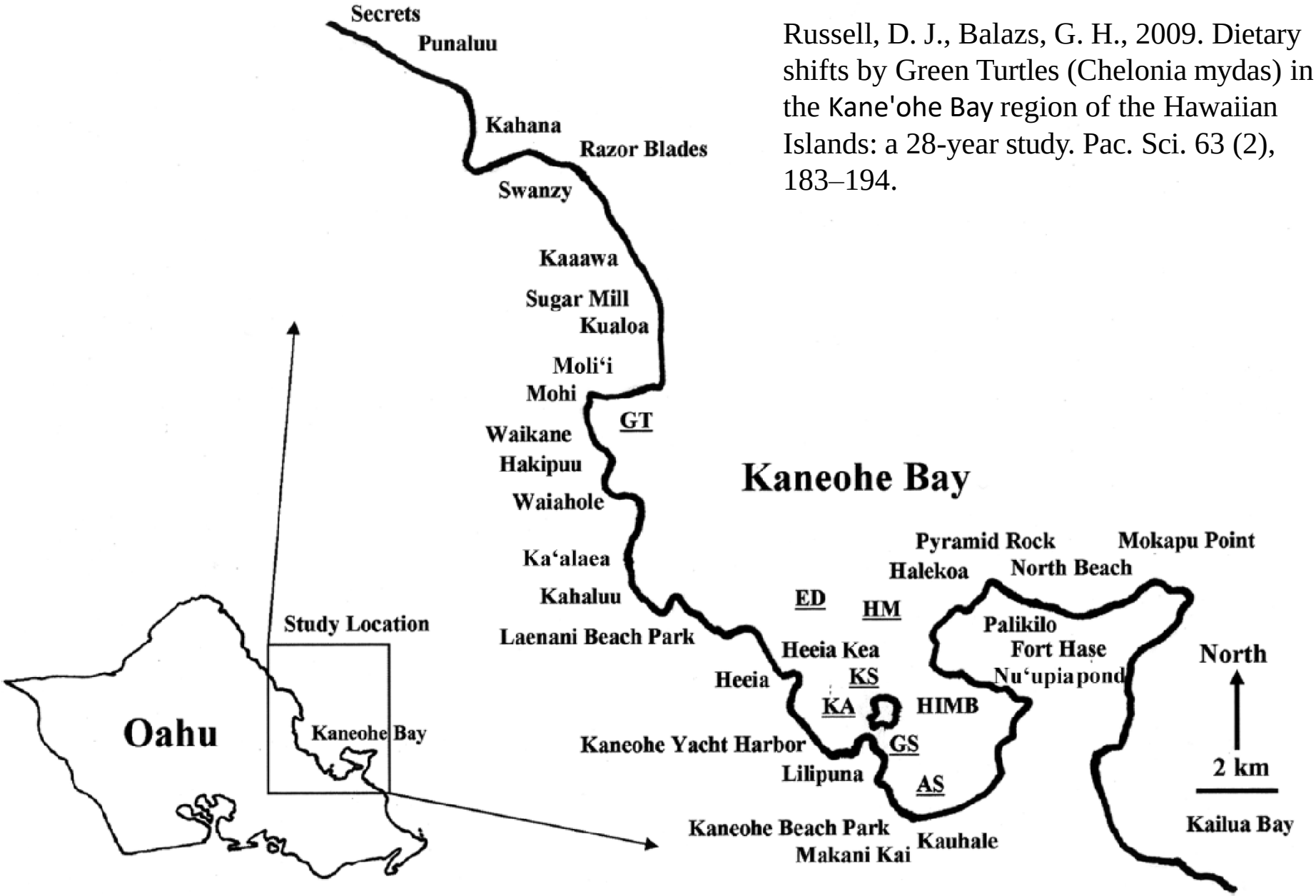



FIGURE 1. O'ahu, Hawai'i, showing the location of the study: the Kāne'ohe Bay region including adjacent shores, the locations where stranded turtles were found, and the initial locations where nonnative algae were introduced. AS, *A. spicifera;* HM, *H. musciformis;* GS, *G. salicornia;* ED, *E. denticulatum;* GT, *G. tikvahiae;* KA, *K. alvarezii;* KS, *K. striatum.*

TABLE 1

Algae and Sea-Grass Species Listed in Order of Number of Times They Were Found in Turtle Samples, Their Frequency (% Smp) in 372 Samples, and Average Percentage Amounts or Quantity (Avg %) in the Samples

| Species | No. of Times Found | % Sample | Avg %[a] (SD) |
|---|---|---|---|
| **Acanthophora spicifera* | 237 | 64.0% | 44.1% (32.8) |
| **Hypnea musciformis* | 154 | 41.4% | 42.0% (32.7) |
| **Gracilaria salicornia* | 138 | 37.0% | 40.9% (33.0) |
| *Codium edule* | 95 | 25.5% | 32.1% (30.5) |
| *Laurencia nidifica* | 88 | 23.7% | 12.5% (16.5) |
| *Codium arabicum* | 78 | 21.0% | 28.9% (30.5) |
| *Amansia glomerata* | 70 | 18.8% | 30.0% (34.1) |
| *Dictyosphaeria cavernosa* | 62 | 17.0% | 20.2% (27.6) |
| *Halophila hawaiiana* | 59 | 15.9% | 24.0% (14.3) |
| *Pterocladiella capillacea* | 57 | 15.3% | 35.5% (31.3) |
| *Dictyota acuteloba* | 50 | 13.4% | 8.5% (8.5) |
| *Lyngbya majuscula* | 49 | 13.2% | 4.0% (3.5) |
| *Spyridia filamentosa* | 49 | 13.2% | 15.7% (25.7) |
| *Dictyosphaeria versluysii* | 36 | 9.7% | 5.5% (5.8) |
| *Sargassum echinocarpum* | 36 | 9.7% | 10.9% (13.2) |
| *Halimeda discoidea* | 29 | 7.8% | 7.2% (9.6) |
| *Sargassum* sp. | 29 | 7.8% | 36.3% (32.0) |
| *Gracilaria coronopifolia* | 25 | 6.7% | 20.8% (28.9) |
| *Sargassum polyphyllum* | 25 | 6.7% | 12.6% (22.6) |
| *Valonia aegagropila* | 21 | 5.7% | 3% (2.8) |
| *Halophila decipiens* | 15 | 4.0% | 28.4% (28.8) |
| *Ulva reticulata* | 15 | 4.0% | 33.8% (40.0) |

* Indicates a non-native species

Russell, D. J., Balazs, G. H., 2009. Dietary shifts by Green Turtles (Chelonia mydas) in the Kaneohe Bay region of the Hawaiian Islands: a 28-year study. Pac. Sci. 63 (2), 183–194.

**Table 1.** The number of samples in which each algae species was found in 194 Green Turtle samples, percent of the number of samples represents only the number of samples that species was found out of the total 194 samples, average amounts (% cover with SD) is the amount of that species present as a % of cover and is an indication of possible biomass and the proportion is the combination of % of samples and the % amount. The remaining 33 species, not shown in the table, were found in only one sample, were less than 1% average amount and had <0.01 frequency out of a total of 72 species that were found in Turtle samples between (2005–2012). They were generally microscopic species and contributing an insignificant amount to the Turtle diet.

| Species | No. of Samples | % No. Smp | Avg % Amt | Proportion |
|---|---|---|---|---|
| **Acanthophora spicifera* | 137 | 71.00% | 33.7 ± 5.0 | 0.26 |
| **Gracilaria salicornia* | 130 | 67 | 54.0 ± 9.4 | 0.38 |
| *Laurencia nidifica* | 41 | 7.2 | 7.5 ± 2.3 | 0.02 |
| *Codium arabicum* | 39 | 20.1 | 16.4 ± 3.6 | 0.03 |
| *Amansia glomerata* | 37 | 19.1 | 39.2 ± 7.1 | 0.08 |
| **Hypnea musciformis* | 37 | 19 | 15.5 ± 5.9 | 0.03 |
| *Codium edule* | 34 | 17.5 | 23.2 ± 6.8 | 0.04 |
| *Pterocladiella capillacea* | 34 | 17.5 | 20.3 ± 3.5 | 0.04 |
| *Lyngbya majuscula* | 22 | 11.3 | 2.2 ± 1.0 | <0.01 |
| *Dictyosphaeria verslysii* | 16 | 8.3 | 18.6 ± 5.2 | 0.02 |
| *Halophila decipiens* | 14 | 7.2 | 40.2 ± 8.1 | 0.03 |
| *Spyridia filamentosa* | 14 | 7.2 | 0.6 ± 0.3 | <0.01 |
| *Halophila hawaiiana* | 13 | 6.7 | 47.0 ± 8.5 | 0.03 |
| ***Cladophora* sp. | 11 | 5.7 | 0.1 ± 0.1** | <0.01 |
| *Microdictyon umbellicatum* | 11 | 5.7 | 0.6 ± 0.3 | <0.01 |
| *Turbinaria ornata* | 11 | 5.7 | 6.6 ± 4.0 | <0.01 |
| *Sphacelaria* sp. | 10 | 5.2 | <0.1 ± 0.1 | <0.01 |

* Indicates a non-native species

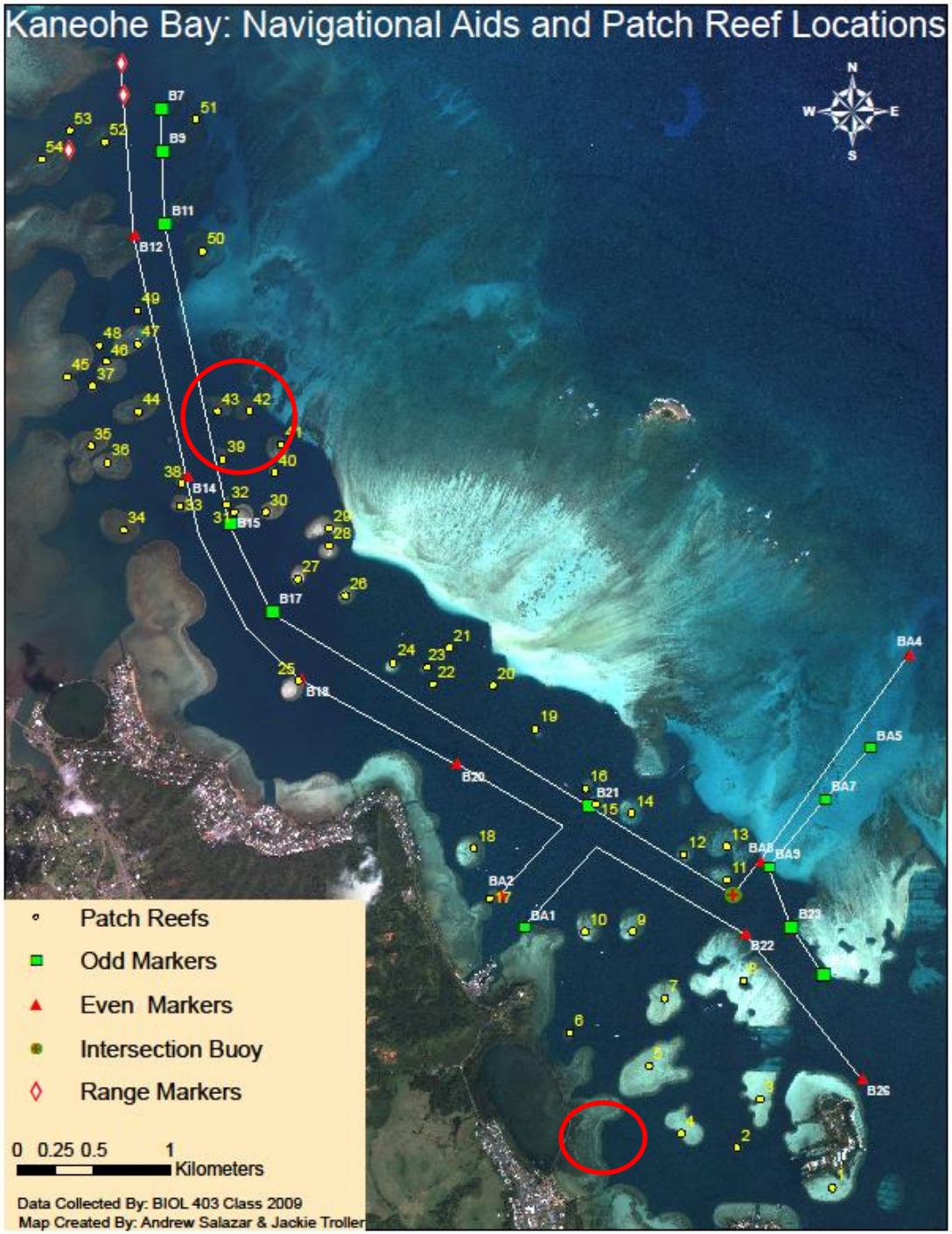
Russell, Dennis J., and George H. Balazs. "Increased use of non-native algae species in the diet of the green turtle (Chelonia mydas) in a primary pasture ecosystem in Hawaii." *Aquatic ecosystem health & management* 18.3 (2015): 342-346.

Figure 1. Green turtle, *Chelonia mydas*, feeding on *Gracilaria salicornia* in the back lagoon of Moku o Lo'e, Kāne'ohe Bay, O'ahu, Hawai'i in March 2017. Photo by KD Bahr.

Bahr, K.D., D.M. Coffey, K. Rodgers & G.H. Balazs. 2018. Observations of a rapid decline in invasive macroalgal cover linked to green turtle grazing in a Hawaiian marine reserve, *Micronesica* 2018-07, 11 pp. Published online 31 December, 2018. http://micronesica.org/volumes/2018

Capture and sampling of green turtles in March, May, and June 2019. Additional sample collected from reef north of Coconut Pier in January 2020.

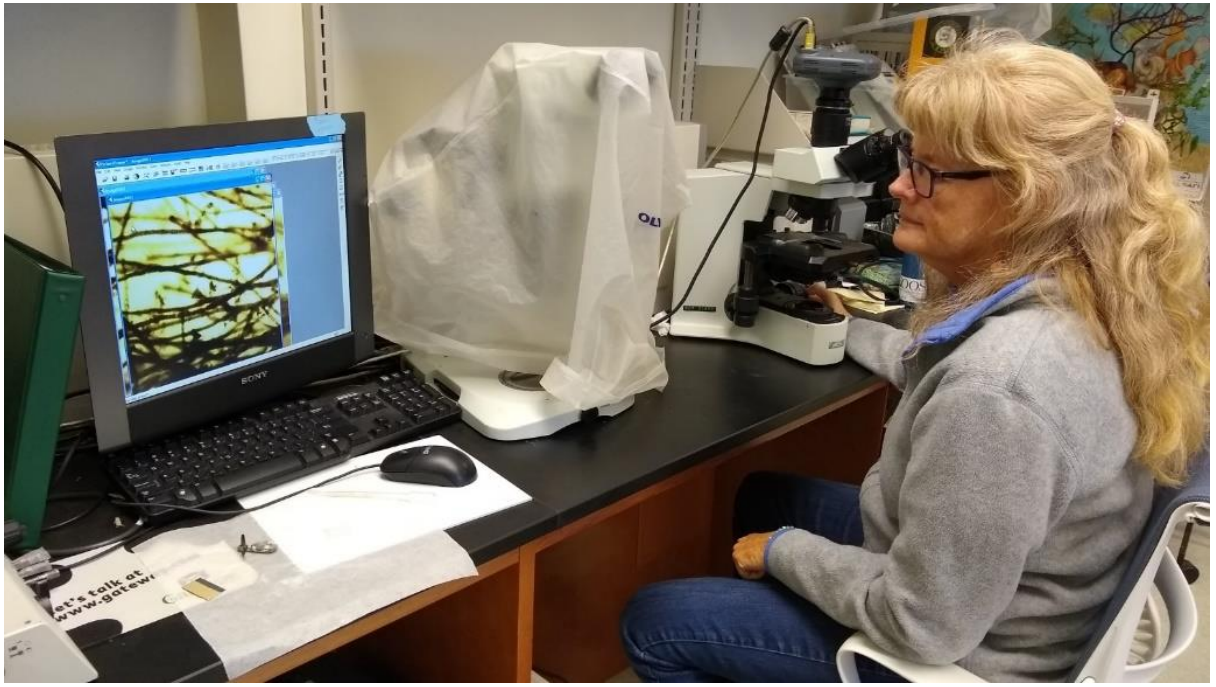
Dr. Cindy Hunter



Esophageal lavage technique

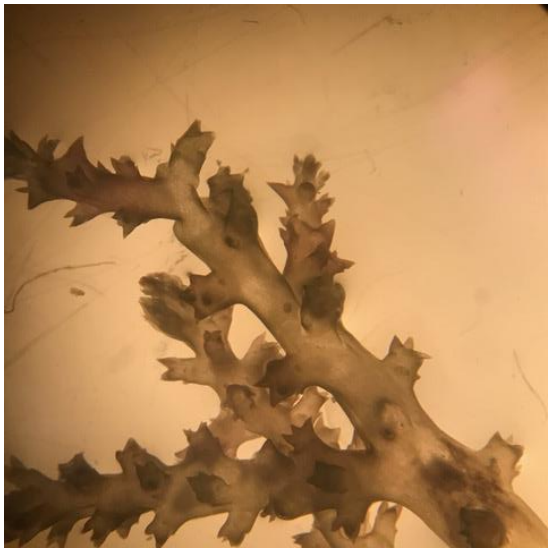
Forbes, G. A. "Diet sampling and diet component analysis." *Research and management techniques for the conservation of sea turtles. IUCN/SSC Marine Turtle Specialist Group Publication, Washington, DC* (1999): 235.

Forestomach samples collected at Reef 43, Kane'ohe Bay on 5-2-19



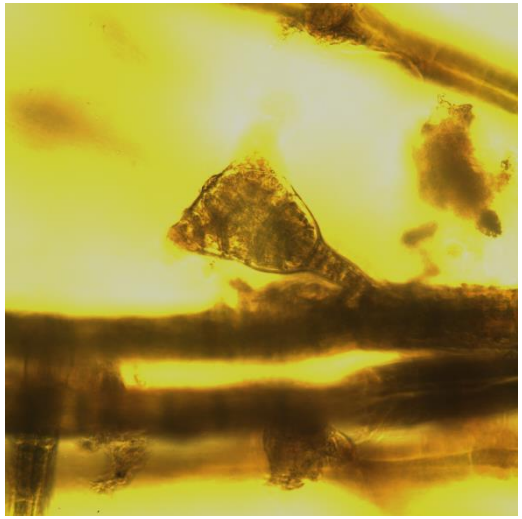
Algae identification
by Donna Brown in
Dr. Celia Smith's lab

*Gracilaria salicornia*

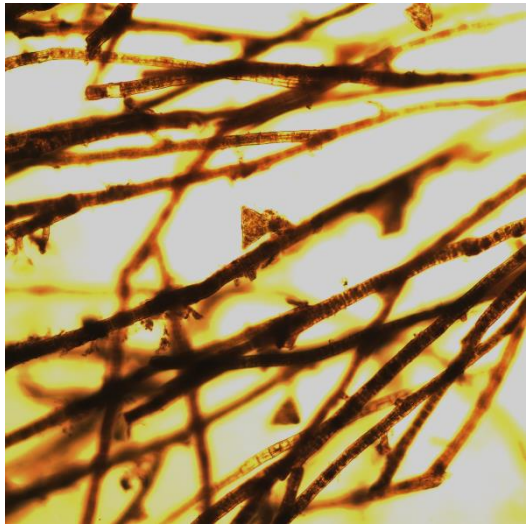


*Acanthophora spicifera*

*Halimeda discoidea*



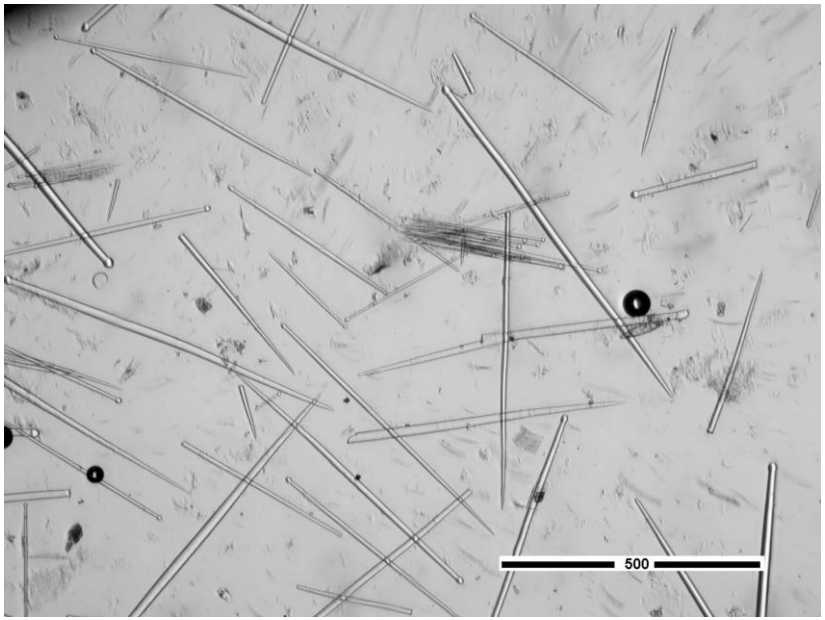
*Sphacelaria novae-hollandiae*
(turf algae)

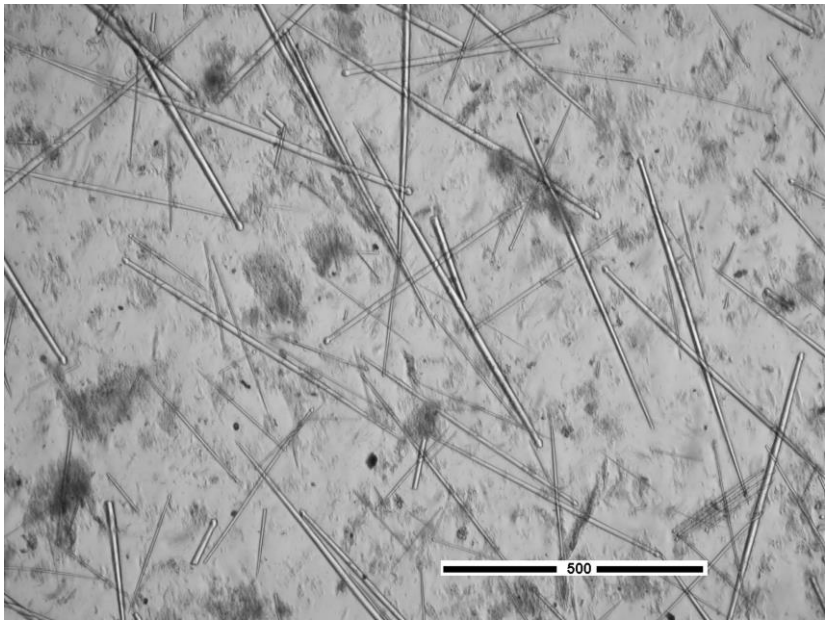


# Analysis of 5 forestomach samples from green turtles in Kane'ohe Bay

| | OA42 | OA43 | OA77 | OA78 | OA106 |
|---|---|---|---|---|---|
| Date | March 2019 | March 2019 | May 2019 | May 2019 | January 2020 |
| SCL (cm) | 78.4 | 79.4 | 91.3 | 89.7 | 64.5 |
| Location | Reef 39 | Reef 39 | Reef 42 | Reef 43 | Coconut Pier,North |
| Previously tagged | No | No | Yes East 2012 | Yes East 1992 | No |
| Forestomach contents | *G. salicornia* 98.3% | *G. salicornia* 99.1% | *A. spicifera* 52.5% | *G. salicornia* 99.1% | *G. salicornia* 94.6% |
| | *A. spicifera* 1.7% | *A. spicifera* < 1% | *G. salicornia* 24.5% | *A. spicifera* < 1% | Sponge 5.4% |
| | | Coral rubble | *H. discoidea* 22.4% | Coral rubble | |
| | | | *S. novae-hollandiae* < 1% | | |
| | | | Shell fragments | | |

Sponge identified by Dr. Christopher Kelley and Rob van Soest as *Terpios zeteki*.
Sponge was 7% of forestomach sample.



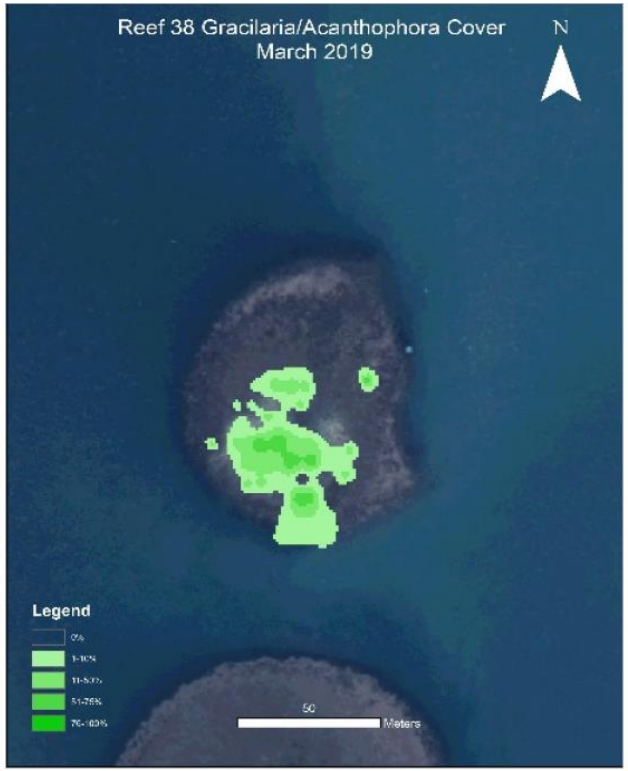



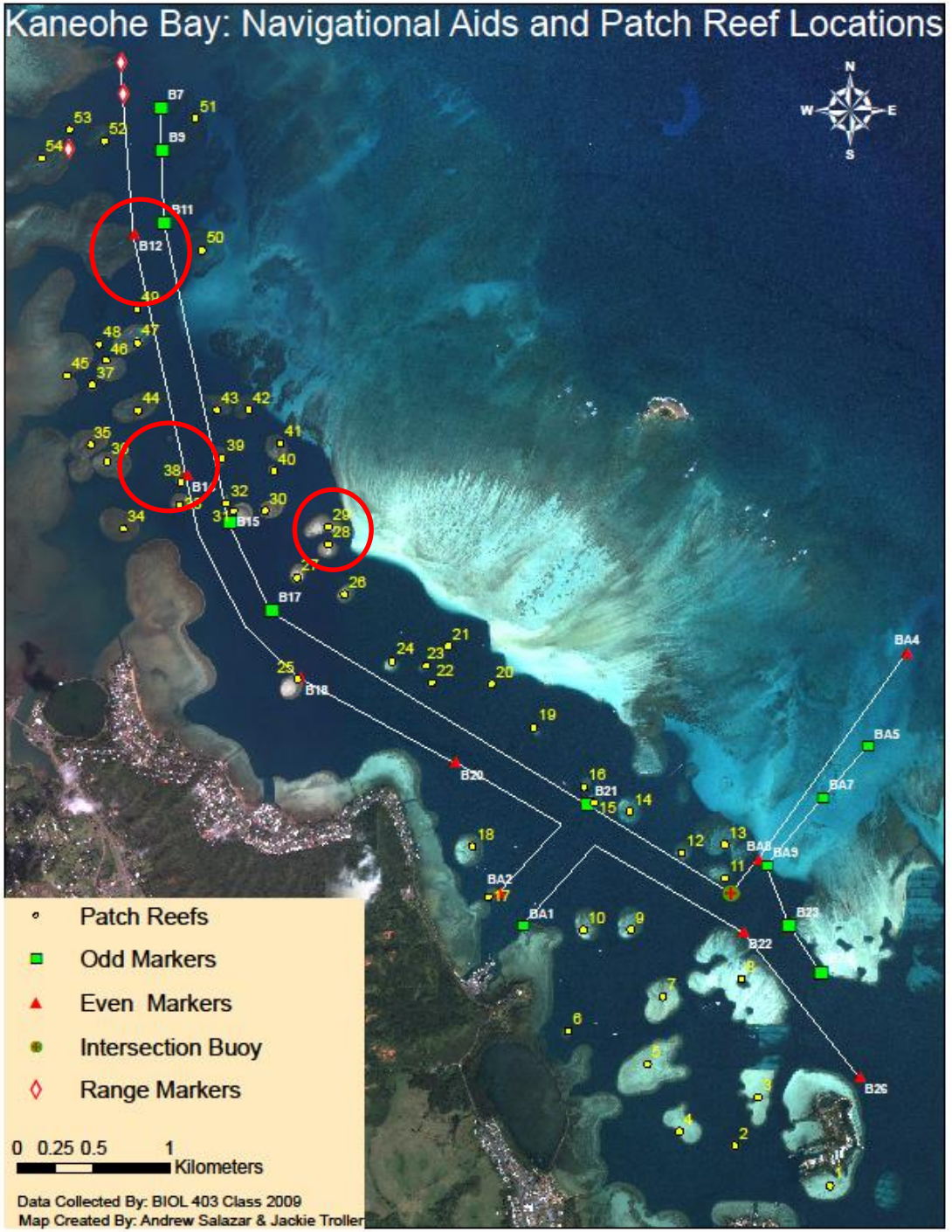
Survey data of *Gracilaria sp.* and *Acanthophora sp.* cover taken by Division of Aquatic Resources (DAR) in March 2019.

Marker 12


Reef 28


Reef 38



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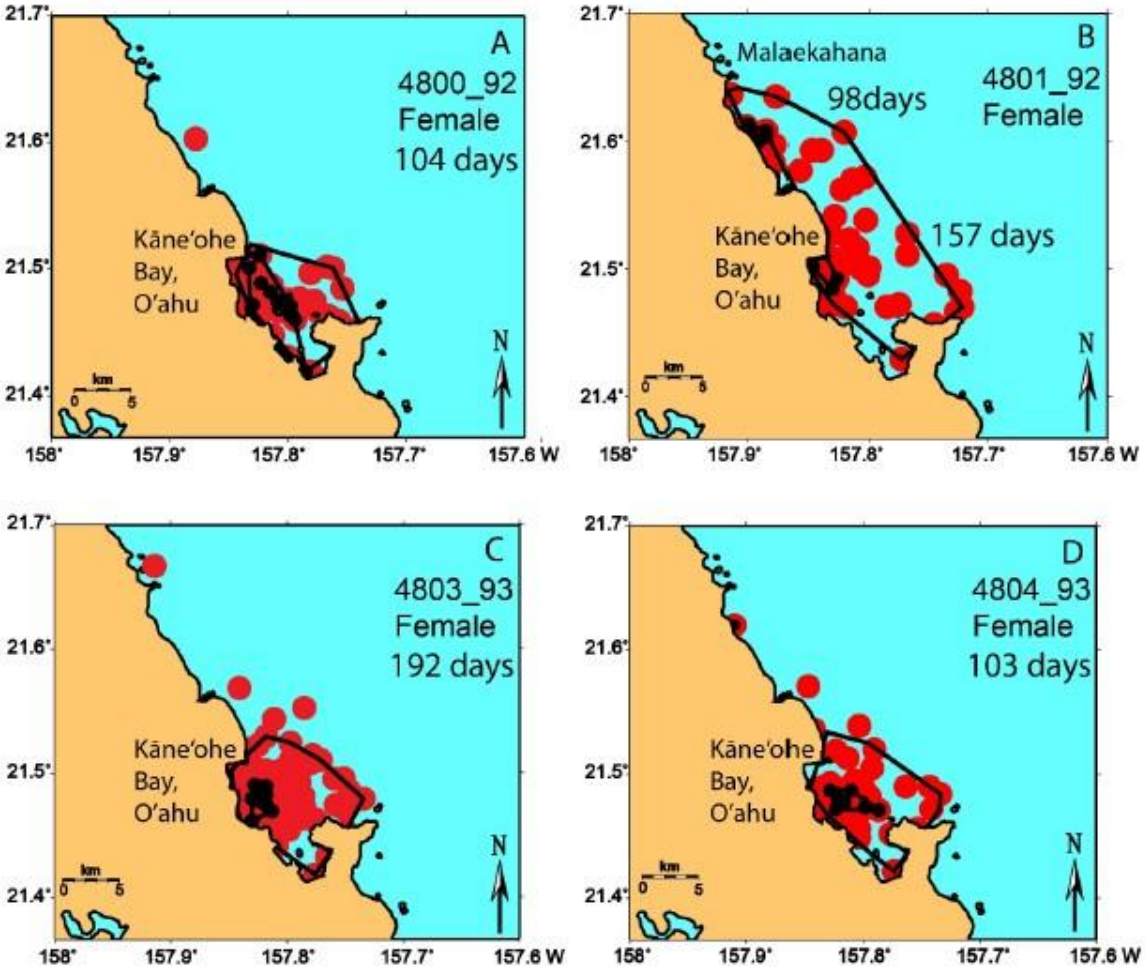


Figure 6A-D. Home ranges for four female green turtles that migrated to Kāne'ohe , O'ahu from French Frigate Shoals. Large colored circles indicate 1 km radius around each position. Black circles indicate positions with LC 1, 2 or 3 data. Black lines outline the Minimum Convex Polygons for Minimum Home Range and Full Home Range areas. Two Minimum Home Ranges are indicated for female 4801_92 in Figure 6B.

Not surprisingly, two of the largest bays in the Hawaiian Islands, Kāne'ohe (41 km2), O'ahu and Kahului (34 km2), Maui, were the destination for more than half (60%) of the 15 turtles migrating to home foraging habitats in the MHI, thereby emphasizing the conservation importance of these two residential areas for breeding adults in the Hawaiian green turtle population. Green turtles are known to occur in abundance at both locations, undoubtedly due to availability of desirable algal forage and benthic terrain providing ideal underwater refugia (Balazs et al. 1987,Brill et al. 1995, Russell & Balazs 2009)

Balazs, GEORGE H., DENISE M. Parker, and MARC R. Rice. "Ocean pathways and residential foraging locations for satellite tracked green turtles breeding at French Frigate Shoals in the Hawaiian Islands." *Micronesica* 4 (2017): 1-19.

# Moving forward and future collaborations

- Continued diet content analysis of lavage and necropsy forestomach contents
- Calculation of wet mass to dry mass ratio of individual components of forestomach contents and percentage ash, which represents inorganic content of the algae
- Satellite tracking of two turtles in Kane'ohe Bay to look at fine scale movements within their foraging habitat

# Mahalo!

## University of Hawaii

- Dr. Cindy Hunter
- Donna Brown
- Dr. Celia Smith
- Dr. Christopher Kelley

## MTBAP Team

- Dr. Summer Martin
- Dr. T. Todd Jones
- Dr. Camryn Allen
- Dr. Alexander Gaos
- Marylou Staman
- Jan Willem Staman
- Shawn Murakawa
- Alexandra Reininger
- Lindsey Bull
- Marina Praet

## Collaborating Agencies

- University of Hawai‘i
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- Hawai‘i Institute of Marine Biology
- State of Hawai‘i
  DAR – DLNR - DOCARE
- Dr. Thierry Work, USGS
- George Balazs,
  Golden Honu Services of Oceania
- Joint Institute for Marine and
  Atmospheric Research
- Hawai‘i Preparatory Academy
- Maui Ocean Center Marine Institute
- Hawai‘i Marine Animal Response
- Hanauma Bay