Dossier of Documents
for the
First Annual Workshop on
Green Turtle Diets in Hawai`i-
Food for Thought in 2020

February 10, 2020
Hawai`i Pacific University
Aloha Tower Marketplace
Campus, Honolulu, Hawai`i

HAWAI'I PACIFIC UNIVERSITY

UNIVERSITY OF HAWAI'I

USGS
science for a changing world

www.GeorgeHBalazs.com

Program for
Workshop on Green Turtle Diets in Hawai`i--
Food for Thought 2020

8:00 **Registration & Coffee**

8:45 **Welcome and *Honu* Blessing**
Brenda Jensen, Dean, College of Natural and
Computational Sciences, Hawai`i Pacific University

9:00 **Reflections**
George Balazs, Golden Honu Services of Oceania
Thierry Work, Honolulu Field Station, NWHC, USGS
Karla McDermid, Marine Science Department,
University of Hawai`i-Hilo
George Balazs 2/9/2020 Diet Workshop- Brief Introductory Reflections.

9:20 **Growth rates of green turtles at several sites on Hawai`i Island from 1995-2018**
Marc Rice and Laura Jim,
Hawai`i Preparatory Academy, Kamuela, Hawa`i
Marc Rice and Laura Jim 2/9/2020 Diet Workshop Presentation (Shown by Thierry Work)- Growth Rates of Green Turtles (*Chelonia mydas*) at Several Sites on Hawaii Island from 1995-2018.

9:40 **Contemporary assessment of forestomach contents from Hawaiian green sea turtles in Kane`ohe Bay**
Shandell Brunson, Biology Department,
University of Hawai`i-Manoa
Shandell Brunson 2/9/2020 Diet Workshop Presentation- Contemporary Assessment of ForeStomach Contents from Hawaiian Green Sea Turtles in Kane'ohe Bay, Oahu.

10:00 **What's in the gut? Insights into the gastro-intestinal microbiome in the Hawaiian green turtle**
Ronald Kittle, Biology Department,
University of Louisiana at Lafayette
Ronald Kittle III 2/9/2020 Diet Workshop Presentation- What's in the Gut? Insights into the Gastrointestinal Microbiome in the Hawaii Green Turtle.

10:20 **Break for 20 Minutes**

10:40 **Eutrophication, invasive algae, and green turtle fibropapillomatosis**
Migiwa Kawachi, Botany Department,
University of Hawai`i-Manoa
Migiwa Kawachi 2/9/2020 Diet Workshop Presentation- Eutrophication, Invasive Algae, and Green Turtle Fibropapillomatosis.

11:00 **Changes in the benthic algal community in Kane`ohe, O`ahu and the possible role of green turtles**
John Stimson, Zoology Department,
University of Hawai`i-Manoa
John Stimson 2/9/2020 Diet Workshop Presentation- Thirty Years of Changes in the Benthic Algal Community in Kaneohe Bay, and the Possible Role of Green Sea Turtles.

11:20 **Observations of a rapid decline in invasive macroalgal cover linked to green turtle grazing at the Moku o Lo'e Marine Reserve**
Ku'ulei Rodgers, Hawai`i Institute of Marine Biology
Ku'ulei Rodgers 2/9/2020 Diet Workshop Presentation- Observations of a Rapid Decline in the Invasive Macroalgae *Gracelaria salicornia* associated with Chelonia mydas Grazing in the Moku O Lo'e Marine Reserve.

11:40 **Green turtles on the move for food: newly found foraging grounds in the Nu`upia Ponds, Marine Corps Base Hawai`i Kane`ohe Bay**
Lance Bookless, United States Marine Corps
Lance Bookless 2/9/2020 Diet Workshop Presentation- Green Turtles on the Move for Food: Newly Found Foraging Grounds in the Nu'uipa Ponds, Marine Corps Base Hawaii.

12:00 **No Host Lunch and Group Photo**

1:00 **Invasive algae management in the State of Hawai`i**
Kimberly Fuller, Division of Aquatic Resources,
Hawai`i Dept. of Land and Natural Resources
Kimberly Fuller 2/9/2020 Diet Workshop Presentation- Invasive Algae Management in the State of Hawaii.

1:20 **Exploring patterns of foraging by Hawaii green sea turtles on *Gracilaria salicornia* in Kane`ohe Bay**
Cindy Hunter, Biology Department,
University of Hawai`i-Manoa
Cynthia Hunter 2/9/2020 Diet Workshop Presentation- Exploring Patterns of Foraging by Hawaiian Green Sea Turtles on Gracilaria salicornia in Kaneohe Bay.

1:40 **Implications of plastic ingestion by green turtles**
Jennifer Lynch, National Institute of Standards and Technology at Hawai`i Pacific University, Makapu`u Point
Jennifer Lynch 2/9/2020 Diet Workshop Presentation- Implications of Plastic Ingestion by Green Turtles.

2:00 **Break for 10 Minutes**

2:10 **Food for Thought Discussion Session**
ALL INVITED TO PARTICIPATE!

4:15 **Closing Remarks**
Brenda Jensen, Dean, College of Natural
and Computational Sciences, Hawai`i Pacific University

Dis-moi ce que tu manges, je te dirai ce que tu es.
Tell me what you eat, and I will tell you what you are.

Anthelme Brillat-Savarin 1826

First Announcement

First Announcement

Large green turtles voraciously foraging during the daytime on the inter-tidal native red limu, *Pterocladiella capillacea*.

First Annual Workshop on Green Turtle Diets in Hawaii- Food for Thought in 2020

An all-day workshop will be convened to explore the historical transition and current status of the Hawaiian honu (green turtle) foraging ecology and potentials for future conservation-related research and management actions. A series of relevant presentations will be given by invited speakers. A moderated panel discussion will take place in the afternoon to address several key topics to arrive at useful conclusions and recommendations. Everyone in attendance will have the opportunity to give input and ask questions. The workshop is designed to attract the interests of researchers, students, resource managers, and the general public. All are welcome. The entire day of attendance is desirable, but not required.

Monday February 10, 2020

8:30am-4:30pm

Aloha Tower Marketplace

Hawai'i Pacific University

HAWAI'I PACIFIC UNIVERSITY

Invited Speaker Invitation

Request to be an Invited Speaker at the First Annual Workshop on Green Turtle Diets in Hawaii:

On behalf of my co-conveners, I would like to invite you to be a speaker at the "First Annual Workshop on Green Turtle Diets in Hawaii--Food for Thought in 2020" on Monday, February 10, 2020 at Aloha Tower Marketplace Campus of Hawaii Pacific University in Honolulu. We would be honored if you would give a 15-minute presentation to share your past or current research, knowledge, experiences, and/or observations involving green turtle foraging ecology or the marine plants in their diet. We have identified some important topics you may wish to consider in deciding what you would like to speak on, as follows:

✳ Nonnative algae and non-traditional items in the current diets of Hawaiian green turtles;

✳ Possible effects of toxicants in the green turtle diet;

✳ Foraging pasture carrying capacity, slow growth rates, and poor body condition in some Hawaiian green turtles;

✳ Implications of plastic ingestion by green turtles;

✳ Green turtle microbiome, diet, and health;

✳ Impacts of climate change on green turtle forage food;

but would welcome other topics you propose, as well.
We request that you let us know of your acceptance on or before December 6, 2019.
Looking forward to seeing you in February!

Sincerely, Karla McDermid

Workshop Conveners and Steering Committee Members:
Karla McDermid, Marine Science Department, UH Hilo
Brenda Jensen, Dean of the College of Natural and Computational Science, HPU
Thierry Work, Wildlife Disease Specialist, Honolulu Field Station, NWHC, USGS
George Balazs, Golden Honu Services of Oceania- www.GeorgeHBalazs.com

Open Invitation to Everyone

"Food for Thought in 2020"- A Workshop on Green Turtle Diets in Hawaii- February 10th at Hawaii Pacific University's Aloha Tower Campus- Everyone Welcome to Attend

Dear Friends and Colleagues: The 1st Annual Workshop Food for Thought- Diets of Green Turtles in Hawaii is just nine days away from convening on February 10th. Please see the web site below- Registration is Free- and indeed you don't even have to register, just show up at the door, sign in, and receive a program for the day. However, we do encourage you to join us for lunch- you can select your lunch choice on the web site and conveniently pay by credit card.

https://www.hpu.edu/cncs/green-turtle-diet-symposium.html

If you have interests, - professional or casual, - in Hawaii's honu the green sea turtle, then this is the workshop for you.

If you have interests, professional or casual, in alien invasive non-native algae in Hawaii, then this is the workshop for you.

If you are a federal or state manager, or NGO, with interests in both of the above, then this is the workshop for you.

Along with this message we are providing easy access to some background papers relevant to the workshop. Please find below links to 20 publications ranging in time from 1961-2018. Simply click on the link to bring up the full paper. We realize no one will want to read and digest all 20. So, you may pick and choose to browse a few, or, just read the half-page Abstract that appears on the first page of each paper. This is for your convenience; you will be perfectly fine attending the workshop even if you don't look at a single paper.

Please recall that the workshop is intended to include a broader spectrum of the Hawaii community- and not simply confined to scientists, researchers, and managers.

Looking forward to seeing and greeting you! Please share this message with others as a way to raise awareness of the workshop.

Sincerely, Your Conveners and Steering Committee Members,

Brenda Jensen, Dean of the College of Natural and Computational Science, HPU
bjensen@hpu.edu

Karla McDermid, Professor, Marine Science Department, UH-Hilo
mcdermid@hawaii.edu

Thierry Work, Wildlife Disease Specialist, Honolulu Field Station, NWHC, USGS
thierry_work@usgs.gov

George Balazs, Golden Honu Services of Oceania- www.GeorgeHBalazs.com
itsahonuworldinhawaii@hotmail.com

LINKS to 20 Papers Relevant to the Workshop:

Doty (1961) Acanthophora, a possible invader of the marine flora of Hawaii. PS.

Russell and Balazs 1994. Colonization by the alien marine alga Hypnea musciformis in the Hawaiian Islands and its utilization by the green turtle. Aquatic Botany.

Russell and Balazs (2000) Identification Manual for Dietary Vegetation of the Hawaiian Green Turtle.

Smith et al. (2002) Distribution and reproductive characteristics of nonindigenous and invasive marine algae in the Hawaiian Islands. PS.

Balazs and Chaloupka (2004) Spatial and temporal variability in somatic growth of green sea turtles resident in the Hawaiian Archipelago.

McDermid, Stuercke and Balazs (2007) Nutritional composition of marine plants in the diet of the green sea turtle in the Hawaiian Islands. Bulletin of Marine Science.

Arthur and Balazs (2008) A comparison of immature green turtle diets among seven sites in the main Hawaiian Islands. Pacific Science.

Russell and Balazs (2009) Dietary shifts by green turtles in the Kaneohe Bay region of the Hawaiian Islands. Pacific Science.

Wabnitz, Balazs, Beavers, Bjorndal, Bolten, Christensen and Hargrove (2010) Ecosystem structure and processes at Kaloko Honokohau, focusing on the role of herbivores, including the green turtle in reef resilience. MEPS.

Van Houtan, Hargrove and Balazs (2010) Land Use, macroalgae, and a tumor-forming disease in marine turtles. PLoS One

Russell, Hargrove and Balazs (2011) Marine sponges, other animal food, and nonfood items found in digestive tracts of the herbivorous marine turtle in Hawaii. Pacific Science.

Van Houtan, Smith, Dailer and Kawachi (2014) Eutrophication and the dietary promotion of sea turtle tumors. PeerJ.

LINKS to 20 Papers Relevant to the Workshop (continued):

Russell and Balazs (2015) Increased use of non-native algae species in the diet of the green turtlle in a primary pasture ecosystem in Hawaii. AEHM.

McDermid, Lefebvre and Balazs (2015) Nonnative Seashore Paspalum Consumed by Hawaiian Green Sea Turtles: Evidence for Nutritional Benefits. Pacific Science

Balazs et al. 2015. A review of the demographic features of Hawaiian green turtles. Chelonian Conservation and Biology

Kittle and McDermid (2016) Glyphosate herbicide toxicity to native Hawaiian macroalgal and seagrass species

McDermid, Jha, Rice,and Balazs (2018) Of Turtles and Trees: Nutritional Analysis of Tree Heliotrope leaves Consumed by Green Turtles in Hawaii. Micronesica

Bahr, Coffey, Rogers and Balazs (2018) Observations of a rapid decline in invasive macroalgal cover linked to green turtle grazing in a Hawaiian marine reserve. Micronesica.

Kittle, McDermid, Muehlstein and Balazs (2018) Effects of glyphosate herbicide on the gastrointestinal microflora of Hawaiian green turtles. Marine Pollution Bulletin.

Jung et al. (2018) Polymer identification of plastic debris ingested by pelagic-phase sea turtles in the Central Pacific. Environmental Science & Technology.

Take-Home Points from Participants

A Qualifying Message:

Twenty responses were received, shown as follows, to the request for feedback and take-home points sent to the 61 workshop participants. The objective was to gauge the way folks perceived the messages of the workshop. Please note that some scientific inaccuracies may be present in the following. It is envisioned that any points of misunderstanding and disagreement can be taken up in future workshops, either as more data become available or better ways to communicate the science are devised. What has been done here is to simply remove the respondents' names and provide the unedited version of what was received. I am proud and pleased by the sincere and positive responses compiled here providing ample "Food for Thought" to address in the future. – George Balazs – Dossier Compiler

Respondent 1

1) There is a great need to continue research on the long-term conservation of these magnificent creatures, and with advances into molecular technologies allowing more cost-efficient techniques to be available- researchers can address many threats and issues that the green turtle faces.
2) This workshop had an integrative approach with many stakeholders, community members, and multi-level agencies. This was very well-done and I hope more are in the future, and maybe incorporate Hawaiian cultural practitioners or more indigenous points of views to attend and give oli or similar chant/blessings in person.
3) Many of the talks allowed collaborative discussions with one another to bounce ideas and looked into where the "future" could be headed into pockets of research knowledge that needs to be expanded or developed.
4) More knowledge of what is being done to other islands should be addressed, maybe have more talks on other islands/ highlights on what's being done with collaborators on other islands if they cannot present.
5) Some NOAA officials with the Papahanaumokuakea Marine National Monument were in attendance and could maybe give a talk about the population in NWHI- what are they eating/challenges they face vs main Hawaiian Islands. Maybe even having something from an educator's standpoint, how can we effectively communicate information on green turtle diets to the community/what's being done to educate Pre-K to grade 12+ in education facilities (public, private, or informal science education). Or have a collaborative team to design/brainstorm ideas for curriculum development for outreach. Could be a great alleyway for this.
6) Where do we see the future of the green turtle? Their diets? Do you think climate change may impact their food resources/availability? The meeting focused a lot on one invasive food resource, what about others?

Respondent 2

I really enjoyed this workshop and I learned a lot from it. I hope there will be more in the future!

1) Is there more emancipated turtles on the Kona coast due to lack of nutrient content for algae growth...if we compare to the east side of the island, there is a lot more runoff. Do turtles prefer their foraging grounds to have more nutrients?
2) Are there other researchers/organizations looking at forestomach contents of green sea turtles in Hawai'i besides in Kane'ohe Bay? I enjoyed Shandell's master's thesis project. I would like to see her conclusion in the next diet workshop.
3) For presenters, it would be best to present their work assuming that there will be some people there that have little to none scientific knowledge. I overheard a few people that didn't know what some presenters were talking about.
4) I remember George mentioning later in the workshop that we can't assume arginine in algae promotes the herpes virus...why is that? I would like to know more on George's take-home on Migiwa Kawachi's presentation.
5) What are other algae species that turtles don't prefer other than *Dictyosphaeria cavernosa*? Can we look at other locations besides Kane'ohe Bay and Kona coast?
6) In areas that we are seeing less macroalgal cover and a higher turtle population, is it okay to assume that there is a connection?
7) For a future workshop, it would be interesting to get an insight of a Hawaiian ethnobotanist...I remember someone mentioned a "limu honu."
8) Is adding urchins to remove algae the best option? Can we substitute for a herbivore fish?
9) Is it possible to look at other algae species other than *Gracilaria salicornia*?
10) Plastic ingestion is a hot topic ~ I think it is important to have at least one presentation about plastic in future workshops.

Respondent 3

One of the most surprising things I learned about GST diets is that pelagic plastic pollution (small pieces of floating plastic) does not harm GSTs in their juvenile, pelagic stage of life, when they are riding the currents in the open ocean. In fact, the more plastic bits they had in them, the healthier they were. Up to 200 small pieces of plastic were found in some healthy juvenile GSTs. One possible explanation is that the pelagic mollusks and other organisms that GSTs eat need to live on something floating, and little pieces of plastic are ideal. Thus, the more plastic a turtle eats, the more actual food they get as well. And the plastic appears to pass through their digestive systems without harming them--no perforations, obstructions, or torsions. In contrast to small pelagic floating plastic, fishing gear and other marine plastics do have an adverse impact on GSTs and other marine life, particularly in coastal waters. This from Jennifer Lynch's presentation titled "Implications of plastic ingestion by green turtles".

Several presentations had to do with GST diets in Kaneohe Bay, and 2-3 of these directly addressed the interplay between GSTs and the invasive seaweed Gorilla ogo (*Gracilaria salicornia*). The bottom line is that GSTs appear to LOVE eating *Gracilaria* and have sought out areas in Kaneohe Bay where it grows and then nibble it down to near non-existence. What good news! An energetic invasive that is a treat to GSTs!

One slide I remember showed a map with the location of 3 Maui sewer injection wells, and the location of major algal blooms nearby the wells. Discussion centered on the impact on GSTs and possible engendering of fibropapilloma in GSTs.

Contrary to the GSTs in Kaneohe Bay, which appear to be thriving, many of the turtles along the Kohala Coast are not doing so well, with stunted growth. Discussion centered around carrying capacities, migration of GSTs, and what GSTs appear to be eating.

Respondent 4

The workshop was so informative, visual and engaging! I learned so much about *Gracilaria salicornia*, plastic ingestion and Big Island turtles.
Thank you so much for coordinating this event. I was honored to be included.

Respondent 5

I think the workshop is great in that it provided information to an audience that would otherwise be excluded from attending conferences due to cost (students and non-profits). The speakers provided excellent talks that were in "plain language" and laying out their projects from the issues or questions they encountered, how they tackled the issue and what the outcomes were. The workshop agenda also brought together individuals for networking and re-bonding.

Respondent 6

Neither one of us has a science background but both share a sincere interest in the honu. With that said, here are a few thoughts and reflections on the workshop.

Perhaps the most interesting idea we picked up from the seminar is that there is actually confirmed evidence that the consumption of plastics does not seem to harm turtles to near the extent that we were led to believe through media accounts of the situation. We personally see the logic to how other things ingested may actually be the more serious culprits in this situation.

It's also interesting that the nutritional value of invasive algae as opposed to indigenous algae is being called into question. We have to wonder if the pollution of the waters in the Kaneohe Bay area is damaging the quality of the algae or is it the proliferation of lower quality invasive algae that causes the problem.

During a break that day, Joe approached Thierry with a question. Joe told him that years ago he had read that Big Island Greens, due to a substantial shortage of edible algae, sometimes reverted to omnivorous behavior of their early years to keep from starving. Thierry indicated there was really no evidence of that and for whatever reason, Joe failed to ask him if he had a theory on why.

Over the ten years of our involvement with Malama na Honu, we have always been under the impression that the quality of the algae species growing off Laniakea is healthy. After listening to so many reports on diet and related issues, we naturally are curious about the extent to which invasive algae has infiltrated the North Shore waters and specifically Laniakea.

We appreciate all of your efforts and expertise as you continue to study sea turtles. We look forward to attending next year's Second Annual Seminar!

Respondent 7

First off, mahalo nui for inviting me to the turtle workshop. Maika'i, excellent job pulling that together and I enjoyed the presentations which I was able to hear. I hope it's an annual affair and you consider broadening the topics for participation. Regarding the topics covered I must ask myself if we are seeing a product of protection success and reaching carrying capacity in some of the grazing areas. I know just a fast forward 30 yrs from the time I stopped working in the bay with you and NMFS until today where I dive once or twice a week I see many more turtles in areas I almost never saw them before. Much fewer with tumors, all good signs to me. The talks on gorilla ogo and how they were grazed down nearly completely around HIMB and off the base was somewhat surprising to me. I have to think if that occurred in the time frame it did the bay is in trouble of being over grazed and we'll see nutritional deficiencies like we see on the big island in the coming years. I think protection, limiting of gillnets (much more restrictive) like of predation and reduced tumors (healthier population) may be a dual edged sword.

I also note there is much less, or basically none of that black filamentous algae we'd see floating along when if got windy and rough. Not sure if it's been replaced or gone due to grazing as well. I guess the question is are we at a point where we need to have limited take? Will we see more large predators in kbay and interactions with humans like tourists one day? Should there be a relocation plan, to areas around the state perhaps under grazed? More study on turtle energetics and actually how much they eat?

Respondent 8

Thanks very much being able to participate in this workshop, you did an excellent job of putting it on. I appreciated the information on turtles and their invasive algal diets. Apologies for not getting back to you all sooner. I have attached my take aways and look forward to incorporating the new information I gained from this workshop when thinking about invasive algae issues.

1. HPA growth study: Turtles in Hilo are starving, turtles in Kona are healthy. Not being a turtle biologist- I learned that as adults green sea turtles will stay in the same general foraging grounds even if they are not getting enough food on Hawaii Island. Is this true elsewhere?
2. Forestomach contents: Green Sea Turtles in Kaneohe eat a lot of invasive algae. The question I have is that because of algal composition in the Bay or is it preference? Are there gut content studies in other areas with different algal composition?
3. Eutrophication, invasive algae and fibropapilomatosis: In certain conditions invasive algae consumption MAY be linked to fibropapilomatosis due to the presence of higher levels of arginine.
4. Green Sea Turtles in KBAY: *Gracilaria* cleared in a short amount of time, plenty of turtles exploiting foraging areas they have not been seen in before and congregating in numbers that have not been observed.
5. Turtles play a role in invasive algal cover! Might be interesting to overlay algae data with turtle presence in areas besides Kaneohe Bay. Are there current turtle numbers for all shores/ islands?
6. Plastic ingestion: Turtles eat a lot of plastic, but it doesn't appear to be killing them outright. Marine debris does kill turtles by entanglement, so it is still bad.

Respondent 9

The one take home point would be that we still need more investigation into what green turtles are eating and at what level, if any harm is occurring with them long term. While we know the Greens are eating the invasive algaes, what impact will that have they eat it all; what will they turn to next. I was surprised to find they cleaned out all the red algae (*Spyridia*) near our smaller culverts; a species of algae that had not been identified as palatable to Green turtles. Does this mean the Green turtle population is getting so large that finding a food source has become critical to them?

Respondent 10

- Marc Rice: HPA's sea turtle research program has been doing a great job tracking turtles for a long time (> 30 yrs !?). Great model for other schools.

- Shandell Brunson: Maybe I can help her algae ID. Donna Brown from our lab is helping her, but Donna is on Maui but I'm on Oahu :)

- Kuulei Rodgers: Green turtles removed much of *G. salicornia* in Kaneohe Bay within 30 days - did they remove whole plants? Regrowth rates?

- Lance Brookless: What are the turtles doing there?? Would like to check the benthic community.

- Kimberly Fuller: Avrainvillea control using hot water in Maunalua Bay

- Cindy Hunter: Possible collaboration with UH Marine Biology undergrad summer BIOL 403 course

- Jennifer Lynch: Effects of plastic ingestion not as bad as we have expected. Plastic can be used for detox???

Thank you so much again for the opportunity! Hope to see you again soon.

Respondent 11

These are not take-home points, but questions generated by what I have heard at the meeting and read in preparation.
1) Given the apparent importance of turtles in controlling the abundance of alien invasive macroalgae, it would be great if there were further research at a variety of sites on: the number of turtles, their condition factor, their growth rates and their diets. This is particularly important because of the issue of whether turtles have reached carrying capacity at some sites.
2) Given that turtles at some sites are showing signs of food shortage, it would be good to have behavioral studies of their movements among sites, and how they disperse in the course of movements unrelated to breeding. Are there maps showing the movements of tagged turtles here in Hawaii?. I know they ask for reports of tagged turtles. Has the data been plotted?
3) If there is size distribution data for turtles in the main Hawaiian islands in recent years, does it show there has been recent heavy recruitment which could account for the spread of turtles into southern Kaneohe Bay and the associated drastic reduction in Gracilaria salicornia cover.

Respondent 12

1. In many places on the leeward coast of the Hawaii Island growth rates of juvenile and sub-adult green turtles is very slow.

2. In some areas, growth rates are higher and the turtles look more robust that our typical leeward turtles. (turtles inhabiting the Hilton Lagoon and Honokohau Harbor for example).

3. When we transported three Kiholo turtles to Honolulu and fed them a high protein, enhance diet their growth rate increase more than 3X.

4. The Mauna Lani captive juveniles are growing at a rate of more than 1 cm/month on a pelletized diet.

Take away for me is that, in all likelihood, the slow growth rate is the result of insufficient forage.
Often, the obvious answer chosen to justify this situation is that there are too many grazers. The other side of the coin could just as well be that algal growth is insufficient... lower or of poorer quality than in the past. We have seen such a situation in Kahalu'u, Hawaii Island where turtles used to be commonly seen feeding on the shallow rock bench. There are far fewer turtles in the bay now and hardly any foraging on the rock bench. Recent work on the concentrations of

Oxybenzone in the park waters has shown very high values which could point to that and other sunscreen chemicals causing the decline in algal growth and, consequently, a decline in the number of turtles.

Respondent 13

1) We need to learn more about how green turtles shape natural macroalgal communities, not just *Gracilaria salicornia* populations.
2) We need to add sites of study on each island, so we have more comparisons to make with Kaneohe Bay.
3) We need to compare the GI microbiomes of green turtles, both healthy and stranded, in different habitats, eating different diets, and exposed to different stressors.
4) We should try to use metagenomic methods to identify the macroalgae in the GI tracts of green turtles from different sites. This might be a better more accurate method to identify crop samples!
5) We need to test whether arginine acts as a trigger or suppressor for specific GI tract bacteria whose role in the microbiome is linked to immune system health in green turtles.

Respondent 14

Turtles provide indirect benefits to the coral reefs by feeding on invasive algae.

The green sea turtle is underestimated in their role in shaping Hawaiian coral reefs and may be more important than once expected.

Respondent 15

My take-home points from the turtle conference are:

- Green sea turtles may be reaching carrying capacity along the Kona coast of Hawai‘i Island.

- Plastic ingestion in GSTs happens primarily during the pelagic years but does not necessarily indicate a negative impact since the GSTs with the highest amount of plastic were also the heaviest. This perhaps suggests that plastic may be consumed with prey items attached, or better foragers just accumulate more plastic.

- GSTs have learned to eat non-native algae and may have a regulatory effect in keeping these algae from taking over. This presents a management conundrum in removing these algae since we may be removing a GST food source.

- Herpes virus growth in GSTs is fueled by excess consumption of arginine, which is stored by algae in response to excess Nitrogen from agricultural runoff or waste.

- It is very challenging to sample the gut biome of a live GST.

- Fibropapiloma is a primary health concern for GSTs in Hilo watershed.

- GSTs, through consuming invasive algae, may be responsible for spreading it since it can take three weeks for algae to clear the digestive tract.

- Perhaps the loss of East island at FFS is not necessarily a bad thing since GSTs may be reaching carrying capacity in parts of the archipelago.

Respondent 16

I was unable to attend entire workshop, but my take home point is: "What is it about Kona coast exactly that is not conducive to turtle growth (e.g. nutritional content of algae? type or amount of algae? all?
A take home point presented was that arginine in invasive algae promotes herpesvirus growth and tumor development in Hawaiian green turtles. However, another perspective of this is available here: https://peerj.com/preprints/539.pdf

Respondent 17

I think a take-home message that was mentioned in the panel discussion was to branch out to other areas around the islands outside of the focus of Kaneohe Bay.

Respondent 18

1) Plastics do not belong in the ocean and they kill sea turtles, mainly through entanglement, not ingestion.
2) Pelagic green sea turtles ingest large quantities of plastic, they rarely die from this.
3) Neritic green sea turtles in nearshore Hawaiian foraging grounds ingest little plastic.
4) Implications of ingestion in pelagic green sea turtles are not evident.

Respondent 19

1. West Coast of Big Island Turtles.
Has anyone done surveys of the area to determine insufficient food source or are turtles not foraging there because algal species is not preferred?

2. What's in the gut?
Is there a method to obtaining gut samples on live turtles to get a better understanding on how their digestion is working? Could this then help determine any issues concerning an ill turtle?

3. Fibropapillomatosis.

Has there been further studies in the areas mentioned to see if the problem still persists today? Increase of decrease? Will invasive species of algae such as *Hypnea* and *Acanthophora* need to be tested for high contents of arginine in other injection sites on Maui or can it be assumed they have it?

4. Observations of a rapid decline in invasive macroalgal cover...

If turtles are seeding new grounds of *Gracilaria* in Kaneohe Bay, would it be possible to obtain stool samples to confirm there are remnants that remain so that seeding is possible? Can algal cells even survive the digestion process to repopulate?

5. Green Sea Turtles on the move for food...

Has Nu'upia Ponds been surveyed for algal cover and can Shandell and her team obtain lavage samples from the current turtle population to see what they are foraging on? If the stomach contents do not match what's in the ponds, it would be evident that the turtles are leaving the pond to forage and returning to relax.

6. Discussion at the end (Things to work on/find out)

a. Identify native algal species and their abundance. What are their challenges/tolerances?

b. Need to focus more on our own areas. A lot of studies have been conducted in Kaneohe Bay. What about Maui, Kauai, and Big Island?

c. Lots of talk about removing alien species of algae from certain areas, but maybe we must look into replacing those sites with native species.

d. Since some invasive species have been correlated with higher occurrences of FP, maybe introducing native species for turtles to forage on would help them recognize it and would benefit them from not contracting FP?

Respondent 20

1) The dietary change by green turtles in Hawaii from native to alien algal species started occurring decades ago and has been documented and made well-known through several journal publications.

2) Do green turtles 'seed' new areas of alien algal growth by consuming and expelling undigested/partially digested algal particles during their short- and long-range movements? Expulsion of algal particles in the feces is well-known by Hawaiian green turtles.

3) The paramount question that evolved during the workshop seemed to be- How many post-pelagic phase green turtles can Hawaii's coastal neritic foraging areas support? The question seems to have already been answered de-facto in that government funds have facilitated and/or promoted removal and reduction of those alien algae known for many years to be major forage for Hawaii's green turtles.

4) The best available published information indicates there are currently too many turtles for neritic habitats of the main Hawaiian Islands to support in a manner that fosters reasonable somatic growth, body condition, and well-being (e.g. Wabnitz et al. 2010; Balazs and Chaloupka 2004).

5) Published literature on green turtle growth rates in Hawaii shows that in the 1970s/early 1980s, when turtles were far fewer in number, faster somatic growth occurred than it does presently.

6) Has an Environmental Assessment (EA) or Environmental Impact Statement (EIS) ever been considered or prepared on the removal of alien algae consumed by Hawaii's green turtles? This question is important considering that the sub- population (Central North Pacific DPS) is listed and protected as a Threatened Species under the US Endangered Species Act and State of Hawaii Endangered Species law.

7) There exists a voluminous body of unpublished data on Hawaii's green turtles, including aspects of diets, that is freely available to students and others that may wish to use for research and publication (for guidance see Balazs and Work 2015).

8) All researchers of green turtles and dietary algae in Hawaii need to do more in disseminating their findings timely to others- including especially to the general public of Hawaii. The news media needs to do more in facilitating this process; in spite of several News Releases about the workshop no members of TV, radio or newspaper media attended.

Request for Take-Home Points

Dear Attendees- We have created this Group Mailing Attendee List as a means to easily communicate with you. We congratulate you once again for coming and contributing to the workshop. There is now one final item we as Conveners wish you to help us with, as a last task of this year's workshop.

We ask that each of you please send us your Take-Home Points, to a maximum of 10 per person. Of course, fewer than 10 is perfectly fine- we chose 10 as a cap because there were 10 presentations. However, that doesn't mean you need to provide a Take-Home Point for each presentation. It is your choice. You may do as many as 10, or you can do as few as one total. The Take-Home Points should preferably be in bullet form, or a sentence or two at most. Take-Home Points can be things you learned and felt were of high significance to the workshop theme, and/or things needing addressing that were given exposure/discussed during the workshop. When we compile this list we will likely not attach the person's name with the Take-Home Points or Point contributed.

We are setting a cut-off date of February 22 (next Saturday) for receiving your Take-Home Points- a week from today. So ideally you should check your notes soon, refresh your memory, and send your Take-Home Points to us in the next few days. The more days that pass the more difficult this will be- since (like us) other things will be on your mind.

Lastly, you may send your Take-Home Points to the Mailing Group for everyone to see, Or, you can send them to me (gb) for distribution to Karla, Thierry and Brenda.

And lastly, please know we are doing the above in two separate groupings- the Presenters/Conveners, and, All Other Attendees. So, a separate mailing group request has been sent to the Presenters requesting exactly the same as we are asking of you the Attendees with the same deadline date of February 22.

With Appreciation
George, Karla, Brenda and Thierry
itsahonuworldinhawaii@hotmail.com

Attendees of the First Annual Workshop on Green Turtle Diets in Hawaii convened at Hawaii Pacific University on February 10, 2020. Photo by Andy Collins.