Eutrophication, invasive algae, and green turtle fibropapillomatosis

February 10, 2020

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Workshop on Green turtle diets in Hawaii

Green turtle fibropapillomatosis

Van Houtan et al. (2014) PeerJ 2:e602


Van Houtan et al. (2010) *PLoS ONE 5 (9)*

Fibropapillomatosis

- Tumor forming disease
- First reported in 1958 in HI
- Chelonid herpesvirus 5 (ChHV5)
- Not found in pelagic juvenile
- Higher disease rate found in regions with eutrophication
- Cause was unknown

Van Houtan et al. (2010)

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PLoS one

Land Use, Macroalgae, and a Tumor-Forming Disease in Marine Turtles

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Abstract

Wildlife diseases are an increasing concern for endangered species conservation, but their occurrence, causes, and human influences are often unknown. We analyzed 3,939 records of stranded Hawaiian green sea turtles (*Chelonia mydas*) over 28 years to understand fibropapillomatosis, a tumor-forming disease linked to a herpesvirus. Turtle size is a consistent risk factor and size-standardized models revealed considerable spatial and temporal variability. The disease peaked in some areas in the 1990s, in some regions rates remained constant, and elsewhere rates increased. Land use, onshore of where the turtles feed, may play a role. Elevated disease rates were clustered in watersheds with high nitrogen-footprints; an index of natural and anthropogenic factors that affect coastal eutrophication. Further analysis shows strong epidemiological links between disease rates, nitrogen-footprints, and invasive macroalgae and points to foraging ecology. These turtles now forage on invasive macroalgae, which can dominate nutrient rich waters and sequester environmental N in the amino acid arginine. Arginine is known to regulate immune activity, promote herpesviruses, and contribute to tumor formation. Our results have implications for understanding diseases in aquatic organisms, eutrophication, herpesviruses, and tumor formation.

Citation: Van Houtan KS, Hargrove SK, Balazs GH (2010) Land Use, Macroalgae, and a Tumor-Forming Disease in Marine Turtles. PLoS ONE 5(9): e12900. doi:10.1371/journal.pone.0012900

Editor: Simon Thrush, NIWA, New Zealand

Received May 6, 2010; **Accepted** August 23, 2010; **Published** September 29, 2010

Funding: The authors have no support or funding to report.

Competing Interests: The authors have declared that no competing interests exist.

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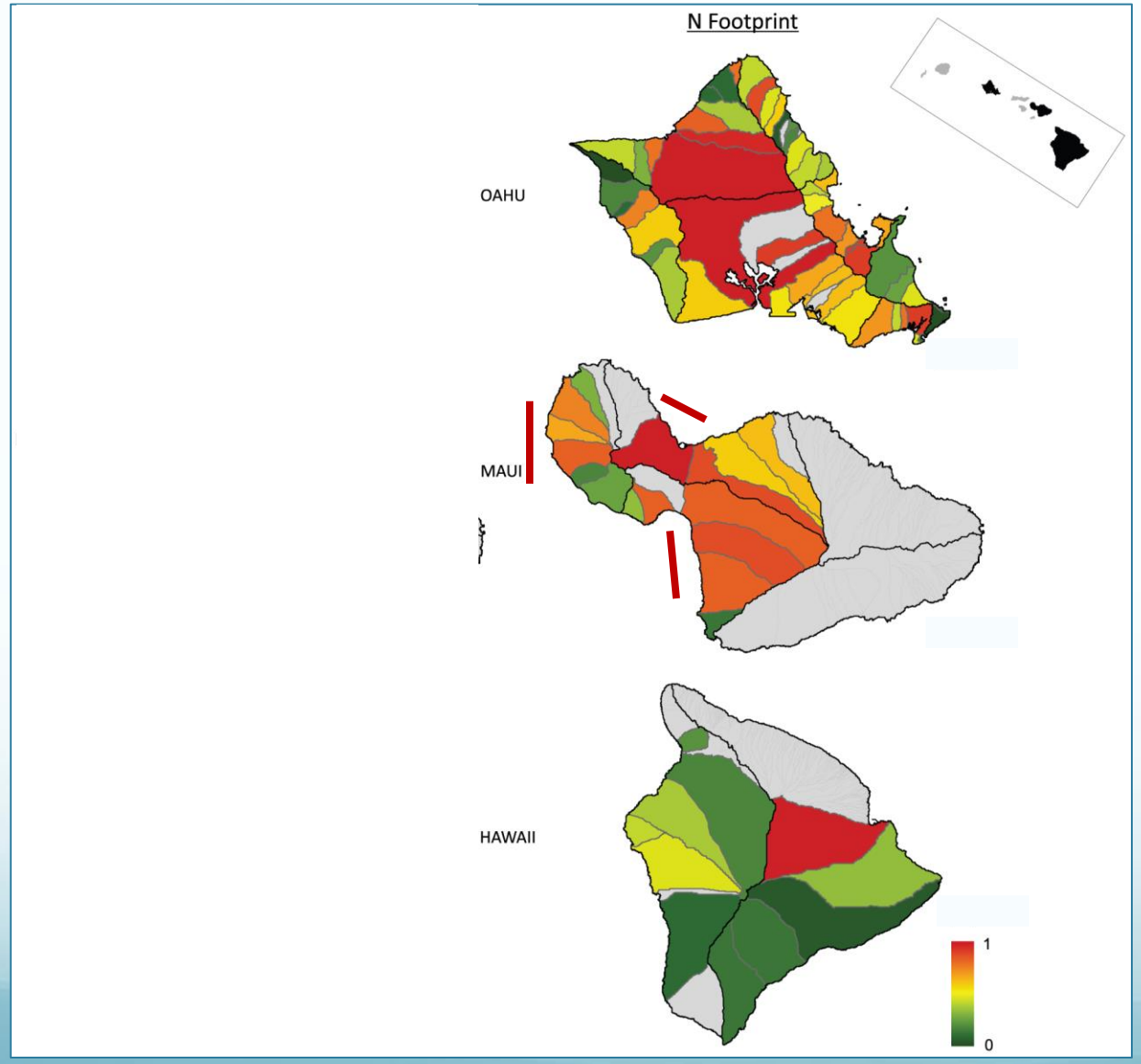
Nutrient input and disease rate



Algae bloom

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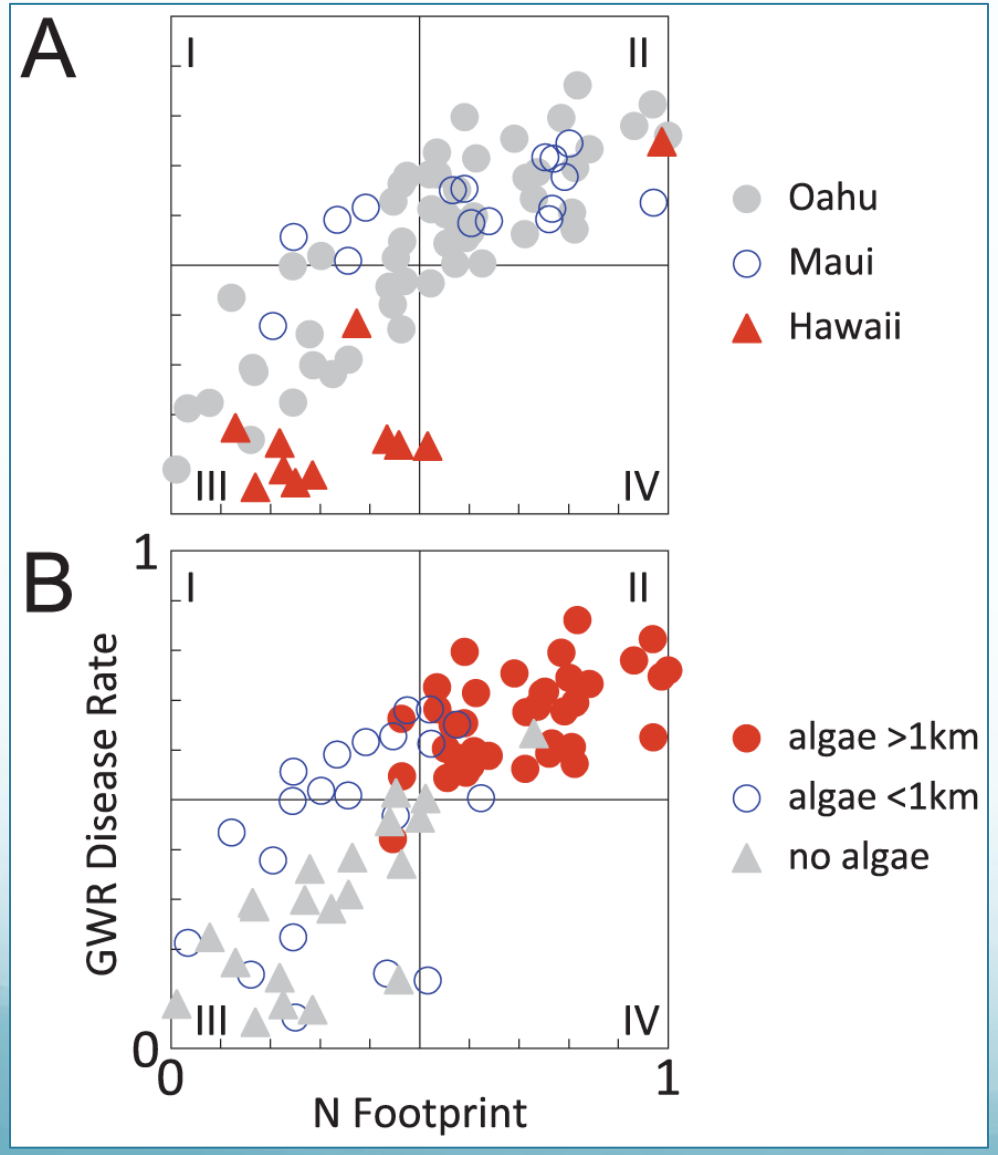
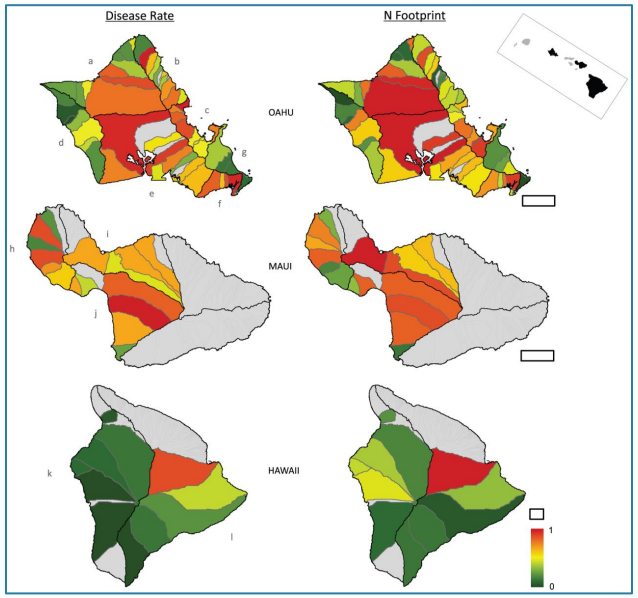
Disease rate and invasive algae blooms





- Disease rates are higher where invasive algae are found
  - *Hypnea musciformis*
  - *Gracilaria salicornia*
  - *Acanthophora spicifera*

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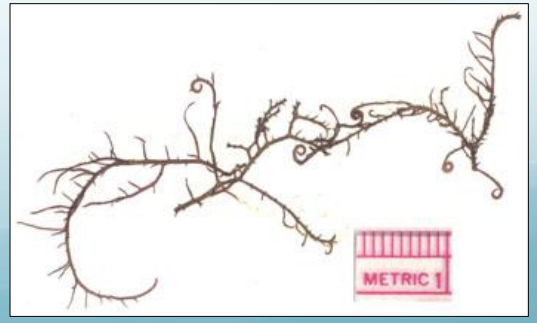
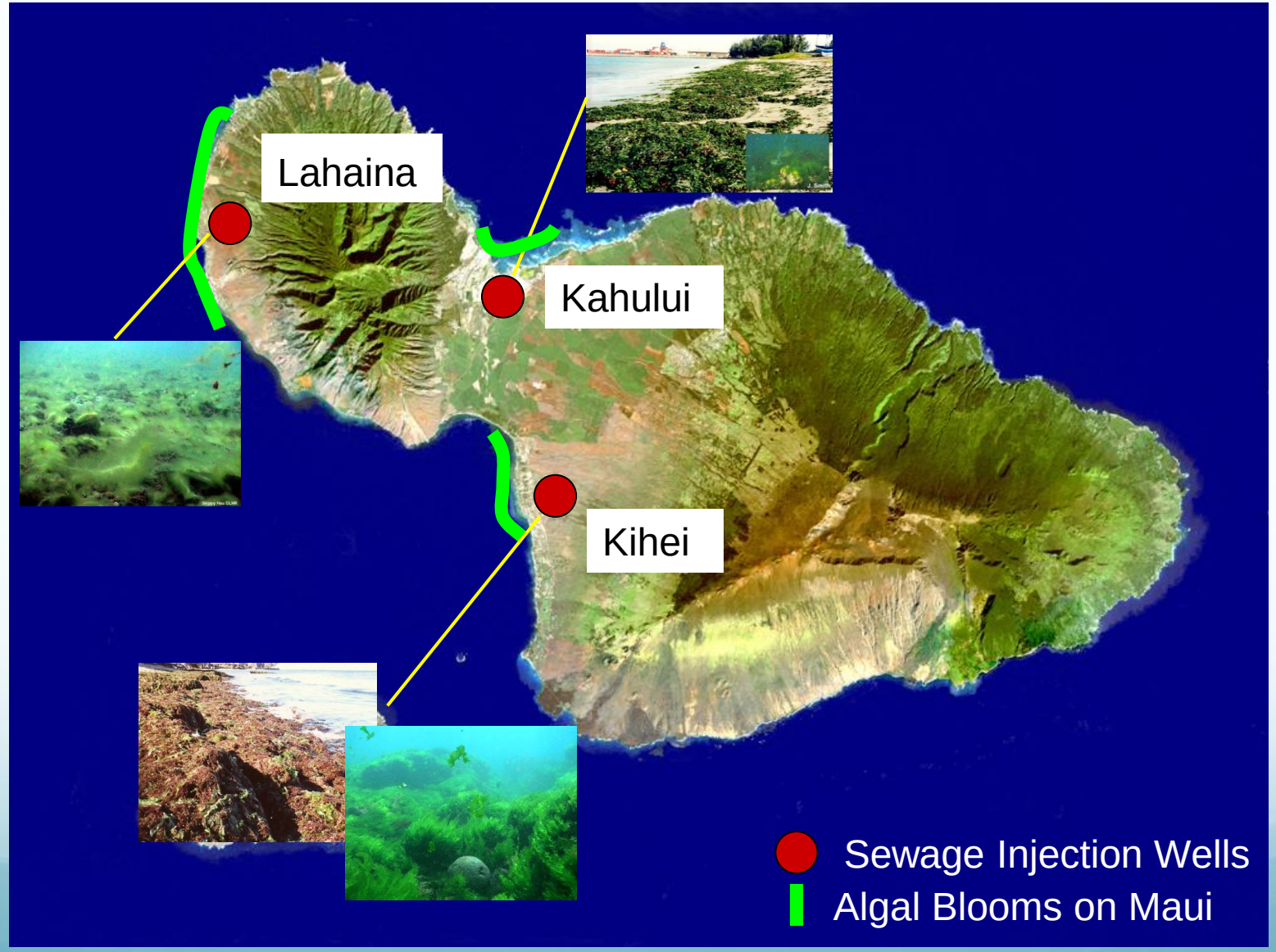
Diet shifts to alien algae

- By early 1990's, *Acanthophora spicifera* and *Hypnea musciformis* became major bloom algae and major food sources for green turtles
- By early 2000's, *Gracilaria salicornia* was established in diet



Eutrophication and algal blooms



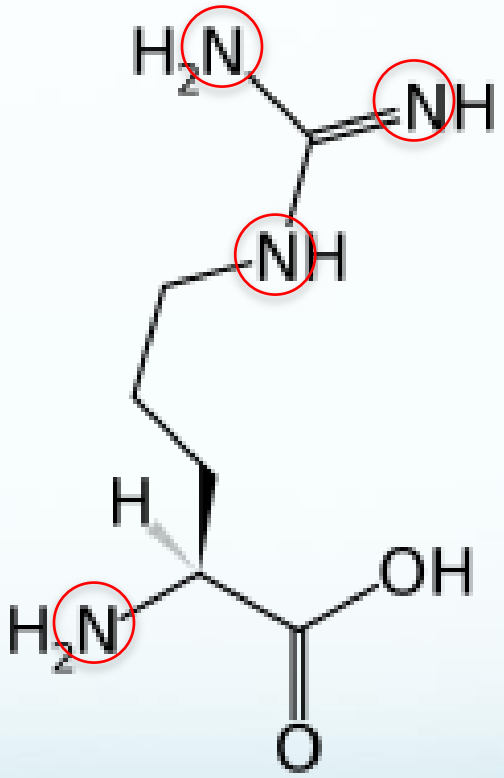
Arginine content in algae

Species	Site	Eutrophic	Arg (% dry weight)
Codium hawaiiense	Midway	No	0.14
Codium reediae	Kanahā, Maui	Yes	0.28
Ulva lactuca (*fasciata*)	Māʻalaea, Maui	Yes	1.26
Ulva lactuca (*fasciata*)	Papaʻiloa, Oʻahu	Yes	0.74
Acanthophora spicifera	Kaneʻohe Bay, Oʻahu	Yes	0.17
Amansia glomerata	Leleiwi, Hawaii	No	0.41
Gracilaria salicornia	Kaneʻohe Bay, Oʻahu	Yes	0.18
Hypnea musciformis	Kanahā, Maui	Yes	2.23
Hypnea musciformis	Laniākea, Oʻahu	Yes	1.87
Pterocladiella capillacea	Punaluʻu, Hawaii	No	0.46

Excerpt from McDermid et al. (2007)

Luxury consumption

- Plants store excess environmental N in **arginine**
  - Arginine is the only tetra-amine amino acid (4 N in one molecule)



Arginine, herpesvirus, and fibropapillomatosis

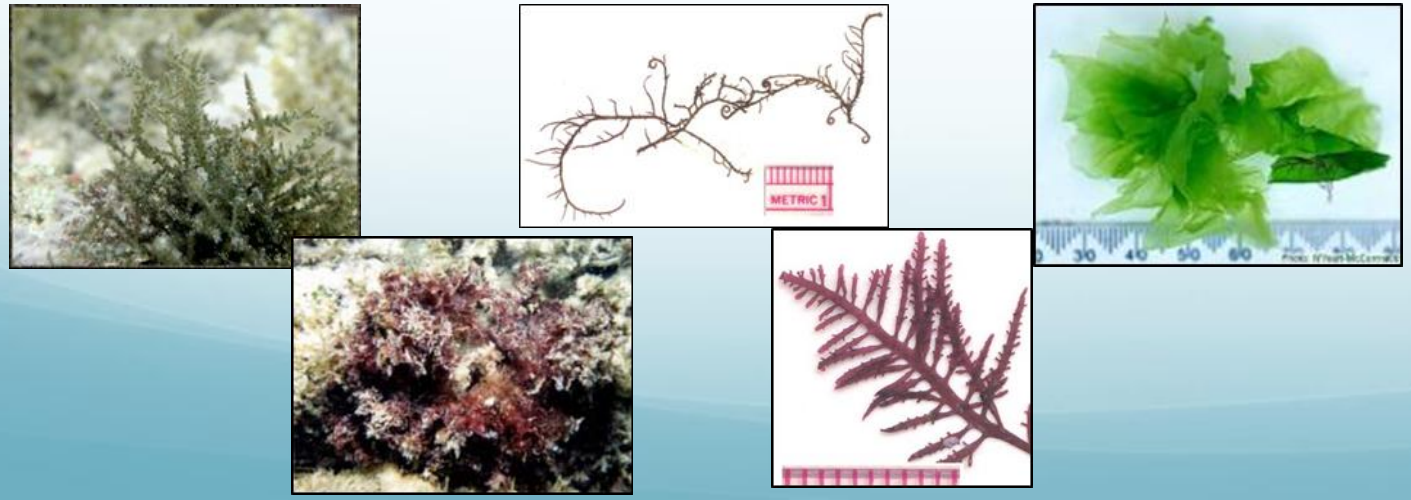
- Arginine promotes herpesvirus growth
- Some invasive algae in eutrophic region seem to have higher arginine levels because of the luxury consumption
- Green turtles in eutrophic region eat algae enriched with arginine
- Herpesvirus growth in turtles

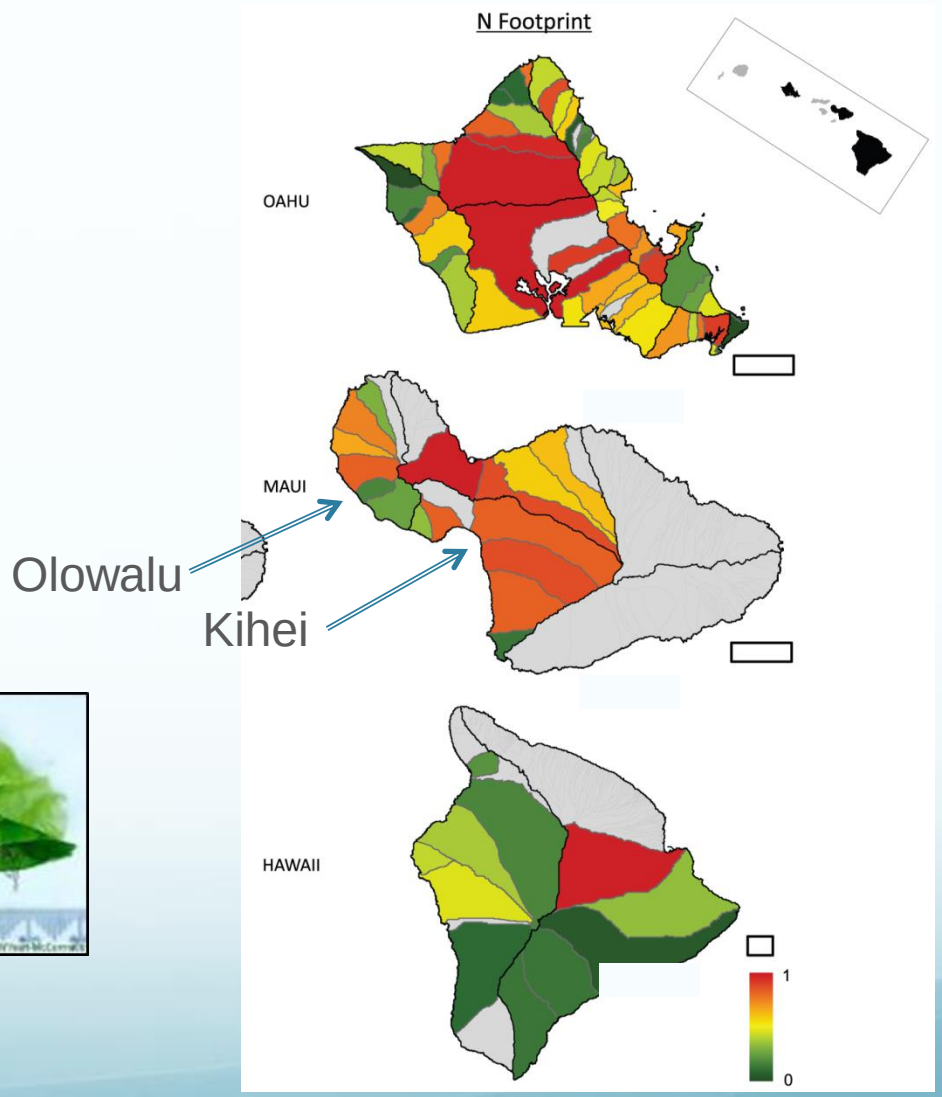
Question

- Do invasive algae really accumulate arginine in eutrophic regions?

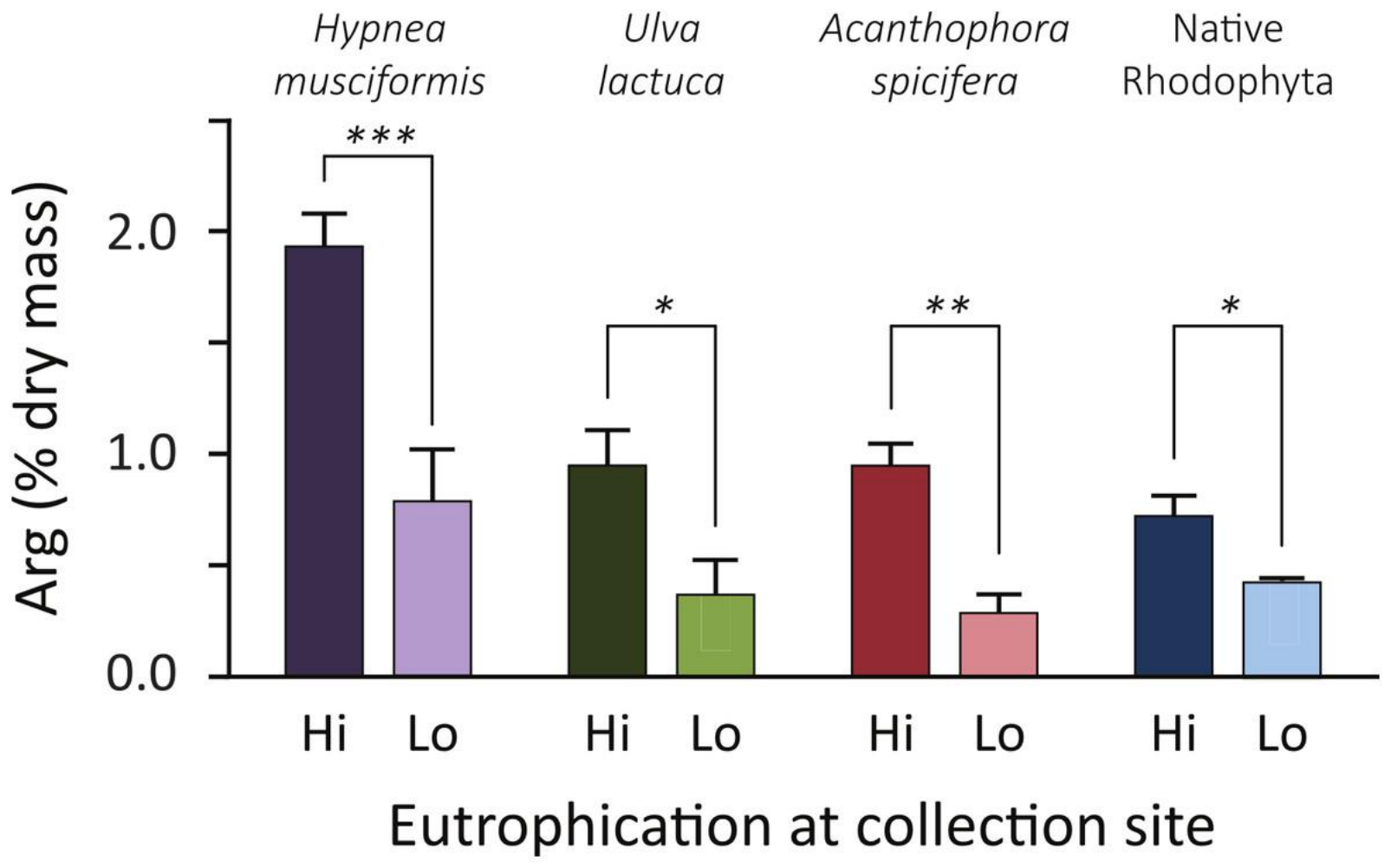
Analyses of algal tissue amino acids

- Wild samples from eutrophic and oligotrophic sites
  - ★*Acanthophora spicifera*
  - ★*Hypnea musciformis*
  - ★*Ulva lactuca*
  - *Amansia glomerata*
  - *Pterocladiella capillacea*





Arginine content in algae



*: $P < 0.05$
**: $P = 0.01$
***: $P < 0.01$

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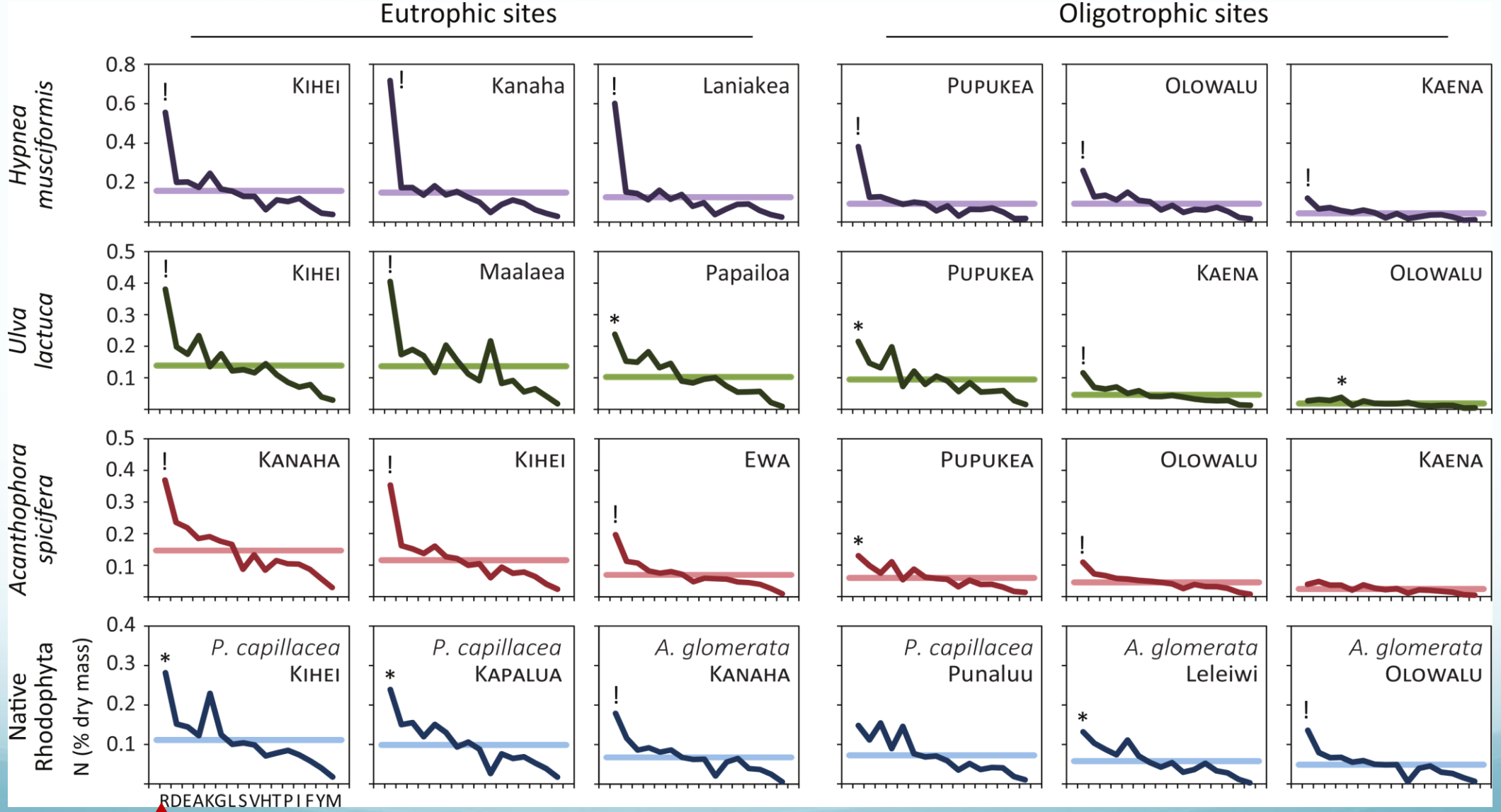
Nitrogen in amino acids



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Summary

- Algae in eutrophic water had elevated arginine
- Algae store environmental N as arginine even in oligotrophic water
- *Hypnea musciformis* is more proficient at sequestering environmental N
- Adult turtles in eutrophic region feeding on invasive algae may intake 5-14 times higher arginine

Conclusion

- Invasive algae may not be healthy diet options for Hawaiian green turtles – turtles in eutrophic area eat more invasive algae enriched with arginine
- Watershed based management such as land-based nutrient input into coastal waters is very important for the conservation of marine organisms including green turtles

Acknowledgement

- Disney Worldwide Conservation Fund
- Hawaii Coral Reef Initiative