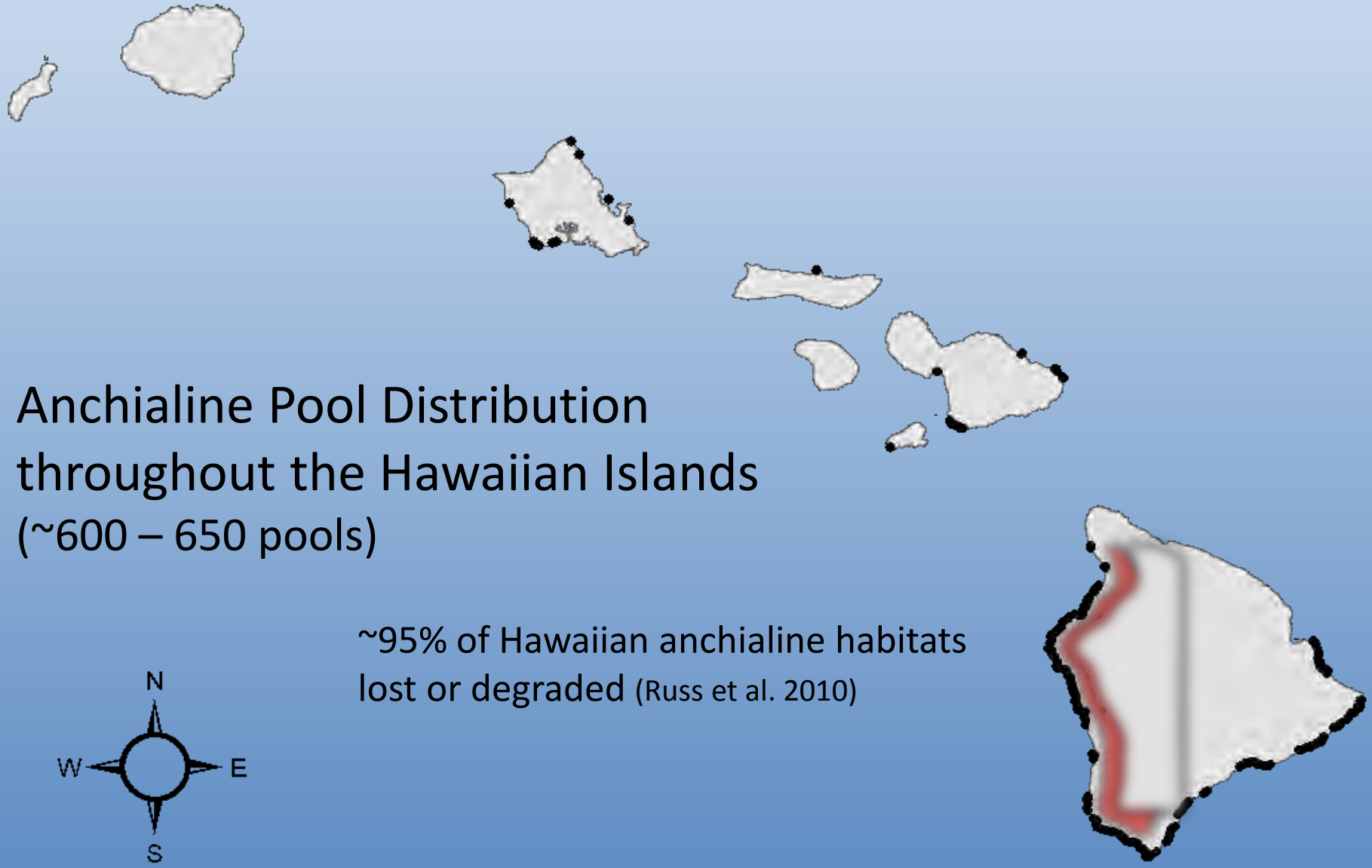
Hawaiian Anchialine Pool Ecology

Troy Sakihara
Division of Aquatic Resources, DLNR, State of Hawaii
1160 Kamehameha Avenue, Hilo, HI 96720

Anchialine Pool Distribution throughout the Hawaiian Islands
(~600 – 650 pools)



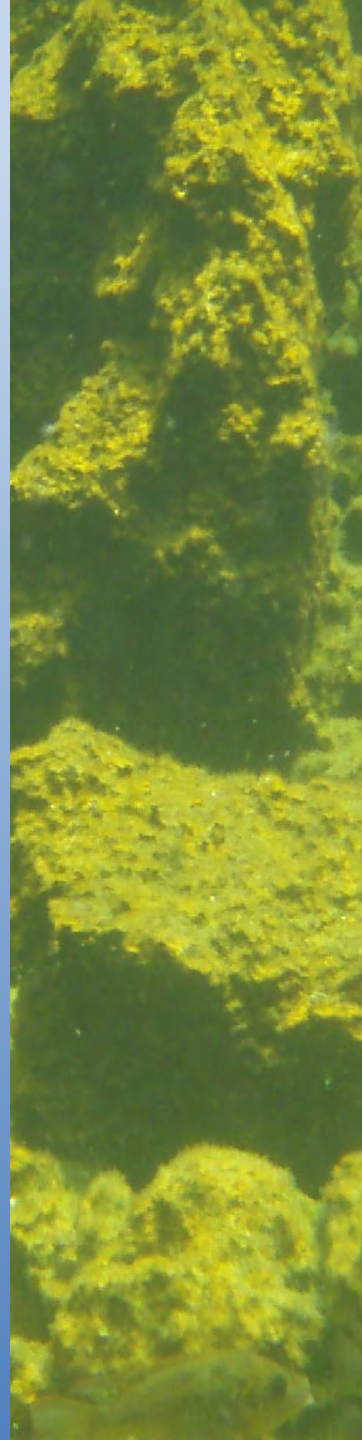
~95% of Hawaiian anchialine habitats lost or degraded (Russ et al. 2010)

Nature Conservancy , 2012

Native and Endemic Fauna (non-exhaustive list)

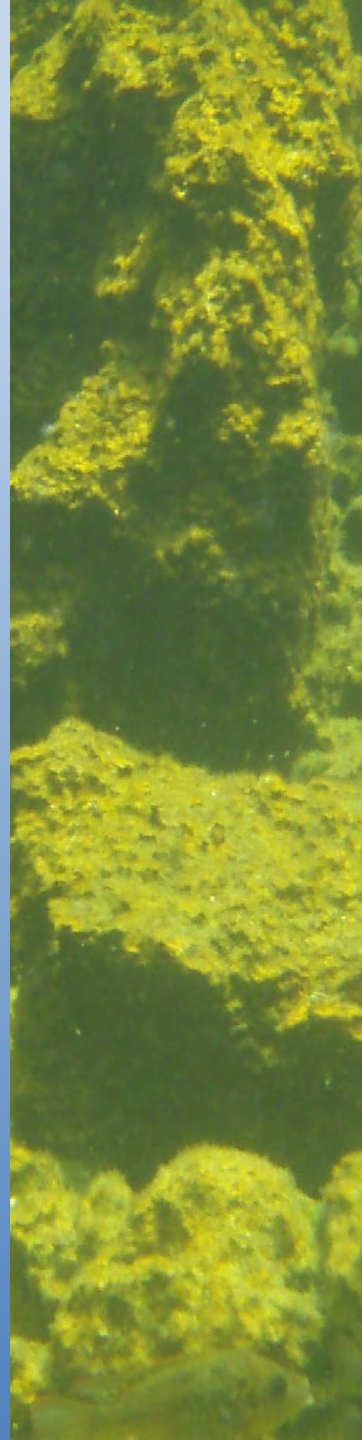

ʻōpae ʻula
Halocaridina rubra

Effects of grazing and nutrients on microalgae across contrasting levels of groundwater influence



Driving Questions

- How do salinity and nutrient concentrations affect primary productivity and algal biomass in anchialine pools?
- Do specific nutrients have notable effects on algal growth and biomass?
- How do primary grazers affect algal biomass?
- What are the combined effects of salinity, nutrient additions and grazing?



Experimental Design

SALINITY

"HIGH" vs "LOW"

≥20 ppt vs <5 ppt

NUTRIENT LIMITATION

- **N Enrichment ($NaNO_3$)**
- **P Enrichment (KH_2PO_4)**
- **N+P Enrichment ($NaNO_3$ + KH_2PO_4)**
- **No Enrichment**

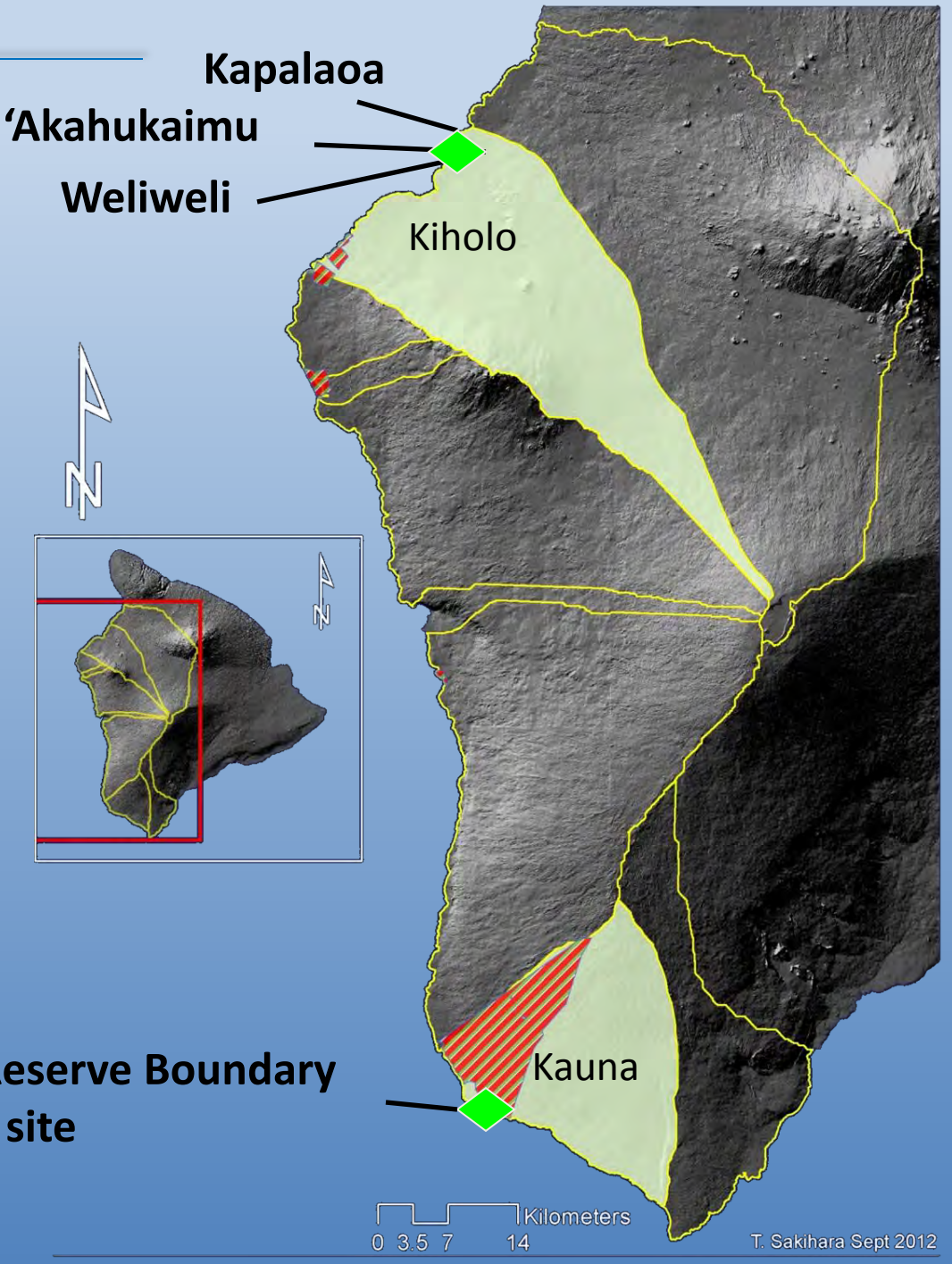
GRAZING EFFECT

- **GRAZED (N, P, N+P, None)**
- **UNGRAZED (N, P, N+P, None)**

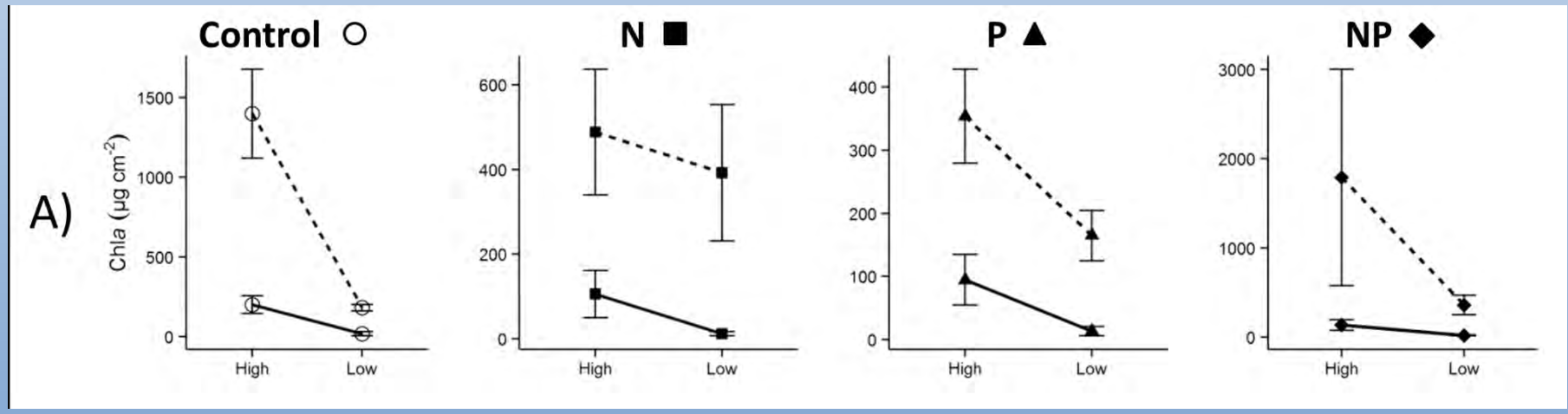
Methods

Sampling Locations

- 11 pools across four sites
- Open pools (no vegetation)
- No invasive fish
- Established *H. rubra* population
- "high" vs. "low" Background nutrient concentration and salinity



No significant nutrient effects on microalgal biomass



Salinity: “high” (≥20 ppt) vs. “low” (<5 ppt)

UNGRAZED - - - - GRAZED ———

Significant reduction in algal biomass by ‘ōpae ‘ula grazing and lower salinity

Key Findings

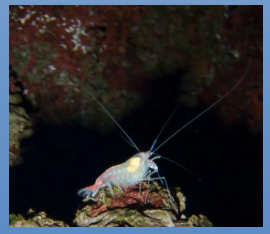
- Not all Hawaiian anchialine pools are nutrient-limited
  - ❖ High background nutrient concentrations
- ʻōpae ʻula consistently play a key function across a range of habitat conditions by grazing
  - ❖ Engineering organisms that maintain biological integrity of the pools
- Salinity may influence microalgal community structure
  - ❖ Provide different food resources available to ʻōpae ʻula

Further Points of Interest

- Common shrimps (ʻōpae ʻula and *M. lohena*) tolerate a wide range of habitat conditions (e.g., salinity)
  - ❖ Strong osmoregulatory traits (Havird et al. 2014)
  - ❖ Optimal conditions for ōpae ʻula in lab: 9-20 ppt (Tagawa and Iwai pers. comm.)





- Less-common species limited to higher salinity (≥20 ppt)
  - ❖ Different habitat requirements?
  - ❖ Suggested oceanic larval stages require subterranean connectivity between anchialine habitat and ocean

Salinity Preferences and Overall Range

(De Silva and Perera 1976, Bok 1983, Barman et al. 2005, Cardona 2006)

‘ama‘ama, striped mullet
Mugil cephalus

(Tango 2010)

Pinao ‘ula nymph
Megalagrion xanthomelas

(Tagawa and Iwai pers. comm)

(Maciolek 1983)

‘ōpae ‘ula
Halocaridina rubra

Preferred Range

Total Range

0.00 5.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00

Salinity (ppt)

Wai → Muliwai → Kai

Maintaining Connectivity to Support Resiliency

Artwork by:
Michael Furuya

Mahalo

References

- Barman UK, Jana S, Garg S, et al. (2005) Effect of inland water salinity on growth, feed conversion efficiency and intestinal enzyme activity in growing grey mullet, Mugil cephalus (Linn.): Field and laboratory studies. Aquaculture International 13:241-256
- Bok AH (1983) The demography, breeding biology and management of two mullet species (Pisces: Mugilidae) in the Eastern Cape, South Africa. PhD dissertation, Rhodes University, Grahamstown
- Cardona L (2006) Habitat selection by grey mullets (Osteichthyes: Mugilidae) in Mediterranean estuaries: the role of salinity. Scientia Marina 70:443-455
- De Silva S, Perera P (1976) Studies on the young grey mullet, *Mugil cephalus* L.: I. Effects of salinity on food intake, growth and food conversion. Aquaculture 7:327-338
- Havird JC, Santos SR, Henry RP (2014) Osmoregulation in the Hawaiian anchialine shrimp Halocaridina rubra (Crustacea: Atyidae): expression of ion transporters, mitochondria-rich cell proliferation, and hemolymph osmolality during salinity transfers. The Journal of experimental biology:jeb. 103051
- Maciolek JA (1983) Distribution and biology of Indo-Pacific insular hypogeal shrimps. Bulletin of Marine Science 33:606-618
- Russ A, Santos S, Muir C (2010) Genetic population structure of an anchialine shrimp, Metabetaeus lohena (Crustacea: Alpheidae), in the Hawaiian Islands. Revista de biología tropical 58:159-170
- Tango LK (2010) The effect of salinity and temperature on survival of the orange-black Hawaiian damselfly, Megalagrion xanthomelas. University of Hawai'i at Hilo