Anchialine restoration in Hawai‘i – One pool complex at a time

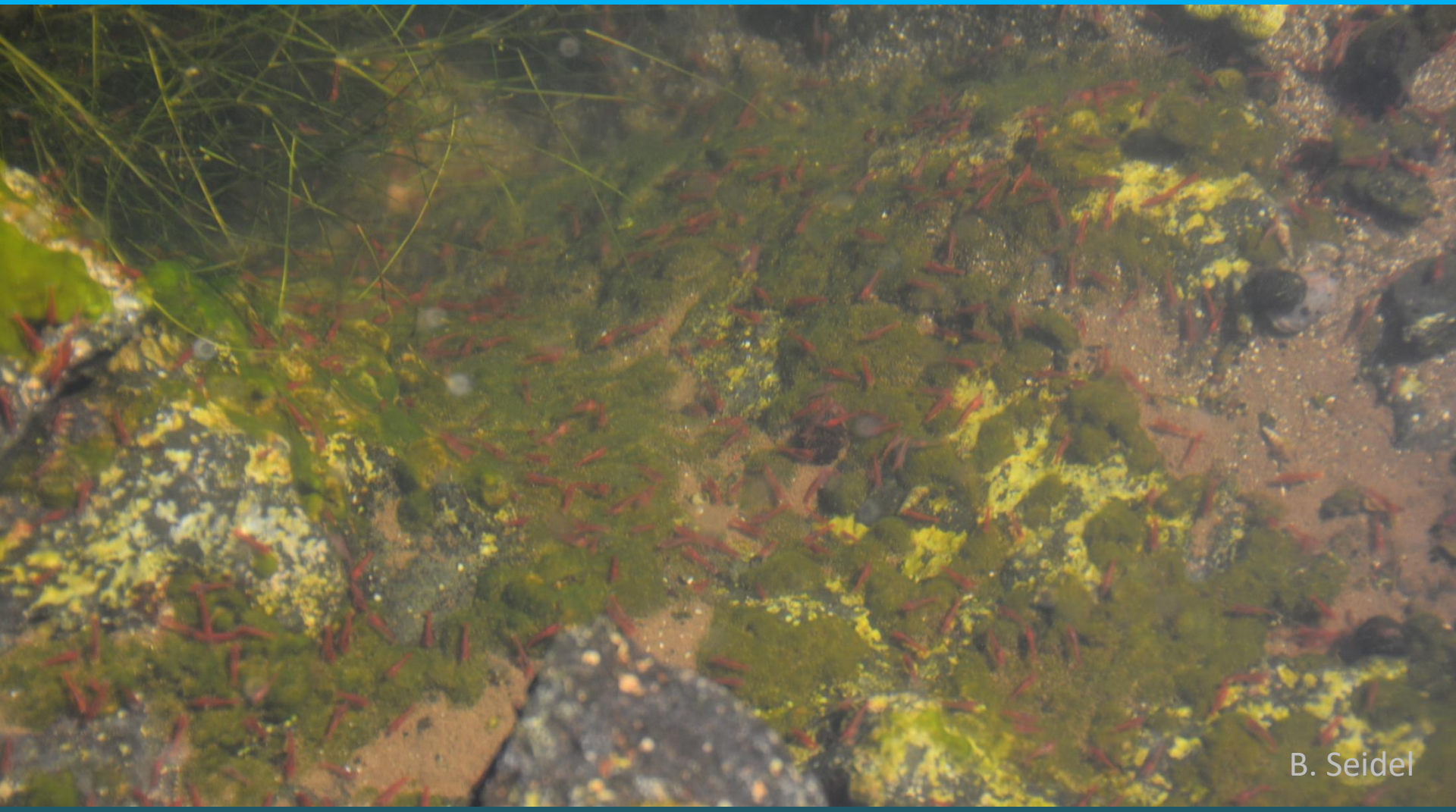
Megan Lamson, Stacey Breining & Bill Gilmartin

Hawai‘i Wildlife Fund *(wildhawaii.org)*

4th Int’l Symposium for Anchialine Ecosystems – Oct 2018

ʻUla ka loko kāheka i ka ʻula o loko.

Sacred is the red pond where the red shrimp dwell within.



Hawai‘i Wildlife Fund

HAWAI'I WILDLIFE FUND

Our mission is to **protect the native wildlife of Hawai‘i** through research, education & conservation projects.







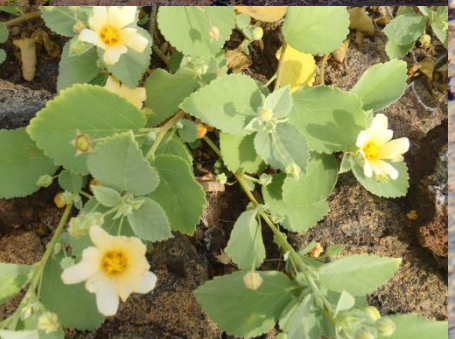
Anchialine Pools in Hawai‘i

Where in the ….

?

Maps from:
http://www.hawaiiecoregionplan.info/anchpoolNC.html

Wai‘ōhinu Forest Reserve (Hawai‘i Island)



1,331 acres (538 ha) / 2 mi (3.3 km) of coastline:

- **P**lants: 36 species of native coastal vegetation, including endangered ‘ōhai (*Sesbania tomentosa*)
- **P**ools: *At least* 6 anchialine pools with 3 species of shrimp *(Halocaridina rubra, Metabetaeus lohena, Palaemon debilis) &* a cave
- **P**etroglyphs: Several petroglyph fields & numerous other cultural resources / archeological features


1
2
3

Native wildlife utilizing pools

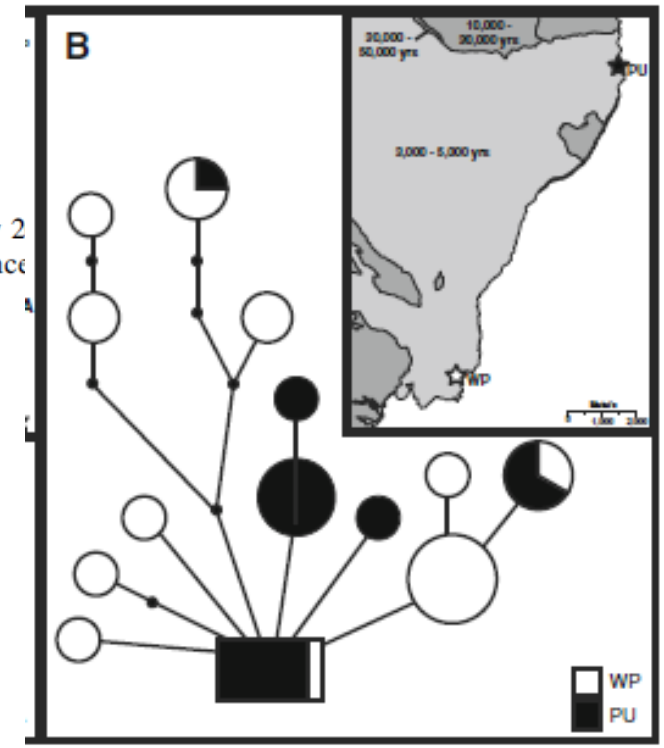
Hydrobiologia
DOI 10.1007/s10750-010-0588-x

ANCHIALINE ECOSYSTEMS

Rocks and clocks: linking geologic history and rates of genetic differentiation in anchialine organisms

Scott R. Santos · David A. Weese

Received: 6 May 2



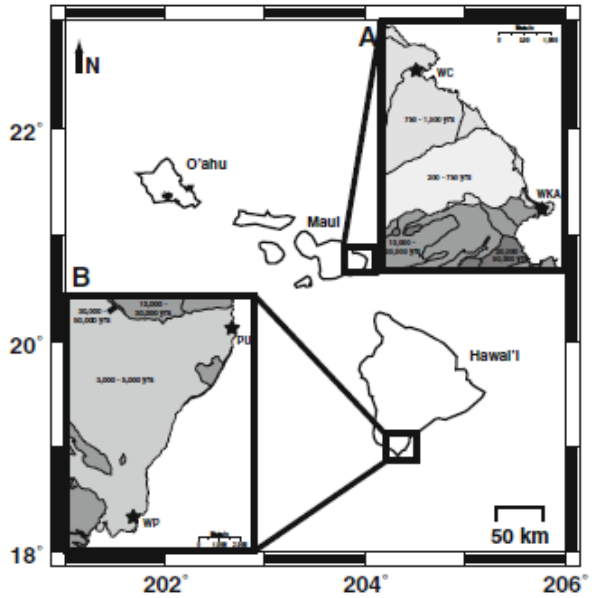
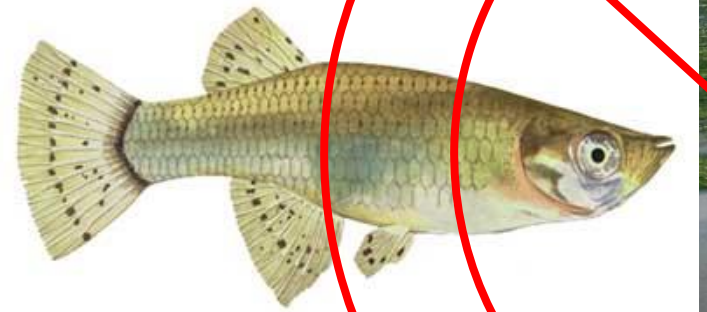
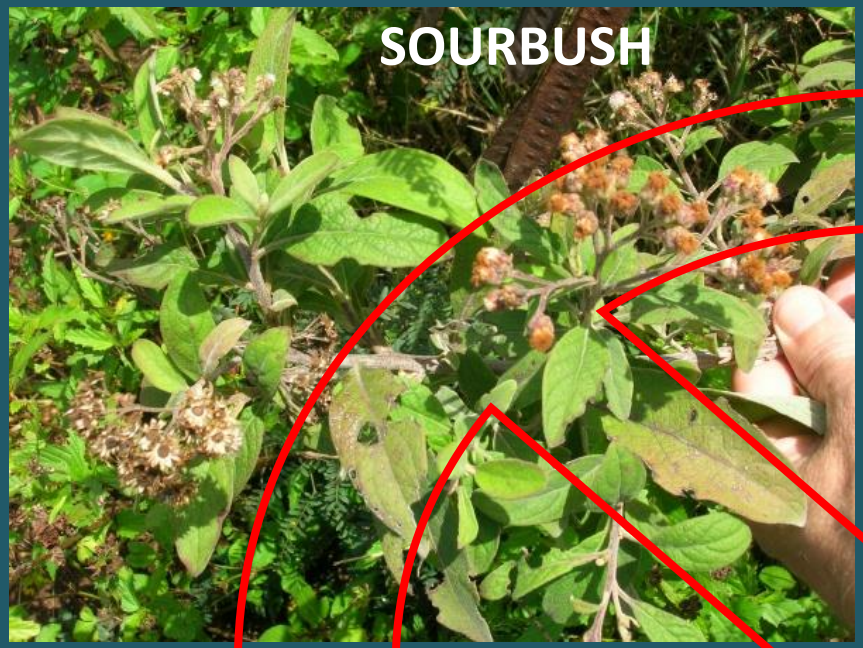


Fig. 1 Map of the high Hawaiian Islands depicting anchialine pools where *Halocaridina* were sampled for this study. *Inserts* Geologic maps, including ages of local basalt (i.e., lava) flows, for the northeastern coast of Maui (A) and the southeastern coast of the island of Hawai'i (B). Site codes: Waianapanapa Cave (WC), Waikoloa (WKA), Puhi Ula Cave (PU), and Wai'ohinu (WP)

Native plants in/around pools

Threats to anchialine ecosystems





Misc. photographers – thank you google.

Restoration Phase I (Plants)


TURTLE TEAM

Restoration Phase II (Sediment)

Restoration Phase III (Fish)

Photo by John Hoover.

P-35
Rev. 07/00

HAWAII DEPARTMENT OF AGRICULTURE EXPERIMENTAL USE PERMIT APPLICATION – PESTICIDES

1. APPLICANT

a. Name of Applicant: Megan Lamson
c. Title of Applicant: Hawaii Island Program Director
d. Telephone No.: (808) 217-5777
e. Fax No.: (808) 985-7041
b. Company Name and Address: Hawaii Wildlife Fund (HWF), P. O. Box 70, Volcano, HI 96785

2. PESTICIDE

a. Brand Name (if any): CFT Legumine Fish Toxicant
b. EPA Registration Number or other I.D. number: 89459-48
c. Active Ingredient(s) (by chemical name): Rotenone & Cube resins
d. Is Product Licensed in Hawaii? ☑ Yes ☐ No

3. DESCRIPTION OF EXPERIMENT (submit copy of experimental protocol)

a. Location of Trial(s) (Area, Town or City, Field No., and Island): Hawaii Island: Hualalai Four Seasons Resort N. Kohala. 2. Mauna Lani Resort Assn - S. Kohala. 3. Ka'u Forest Res..
b. Size of Trials (acres, sq. ft., etc.) 1. ~ 1/10 Acre, 2. ~ 0.0127 Acre, 3. ~ 1/8 Acre
c. Number of Trials: Up to two trials per site
d. Number of Replications: see attached protocol from HWF
e. Commodity (crop) to be Treated: 3 anchialine pools
f. Stage of Growth of Commodity: N/A
g. Pest(s): Invasive Fish: Mozambique tilapia (Oreochromis mossambicus; Guppy (Poecilia reticulatra); Mosquitofish (Gamubusia affinis), Mollies (Poecilia spp.)
h. Dosage Rate(s) (lbs. active ingredient per unit area): dose of 4 ppm concentration CFT Legumine
i. Method of Application: ☑ Ground ☐ Aerial ☐ Other (specify):

4. DURATION OF EXPERIMENT

a. Starting Date: January 2018
b. Completion Date: December 2018

5. TYPE OF DATA SOUGHT: To assess efficacy of using Rotenone to Control Invasive Fish in Anchialine Pools in Hawaii

6. DISPOSITION OF TREATED COMMODITY: See attached protocol from HWF

7. PERSON SUPERVISING TRIALS

a. Name of Person: Megan Lamson
c. Title of Person: Program Director
d. Telephone: (808)217-5777
e. Category 10 Certification No.: C50269; exp. 6/15/2022
b. Company Name and Address: Hawaii Wildlife Fund (HWF), P. O. Box 70, Volcano, HI 96785
f. Signature: Megan Lamson
g. Date: Nov. 24, 2017

FOR STATE USE ONLY

Disposition: ☑ Approved ☐ Disapproved
State EUP No.: EUP-17-03
Expiration Date: Dec. 28, 2018

RESTRICTIONS

1. The certified applicator William G. Gilmartin (Cat. 5, Cert No. H72475; exp. 12/02/019), is responsible for all applications and for meeting all requirements as specified under the provisions of this EUP. Megan Lamson (Cat. 10, Cert No. C50269; exp. 6/15/2022 is the person supervising trials.
2. Pesticide shall be applied in accordance with the attached protocol entitled: "Experimental Protocol for CTF Legumine trials in Anchialine Pools in Hawai".
3. All applicable directions, restrictions, precautions and other instructions specified in the section 3 label for CFT Legumine Fish Toxicant, EPA Reg. No. 89459-48 and accompanying labels filled "For Experimental Use Only" must be followed.
4. Label must be in possession of the applicator at the time of each pesticide application.
5. The certified/non-certified applicator is required to remain on site until treatment is completed.
6. The Hawaii Department of Agriculture (HDOA) must be contacted at least 7 days prior to pesticide applications for all trials allowing enforcement staff the opportunity to monitor pesticide use. Contact Inspector Cal Westergard (808) 974-4142 (office), (808) 640-9676 (cell) or email at cal.j.westergard@hawaii.gov
7. Placards must be posted prior to application and posted every 250 feet along treated area/project. Follow pertinent information requirement per Rotenone SOP provided.
8. A dye tracer must be used to assess connectivity between pool and ocean.
9. Rotenone solution should be applied no later than 30 minutes before a high tide will occur in the pool.
10. Please report to HDOA inspector Cal Westergard immediately, any off target kill/death of:
    a. 25 or more fish of any species
    b. 10 or more wild or feral mammals
    c. 10 or more birds of any species
    d. Death of any endangered or threatened species.
11. Adverse effects to human health or the environment resulting from any pesticide application specified in the attached protocol must be reported immediately to HDOA at (808) 973-9401.
12. A final report summarizing the results of this use must be submitted to HDOA within 30 days following the conclusion of this trial.

Name & Title of State Official: Thomas K. Matsuda, Pesticides Program Manager
Signature: Thomas K. Matsuda
Date: Dec. 11, 2017

RESTRICTED USE PESTICIDE
DUE TO APPLICATOR EXPERTISE REQUIREMENTS
AND CHRONIC TOXICITY CONSIDERATIONS
For retail sale to and use only by certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification.

FOR EXPERIMENTAL USE ONLY
Under Hawaii State EUP-17-03
Issue Date: 12/29/2017
Expiration Date: 12/28/2018

REVOKED!

RESTRICTED USE PESTICIDE
to acute inhalation, acute oral and aquatic toxicity. For retail sale to, and use only by, Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification.

THE APPLICATOR IS RESPONSIBLE FOR CONFORMING TO THE LABEL. IMPORTANT GUIDANCE ON THE SAFE AND EFFECTIVE USE OF THIS PRODUCT IS PROVIDED IN THE ROTENONE SOP MANUAL, AVAILABLE FROM THE REGISTRANT OR THE AMERICAN FISHERIES SOCIETY AT www.fisheries.org/units/rotenone

CFT Legumine Fish Toxicant

EPA Reg. No. 89459-48

A fish toxicant for control of Fish in Lakes, Ponds, Reservoirs and Streams.

Active Ingredients:

Rotenone	5% w/w
Cube Resins other than rotenone	5%
Other Ingredients:	90%
Total:	100%

***Contains Petroleum Distillates**

SHAKE WELL BEFORE USING

KEEP OUT OF REACH OF CHILDREN
WARNING

EUP-17-03
CFT Legumine Fish Toxicant; EPA Reg. No. 89459-48

Management of Biological Invasions (2015) Volume 6 in press

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Open Access

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Research Article CORRECTED PROOF

Evaluat
Mozam

Leo G. Ni
[1]US Geologi
[2]Hawaii Biol
E-mail: lnic
*Correspon

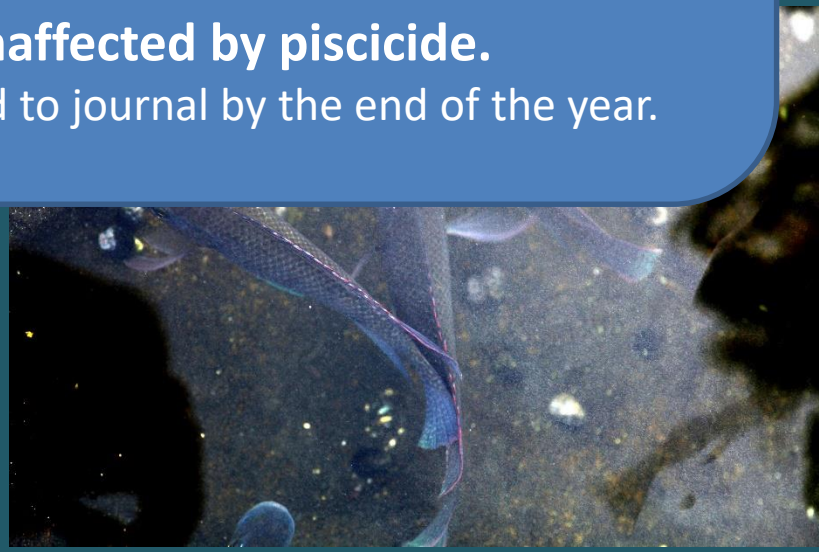
Received: 20
Handling ed

According to **Leo Nico of USGS**, they ran similar bioassays in June 2018 with CFT Legumine (rotenone product) on 3 native neritid snails (*Neripteron vespertinum, Neripteron vespertinum, Nerita picea*) and 2 more invasive fish species: Mollies (*Poecilia sphenops* complex), Western Mosquitofish (*Gambusia affinis*) – all of which are found in anchialine pool ecosystems.

Preliminary results: Mortality of non-native fishes with native inverts relatively unaffected by piscicide.

Manuscript in process – to be submitted to journal by the end of the year.

"deta
Legumine concentra than or equal to 3 ppm (i.e., > 0.15 mg/L rotenone) **achieved 100% mortality of tilapia and 93% of guppies within 24 [hours]** -- whereas there was little or no mortality among invertebrates exposed for 48 to 72 h to 1 to 5 ppm CFT Legumine."



Investigation of the Hawaiian Traditional Fish Poison Plant 'Auhuhu, and the Viability of Its Use Today as a Fish Anesthetic

Leina'ala Bright[1]*, Levon Ohai[1], Clyde S. Tamaru[2], Bradley K. Fox[2], RuthEllen Klinger-Bowen[2], Kathleen McGovern-Hopkins[2] and Hi'ilei Kawelo[3]. Kamakakūokalani Center for Hawaiian Studies[1], Department of Molecular Biosci... He'eia[3]

Kumu Levon Ohai
"E Kū Makani "

Abstract

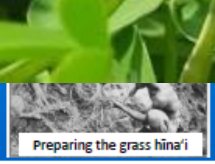
'Auhuhu (*Tephrosia purpurea*) is a Polynesian introduced plant, used by Native Hawaii... system of fishing called hola. The 'auhuhu plant, which contains the chemical ten... traditionally pounded and scattered in tide pools, stunning fish and making th... hand or net. The objectives of this project are: 1) establish the lowest eff... raw extract of 'auhuhu: 2) establish optimal induction and recovery tim... survival of fish which was found to be a concentration of raw extract... time of 30 seconds. This project demonstrates a valuable and viab... natural resource management from a Hawaiian perspective. *Ko ...* ancestors of Hawai'i continually demonstrate the importance of... and nature. Integration of traditional ecological knowledge in ... affirms its necessity in providing alternatives for the many cha... become better stewards of our land.

Introduction

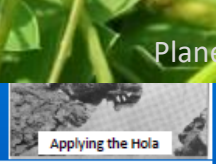
The investigation of the 'auhuhu plant was prompted by the desire... and conservation of Hawaiian and other medicinal plants using aqua... the Waihona Lā'au Lapa'au Project ongoing research has encompassed... medicinal plants and their varied uses by Native Hawaiians. This plant sh... reproductive growth in the aquaponic environment, prompting further inves... various uses as an herbal medicine as well as a fish anesthetic and poison. 'Auhu... antibacterial, anticancer, antioxidant, anti-inflammatory, antiulcer and wound healing... (Chaudhari, Vol 2:8, 2012). Defining the fine line between 'auhuhu as a fish anesthetic as o... to a poison offers alternative for aquaculture research, operations and natural resource... management. A natural... stress and physical injury... other handling procedur... high doses and with prol... Tephrosin does not have...

This project revives a trad... fishing, as well as this typ... along rocky shores and in... *purpurea*) and akia (*Wikst...* were prepared quickly by... poison rapidly dissipated,... crushed vegetation was w... the hola placed in the wa... would be placed in loosel... *nucifera*, coconut) when... minutes the fish would sh... surface . They were easil... left a bitter taste in the e...

Preparing the Hola



Preparing the grass hīna'i



Applying the Hola

Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History , Vol. VIII, No 10 with Plates XVII, XVIII

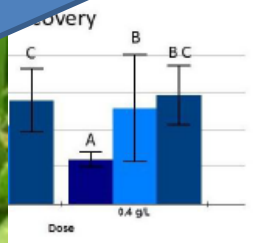
Re 'auhuhu *(Tephrosia purpurea):*
"This once common **powerful plant is now extremely rare** in the main Hawaiian Islands and with its many valuable qualities, it is worthy of propagation and conservation."
– Leina'ala Bright and colleagues

Methods

...culture/Aquaponic Research and ...lue Tilapia (*Orechromis aureus*), ...r and pestle, and a stock ...d to 2 groups of five fish ...ameters routinely ...of the experiment. ...ction and recovery ...fish began to ...very, fish were

...und to decrease remarkably ...esthetic at concentrations that are ...2g/L) concentrations of aqueous 'auhuhu extracts were ...effect on dose and time on induction, recovery appeared to be dependent ...posure.

- Time of exposure was found to be crucial in survival; the difference between 15 seconds of exposure resulted in 5 fold difference in survival.



Conclusion

- This once common powerful plant is now extremely rare in the main Hawaiian islands and with its many valuable qualities it is worthy of propagation and conservation.
- As a medicine, this plant has been used over many centuries by Native Hawaiians externally for skin diseases and internally as a tonic and relaxant when added to other remedies.
- The extended period from induction to recovery observed in the current study (16 to 30 min) is advantageous in the field of aquaculture for handling and surgical procedures as compared to the most commonly used anesthetic, MS-222 (1.5 to 3 min).
- The minimal costs, convenience, ease of propagation, preparation and implementation of this organic plant material offers a valuable alternative to synthetic anesthetics currently used in the aquaculture industry.
- As a fish poison, 'auhuhu shows potential for the eradication of invasive species in our loko i'a (fishponds), kahawai (streams) and along the reefs and warrants further investigation.

References

Abbott, I. A. *Lau Hawaii: Traditional Hawaiian Uses of Plants.* Honolulu: Bishop Museum Press, 1992. p. 225.
Chaudhari, T. B. *Phytopharmacogy of Tephrocia purpurea Pers. (Fabaceae)-A Review.* UPI's Journal of Pharmacognosy and Herbal Formulations, 2012. http://www.ijpijournals.com
Küçük, S. *Efficacy of Tricaine on Poecilia latipinna at Different Temperatures and Concentrations.* African Journal of Biotechnology Vol. 9(5), 2010. p. 733-739. http://www.academicjournals.org/AJB
Stokes, J. *Fish-Poisoning in the Hawaiian Islands. Occasional Papers of the Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History.* Honolulu: Bishop Museum Press, 1921 p. 3-17.

Acknowledgements

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College of Tropical Agriculture and Human Resources, USDA-ARS Agreement No. 58-5320-8-392

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FOR CONTROL OF NON-NATIVE, INVASIVE FISH SPECIES IN ANCHIALINE POOLS IN HAWAII

FOR EXPERIMENTAL USE ONLY
Under Hawaii State EUP-
Issue Date:
Expiration Date:

CFT Legumine Fish Toxicant

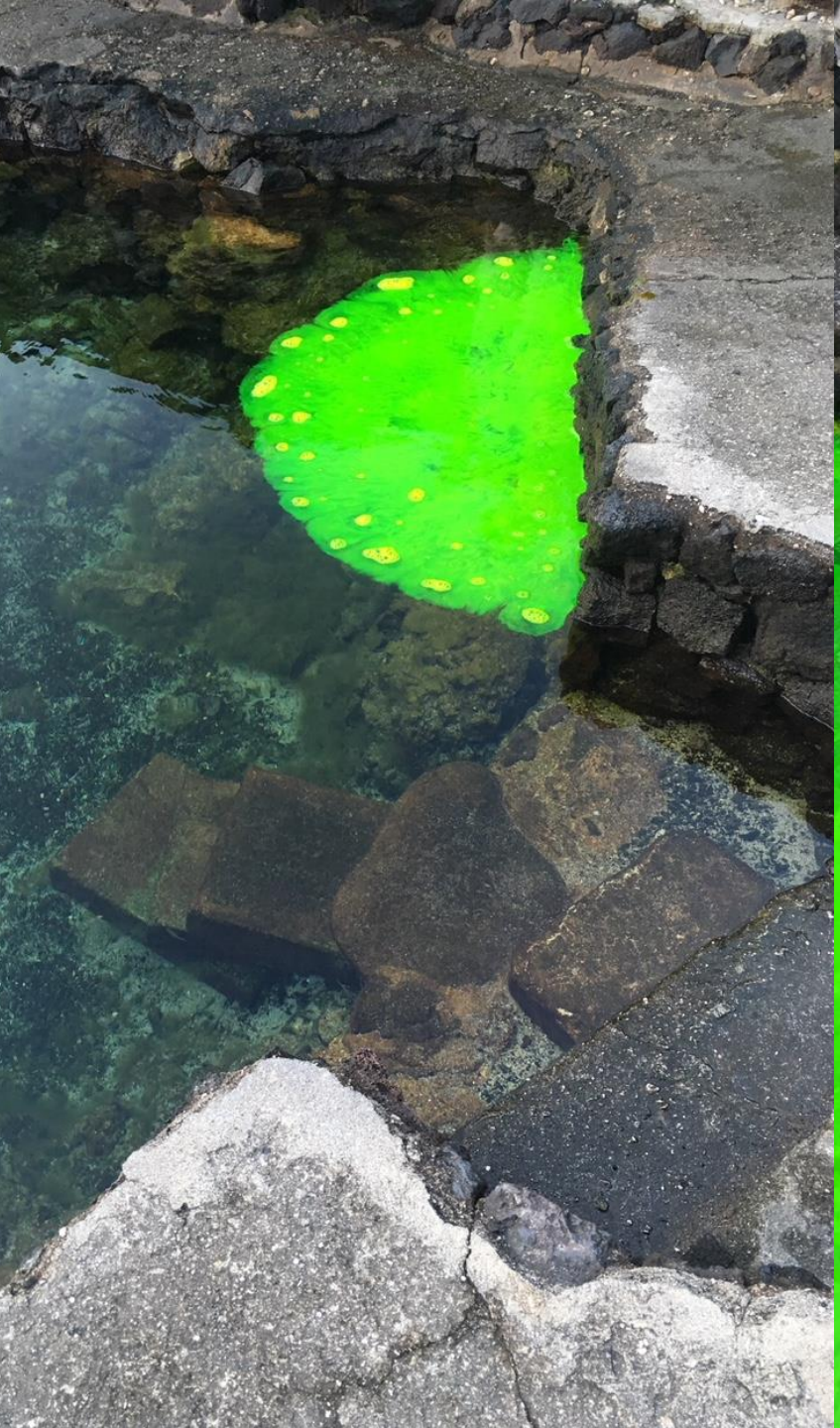
EPA Reg. No. 89459-

ACTIVE INGREDIENTS:
Rotenone.....5% w/w
Cube Resins other than rotenone.....5%
OTHER INGREDIENTS*.....90%
TOTAL.....100%
*Contains Petroleum Distillates

KEEP OUT OF REACH OF CHILDREN

WARNING

SEE ADDITIONAL PRECAUTIONARY STATEMENTS, FIRST AID AND PERSONAL PROTECTIVE EQUIPMENT (PPE) ON THE CONTAINER LABEL




DieHard

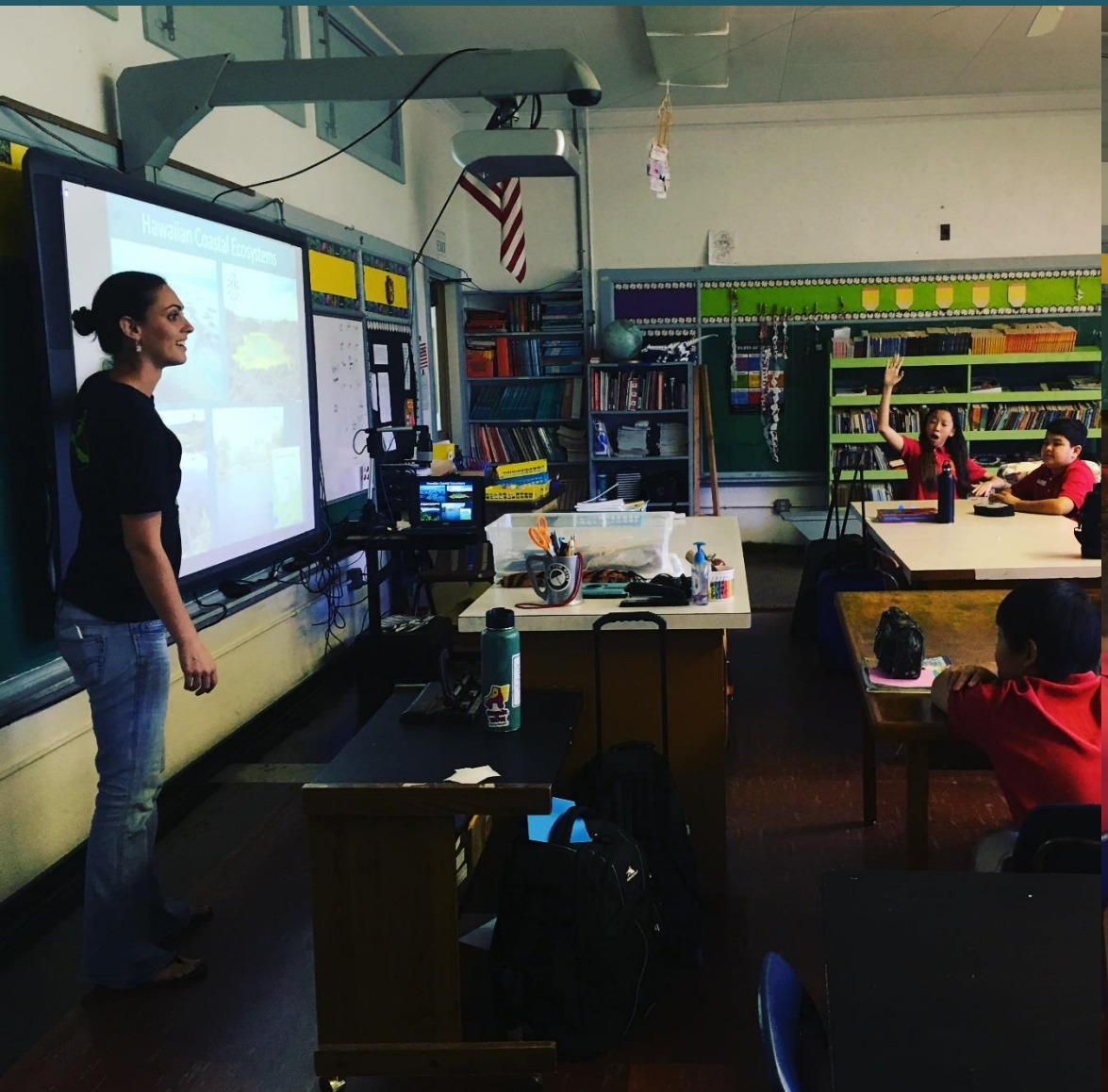
WQ and fauna monitoring

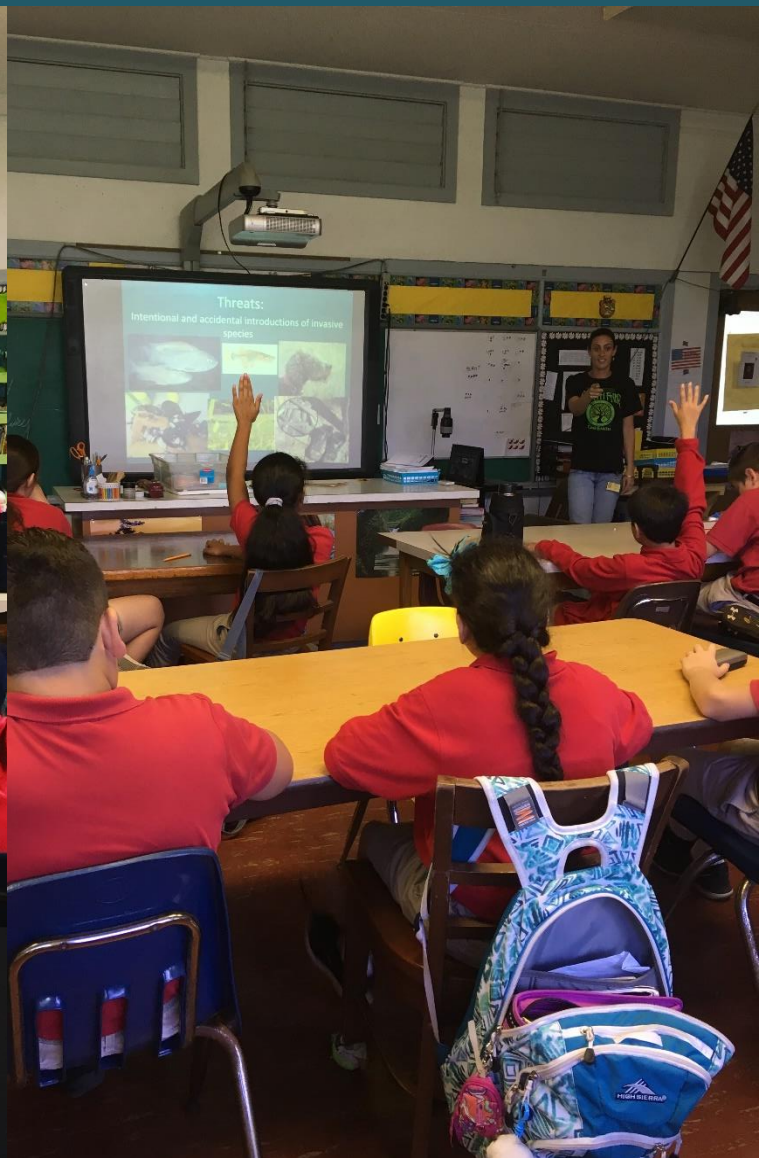
Ho‘onoua Complex Water Quality and Crustacean Survey Averages

		°C		ppt	%	mS	
	→	Temp	pH	Salinity	Diss. O2	Cond.	Shrimp
Pool #1	average (*mean*)	25.13	7.70	11.74	84.69	20.12	0
(Ho'onoua hema)	st. deviation	1.71	0.43	0.86	23.53	0.90	0
	minimum	20.48	6.95	10.08	32.94	18.24	0
	maximum	28.31	8.53	15.13	121.25	22.18	0
	N	34	33	34	15	21	14
Pool #2	average	23.83	7.31	9.45	40.58	17.48	17.64
(Ho'onoua 'ōpae)	st. deviation	1.21	0.48	2.56	27.39	1.07	17.78
	minimum	21.60	6.23	0.10	9.80	15.56	0
	maximum	26.20	8.45	12.10	102.90	20.41	60
	N	22	20	22	11	14	14
Pool #3	average	26.71	7.93	11.90	75.84	20.91	2.32
(Ho'onoua 'ākau)	st. deviation	3.02	0.59	2.50	42.47	4.40	5.72
	minimum	20.30	7.04	0.90	3.70	5.00	0
	maximum	32.90	9.07	15.00	159.00	25.70	25.00
	N	31	30	30	12	17	22
All Pools	**average**	**25.36**	**7.69**	**11.21**	**69.13**	**19.67**	**5.96**
	st. deviation	2.47	0.56	2.30	37.25	3.00	12.53
	N	87	83	86	38	52	50

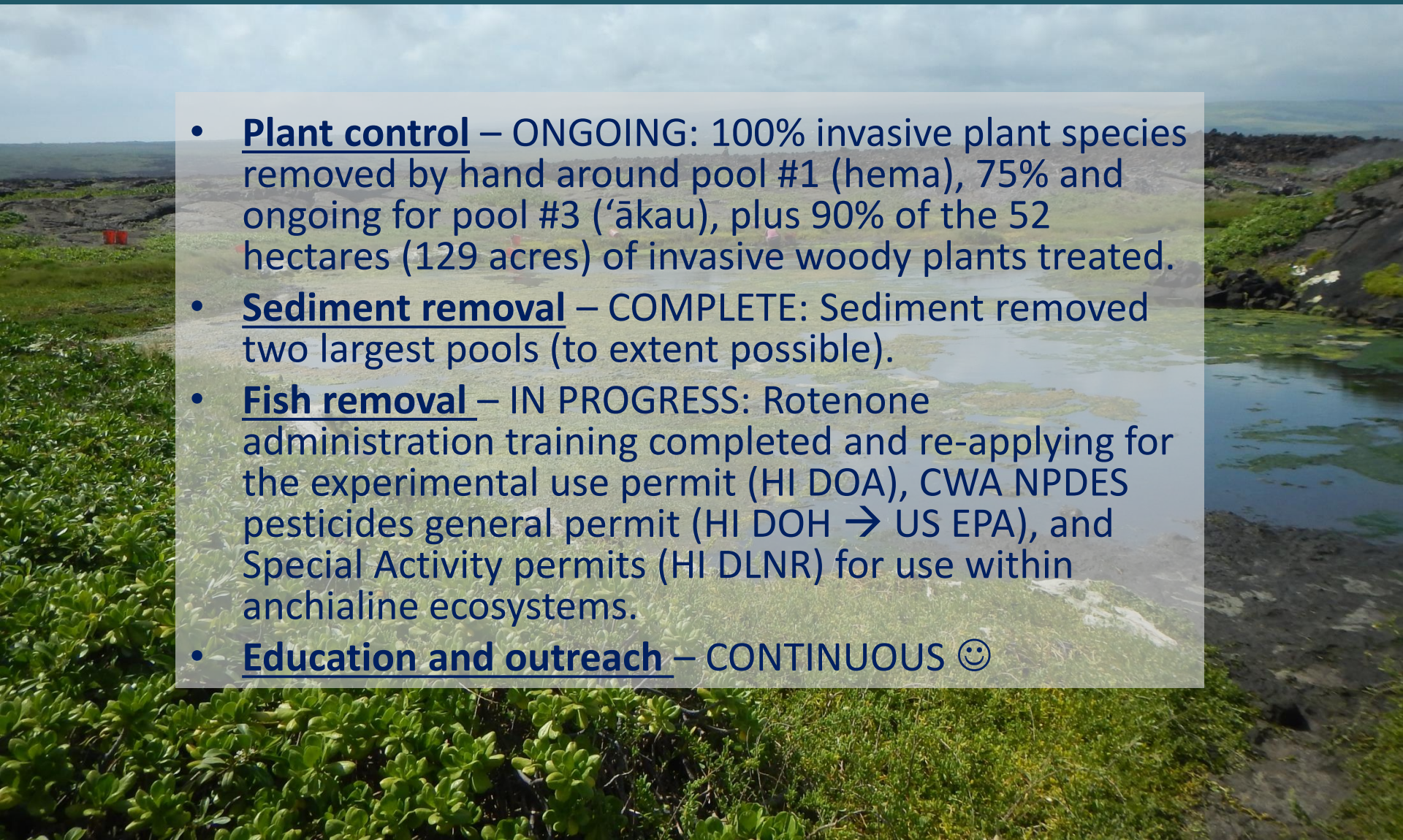
Table 1. The above table shows the results from water quality samples and crustacean surveys conducted by HWF from 2009-2012 and 2009-2014 respectively.

Education and outreach (ongoing)





Current restoration status



- **Plant control** – ONGOING: 100% invasive plant species removed by hand around pool #1 (hema), 75% and ongoing for pool #3 (‘ākau), plus 90% of the 52 hectares (129 acres) of invasive woody plants treated.
- **Sediment removal** – COMPLETE: Sediment removed two largest pools (to extent possible).
- **Fish removal** – IN PROGRESS: Rotenone administration training completed and re-applying for the experimental use permit (HI DOA), CWA NPDES pesticides general permit (HI DOH → US EPA), and Special Activity permits (HI DLNR) for use within anchialine ecosystems.
- **Education and outreach** – CONTINUOUS ☺

Ka ʻinana lā mele ʻōpae ula.

Lively and active is the freshwater shrimp, *Halocaridina rubra.*

Mahalo and questions?

megan@wildhawaii.org

@wildhawaii