Nā Wai ʻEkolu: Stream Biodiversity, Watershed Health, and Citizen Science in the Ala Wai Watershed

Cory Yap, Yvonne Chan, Kelly Lariosa, and Megan Kawatachi

INTRODUCTION

Hawaiian Stream Animals

In Hawaiʻi, the freshwater macrobiota of relatively natural streams is dominated by native amphidromous species that have a marine larval phase but spend the juvenile and adult phases in freshwater (Mcdowall 1992). These endemic migratory species, including five gobioid fishes, two decapod crustaceans, and two neritid mollusks, are of conservation concern and under differing levels of protection by the International Union of Conservation of Nature (Table 1). Habitat partitioning has been well-described along longitudinal stream gradients, where adults of two, three, and four species are predominantly found at upper, middle, and lower stream reaches (Nishimoto and Kuamoʻo 1991, Kinzie 1998, Fitzsimons et al. 2002, Fitzsimons et al. 2007, Kido 2008, and McRae et al. 2013), but also may vary by island age and topography (Fitzsimons et al. 2007). Although older animals may not overlap in their distributions, they all have to pass through stream mouths and estuarine habitats when they are larvae or post-larvae. To ensure reproductive success of Hawaii's amphidromous fauna, their offspring must successfully migrate between instream hatching sites and oceanic larval habitats (McRae 2007).

TABLE 1. Native amphidromous macrobiota in Hawaiian Streams

Species	Hawaiian / Common Name	Origin	Threat
Awaous stamineus	(ʻOʻopu nākea, Pacific river goby)	Endemic	LC
Sicyopterus stimpsoni	(ʻOʻopu nōpili, Stimpson's goby)	Endemic	NT
Lentipes concolor	(ʻOʻopu ʻalamoʻo or ʻOʻopu hiʻu kole)	Endemic	DD
Stenogobius hawaiiensis	(ʻOʻopu naniha, Naniha goby)	Endemic	LC
Eleotris sandwicensis	(ʻOʻopu ʻakupa, Hawaiian Sleeper)	Endemic	LC
Atyoida bisulcata	(ʻŌpae kalaʻole, Hawaiian freshwater shrimp)	Endemic	NT
Macrobrachium grandimanus	(ʻŌpae ʻoehaʻa, Hawaiian river prawn)	Endemic	LC
Neritina granosa	(Hīhīwai, Hawaiian freshwater snail)	Endemic	VU
Neritina vespertina	(Hapawai, Hawaiian freshwater snail)	Endemic	NE

IUCN (2020) categories: Not Evaluated [NE], Data Deficient [DD], Least Concern [LC], Near Threatened [NT], Vulnerable [VU], Endangered [EN], Critically Endangered [CE], Extinct in Wild [EW], Extinct [EX].

Habitat Loss and Threats

Anthropogenic influences have drastically altered the environment of Hawaiian streams where native amphidromous freshwater stream species occur (Ford and Kinzie 1982, Brasher 2003). Factors associated with habitat alteration include the introduction of nonnative flora and fauna, riparian zone alteration, water diversions, stream channel modification and water quality degradation (Ford and Kinzie 1982, Brasher 2003). Reductions in stream velocity and depth caused by water diversions may result in higher water temperatures and concomitant decreases in dissolved oxygen levels (Timbol and Maciolek 1978). Most human activity in Hawaiʻi is concentrated in the lowlands and the changes in Hawaiian streams tend to be greatest in these areas (Ford and Kinzie 1982, Brasher 2003). While the upper reaches of streams may remain pristine, the lower reaches are often made nearly uninhabitable to the native fishes and invertebrates by habitat alterations (Ford and Kinzie 1982, Brasher 2003, Luton *et al* 2005). Additionally, vital access to the sea is lost to seaward moving larvae and returning juveniles of native amphidromous fauna because of habitat alterations listed above (Ford and Kinzie 1982, Brasher 2003, Luton *et al.* 2005). Stream flow alterations can also negatively impact competition, predation, behavioral changes, changes in life history characteristics and alterations of food chains (McIntosh *et al.* 2002). The combined effects of all these impacts on Hawaiian streams means that the management of these intensely modified ecosystems requires detailed knowledge of how cumulative stresses may affect native species (Timbol and Maciolek 1978, Ford and Kinzie 1982, Kinzie 1988, Luton *et al.* 2005, Brasher and Wolff 2007). And the successful maintenance of natural streambeds and adequate water quality of Hawaiian streams may be necessary to insure the retention of populations of Hawaiʻi's endemic aquatic fauna, including the native fishes.

Although long-term habitat restoration efforts in densely urbanized landscapes are not realistic, we believe it is still possible to remove invasive species from waterways with considerable intensive effort. Most recent freshwater alien introductions come from the aquarium trade, where unwanted fish and macro-invertebrates are discarded in streams and other water bodies around the state (Yamamoto and Tagawa 2000, Brasher 2003). The largest occurrence and diversity of these aquarium-introduced species often correlates to low elevation areas (Martin et al. 2019), areas of increased human disturbance (Brasher 2006, Kido 2013, Martin et al. 2019), and even locations where animals can be conveniently introduced to streams, i.e., road crossings in residential areas (personal obs, and Martin et al., 2019). At high densities, introduced freshwater fishes are habitat and food resource competitors that can cause significant changes in structure of native food webs (Brasher 2003), as well as introduce disease and parasites (Font and Tate 1994). Introduced, predatory freshwater game fishes, e.g. *Micropterus dolomieu* (Smallmouth Bass), directly consume native migratory species (Yamamoto and Tagawa, 2000), thus affecting fish passage through stream reaches to which they have been introduced (Brown et al. 1999, March et al. 2003, Higashi and Friaola, pers. comms). Like other introduced species, catfishes of the family Loricariidae are generalists, able to tolerate a broad range of environmental conditions, and thus have a competitive advantage over native species (Brasher et al. 2006). In aggregations, loricariids can directly impact and degrade water and habitat quality in streams (Brasher 2003). For example, high population densities of loricariid catfishes in Hawaiian streams have been documented to increase turbidity and sedimentation, as well as compromise bank stability, due to their burrowing behavior undercutting stream banks (Devick 1989, Nico and Martin 2001, Brasher 2006). Furthermore, aggregations of loricariids create biogeochemical hotspots through nitrogen and phosphorus excretion and remineralization (Capps and Flecker 2013; Tan 2018 [unpublished data]).

The Ala Wai Watershed

Mānoa, Pālolo, and Makiki Valleys comprise the highly urbanized "Ala Wai Watershed" (Figure 1). The Ala Wai Watershed is one of the most densely populated areas in the state with ~ 200,000 residents in a total land area of only 26.2 km^2 Natural stream flows to the ocean from these valleys in the Koʻolau Mountain Range are today interrupted by the Ala Wai Canal. Roughly one-third of the upper / headwater region are in forested watershed, while the majority remainder is moderate to heavily urbanized, supporting residencies, condominiums, hotels, businesses, and educational institutions. The middle to lower reaches of Mānoa Stream are significantly modified for flood control with its channel widened and banks earthen-shaped or hardened with concrete walls. Of the three streams, Mānoa is the least modified, whereas Pālolo and Makiki have a more infrastructure for flood control. With this kind of intense urbanization and public use, it is not surprising that the Ala Wai Watershed has amongst the lowest populations of native stream animals, and the highest densities and diversity of invasive species in the State of Hawaiʻi.

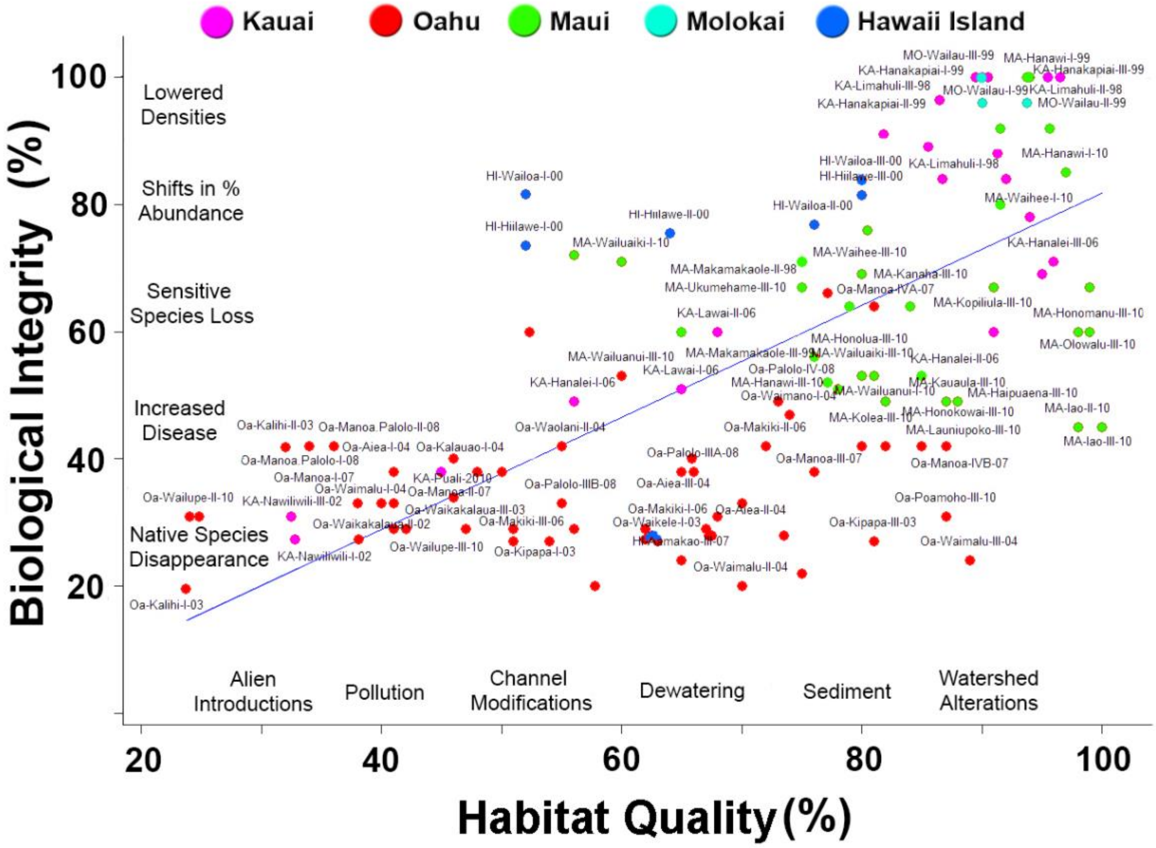
The Hawaiian Stream Index of Biological Integrity

The concept of "integrity" incorporates the idea that comparisons are made using the "functions and components of whole natural systems" as examples of robust ecological health (Karr and Chu 1999). The Hawaiian Stream Index of Biological Integrity (HS-IBI) incorporates 11 metrics covering five ecological categories, and has shown to effectively differentiate relative environmental/habitat quality in streams on all Hawaiian Islands across gradients of human influence, from near-pristine to severely impaired (Table 2, Figure 1)(Kido 2013). To determine biological integrity scores for a given site, counts and measurements of fishes and macro-invertebrates are obtained by either underwater visual census or electrofishing techniques. The sites with the highest native species densities are designated as reference sites and obtain the maximum of 55 points and up to 5 points per metric. Any deviation in native species abundance and distribution, or presence of non-native species will result in lower HS-IBI scores, which presumably corresponds to lower overall ecosystem health (Table 2, Figure 1).

TABLE 2. Metrics / scoring criteria for the Hawaiian Stream Index of Biological Integrity

		Scoring criteria		
Category	Metric	5 (best)	3	1 (worst)
Taxonomic richness	1a. Number native species (non-estuary)	4–3	2–1	0
	1b. Number native species (estuary reach)	6–5	4–2	1–0
	2. % native taxa	100–75 %	74–50 %	≤49 %
	3. Number alien taxa	0–1	2–3	>3
Sensitive "sentinel"	4. % sensitive native fish[a]	≥50 %	49–20 %	≤19 %
Species	5. Sensitive native fish density (fish m^{-2})[b]	≥0.46	0.45–0.20	≤0.19
Reproductive capacity	6. Sensitive native fish size (%≥6.0 cm TL)[c]	≥50 %	49–25 %	≤24 %
	7. *Awaous guamensis* size (%≥8.0 cm TL)[c]	≥50 %	49–25 %	≤24 %
Trophic/habitat	8. Total native fish density (fish m^{-2})	≥0.75	0.74–0.36	≤0.35
Capacity	9. Community weighted average (CWA)	1.0–4.0	4.1–9.0	9.1–10
Tolerance capacity	10. % Tolerant alien species	0 %	1–4 %	≥5 %
	11. % Diseased or parasitized fish	≤1 %	2–10 %	≥11 %

aSensitive species are *L. concolor* and *S. stimpsoni*, **b***L. concolor* or *S. stimpsoni* (whichever is in higher density), and **c**Excluding post-larval size classes (≤ 3.0 cm TL).



Data collected by Hawaii DOH and UH Manoa CCRT (1998 - 2010)

Figure 1. Significant relationship between biological integrity and habitat quality in Hawaiian Streams. Scores displayed as % for each of the five islands samples.

Nā Wai ʻEkolu: Community Outreach and Stream Restoration

Direct removal of invasive species is a means to restoring habitat, while education and outreach is a critical strategy for stopping new introductions and limit the spread of invasive aquatic species (Hain et al. 2019, Martin et al. 2019). As many exotic fish species are imported for the home aquarium trade, they are often introduced when unwanted pets are discarded into streams in direct relation to urban centers around the state (Brasher 2006). Some of these species quickly dominate stream habitats (Brasher 2006), and can also restrict upstream migration from the ocean (Hain et al. 2019, Higashi and Fraiola, pers. comms.). Removal of invasive animals through community involvement not only provides a realistic removal strategy, but also has the valuable benefit of engaging and educating people in conservation, while enhancing native fish habitat in their own communities.

ʻIolani School has helped unify a consortium of educational institutions with the common interests of protecting the health of their watershed and educating students to become better stewards in their community. With the assistance of the University of Hawaiʻi at Mānoa Center for Conservation Research and Training (UH-CCRT), the consortium developed a stream outreach and watershed restoration project called, “Nā Wai ʻEkolu,” whose initial focus was educating local communities about Hawaiʻi’s unique migratory freshwater species and the effect of anthropogenic influence on their habitat. More recently, the consortium believed that caring for and restoration of the three streams that flow through the Ala Wai Watershed was of critical importance to community responsibility. Place-based classroom curricula and modified HS-IBI field protocols were developed for use in K-12 public, private, and charter schools in the Ala Wai Watershed and emphasize biological integrity, i.e., the health of a system as indicated by species diversity / abundance, through four sequential training workshops. With the number of schools, educators, and students interested in participating in Nā Wai ʻEkolu, stream ecosystem restoration and enhancement are realistic goals. In addition to annual statistics documenting the number of schools, educators, and students reached, the following questions will continue be investigated over the course of the study:

1) Can invasive species be controlled by regular removal efforts by the community?

2) Will native migratory species return to urbanized stream habitats if invasive species populations are suppressed?

3) Does stream biological integrity improve if invasive stream animal populations are controlled?

METHODS

Study sites

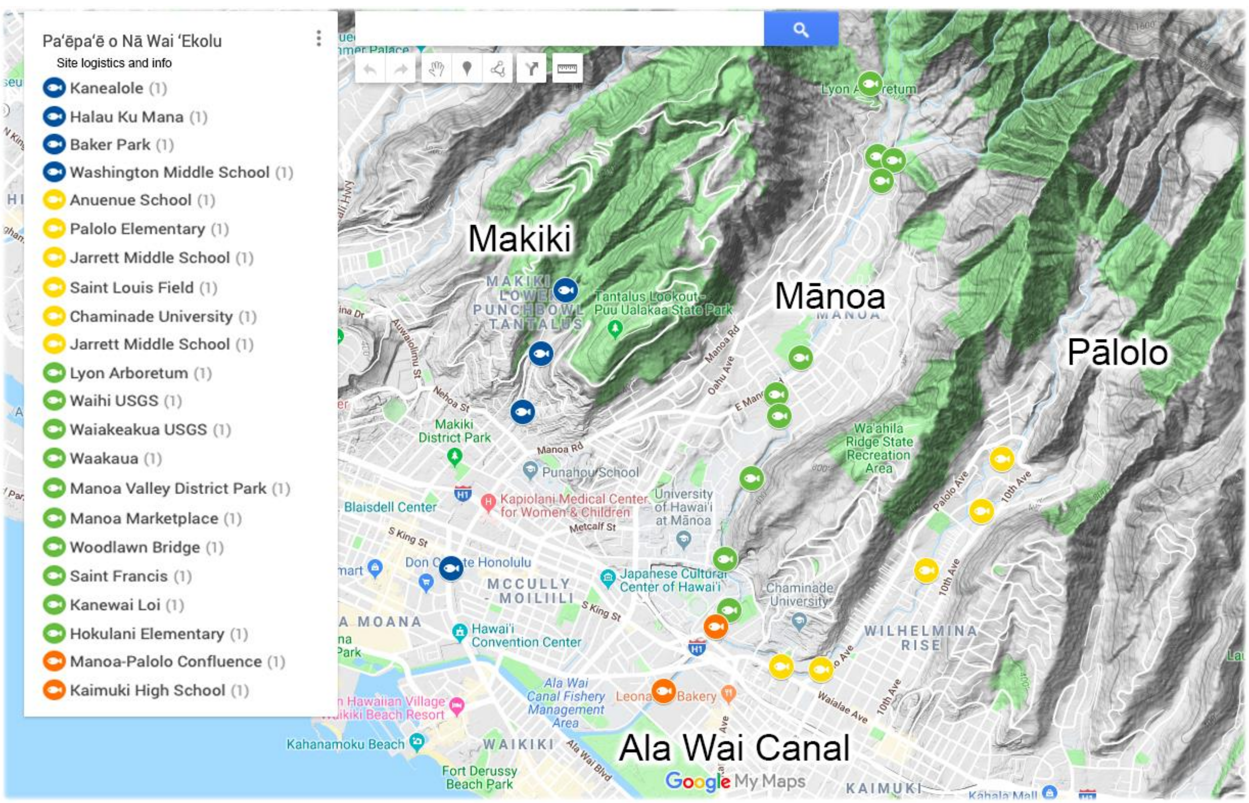


Figure 2. Current and near-future stream sites in Makiki, Mānoa, and Pālolo Valleys

Study reaches (n=20) were selected in Makiki, Manoa, and Palolo Streams (Figure 2) to correspond to stream sites established and sampled in each stream by Kido in 2007, 2008, and

2009, respectively. The length of each study reach was determined by multiplying each site's mean stream width 10x or a minimum of 50 m, to ensure that captured animals represented the biodiversity and habitat types of that area (Nielson and Johnson 1983, Kido 2002). Over the course of one year, a maximum of 50 field surveys will be conducted (~ once per week), where each site will be visited a minimum of two times per year.

Community Training

Participants will go through two-day in-person training workshops provided by UH-Mānoa CCRT and ʻIolani School staff, and are based in part upon the recommendations of the AFS/ASIH Guidelines for the Use of Fishes in Research (Figure 2). During the first workshop, participants will learn about stream biodiversity in Hawaiʻi, habitat loss, challenges to native fish species migration, identification of native and non-native species, various methods of capture of stream species, as described by Kido (2002) (Figure 2). In the second workshop, participants will rehearse capture methods on dry land (See Capture), and identification of native and non-native animals using scaled, laminated models of all species known to occur within a site, as listed by Kido in 2007, 2008, and 2009 (Figure 2). Once capture rehearsal is complete, participants will have to sort through species models found in their nets and learn how to properly remove and transport them to buckets / bins of stream water (see *Capture*) (Figure 2). Online tools on nawaiekolu.org further review workshop curriculum and concepts, as well as exams are provided to ensure volunteers are trained for field surveys.

Figure 3. Four sequential workshops offered to K-12 public and private schools from UHM / ʻIolani partnership

Capture (Workshop / Lesson 3)

Fishes (see Table 3) were captured by wading in stream water depth ≤ 0.5 m, using A-framed ‘ōpae nets measuring 0.92 m x 1.22 m in dimension and a 3.0 -4.57 m seine net / barrier, both with 3/16-in mesh (Figure 4 and 5). An average of 6 nets were placed to span the width of a downstream border of a study site, and the ~ 3.0 m – 5.0 m seine net was stretched across the upstream border of the study site. Fishes between the up and downstream borders were then herded and captured in the downstream ‘ōpae nets. Once nets were removed from the water, netted animals were placed on shaded streambank, with rock or grassy substrate. Native fishes were identified and removed from the nets first by hand (wetted and gloved), followed by the same procedure non-native fishes. Biological surveys by Kido (2007, 2008, 2009) have shown that native species are rare to absent in the proposed study sites, and therefore native species, when found, were not exposed to air for more than 1 – 2 minutes after capture and identification. Non-native animals were not be exposed to air for more than 3 minutes after capture, during counting and identification. Professional researchers and/or a representative from DLNR Division of Aquatic Resources was present to confirm identification of any species before any animals were placed in their respective holding containers. Native animals were be placed in battery-aerated 5-gallon plastic buckets of fresh water from their capture location. Native predatory animals, e.g. ‘o‘opu akupa, were held in separate buckets from other native species and smaller conspecifics to ensure no predation occurs in captivity (Yap 2009). Professional personnel exchanged / changed-out water in buckets / bins after each replicate, in order to maintain a healthy dissolved oxygen concentration and temperature, until native species were released. Once all fishes were sorted, native fishes were released back to their capture locations. Identified non-native fishes were not released back into the stream (See *Euthanasia*). Holding time for both native and non-native species was between 20 minutes to 120 minutes, depending on the site dimensions.

Euthanasia (See new section)

Under our current special activity permit and advisement by DAR personnel, non-native animals have been euthanized by ice-bath immersion in either 5 gallon or 18 gallon plastic containers.

Table 3. Listed freshwater fish species, total expected number captured over one year period / per survey, maximum fish length, and if euthanasia will be administered. Estimates based on historical data for Mānoa, Pālolo, and Makiki Stream surveys. NOTE, the effect of the number of animals sampled is not a result of a particular number being needed for statistical significance, but a reflection of sampling enough sites at a high enough frequency to achieve statistical significance.

Common Name	Scientific Name	Annual Total	per survey	*size range (cm)	Euthanasia
**Oopu naniha	*Stenogobius hawaiiensis*	76	< 2	4-8	No
**Oopu nakea	*Awaous stamineus*	64	< 2	4-20	No
**Oopu akupa	*Eleotris sandwicensis*	90	< 2	4-16	No
**Oopu nopili	*Sicyopterus stimpsoni*	1	< 1	4-8	No
**Aholehole	*Kuhlia xenura*	186	< 4	4-15	No
Blackchinned Tilapia	*Sarotherodon melanotheron*	26	< 1	2-20	Yes
Mozambique Tilapia	*Oreochromis mossambicus*	108	< 2	2-20	Yes
Convict Cichlid	*Amatitlania nigrofasciata*	213	< 4	2-12	Yes
Red Devil Cichlid	*Amphilophus labiatus*	3	< 1	2-18	Yes
Suckermouth Catfish	*Hypostomus watwatta*	1272	< 24	3-28	Yes
Bristlenose Catfish	*Ancistrus spp.*	1450	< 27	3-12	Yes
Chinese Catfish	*Clarius fuscus*	1	< 1	4-28	Yes
Rainbow Guppy	*Poecilia reticulata*	3078	< 58	1-4	Yes

Mexican Molly	*Poecilia sphenops*	3580	< 68	1-8	Yes
Mosquitofish	*Gambusia affinis*	7	< 1	1-6	Yes
Swordtail	*Xiphophours helleri*	202	< 4	1-6	Yes
Smallmouth Bass	*Micropterus dolomieui*	43	< 1	3-28	Yes

**Native species.
*Very few fishes captures will attain the maximum size above, with 88 % of fishes measured less than 10 cm and weighed less than 20 g. The biggest fish caught in previous studies weighed 180 g.

However, under recommendation from University of Hawaiʻi at Mānoa veterinarians, literature reviews, and colleagues, we propose that non-native species will be immediately euthanized using a clove-oil solution, of which concentration depends on the maximum fish size class present (Table 3). Both volumes of containers will be dark colored, and covered, so that no volunteers will be able to view euthanized animals. Small fishes (< 5cm) will be subjected to a dilution of 0.25 mL / L, medium fish 0.50 ml / L (5-15cm), and large fish (>15cm +) captured of 1.0 mL per 1.0 L, of clove oil to stream water, respectively. Since clove oil has a low solubility in water, the clove oil will be dissolved in 1 part clove oil to 10 parts ethanol, before adding it to the contained stream water (Holloway et al. 2004). After fishes are added, trained personnel will observe decreasing of levels of fish behavior (swimming / equilibrium / gill movement), culminating with euthanasia, as identified by cessation of any opercular / gill plate movement for 30 minutes. Euthanized fishes will then be removed from the clove oil mixture, and placed in coolers with ice for transport to Hoʻoulu ʻāina, an organic reforestry and agroforestry project in Kalihi Valley, for composting. Further information about organic composting methods are available upon request. If any native species are mortally injured during a survey, they will be subjected to the same euthanasia procedures as non-native species.

Before disposal, the clove oil solution will be decreased in concentration 10-fold, using additional stream water. In addition to a food flavoring additive, the US EPA exempted clove oil as a minimum risk active ingredient in pesticide. The MSDS indicates clove oil is not environmentally hazardous, and therefore the resulting dilution will be disposed of in a vegetated area, > 200 ft from the edge of the water.

Decontamination

All equipment was either submerged in or sprayed with a 10% bleach dilution and rinsed thoroughly with freshwater. All equipment was dried for 24 hours between uses to disinfect and mitigate spread of disease or invasive species, respectively.

RESULTS and DISCUSSION

From November 2015 to July 2020, we have worked with 16962 students and 1938 educators from over 50 educational and professional institutions around the island of Oʻahu (Appendix 1). During this period, Lessons 1, 2, 3, and 4 were performed 332, 249, 338, and 17 times, respectively (Appendix 1). Total number of fishes and macroinvertebrates captured during field lessons was ~ 42165, of which only 1059 were native species (Table 4). All invasive animals were removed from the stream, totaling ~1654 pounds, and converted into compost or adopted as household pets from students, parents, and teachers (Appendix 1). Native species were always released back to their capture location following the field activity.

Table 4. Preliminary results of students participating in Lesson 3 surveys (Jan 2016 to Feb 2020*)

	2016	2017	2018	2019	2020*
Site Visits	24	47	49	56	12
Total Captured	4536	14278	9701	11007	1694
Total Natives Captured	26	183	313	420	92
% Natives	0.6	1.3	3.2	3.8	5.4
Ave Native Captured/Survey	1.1	3.9	6.4	7.5	7.7
Total Invasives Captured	4510	14095	9388	10587	1602
Ave Invasive Captured/Survey	187.9	299.9	191.6	189.1	133.5
% Invasives	99.4	98.7	96.8	96.2	94.6
HSIBI	30.3	30.2	32.7	33.0	33.7
Total Biomass Removed (lbs)	176.8	709.8	414.6	263.95	57.9
Ave Biomass Removed	7.4	15.1	8.5	4.7	4.8

*Covid-19 Pandemic cut our surveys short by up to 18 surveys during this permitting period.

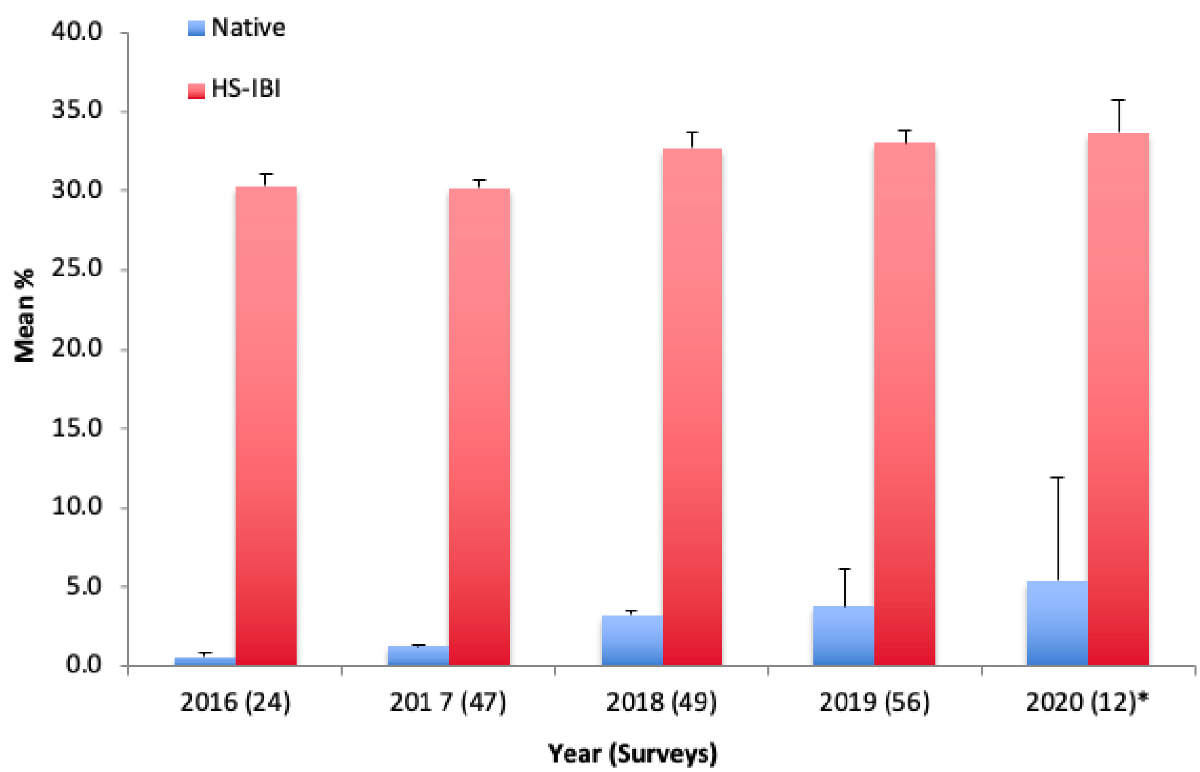


Figure 3. Mean percent (+SE) native and Hawaiian Stream Index of Biological Integrity (HS-IBI) scores during project period. *Covid-19 Pandemic cut our surveys short by up to 18 surveys during this permitting period. The last survey was performed on February 28, 2020.

Preliminary mean native species and biological integrity scores show an increasing trend when averaged across all study sites (Table 4, Figure 3). Average invasive species captured and invasive biomass removed per survey have are also decreasing from 2017 to 2020 (Table 4). Unfortunately, only 12 surveys were performed in 2020, prior to the covid-19 pandemic shutdown. As our study sites decrease in invasive species densities, we expect our activities will further provide important refuges for native recruiting or migrating animals, as they are likely to be areas of decreased competition / predation, with / from invasive species. There are at least small populations that persist in all three streams in these degraded environments, even in our upper-most study sites.

Despite how encouraging our survey data and how unified our community has become, we cannot continue our physical interactions with schools until it is deemed safe by their administrations, families, and health officials. Our findings, when are able to safety start again, will be critical to validate our work over the past five years. Although we are still able to hold live, virtual classrooms and field trips, we are aware of the technological difficulties both teachers and students may have coordinating simultaneous access to smart devices and/or computers at home. In the meantime, we have developed a large amount of distance learning materials; e.g., prerecorded lessons and virtual field trips, tutorial videos for independent teaching activities, Kahoot! Quizzes, interactive species and data maps, etc.; for all of our educators who are able to remotely communicate with their students (Appendices 2 and 3). A large number of students and teachers have already used these resources during the pandemic and have also redistributed them to colleagues and friends working at other schools we have yet to meet in person. In addition to what we've taught in the past years, schools are independently analyze our data to determine which streams have the most native species; which streams have responded most to our removals of non-native species; and estimate which streams have the most diverse and largest populations on non-native species; as well as to better understand distributions of all aquatic macrofaunal species within the Ala Wai Watershed.

CONCLUSIONS

Although having received high community support for this activity in a relatively short time, improvements in stream biological integrity and/or health of Hawaiian Streams will require consistent participation from educational and professional institutions. With the current commitments of participating community members, we will be able to maintain these intensive efforts to improve stream health in Hawaiʻi's watersheds that need it most. We believe these participants have a stronger responsibility and connection to their place, as well as a better understanding of watershed health. Based on preliminary communications, we anticipate Nā Wai ʻEkolu participants from outside of the Ala Wai Watershed intend to start stream restoration programs in their communities.

ACKNOWLEDGEMENTS

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APPENDIX

Stream Outreach Activity Statistics (Nov 2015 - Jul 2020)

Number Reached

Grades (K - 12+)

Students (16962)

Educators (1938)

Lessons Given: (936)

Lesson 1 (332)
Lesson 2 (249)
Lesson 3 (338)
Lesson 4 (17) new for 2019/2020

Animals Captured (42165):

Invasive Species (41106)

Native Species (1059)

Biomass Removed (1654 lbs)

Educational institutions involved (* multi-grade): > 50

Kuhio Elem
Aliiolani Elem
Hokulani Elem*
Hauula Elem*
Aiea Elem
Pauoa Elem
Jefferson Elem
Haleiwa Elem
Noelani Elem
Manoa Elem
Palolo Elem
Waikiki Elem
Ala Wai Elem
Hahaione Elem

Blanche Pope Elem
Kaahumanu Elem*
Hawaii Tech Academy
Stevenson Middle
Washington Middle
Kailua Intermediate
Jarrett Middle
Myron B. Thompson*
Halau Ku Mana
SEEQS*
Voyager Academy
Hanahauoli School
University Laboratory*
St. Louis School

Anuenue School*
Radford High
Roosevelt High
Waialua High*
Kaimuki High*
Kalani High
Mililani High
McKinley High
Mid Pacific Institute*
Punahou School*
Iolani School*
Kamehameha School*
Hawaii Baptist Academy
Pacific Buddhist Acad.

Chaminade University
(College of Education)
University of Hawaii*
(NREM, College of Education
Oceanography, Urban Planning
Hawaii Nature Center*
Queen Liliuokalani CC*
Ka‘i Program*
Mele Murals Program
Project BEAM
STEAM Project
Home School Students*
Waipahu Complex Educators
KUPU*

APPENDIX 2: Distance Learning Curriculum (nawaiekolu.org/n-wai-ekolu-curriculum)

Stream Fauna Identification

- Native Stream Animals (flash cards) (sheet)
- Invasive Stream Animals (flash cards) (sheet)
- Species List (Sheet)

Online Lecture and Story Map

- Online Stream Biodiversity Lecture: (Grades 7-12) (Grade 3-6 coming soon!)
- Interactive ArcGIS Story Map (All Ages)

Virtual Field Trips (map view):

- Kaimukī High School site, Mānoa-Pālolo Stream
- Kānewai Lo'i site, Mānoa Stream
- Mānoa Park site, Mānoa Stream
- Waihī USGS site, Mānoa Stream (stay tuned!)
- Saint Louis School site, Pālolo Stream
- Ānuenue School site, Pālolo Stream
- Hālau Kū Māna study site, Makiki Stream
- Washington Middle School, Makiki Stream (stay tuned!)

Stream Habitat Assessment

- Visual Assessment Activity w/ Illustrations (Grades 4-12)
- Stream Assessment Scorecard (Grades 4-12)

Kahoots:

- Grades 1 to 6 Kahoot
- Grades 7 to 12 Kahoot
- ArcGIS Story Map Kahoot

Literature (Grades 9-12)

- Impacts of Human Disturbance on Biotic Communities in Hawaiian Streams
- Climate change and conservation of endemic amphidromous fishes in Hawaiian streams
- A native species-based index of biological integrity for Hawaiian stream environment

GRADES 9-12

Calculating a Biodiversity Index to Assess Stream Health

Goal: Using data collected by the students on their stream field trip and by other schools collected previously, students will be able to calculate an Hawai'i Stream Index of Biological Integrity (HS-IBI) and understand how it can be used to assess stream health

Lesson Plan

HS-IBI tutorial video (Part 1) (Part 2)

How healthy are stream ecosystems?

- Calculate the Hawaii Stream Index of Biological Integrity (HS-IBI)
- HS-IBI example calculations at Makiki Stream
- HS-IBI example calculations at Manoa-Palolo Stream
- Use sample data to determine how the HS-IBI varies at a site over time
- Use sample data to determine how the HS-IBI varies at different sites
- Use sample data to determine how the HS-IBI varies with elevation along a stream
- Answer questions about your data

GRADES 6-8

Find Your Soapbox

Goal: Using data collected by the students on their stream field trip and by other schools collected previously, students will be able to understand, analyze, interpret, and use data to support an argument.

Lesson Plan and Tutorial Video

How healthy are stream ecosystems?

- Use sample data to graph the percent of native and invasive species found along a stream
- Use sample data to illustrate the ratio of native and invasive species found along a stream
- Use sample data to look at different variables in a stream
- Answer questions about your data

GRADES 3-5

Exploring the Possible

Goal: Using data collected by the students on their stream field trip and by other schools previously, students will understand and articulate the long-term effects of invasive species removal and their contribution to the health of the watershed.

Lesson Plan and Tutorial Video

How healthy are stream ecosystems?

- Interpret sample data collected on the same date but in different locations
- Interpret sample data collected at the same site over time
- Answer questions about your data

GRADES K-2

What's In a Number?

Goal: Using the data that students collected on their stream field trip, students will explore and visualize numbers. In deepening their number sense, students will then understand more fully their impact on stream health through the removal of invasive species.

Lesson Plan and Tutorial Video

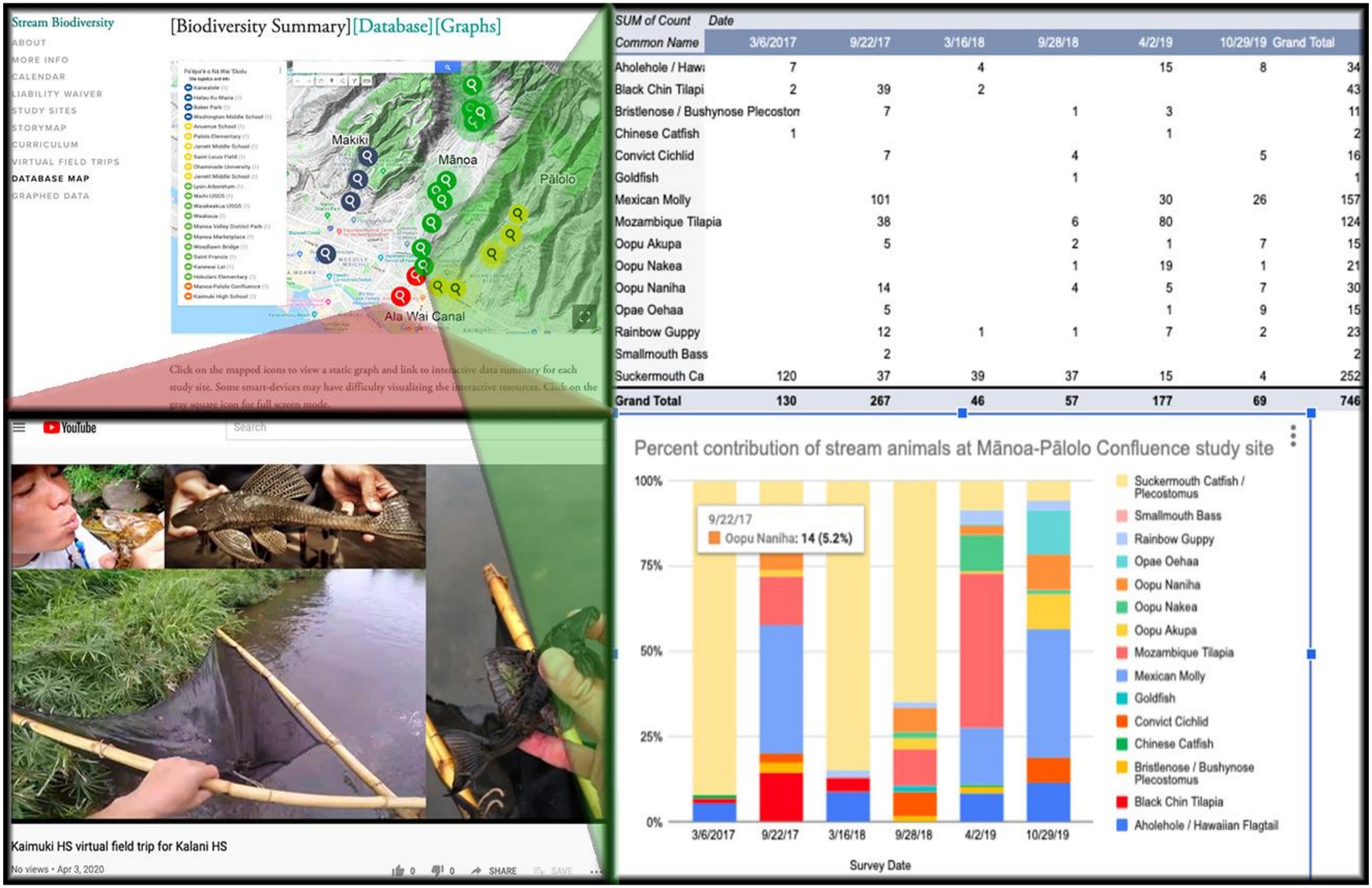
How healthy are stream ecosystems?

- Use sample data to determine the number of native and invasive stream fauna at a site
- Answer questions about your data

Please enjoy these resources and we welcome any feedback. If you use them in your classroom we would love to see what you did, and any additional worksheets or resources you developed. Please email ychan@iolani.org

This curriculum was developed by Patti

Appendix 3: Interactive Maps for viewing / analyzing data and virtual field trips



SUM of Count	Date						
Common Name	3/6/2017	9/22/17	3/16/18	9/28/18	4/2/19	10/29/19	Grand Total
Aholehole / Hawa	7		4		15	8	34
Black Chin Tilapi	2	39	2				43
Bristlenose / Bushynose Plecoston		7		1	3		11
Chinese Catfish	1				1		2
Convict Cichlid		7		4		5	16
Goldfish				1			1
Mexican Molly		101			30	26	157
Mozambique Tilapia		38		6	80		124
Oopu Akupa		5		2	1	7	15
Oopu Nakea				1	19	1	21
Oopu Naniha		14		4	5	7	30
Opae Oehaa		5			1	9	15
Rainbow Guppy		12	1	1	7	2	23
Smallmouth Bass		2					2
Suckermouth Ca	120	37	39	37	15	4	252
Grand Total	**130**	**267**	**46**	**57**	**177**	**69**	**746**