

**Water Resources Research Center
Hawaii and American Samoa**

**Annual Technical Report
2018**

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Likely hotspots for algal blooms: A multi-dimensional analysis to evaluate seasonal impact of land-based sources of pollution on the health of American Samoa's coasts

Project ID:

2016AS456B (Rosanna Alegado)

Project Impact:

Anthropogenic nutrient loading is recognized as a stressor to coastal ecosystem health. However, resource managers are often focused on addressing point source or surface water discharge, whereas the impact of submarine groundwater discharge (SGD) as a nutrient vector is often unappreciated. This project examined the connections between land use and nutrient loading through comparisons of four watersheds and embayments spanning a gradient of human use impact on Tutuila, a high tropical oceanic island in American Samoa. In each study location, coastal radon²²² measurements, dissolved nutrient concentrations, microbial community composition, and nitrogen isotope values ($\delta^{15}\text{N}$) in water and *in situ* macroalgal tissue collection and analyses were used to explore SGD and baseflow derived nutrient impacts, and to determine probable nutrient sources. In addition to sampling *in situ* macroalgae, pre-treated macroalgal specimens were deployed throughout each embayment to uptake ambient nutrients and provide a standardized assessment of differences between locations. Results showed SGD-derived nutrient flux was more significant than baseflow nutrient flux in all watersheds, and $\delta^{15}\text{N}$ values in water and algae suggested wastewater or manure were likely sources of elevated nutrient levels in all watersheds. While nutrient loading correlated well with expected anthropogenic impact, other factors such as differences in hydrogeology, distribution of development, and wastewater infrastructure also likely played a role in the visibility of impacts in each watershed. This is one of the first studies to use microbial community analysis to assess watershed health in American Samoa.

Publications:

“Assessment of terrigenous nutrient loading to coastal ecosystems along a human land-use gradient, Tutuila, American Samoa,” Presented at Water Resource Research Center Advisory Board Meeting, Tauese P.F. Sunia Ocean Center, Pago Pago, American Samoa, October 16, 2018.

Shuler C.K., 2019, “From recharge to reef: Assessing the sources, quantity, and transport of groundwater on Tutuila Island, American Samoa,” Ph.D. dissertation, Department of

Geology and Geophysics, School of Ocean and Earth Sciences Technology, University of Hawai'i at Mānoa, Honolulu, HI, 301 p.

Shuler, Christopher K., Daniel W. Amato, Veronica Gibson, Lydia Baker, Ashley N. Olguin, Henrietta Dulai, Celia M. Smith, and Rosanna A. Alegado, 2019, "Assessment of terrigenous nutrient loading to coastal ecosystems along a human land-use gradient, Tutuila, American Samoa," *Hydrology*, 6(1), 18. doi:10.3390/hydrology6010018

Information Transfer Program:

We presented our initial results and ongoing research at the 2018 WRRC meeting in Pago Pago, American Samoa. Community stakeholders present included representatives from American Samoa Power Authority, American Samoa Coral Reef Advisory Group, U.S. National Park Service, NOAA, and the American Samoa Community College.

Student Support:

| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
|---------------|------------------------|------------------------|----------------------|---------------------|----------|
| Undergraduate | 1 | | | | 1 |
| Masters | 1 | | | 1 | 2 |
| PhD | 2 | | | 2 | 4 |
| Post-Doc | 1 | | | | 1 |
| TOTAL | 5 | | | 3 | 8 |

Notable Achievements and Awards:

None

Student Internship Program:

Nalani Olguin was an undergraduate intern on this project for two years. Over this period she improved her molecular skills in isolating DNA and preparing these samples for high throughput sequencing. She gained ample field experience, particularly in logistical organization and experimental design. Olguin exhibited both outstanding work ethic and commitment to engaging with the Tutuila community, particularly in the village of Vatia. She worked extremely well with others on her team, including our on-the-ground contact, Faasalafa Kitiona.

Veronica Gibson is a Ph.D. candidate in the Botany department and has been a graduate intern on this project for two years. Gibson's skills in phycology as well as in the water were invaluable to deployment and collection of our seaweed cages for $\delta^{15}\text{N}$ measurements. She has displayed a commitment to engaging the Tutuila community. Gibson clearly demonstrated leadership skills by becoming the Chief Scientist in year 2 of our field campaign.

Eric Welch was an M.S.-level intern in the Department of Earth Sciences for one field season. He demonstrated a strong work ethic and brought expertise in hydrology to our field work. Although he was not as strong in marine deployments, he did demonstrate a commitment to his responsibilities.

Chris Shuler was a valuable team member to this project. As the field leader of our first phase, he provided on-the-ground contacts in Tutuila and his experience and insight enabled our field sampling design to capture the patterns we hypothesized we might observe. Shuler was willing to share his considerable knowledge of hydrology and water quality on the island of Tutuila.

Dan Amato was a postdoctoral fellow who acted as Chief Scientist for our first field season. His attention to detail and commitment to collecting a comprehensive data set directly contributed to the success of our project. Amato is a long-range thinker, always striving to understand and connect our work to policy implications, and able to shepherd our field team effectively.

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Assessing recharge mechanisms of groundwater under the influence of surface water with isotopic and microbiological tracers, Tutuila, American Samoa

Project ID:

2017AS471B (Marek Kirs)

Project Impact:

On Tutuila, American Samoa, a boil-water advisory has been in effect since 2010 due to turbidity and *E. coli* detections in the island's highest producing wells. The U.S. Environmental Protection Agency designated groundwater from certain wells to be under the direct influence of surface water (GUDI). The goal of this project is to determine if the problem is caused by highly permeable aquifer material or poorly constructed wells, by studying mechanisms and travel time of groundwater recharge.

In this study, three independent surface-water tracers, turbidity, indicator bacteria, and water isotopes were used to assess recharge timing and determine contamination mechanisms. Results from each method were reasonably consistent, revealing average GUDI well breakthrough times of 37 ± 21 hours for turbidity, 18 to 63 hours for bacteria, and 1 to 5 days for water isotopes. These times correspond with the estimated subsurface flow rates through highly-permeable aquifer materials. In contrast, where one well casing was found to be compromised, turbidity breakthrough was observed at 3 to 4 hours. These results support local management decisions by showing that repairing or replacing the GUDI wells will only result in continued contamination. Additionally, differences in observed rainfall response for each tracer provide insight into the recharge dynamics and subsurface flow characteristics of this and other highly-conductive young-basaltic aquifers.

Publications:

Shuler, C.K., 2019, "From recharge to reef: Assessing the sources, quantity, and transport of groundwater on Tutuila Island, American Samoa," Ph.D. dissertation, Department of Geology and Geophysics, School of Ocean and Earth Sciences Technology, University of Hawai'i at Mānoa, Honolulu, HI, 301 p.

Shuler, C.K., H. Dulai, R. DeWees, M. Kirs, C.R. Glenn, and A.I. El-Kadi, 2019, "Isotopes, Microbes, and Turbidity: A Multi-tracer approach to understanding recharge dynamics and groundwater contamination in a Basaltic Island aquifer," *Groundwater Monitoring & Remediation*, 39(1):20–35. <https://doi.org/10.1111/gwmr.12299>

Information Transfer Program:

The results for this project were presented at the:

- 2017 Geological Society of America (GSA) Annual Meeting, Seattle Convention Center, Seattle, WA, October 2017.
- Individual stakeholder meetings from August 24 to 27, 2018. Primary stakeholder of interest was the American Samoa Power Authority Water Engineering Services Division, as the work is directly applicable to their decision making. Other stakeholder groups include: NOAA Marine Sanctuaries, Coral Reef Advisory Group and NOAA representatives, American Samoa Community College research coordinator and American Samoa Community College Land Grant Director, American Samoa EPA, and American Samoa congressional office.

Student Support:

| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
|---------------|------------------------|------------------------|----------------------|---------------------|----------|
| Undergraduate | | | | | |
| Masters | | | | | |
| PhD | 1 | | | | 1 |
| Post-Doc | | | | | |
| TOTAL | 1 | | | | 1 |

Notable Achievements and Awards:

Chris Shuler, the student supported on project 2017AS471B won the Toby Lee award in Geology and Geophysics from the ARCS Foundation for 2018, and the University of Hawai'i Foundation's Scholar of the Year Award.

Student Internship Program:

None

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Real-time optimization of irrigation scheduling for farmlands in American Samoa

Project ID:

2017AS472B (Sayed Bateni)

Project Impact:

Irrigation is an important issue in American Samoa and has raised concerns for farmers due to the high cost of water and energy. One of the easiest and most affordable ways to protect water resources in American Samoa is to design an optimal irrigation scheduling. In this project, two weather stations were installed in the Malaeimi and Tafeta farms in American Samoa to measure micrometeorological variables. The measured air temperature and humidity, wind speed, and incoming solar radiation were used in the Penman-Monteith equation to estimate reference evapotranspiration (ET_0). The fractional canopy coverage and root depth were measured for Chinese cabbage, cucumber, edible hibiscus, and pak choi in the Malaeimi and Tafeta farms. The fractional canopy coverage measurements were utilized to estimate the crop coefficient (K_c). The product of reference evapotranspiration and crop coefficient generated the actual evapotranspiration ($ET = K_c \times ET_0$). The measured rainfall and calculated actual evapotranspiration values at the collaborating farmers were incorporated into the CropManage irrigation software on a daily basis via the Application Programming Interface (API).

The CropManage tool offers several advantages to the farmers in American Samoa: (1) enables farmers to schedule watering to minimize crop water stress and maximize yields, (2) reduces farmer's cost of water and labor through fewer irrigation rounds, thereby making maximum use of soil moisture storage, (3) lowers fertilizer costs by holding surface runoff and deep percolation (leaching) to a minimum, and (4) increases net returns by increasing crop yields and crop quality.

Publications:

Bateni, S., J. Deenik, M. Golabi, I. Gurr, M. Cahn, and C. Neale, 2019, "Conserving Water Resources in the US Pacific Islands Region by optimal irrigation of farmlands," Presented at 74th SWCS International Annual Conference, Pittsburgh, PA, July 28–31.

Lum, M., S. Bateni, J. Shiri, and A. Keshavarzi, 2017, "Estimation of reference evapotranspiration from climatic data," *International Journal of Hydrology*, 1(1):25–30. doi: [10.15406/ijh.2017.01.00005](https://doi.org/10.15406/ijh.2017.01.00005).

Information Transfer Program:

- Results of this project were disseminated by one journal paper and one conference abstract.
- The CropManage online tool is available to farmers in American Samoa freely: <https://cropmanage.ucanr.edu/Home/SplashPage?ReturnUrl=%2F>
- The measured micrometeorological data by weather stations in the collaborating farms were connected to the Weather Underground website (<https://www.wunderground.com/>) to increase their exposure.
- Workshops were organized in the cooperating farms. The purpose of these workshops was to increase farmers’ awareness of irrigation scheduling and the components of the web-based irrigation tool.
- This work was broadcast by the Olelo TV. In 1989, Olelo Community Media became Oahu’s non-profit community Public, Education, and Government access provider created to empower the voice of community (<http://olelo.org/info/>).

Student Support:

| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
|---------------|------------------------|------------------------|----------------------|---------------------|----------|
| Undergraduate | | | | | |
| Masters | 2 | | | | 2 |
| PhD | 1 | | | | 1 |
| Post-Doc | | | | | |
| TOTAL | 3 | | | | 3 |

Notable Achievements and Awards:

None

Student Internship Program:

None

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Characterizing the impact of advection on evapotranspiration in American Samoa

Project ID:

2018AS485B (Sayed Bateni)

Project Impact:

Numerous studies have estimated surface heat fluxes by assimilating land surface temperature (LST) observations (as the state variable of the land surface) into the heat diffusion equation. A number of other studies have focused on the estimation of surface energy balance components by assimilating air temperature and specific humidity (as the state variables of atmosphere) into an atmospheric boundary layer model. This study advances the existing variable data assimilation (VDA) approaches by the synergistic assimilation of LST, air temperature, and specific humidity into a coupled land surface-atmospheric boundary layer model. The developed VDA approach is tested at the First International Satellite Land Surface Climatology Project Field Experiment (FIFE) site in the summer of 1987 and 1988. Results indicate that it performs well in both wet and dry-down periods. The root-mean-square-error (RMSE) of estimated daily sensible and latent heat fluxes are 21.80 Wm^{-2} (22.10 Wm^{-2}) and 39.32 Wm^{-2} (36.89 Wm^{-2}) for FIFE 87 (88). The new VDA system outperforms the previous studies that assimilated either LST or air temperature/specific humidity. For FIFE 87, this study decreases the RMSE of daily sensible and latent heat fluxes estimates by 12.5% and 24.4%, respectively, compared to assimilating only LST, and by 15.2% and 26.7%, respectively, compared to assimilating only air temperature and specific humidity. A similar improvement is obtained for FIFE 88 as well. The next step is to add a model error term to the VDA approach and develop a weak-constraint VDA approach to take into account the impact of advection on evapotranspiration.

Publications:

Bateni, S., E. Tajfar, C. Neale, T. Auligne, and T. Xu, 2018, "Estimation of turbulent heat fluxes over different sites with contrasting climate and vegetation conditions via variational assimilation of air temperature and specific humidity," Presented at American Geophysical Union (AGU), Fall Meeting 2018, Washington, D.C., December 10–14.

<http://adsabs.harvard.edu/abs/2018AGUFM.H51V1626B>

Tajfar, E., 2019, "Estimation of turbulent heat fluxes via the synergistic assimilation of land surface temperature, and air temperature and specific humidity into a variational data assimilation model," Ph.D. dissertation, Department of Civil and Environmental

Engineering, College of Engineering, University of Hawai‘i at Mānoa, Honolulu, HI, 211 p.

Tajfar, E., S. Bateni, S. Margulis, P. Gentine, and T. Auligne, 2019, “Estimation of turbulent heat fluxes via assimilation of air temperature and specific humidity into an atmospheric boundary layer model,” *Journal of Hydrometeorology*. (in review)

Tajfar, E., S. Bateni, V. Lakshmi, and M. Ek, “Estimation of turbulent heat fluxes via assimilation of land surface temperature, and air temperature and specific humidity into a coupled land surface-atmospheric boundary layer model,” *Journal of Hydrology*. (in review)

Information Transfer Program:

Results of this project were disseminated by two journal papers, one conference abstract, and one Ph.D. dissertation.

Student Support:

| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
|---------------|------------------------|------------------------|----------------------|---------------------|----------|
| Undergraduate | | | | | |
| Masters | | | | | |
| PhD | 1 | | | | 1 |
| Post-Doc | | | | | |
| TOTAL | 1 | | | | 1 |

Notable Achievements and Awards:

None

Student Internship Program:

None

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Collaborative investigation of hydraulic and geochemical connectivity between wastewaters and other land uses with the ocean waters of Waialua Bay, Oahu

Project ID:

2018AS487B (Craig R. Glenn)

Project Impact:

The risk that sewage effluent poses to human health and the environment is well documented, and on-site sewage disposal systems (OSDS) are a substantial threat to groundwater quality and the second most frequently reported cause of contaminated groundwater in the USA. Lands draining to Waialua Bay, O‘ahu, contain ~2,000 OSDS, of which ~75% are cesspools. The area’s high OSDS density, agricultural fertilization, and history of opportunistic invasive algal blooms put Waialua Bay at high risk for groundwater and stream pollution. Our objective is establishing the location, differentiation, and source tracking of contaminant sources, and their connections to the coastal waters of this region. Thermal infrared mapping by drone has identified both point-sourced and large areas of diffuse groundwater discharge into the coastal zone. Water samples from rivers, groundwater wells, porewaters and beach face piezometers were analyzed for nutrients and isotopic tracers to identify areas with high-nutrient concentrations. In tandem, multiple species of deployed and wild macroalgae throughout the area were analyzed for tissue nitrogen uptake and ^{15}N -isotopes. Combined results showed areas where water is contaminated with wastewater and/or agricultural runoff. Future work will refine these results into the next year. An overall groundwater contaminant transport model for O‘ahu’s North Shore is being constructed that will integrate the geochemical findings to best track and understand the impact OSDS effluent has on the community and environment.

Publications:

Barling, N., J.L. Blaha, L. Ellison, J. Mason, C.M. Smith, and C.R. Glenn, 2019, “Using in-situ collections of reef algae to examine land-based sources of pollution in Kaneohe and Waialua Bays on Oahu, Hawaii,” Abstract submitted for 2019 AGU Fall Meeting, San Francisco, CA, December 3–9, 2019.

Blaha, J.L., N. Barling, L. Ellison, J. Mason, C.M. Smith, and C.R. Glenn, 2019, “Inter-calibration of common bio-assay species: D^{15}N and \%N parameters of algal tissues as

biogeochemical indicators on Oahu,” Abstract submitted for 2019 AGU Fall Meeting, San Francisco, CA, December 3–9, 2019.

Ellison, L., C.R. Glenn, J.P. Mason, C.M. Smith, and V. Gibson, 2019, “Assessment of land use impacts on the coastal waters of Waialua Bay, North Shore of Oahu, Hawaii,” Abstract submitted for 2019 AGU Fall Meeting, San Francisco, CA, December 3–9, 2019.

Information Transfer Program:

One Masters thesis and one Ph.D. dissertation will result from this project and will be available at the UH Department of Earth Sciences website. Findings for both are in preparation for submission to peer-reviewed journals and are being disseminated as reports to the Hawai‘i Department of Health. Current results are being presented as three papers at the AGU Fall Meeting in San Francisco, December 2019. The M.S. and Ph.D. students have given presentations outlining the goals of the project as part of the Sea Grant Outreach Program, the Hanauma Bay Community Science Talk Seminars, and will give follow up presentations this Fall (Fall 2019 AGU, Abstracts accepted) and Spring with further results.

Student Support:

| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
|---------------|------------------------|------------------------|----------------------|---------------------|----------|
| Undergraduate | 3 | | | | 3 |
| Masters | 1 | | | | 1 |
| PhD | 2 | | | | 2 |
| Post-Doc | | | | | |
| TOTAL | 6 | | | | 6 |

Notable Achievements and Awards:

This project has produced the first thermal infrared maps of Waialua Bay on the north shore of O‘ahu, which revealed the locations of previously unknown diffuse and point-sourced submarine groundwater discharge, as well as detailing how these waters mix and interact with both river runoff and seawater. Our use of low-altitude drones to acquire these data has resulted in a uniquely high level of spatial and temporal detail. Also of notable achievement is our coupling of surface and groundwater geochemistry with metabolic biogeochemistry of macroalgae as multiple tracers of environmental concern for coastal zones.

Student Internship Program:

This project has supported the research activities of 6 students:

Lucas Ellison (Ph.D. candidate) has gained extensive knowledge in various geochemical sampling techniques and stable isotope analyses and interpretation. Ellison has gained further experience operating a UAV drone equipped for photography and thermal infrared imaging and has become an FAA-certified UAV pilot. Ellison has also been trained in techniques and interpretations using aqueous geochemistry, light stable isotopes, and hydrology and groundwater modeling. He has also learned and is using groundwater modeling software (GMS) to develop groundwater models for contaminant transport of effluent coming from agricultural OSDS sources that uses both MODFLOW and MT3DMS.

Jordan Mason (M.S. candidate) has worked full-time on this project. He has become a licensed and an experienced FAA-certified UAV pilot. Additionally, he has learned numerous techniques for thermal infrared image processing in ArcGIS and other programs. Mason has also been

trained in environmental geochemistry with a specialization in hydrology and groundwater modeling. He has also learned and is using groundwater modeling software (GMS), that uses both MODFLOW and MT3DMS, to develop groundwater models for contaminant transport of effluent coming from agricultural OSDS sources.

Veronica Gibson (Ph.D. candidate) has worked part-time on the project in the area of marine biology. She has been conducting benthic seafloor ecological mapping and assisting with the collection of wild macroalgae and the deployment of macroalgae for time series analysis of multi-species macroalgae tissue ^{15}N isotopes and $\delta^{15}\text{N}$.

In addition to the above, this project formed the basis of three undergraduate summer intern research projects (Daniel Harrington, University of South Carolina; Jiana Blaha, American University, Washington DC; and Nerissa Barling, Colorado College).

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Providing information and technology in support of hydrological research in American Samoa

Project ID:

2018AS488B (Kelley Anderson Tagarino)

Project Impact:

This project enabled the existing weather station infrastructure in American Samoa to be strengthened and expanded. The improved infrastructure has facilitated the quantification of hydrological parameters such as precipitation, streamflow, and evapotranspiration, which are fundamental pieces of information for developing a better understanding of hydrological budgets, the availability of water resources, and the processes that affect environmental water quality. In FY2018 we purchased three autonomous weather stations and instruments used for stream gauging and water quality monitoring. We installed these on Tutuila American Samoa cooperatively with the American Samoa Power Authority (ASPA), a project partner, to provide data in an island wide hydrologic monitoring network. As the island's sole water utility, ASPA uses information from the monitoring network, and research products derived from the monitoring data, to manage the island's limited water resources more sustainably.

Publications:

Shuler, C.K., 2019, "From recharge to reef: Assessing the sources, quantity, and transport of groundwater on Tutuila Island, American Samoa," Ph.D. dissertation, Department of Geology and Geophysics, School of Ocean and Earth Sciences Technology, University of Hawai'i at Mānoa, Honolulu, HI, 301 p.

Shuler, C. and A.I. El-Kadi, 2018, "WRRC-ASPA hydrologic monitoring network handbook," WRRC Special Report SR-2018-02, University of Hawai'i at Mānoa Water Resources Research Center, Honolulu, HI, 58 p.

Information Transfer Program:

A key component of this project is to make all monitoring data available online for public use. Data were previously hosted on the ASPA website at:

<https://www.aspower.com/Water-ASPA-weather-station-data.html>

and updated data are currently hosted at:

https://github.com/cshuler/ASPA-UH_Integrated_Modeling_Framework

Student Support:

None

Notable Achievements and Awards:

None

Student Internship Program:

None

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Determining research needs and priorities for American Samoa

Project ID:

2018AS490B (Darren T. Lerner)

Project Impact:

In October 2018, a workshop was conducted in support of solving water resource issues in American Samoa. The objective was to engage all the major water resource stakeholders in American Samoa and develop an understanding of the water issues and future direction.

A team of five research faculty from the University of Hawai'i (UH), led by Dr. Darren Lerner, participated in a two day workshop with an additional day for field visits to important water resource sites throughout Tutuila Island, including a visit to Aunu'u. The researchers and Water Resources Research Center (WRRC) administration, along with faculty from Sea Grant (SG) and the Pacific Islands Climate Adaptation Science Center, provided presentations on the type of research conducted at these institutions, while agencies and organizations from American Samoa shared their water research needs.

This became a follow up workshop to the meetings and field visits originally scheduled in August 2018, which were postponed due to Hurricane Lane. However, Dr. Earl Greene (U.S. congressional representative) was still able to travel and work with the original logistics established for August, with the assistance of Chris Shuler (a graduate student) and Kelley Anderson-Tagarino (an extension specialist with UH SG). The results of his trip allowed WRRC to produce a set of research priorities that was co-developed with the major stakeholders described above. These priorities should drive the research engagement through the competitive 104b proposals dedicated to American Samoa and managed by UH WRRC.

Publications:

None

Information Transfer Program:

None

Student Support:

None

Notable Achievements and Awards:

None

Student Internship Program:

None

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Coordination Grant

Project Title:

Evaluating student training and STEM workforce development at the National Institutes for Water Resources (NIWR)

Project ID:

2015HI478S (Darren T. Lerner)

Project Impact:

In collaboration with USGS and NIWR, we (1) successfully extracted archived student data from the national NIWR database, (2) obtained additional state program data on students supported through engagement with the USGS WRRRA/NIWR funded state water institutes, and (3) generated a gap analysis for data opportunities and needs associated with student training. The data and gap analysis were compiled, analyzed, and interpreted for publication.

We provided USGS with access to the University of Hawai'i Sea Grant (SG) database framework as a template to establish a module-based database to document and track USGS/WRRRA supported alumni.

A social science survey was developed, distributed, and analyzed that was appropriate for use in collaboration with USGS to estimate the contribution of NIWR trained students to the current USGS workforce.

Publications:

Donohue, M.J. and D.T. Lerner, 2018, "Student training and workforce development at the USGS Water Resources Research Institutes," *Journal of Contemporary Water Research & Education*, 164(1):3–18.

USGS, 2019, "Water Resources Research Act Program 10–Year Vision—Meeting Imperative for Our Nation's Water Resources (fact sheet)," Honolulu, HI, February 2019.

USGS Water Resources Research Act Program, 2019, "Training America's Next Generation of Water Resources Scientists (brochure)," Honolulu, HI, February 2019.

Information Transfer Program:

Outreach (beyond USGS, NIWR, and state water institutes) and inreach (within USGS, NIWR, and state water institutes) was developed on this initiative and results were shared at state, regional, and national meetings using collateral materials and products, and other modalities. Additional regional meetings with NIWR/SG Directors, national leadership, and NIWR/SGA

were conducted, which generated multiple abstracts, presentations, and sessions at the annual UCOWR and NIWR conferences.

Student Support:

None

Notable Achievements and Awards:

None

Student Internship Program:

None

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Identifying groundwater flow and contamination to streams: Kahalu‘u watershed, O‘ahu

Project ID:

2017HI466B (Craig R. Glenn)

Project Impact:

On O‘ahu, over 1,500 on-site sewage disposal systems (OSDS)—including cesspools and septic tanks—are located throughout the Kahalu‘u region of the Kāne‘ohe Bay drainage basin. These OSDS release one million gallons per day of untreated wastewater to groundwater, which threatens stream and coastal water quality and poses potential public health hazards. This project documents where and how the OSDS leachate differentially impacts areas of shallow groundwater, streams, and Kāne‘ohe Bay shorelines. We located sources and traced subsurface contaminant flow using aqueous geochemistry-stable isotopes, unmanned aerial vehicle thermal infrared (UAV-TIR) of submarine groundwater discharge, groundwater seepage (baseflow) to streams, hydrologic modeling quantifying surface/groundwater flow, and flow paths derived from coupling H₂O-isotopes of groundwater and precipitation. Locations of wastewater-borne nutrient loads in regional groundwater, streams, and seawater were documented and modeled for the study area using a MODFLOW hydrologic model and MT3DMS contaminant transport code. The results accurately predicted areas of groundwater contamination with dissolved inorganic nitrogen, and in situ measurements revealed geochemical transformation of wastewater-borne nutrient loads along the modeled hydrogeologic trajectories. Carbonate geochemistry investigations quantified the extent of organic matter degradation vs. carbonate dissolution, focusing on distinguishing wastewater effluent as the source of the organic materials. Integrated combinations of UAV-TIR, stream gauging and seepage runs, geochemical and stable isotopic analysis, and numerical modeling provided the framework necessary to properly evaluate contaminant flow regimes and water quality impacts in this and other regions of Hawai‘i affected by anthropogenic contamination.

Publications:

Amato, D.W., J.M. Bishop, C.R. Glenn, H. Dulai, and C.M. Smith, 2017, “Reef plants show that groundwater discharge is a major source of anthropogenic nitrogen for coastal ecosystems in Hawaii,” Presented at Geological Society of American 113th Cordilleran Section Meeting, Honolulu, HI, May 23–25, 2017.

- Dores et al., 2019, “Geochemical and stable isotope source-tracking of wastewater contamination pathways to Pacific Island coastal environments: East O‘ahu and Kāne‘ohe Bay, Hawai‘i, USA,” *Marine Pollution* (in review).
- Dores, D.E., M.R. Mathioudakis, C.R. Glenn, R.B. Whittier, and H. Dulai, 2017, “Identifying pollutant sources along groundwater flowpaths in Kaneohe, Oahu, Hawaii,” Presented at Geological Society of American 113th Cordilleran Section Meeting, Honolulu, HI, May 23–25, 2017, Abstracts with Programs (49):4. doi: 10.1130/abs/2017CD-293031.
- Glenn, C.R., D. Dores, and M. Mathioudakis, 2018, “Hydraulic and geochemical connectivity between wastewaters, land-use and Kāne‘ohe Bay, Hawai‘i,” Joint Government Water Conference, Honolulu, HI.
- Kennedy, J.J., C.R. Glenn, H. Dulai, and P.G. Lucey, 2017, “Coupling aircraft and time series unmanned aerial vehicle thermal infrared imaging with simultaneous in situ radon monitoring reveals dynamics of groundwater discharge to the ocean,” Presented at Geological Society of American 113th Cordilleran Section Meeting, May 23–25, Honolulu, HI.
- Litchmore, D.T., M.R. Mathioudakis, D.E. Dores, and C.R. Glenn, 2017, “UAV drone based thermal infrared imaging to delineate end member stream discharge behavior,” 2017 American Geophysical Union Fall Meeting, Abstract EP31B-1869, New Orleans, LA, December 11–15, 2017.
- Mathioudakis et al., 2019, “Hydrology of contaminant flows to groundwater, streams, and the ocean waters of Windward O‘ahu, Hawai‘i, USA,” *Journal of Hydrology* (in review).
- Mathioudakis, M.R., C.R. Glenn, and D.E. Dores, 2017, “Examining groundwater and surface water interactions to determine the effects of anthropogenic nutrient loading on stream and coastal water quality,” Presented at Geological Society of American 113th Cordilleran Section Meeting, Honolulu, HI, May 23–25, 2017, Abstracts with Programs (49):4. doi: 10.1130/abs/2017CD-292737.

Information Transfer Program:

One Masters thesis and one Ph.D. dissertation will result from this project and will be available at the University of Hawai‘i (UH) Department of Earth Sciences website. Findings for both are in preparation for submission to peer-reviewed journals. Current results are being presented as three papers at the AGU Fall Meeting in San Francisco, December 2019. The M.S. and Ph.D. students have given presentations outlining the goals of the project as part of the Sea Grant Outreach Program, the Hanauma Bay Community Science Talk Seminars, and will give follow up presentations this Fall (Fall 2019 AGU, Abstracts accepted) and Spring with further results.

Student Support:

| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
|---------------|------------------------|------------------------|----------------------|---------------------|----------|
| Undergraduate | 1 | | | | 1 |
| Masters | 2 | | | | 2 |
| PhD | | | | | |
| Post-Doc | | | | | |
| TOTAL | 3 | | | | 3 |

Notable Achievements and Awards:

OSDS (e.g., cesspools and septic tanks) are the third leading cause of groundwater contamination in the U.S., and of particular concern to tropical islands where OSDS exist in close proximity to drinking water wells, streams, and coastal waters. Kāneʻohe Bay contains endangered marine ecosystems that are a unique and precious cultural and socioeconomic resource for the State of Hawaiʻi, yet also remains a textbook example of the effects of pollution due to its historical legacy of nutrient-fed eutrophication and ecosystem collapse. Prior studies concentrated on sediment and/or nutrient-loading to Kāneʻohe Bay by streams, but the role of subsurface transfer of agricultural or sewage nutrients and other contaminants by groundwater has gone largely overlooked and/or ignored. This research specifically investigates the sources and sinks and differing flow paths of contaminant transport from OSDS, agriculture, and more by integrating (1) thermal infrared imaging; (2) groundwater modeling; (3) multiple geochemical and stable isotope parameters of groundwaters, streams, and nearshore coastal waters; and (4) the biogeochemistry of invasive macroalgae and mangrove shorelines that inhabit the bay. The results are multidisciplinary and meaningful, and of direct use for resolving the socioeconomic and environmental remediation issues facing Kāneʻohe Bay and the greater Hawaii community in general. Currently, USGS, Hawaiʻi Department of Health, U.S. Environmental Protection Agency, and state legislators are using the data to inform critical decisions regarding water quality and water treatment legislation in Hawaiʻi.

Student Internship Program:

Two M.S. students (Daniel Dores and Michael Mathioudakis) and one summer Research Experiences for Undergraduate program student (Daniel Litchmore) gained valuable experience during this project. Dores and Mathioudakis were both trained in (1) aqueous biogeochemistry with specialization in nutrients; (2) collection, analysis, and interpretation of stable isotopes ^{18}dO and ^{15}dN of dissolved nitrate; (3) collection, analysis, and interpretation of stable isotopes water (deuterium and d^{18}O); (4) groundwater modeling (MODFLOW and MT3DMS); (5) stream gauging and stream flow seepage runs; and (6) certified as UAS drone pilots. Although they have graduated and are employed (Dores is a Geothermal Geology Specialist at UH Mānoa; Mathioudakis is an Environmental Engineer/Geologist at Arcadis Inc., Honolulu), both remain active participants with the ongoing studies in Craig Glenn's Lab.

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Influence of anthropogenic and climatic forcing on water quality within a tropical coastal ecosystem

Project ID:

2017HI467B (Rosanna Alegado)

Project Impact:

A number of temperate estuaries have served as systems for studying the influences of climate change on the coastal environment. Estuaries constitute some of the most geochemically active ecosystems on the planet and the effects of climate change may be particularly enhanced in these environments due to human activity. However, few cognate systems have been examined thoroughly in tropical estuarine environments. Our goal is to find the link between microbial community dynamics and function over physical and chemical gradients, and identify environmental conditions that are predictive of the microbial community succession following physical forcing. We measured physical parameters and collected discrete water samples from sites across He'eia Fishpond, in He'eia Stream, and the nearby reef to characterize the microplankton community (bacteria, primary producers, and zooplankton) over multiple seasons through biogeochemistry cycles. In addition, our sampling regime has allowed us to measure the impact of biocultural restoration of the fishpond; particularly the removal of invasive mangrove, increases in physical water flux, and improvements in circulation. The biocultural restoration increased the flux of freshwater into the fishpond, while the decrease in salinity and increase in mixing resulted in an increase in diatoms and zooplankton in the northern regions of the fishpond. These studies should enable ecosystem modeling of the biomass at each trophic level as well as predictions on how variation in climate will affect the foodweb.

Publications:

Alegado, R.A., 2018, "Deepening our connections: Engagement with indigenous communities," Presented at Capacity Building Programs for Community Engagement Panel, 2018 Sea Grant Week, Portland, OR, September 2018.

Alegado, R.A., L.K. Fox, O.P. Francis, K.L. Frank, and N. Puniwai, 2019, "Kane and Kanaloa are coming: A Kanaka take (talk) on climate change," Presented at 2019 Lāhui Hawai'i Research Conference, Honolulu, HI. *Plenary Panel*

Beebe, C., 2020, "Effects of restoration on diatom abundance on primary productivity within a traditional Hawaiian aquaculture system," M.S. thesis, Department of Oceanography,

- School of Ocean and Earth Science and Technology, University of Hawai‘i at Mānoa, Honolulu, HI. (in preparation)
- Kawelo, A.H. and R.A. Alegado, 2018, “Climate change and the future of loko i‘a (Native Hawaiian Fishponds),” Presented at 2018 ‘Aimalama conference: A Mauliauhonua experience, Maui, HI,” August 2018.
- Kotubetey, K., M. Tamanaha, R.A. Alegado, K. Falinski, K. Perez, and K. Hintzen, 2018, “Kūlana Noi‘i: Building and sustaining equitable partnership between researchers and community,” Presented at 25th Hawai‘i Conservation Conference (Panel), Honolulu, HI, July 2018.
- Kūlana Noi‘i Workshop Group, 2018, Kūlana Noi‘i v. 1, Honolulu: Hawai‘i Sea Grant.
- Lensing, B., “Microbial dynamics of coupled human-natural systems” Ph.D. dissertation, Marine Biology Graduate Program, School of Ocean and Earth Science and Technology, University of Hawai‘i at Mānoa, Honolulu, HI. (in preparation)
- Machado, N., K. Selph, C.A. Beebe, K. Kotubetey, and R.A. Alegado, 2019, “Correlation of He‘eia Fishpond plankton community abundance and distribution in response to environmental conditions,” Poster presented at 26th Hawai‘i Conservation Conference, Honolulu, HI, July 2019.
- Moehlenkamp, P., 2018, “Influence of mangrove removal on water budget and pathogens in Heeia Fishpond,” M.S. thesis, Department of Oceanography, School of Ocean and Earth Science and Technology, University of Hawai‘i at Mānoa, Honolulu, HI.
- Moehlenkamp P., C.K. Beebe, M.A. McManus, A.H. Kawelo, K. Kotubetey, M. Lopez-Guzman, C.E. Nelson, and R.A. Alegado, 2019, “Kū Hou Kuapā: Cultural restoration improves water budget and water quality dynamics in He‘eia Fishpond,” *Journal of Sustainability*, 11(1):161.
- Moehlenkamp, P., C. Beebe, Paepae o He‘eia, M. McManus, and R.A. Alegado, 2018, “Water budget and water quality dynamics in He‘eia fishpond during restoration regimes,” Poster presented at 25th Hawai‘i Conservation Conference, Honolulu, HI, July 2018.
- Nichols, P., F. La Valle, R.A. Alegado, A.H. Kawelo, K. Kotubetey, J. Philippoff, and S. Laliberte, 2019, “Stable Isotopes Reveal Food Web Dynamics for Native and Invasive Mullet Species in He‘eia Fishpond,” Presented at 26th Hawai‘i Conservation Conference, Honolulu, HI, July 2019.
- Thomas, W.H., 2020 (tentative completion date), “Identifying extrinsic conditions favoring multicellularity in natural populations of choanoflagellates,” M.S. thesis, Marine Biology Graduate Program, School of Ocean and Earth Science and Technology, University of Hawai‘i at Mānoa, Honolulu, HI. (in preparation)

Information Transfer Program:

Twice a year, researchers working at He‘eia Fishpond are provided the opportunity to give public talks on their findings at the fishpond. The surrounding community is encouraged to engage with researchers and provide feedback on their work. In addition, their findings are presented directly to the staff of Paepae o He‘eia (POH, the non-profit that stewards He‘eia Fishpond). Dr. Alegado manages a private Google drive folder shared with POH staff that holds data from her lab as well as any other lab that performs research at the fishpond. In this way, POH has access to data that might be useful for their activities (e.g., grants and progress reports). Finally, Dr. Alegado regularly interacts with Hawai‘i Sea Grant to generate press releases of her work.

Student Support:

| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
|---------------|------------------------|------------------------|----------------------|---------------------|----------|
| Undergraduate | | | | 2 | 2 |
| Masters | 2 | | | 2 | 4 |
| PhD | | | | | |
| Post-Doc | | | | | |
| TOTAL | 2 | | | 4 | 6 |

Notable Achievements and Awards:

Grant from Hawai'i State Department of Health Cleanwater Branch: We were able to leverage this project to obtain additional funding from the DOH Cleanwater Branch for removal of mangroves from the interior of He'eia Fishpond.

Kūlana Noi'i: Our interaction with the stewards of the He'eia Fishpond (POH) has motivated the development of Kūlana Noi'i, a process by which we and other researchers can form long-lasting, equitable community partnerships. In collaboration with Hawai'i Sea Grant and the non-profit Kua'āina Ulu 'Auamo (KUA), we have implemented this process at several graduate student and principal investigator trainings.

Partnership with He'eia National Estuarine Research and Reserve (HeNERR): The newly established HeNERR requires monthly water quality monitoring at sites within the He'eia Watershed. Our extensive time series within He'eia Fishpond has provided necessary baseline information to determine ideal locations within the fishpond for the HeNERR sampling regime.

Student Internship Program:

Aka Beebe is an M.S. candidate and head of field operations for the He'eia Fishpond project. He has displayed quiet leadership in mentoring others as well as demonstrating remarkable persistence and independence of thought in the analysis of tremendous amounts of data. Beebe designed a field experiment, executed it flawlessly, processed the sampling with precision and accuracy, and analyzed the data with a great depth of understanding.

Hoaka Thomas is an M.S. candidate and has gained experience in designing fieldwork as well as mentoring undergraduates. Under Beebe's tutelage, Thomas has learned how to maintain our equipment and gained the independence to design his own field experiments.

Becca Lensing is a Ph.D. candidate and taken the lead in processing data for microbial community analysis as well as developing the bioinformatic pipeline for sequence analysis. She has become proficient in molecular biology as well as programming. Lensing was able to bring additional bioinformatic skills to our lab.

No'eau Machado was an undergraduate in the Global Environmental Sciences Program and completed his thesis in my lab. He learned how to carefully collect field samples and ultimately gained the independence to carry out his work with minimal supervision. Machado was able to apply for and win independent funding to carry out his project, and used the funds toward processing his phytoplankton samples using fluorescence microscopy. His skills in phytoplankton identification were gained through meticulous practice and hours at the microscope.

Inny Mareko was a summer undergraduate intern with the NSF Research Experiences for Undergraduates (REU) program for Pacific Islanders in Environmental Biology. His work ethic was commendable—taking timepoints twice a day for 5 weeks straight—followed by manual

enumeration and identification of zooplankton. Even more impressive, Mareko developed an identification key for zooplankton that was not previously available for Kane‘ohe Bay. He took every opportunity to learn more about his project and the impact it would have for our community stakeholder, POH.

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Understanding the hydrology of a rainforest watershed in Hawaii

Project ID:

2017HI474B (Yin-Phan Tsang)

Project Impact:

The objective of this project was to further the understanding of hydrology in a rainforest watershed in Hawai‘i. Our study focused on the Mānoa watershed during rainfall events, and the Mānoa Stream was responsive with the water level rising immediately. A storm peak moving headwater stream to the downstream confluence of Mānoa and Pālolo streams took approximately 30 minutes, depending on the storm size. Our project was able to partially support both the installation of one stream monitoring station at ‘Aihualama Stream (upstream of the watershed), and one real-time weather station at Lyon Arboretum. Both stations continuously monitored surface water to provide quantity, quality, and meteorological information at the watershed in fine temporal resolution at 15-minute intervals. To assess the hydrological model performance, different spatial resolutions of meteorological input (i.e., precipitation and temperature) were applied to the Soil and Water Assessment Tool (SWAT). The results showed that a model with finer spatial resolution of meteorological input was better at predicting the streamflow timing and amount during a storm. This suggests that finer realization of meteorological data are needed to describe the hydrological responses of watersheds. With the establishment of this watershed model, we have the ability to predict the impact of various scenarios of future land use and climate projection on the Mānoa watershed.

Publications:

Huang Y.-F., Y.-P. Tsang, and C. Evensen, “Different approaches of streamflow measurement for rainforest watersheds in Hawaii.” (in preparation)

Tsang, Y.-P., 2019, “Characterizing stream and its association with ecosystem in Hawaii,” Presented at WRRRC/‘Ike Wai Seminar, University of Hawai‘i, Honolulu, HI, April 16, 2019.

Tsang, Y.-P., 2018, “Stream research update and overview,” Presented at Ecohydrology Lab Meeting, Honolulu, HI, September 28, 2018.

Tsang, Y.-P., 2018, “Streams connect fish, watershed, and you,” Presented at Natural Resources and Environmental Management Department Seminar, Honolulu, HI, October 3, 2018.

Tsang, Y.-P., 2018, “Understanding the hydrology of Ala Wai Watershed,” Presented at Smart Ala Wai Workshop III, Honolulu, HI, September 29, 2018.

Tsang, Y.-P., 2018, “Understanding the hydrology of a rainforest watershed,” Presented at Lyon Centennial Symposium, Honolulu, HI, September 13–14, 2018.

Information Transfer Program:

The results for this project were presented at:

- Lyon Centennial Symposium (Understanding the Hydrology of a Rainforest Watershed), Honolulu, HI, September 13–14, 2018.
- Ecohydrology Lab Meeting (Stream Research Update and Overview), Honolulu, HI, September 28, 2018.
- Smart Ala Wai Workshop III (Understanding the Hydrology of Ala Wai Watershed), Honolulu, HI, September 29, 2018.
- Natural Resources and Environmental Management Department Seminar (Streams Connect Fish, Watershed, and You) Honolulu, HI, October 3, 2018.
- WRRC/Ike Wai Seminar (Characterizing Stream and its Association with Ecosystem in Hawaii) University of Hawai‘i, Honolulu, HI, April 16, 2019.

Student Support:

| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
|---------------|------------------------|------------------------|----------------------|---------------------|----------|
| Undergraduate | | | | | |
| Masters | 1 | | | | 1 |
| PhD | 1 | | | | 1 |
| Post-Doc | | | | | |
| TOTAL | 2 | | | | 2 |

Notable Achievements and Awards:

This project laid the foundation for the stream monitoring within the study watershed, and followed by a University of Hawai‘i funded project: Strategic Monitoring and Resilience Training in the Ala Wai Watershed (Smart Ala Wai) project (P.I., Brian Glazer).

Student Internship Program:

None

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Wastewater treatment for point source processing and reuse

Project ID:

2017HI475B (Michael Cooney)

Project Impact:

Many chemical contaminants and enteric pathogens commonly found in wastewater pose health threats to humans, even at low concentrations. Research to eliminate or reduce the concentration of chemical contaminants of emerging concern (CEC) in wastewater effluents is increasing due to U.S. Environmental Protection Agency (EPA) regulations. The objective of this study was to demonstrate the efficacy of a low-energy low-chemical biofilm anaerobic-aerobic treatment process to reduce liquid phase concentrations of select CECs as well as key pathogen indicator organisms from wastewater. The five CECs selected for monitoring are common chemicals frequently found in wastewater treatment plants or compounds included in the Contaminant Candidate List (CCL4) as published by the EPA in 2016. The two microbes monitored are indicator organisms recommended by the EPA to evaluate the safety of drinking and recreational waters. The results of the treatment process suggested the combined anaerobic-aerobic biofilm-based reactor system is capable of treating wastewaters highly concentrated with caffeine, estrone, and 17 β -estradiol, but less so with wastewater contaminated with carbamazepine and 17 α -ethinylestradiol. In analogous experiments, the indicator pathogens *Escherichia coli* (CN-13) and F+ specific coliphage (MS-2 bacteriophage) were spiked in the wastewater feed to concentrations of 1×10^8 MPN/L and 1×10^6 PFU/L, respectively. Across the overall reactor system, *E. coli* achieved an average of 3-log reductions and F+ specific coliphage achieved an average of 1-log reduction.

Publications:

None

Information Transfer Program:

None

Student Support:

None

Notable Achievements and Awards:

None

Student Internship Program:

None

Project Synopsis

Email address:

thomas@hawaii.edu

Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Microbial communities and sources of bacteria in Honolulu's water supply

Project ID:

2017HI476B (Marek Kirs)

Project Impact:

The groundwater biome is a vast, but poorly characterized habitat hypothesized to harbor structurally and functionally diverse bacterial communities. The degree to which these communities differ from associated soils is a central question in environmental microbiology. We used 16S rRNA gene amplicon sequencing to characterize the microbial communities in 37 groundwater and 32 surface soil samples representative of aquifers across the island of O'ahu, the most populated of the Hawaiian archipelago. Several bacterial phyla (Acetothermia, Omnitrophica, Parcubacteria, and Peregrinibacteria) were relatively abundant in groundwater samples, but were rare to absent in soils. Sequences classified to the phyla of Nitrospirae (*Leptospirillum*), Bacteroidetes (*Sedminibacterium*), Chloroflexi (SAR202 clade), Omnitrophica, and Proteobacteria (*Gallionella*, *Ralstonia*) dominated communities, comprising 16% to 62% of basal aquifer and <1% to 32% of dike aquifer communities. Sulfate, nitrate, and sodium concentrations had the most significant correlation with the bacterial community structure in the basal aquifers; when dike aquifer communities were included, chloride and pH levels were also strongly associated with bacterial community composition, consistent with the high proportion of a variety of chemolithoautotrophs observed in basal and dike aquifers. Fecal indicator bacteria and sewage-specific marker data indicated good groundwater quality. The wide variety of taxonomic and functional groups detected in this study likely indicates the existence of a large adaptive potential in O'ahu's aquifers and suggests that deep, dark groundwater environments are not as uniform and constant as one might presume, but does provide various niches and energy sources for a wide variety of bacteria.

Publications:

Kirs, M., V. Kisand, C.E. Nelson, T. Dudoit, and P.S. Moravcik, 2019, "Hidden bacterial diversity in Hawaiian aquifers," Poster presented at 17th International Symposium on Microbial Ecology, Leipzig, Germany, August 12–17, 2018.

Kirs, M., V. Kisand, C.E. Nelson, T. Dudoit, and P.S. Moravcik, 2019, "Microbial communities in tropical island aquifers," mSphere. (in review)

Information Transfer Program:

The results for this project were presented at:

- 17th International Symposium on Microbial Ecology (poster “Hidden bacterial diversity in Hawaiian aquifers”), Leipzig, Germany, August 12–17, 2018.
- WRRC/‘Ike Wai Seminar (Challenges in Evaluating Microbial Beach Water Quality in Hawai‘i), University of Hawai‘i, Honolulu, HI, April 2, 2019.
- NSF-TSUP SOEST Summer Bridge Program (Mauka 2 Makai), University of Hawai‘i, Honolulu, HI, July 5, 2019.
- MIC485 Microbes and Their Environment (University of Hawai‘i Spring 2019 course, ongoing commitment).

Student Support:

| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
|---------------|------------------------|------------------------|----------------------|---------------------|----------|
| Undergraduate | 2 | | | | 2 |
| Masters | | | | | |
| PhD | | | | | |
| Post-Doc | | | | | |
| TOTAL | 2 | | | | 2 |

Notable Achievements and Awards:

None

Student Internship Program:

None

Project Synopsis

Email address:

thomas@hawaii.edu

Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Evaluation of Pepper mild mottle viruses as a sewage marker in Hawaii

Project ID:

2018HI480B (Marek Kirs)

Project Impact:

Due to its high prevalence and concentration in human feces and sewage, pepper mild mottle virus (PMMV) has been proposed as a potential sewage specific marker. The objective of this study was to determine the advantages and limitations of PMMV as a viral indicator in sewage and water quality management in Hawai'i.

The concentrations of PMMV found in untreated sewage samples collected from three wastewater plants on O'ahu (Hawai'i) averaged 3.92×10^7 gc/100 ml (ranging from 9.47×10^6 to 2.19×10^8 gc/100 ml), which is comparable to samples collected in mainland U.S. This exceeded typical concentrations of enterococci in wastewater, indicating it should be measureable when sewage-borne enterococci are detected. Further analyses showed a reduction of 92.0–99.7% PMMV concentration with wastewater treatment.

Additional samples are being collected to explore the seasonal stability of PMMV in wastewater. Also, further experiments are planned to determine the effect of sunlight on the decay of PMMV, as well as field studies to study PMMV concentrations in streams not-impacted and impacted by sewage on the islands of O'ahu, Maui, Kaua'i, and Hawai'i.

To date, this study has demonstrated that PMMV can be used as conservative sewage indicators in Hawai'i as (1) they were abundant in raw sewage and their concentrations exceeded those of the indicator bacteria (e.g., enterococci), (2) there was no cross-reactivity detected with any animal samples studied, and (3) the decay of PMMV in the absence of sunlight was slower when compared to enterococci.

Publications:

None

Information Transfer Program:

The results for this project were presented at:

- WRRC/Ike Wai Seminar (Challenges in Evaluating Microbial Beach Water Quality in Hawai'i), University of Hawai'i, Honolulu, HI, April 2, 2019.

- MIC485 Microbes and Their Environment (University of Hawai‘i Spring 2019 course, ongoing commitment).
- NSF-TSUP SOEST Summer Bridge Program (Mauka 2 Makai), University of Hawai‘i, Honolulu, HI, July 5, 2019.

Student Support:

| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
|---------------|------------------------|------------------------|----------------------|---------------------|----------|
| Undergraduate | 2 | | | | 2 |
| Masters | | | | | |
| PhD | | | | | |
| Post-Doc | | | | | |
| TOTAL | 2 | | | | 2 |

Notable Achievements and Awards:

None

Student Internship Program:

None

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Integrated approach to better understanding groundwater flow in Hawaii: Oxygen/hydrogen stable isotopes and continuous water level monitoring

Project ID:

2018HI481B (Nicole Lautze)

Project Impact:

This project successfully deciphered general groundwater flow directions within the central corridor of O‘ahu using drinking water monitoring data from USGS National Water Quality Assessment (NAWQA) and Hawai‘i Department of Health (HDOH). By examining the legacy data from 2000 to 2002, the study was able to focus on the spatial relationships between concentrations of pineapple production agrochemicals in groundwater and created a new cost-effective methodology for discerning groundwater flows paths. The methodology to process the data included (1) identification and exclusion of outliers, (2) normalization by calculation of standard scores, (3) spatial plotting of concentration values using GIS software, and (4) interpolation to an aquifer-wide scale. Overall, this method was successful at a low resolution, and the results generally agreed with the existing groundwater flow models for O‘ahu.

In partnership with the Hawai‘i EPSCoR ‘Ike Wai, we deployed precipitation collectors across O‘ahu’s tallest peaks (e.g., Manana and Ka‘ala Ridge) and over a broad area of West Hawai‘i. Experimental designs for fog collectors are ongoing and the data will be compared to elucidate the input of fog to recharge and measured in water wells. In turn, those results will be compared with historical NAWQA groundwater well data to assess the flow paths. Funding from HDOH will allow future soil moisture sampling to measure recharge. A comprehensive understanding of the input (recharge) values to our groundwater system should result from studying the O and H isotope value of precipitation, fog, and in soil.

Publications:

Fillinger, S., 2019, “Inferring groundwater flow paths for Pearl Harbor aquifer of O‘ahu, Hawai‘i, based on historical chemical data,” in 2019 Pacific Water Conference, Hawaii Section, American Water Works Association, Honolulu, HI, February 2019.

Fillinger, S., 2019, “Spatially analyzing groundwater flow paths within the Pearl Harbor aquifer of O‘ahu, Hawai‘i, using 2000–2002 pineapple agrochemical data,” M.S. thesis, Department of Civil and Environmental Engineering, University of Hawai‘i at Manoa, Honolulu, HI, 48 p.

Information Transfer Program:

The information transfer for the project remains internal at this stage. Most of the data are posted to <https://www.higp.hawaii.edu/hggrc/> (Google-hosted University of Hawai'i Google Drives). This site provides all of the Hawai'i Groundwater Geothermal Resource Center's data that are accessible to the public. However, data will not be posted until the material is published, in keeping with the funding agency's policies.

Student Support:

| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
|---------------|------------------------|------------------------|----------------------|---------------------|----------|
| Undergraduate | 1 | | | | 1 |
| Masters | 1 | | | | 1 |
| PhD | | | | | |
| Post-Doc | | | | | |
| TOTAL | 2 | | | | 2 |

Notable Achievements and Awards:

Shelby Fillinger, the student supported under this project, placed second place in the Hawaii Water Environmental Association student poster contest at the 2019 Pacific Water Conference, Honolulu, HI, February 2019.

Student Internship Program:

None

Project Synopsis

Email address:

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 Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Economic activity, technological progress, and water resource utilization on Oahu

Project ID:

2018HI482B (Peter Fuleky)

Project Impact:

This grant has supported valuable work on measuring the economic conditions in Hawai‘i. Following a ten-year expansion, global and local economic conditions have now become more volatile. Hawai‘i’s tourism-dependent economy is especially vulnerable to economic fluctuations. We have already found evidence of weaker growth in recent quarters, which does not bode well for local economic performance ahead with a global slowdown on the horizon. The novel indicators of economic performance we developed will help to identify the state of the economy and should be very useful for the local community.

The next phase of our study is to estimate the impact of economic activities and technological progress on water demand on O‘ahu. Our results will promote sustainable coastal development by quantifying water consumption as a function of economic fluctuations. This will help stakeholders to assess the impact of future developments on water demand and sustainability.

Publications:

None

Information Transfer Program:

We have presented our findings to our colleagues with the intent to receive feedback on our work. In the near future, we will share our findings with a broader audience via blog posts, presentations and eventually more formal means.

Student Support:

| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
|---------------|------------------------|------------------------|----------------------|---------------------|----------|
| Undergraduate | | | | | |
| Masters | 1 | | | | 1 |
| PhD | | | | | |
| Post-Doc | | | | | |
| TOTAL | 1 | | | | 1 |

Notable Achievements and Awards:

None

Student Internship Program:

The grant has supported one graduate trainee (Sisi Zhang), working towards her Ph.D. in the Department of Economics. She completed her second year of graduate education at the University of Hawai'i at Mānoa and has made notable progress in her understanding of statistical concepts and methods. Zhang was responsible for data acquisition, data cleaning, writing code to analyze the data and produce predictions, and drafted a paper summarizing her work. Upon completion, the paper is expected to be published in an academic journal.

Project Synopsis

Email address:

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Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Technology Transfer – American Samoa

Project ID:

2017AS473B (Darren T. Lerner)

Project Impact:

Funding for this project was utilized in support of printing supplies and third-party binding services for information provided to water resources stakeholders in American Samoa. This funding allowed Water Resources Research Center to dedicate printing supplies and communication efforts to maintain an informed American Samoa Advisory Council and stakeholders, including leadership at several agencies (local and federal) in American Samoa as well as at the American Samoa Community College. Future projects in this realm are titled “Technology Transfer and Communications—American Samoa.”

Publications:

None

Information Transfer Program:

None

Student Support:

None

Notable Achievements and Awards:

None

Student Internship Program:

None

Project Synopsis

Email address:

thomas@hawaii.edu

Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Travel to American Samoa

Project ID:

2017AS477B (Darren T. Lerner)

Project Impact:

Since 2013, the University of Hawai'i Water Resources Research Center (WRRC) has managed a research, education, and outreach program for American Samoa. This has presented some logistic ramifications since the University of Hawai'i is located more than 2,600 miles from Pago Pago, American Samoa. The funds allocated for travel has promoted conducting programmatic activities encouraging collegial interaction. In 2017, a separate advisory council was established to help guide and focus the research funding. The advisory council consisted of local government agencies, US government agencies operating in American Samoa, nonprofits, non-governmental organizations, and community leaders. In 2018, the advisory council was re-engaged along with visits to American Samoa water-related institutions, which included the community college and their officials, and local government representatives. The purpose of these meetings sought to establish greater cooperation and understanding of the water and water-related sector in American Samoa. Ultimately, this project allocation serves to provide funds for administrative engagement in American Samoa at least once a year to strengthen their Water Resources Research Institute Program and its implementation by increasing awareness of the program among the local stakeholders. The travel also provides an opportunity for WRRC to understand the requirements and priorities of American Samoa and to assess potential local research partners and opportunities.

Publications:

None

Information Transfer Program:

None

Student Support:

None

Notable Achievements and Awards:

None

Student Internship Program:

None

Project Synopsis

Email address:

thomas@hawaii.edu

Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

3rd Conference on Water Resource Sustainability Issues on Tropical Islands'

Project ID:

2018AS479B (Darren T. Lerner)

Project Impact:

This project received a formal no-cost extension as the partners determine an alternate location for the 3rd Conference on Water Resource Sustainability Issues on Tropical Islands. There have been significant delays in the execution due to a series of unforeseen events. The conference was originally planned for 2018 in St. Thomas of the U.S. Virgin Islands. A succession of hurricanes in Fall 2017 decimated the venues set for this meeting. To date, the likely scenario is that this conference will take place in Hawai'i in 2020. A component of the funding has been rebudgeted for purchase of hydrogeophysical equipment.

Publications:

None

Information Transfer Program:

None

Student Support:

None

Notable Achievements and Awards:

None

Student Internship Program:

None

Project Synopsis

Email address:

thomas@hawaii.edu

Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Technology Transfer and Communications – American Samoa

Project ID:

2018AS489B (Darren T. Lerner)

Project Impact:

During FY2018, Technology Transfer activities for American Samoa included personal communication with members of the Advisory Committee, assisting with online proposal system set up, participating in the process to select reviewers for the American Samoa 104B grants, and participating in the review process for awarding of the grants. The Advisory Committee was invited to provide input for the review process of the proposals. Funding was also used to support printing supplies and third-party binding services for information provided to water resources stakeholders in American Samoa. This allowed Water Resources Research Center to dedicate printing supplies and communication efforts to inform American Samoa Advisory Council and stakeholders, including leadership at several agencies (local and federal) as well as leadership at the American Samoa Community College.

Publications:

None

Information Transfer Program:

None

Student Support:

None

Notable Achievements and Awards:

None

Student Internship Program:

None

Project Synopsis

Email address:

thomas@hawaii.edu

Thomas W. Giambelluca, Director

Institute:

Hawaii and American Samoa

Grant Type:

Annual Base Grant

Project Title:

Technology Transfer and Communications – HI

Project ID:

2018HI484B (Darren T. Lerner)

Project Impact:

To assist the Center in transferring information concerning water resource research issues, Water Resources Research Center (WRRC) engaged in a range of media to disseminate their research through bulletins, publications, website(s), workshops, meetings, conferences, and seminars.

WRRC’s activities included (1) organizing WRRC Spring and Fall seminars; (2) participating in research projects, meetings, conferences, and school science fairs; (3) providing research information and assistance to consultants, students of all levels, and the general public; and (4) completely revamping the Center’s web site with current research activities and information. The WRRC website now has dynamic content management, which allows all members of the Center to upload and input content.

The Technology Transfer Office organized biweekly seminar series designed to foster communication among WRRC researchers, students, and the organizational target audience of government agencies, private-sector researchers, and members of the general public with an interest in water resource issues. The following is a list of the seminars presented in FY2018.

Fall 2018 Seminars

| DATE | SPEAKER | TITLE |
|--------------|-------------------------------|--|
| 11 September | Henrietta Dulai | Groundwater Recharge-Discharge Imbalance, Inter Aquifer Flow, and Yet to be Explained Connections in Kona Aquifers |
| 9 October | U’ilani Au and Kilika Bennett | ‘Eli Wai: Excavating Water from the Hawaiian Language Newspapers |
| 23 October | Kawika Winter | Restoring to the Future: Reviving Ahupua‘a in the 21st Century |
| 13 November | Sagy Cohen | Riverine Research Across Scales: From Global Scale Sediment Modeling to Event Scale Flood Analysis |
| 27 November | Marta Echavarría | From the Andes of Colombia to Perú: A Lifetime of Natural Infrastructure Investments |
| 4 December | Roy Hardy | Commission on Water Resource Management 2019 Update to Water Resource Protection Plan of the Hawai‘i Water Plan |

Spring 2019 Seminars

| DATE | SPEAKER | TITLE |
|-------------|--|--|
| 22 January | Sayed Bateni | Estimation of Evapotranspiration and Gross Primary Productivity via Variational Assimilation of Remotely Sensed Land Surface Temperature and Leaf Area Index |
| 12 February | Stephen H. Schoenholtz | A Rising Tide: Complex Water Challenges in the Mid-Atlantic Propel Scholarship, Research, and Engagement |
| 26 February | Sheree Watson | Phylogenetic Diversity of Groundwater Microbes in Hawai'i Reveals Aquifer Characteristics |
| 2 April | Marek Kirs | Challenges in Evaluating Microbial Beach Water Quality in Hawai'i |
| 16 April | Yin-Phan Tsang | Characterizing the Stream and its Association with the Ecosystem in Hawai'i |
| 23 April | Victoria Keener, Laura Brewington, and Alan Mair | Evaluating the Effects of Future Climate and Land-Cover Conditions on Groundwater Resources for the Island of Maui, Hawai'i |

Publications:

Hawai'i Water Resources Research Center, 2019, "2019 Hawai'i WRRC Research (fact sheet)," Honolulu, HI, February 2019.

USGS, 2019, "Water Resources Research Act Program 10-Year Vision—Meeting Imperative for Our Nation's Water Resources (fact sheet)," Honolulu, HI, February 2019.

USGS Water Resources Research Act Program, 2019, "Training America's Next Generation of Water Resources Scientists (brochure)," Honolulu, HI, February 2019.

Water Resources Research Center, 2018, "Hawai'i Water Resources Research Center, Ka Wai Wai O Ka Wai —The Importance of Water," WRRC-IT-2018-02, Honolulu, HI, February 2018, 19 p.

Information Transfer Program:

None

Student Support:

None

Notable Achievements and Awards:

None

Student Internship Program:

None