



Effective Integrated Physical, Chemical, and Biological Aquatic Monitoring in the Pacific Island National Parks

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What is the Inventory and Monitoring Program?

- The Inventory and Monitoring (I&M) Program is a major component of the National Park Service's strategy to improve park management through greater reliance on scientific information.
- The Pacific Island Network (PACN) is one of 32 National Park Service Inventory & Monitoring networks of national parks linked by geography and shared natural resource characteristics.
- The program develops Monitoring Protocols for key Vital Signs to ensure consistent long-term data collection, reporting, and analysis.
- The PACN I&M Program monitors the status and trends of aquatic resources across the tropical Pacific National Parks in Hawaii, Guam, Saipan, and American Samoa.



American Memorial Park,
Saipan (AMME)



War in the Pacific
National Historical Park,
Guam (WAPA)



World War II Valor in the Pacific,
Oahu (VALR)

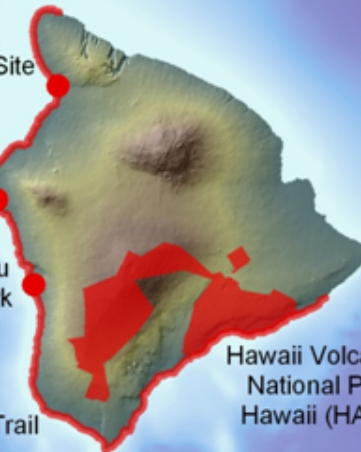


Kalaupapa National Historical Park,
Molokai (KALA)



Haleakala National Park,
Maui (HALE)

Puukohola Heiau
National Historic Site
(PUHE)



Kaloko-Honokohau
National Historical Park
(KAHO)

Puuhonua o Honaunau
National Historical Park
(PUHO)

Ala Kahakai
National Historic Trail
(ALKA)

Hawaii Volcanoes
National Park,
Hawaii (HAVO)



National Park of American Samoa
(NPSA) Manua group



0 10 20 30 40 50 Miles

All Park Maps at same scale

**Produced by I&M Program
Pacific Island Network
June 2009**

PACN Aquatic Resources

Park

- Hawaii Volcanoes NP
- Kaloko-Honokohau NP
- Puukohala Heiau NHS
- Puuhonua o Honaunau NHP
- Ala Kahakai NHT
- Haleakala NP
- Kalaupapa NHP
- War in the Pacific NHP
- American Memorial Park
- National Park of American Samoa
- Valor in the Pacific

Resources

- Anchialine pools
- Marine, Anchialine pools
- Coastal brackish resource
- Anchialine pools
- Anchialine pools
- Freshwater streams, Wetlands, Lake
- Freshwater streams, Marine, Lake
- Freshwater streams, Marine
- Wetlands
- Freshwater Streams, Marine
- Marine

PACN Aquatic Protocols

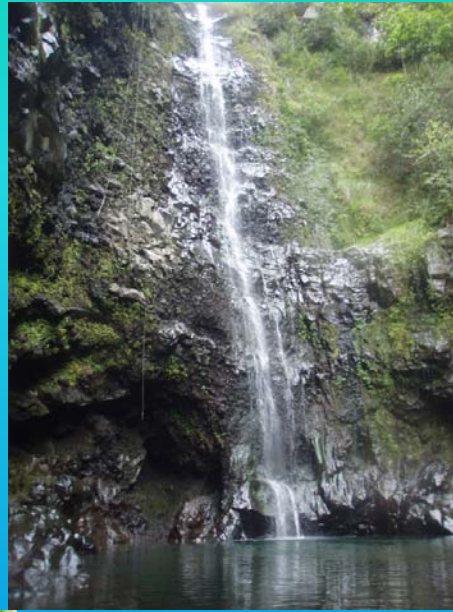
- Water Quality-physical and chemical data collected and monitored in all park aquatic resources
- Freshwater Animal Communities Monitoring: Fish, Shrimp, Snails, Habitat Characterization, and Flow/Discharge-monitored in freshwater streams



4 parks have freshwater stream resources



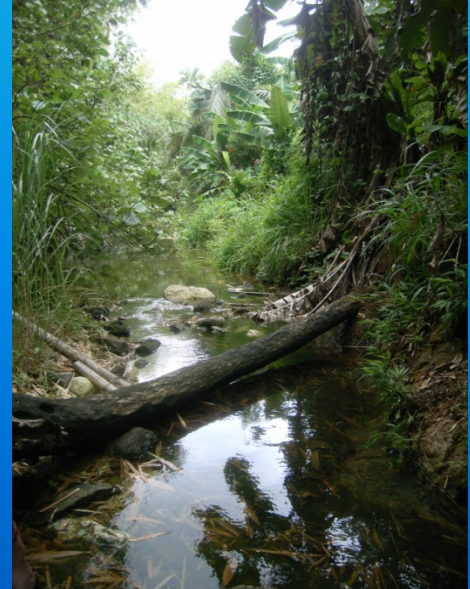
KALA



HALE



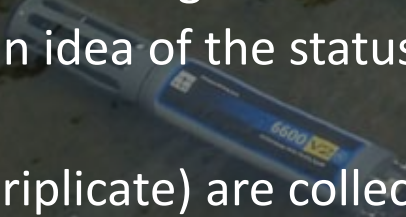
NPSA



WAPA

Water Quality Monitoring

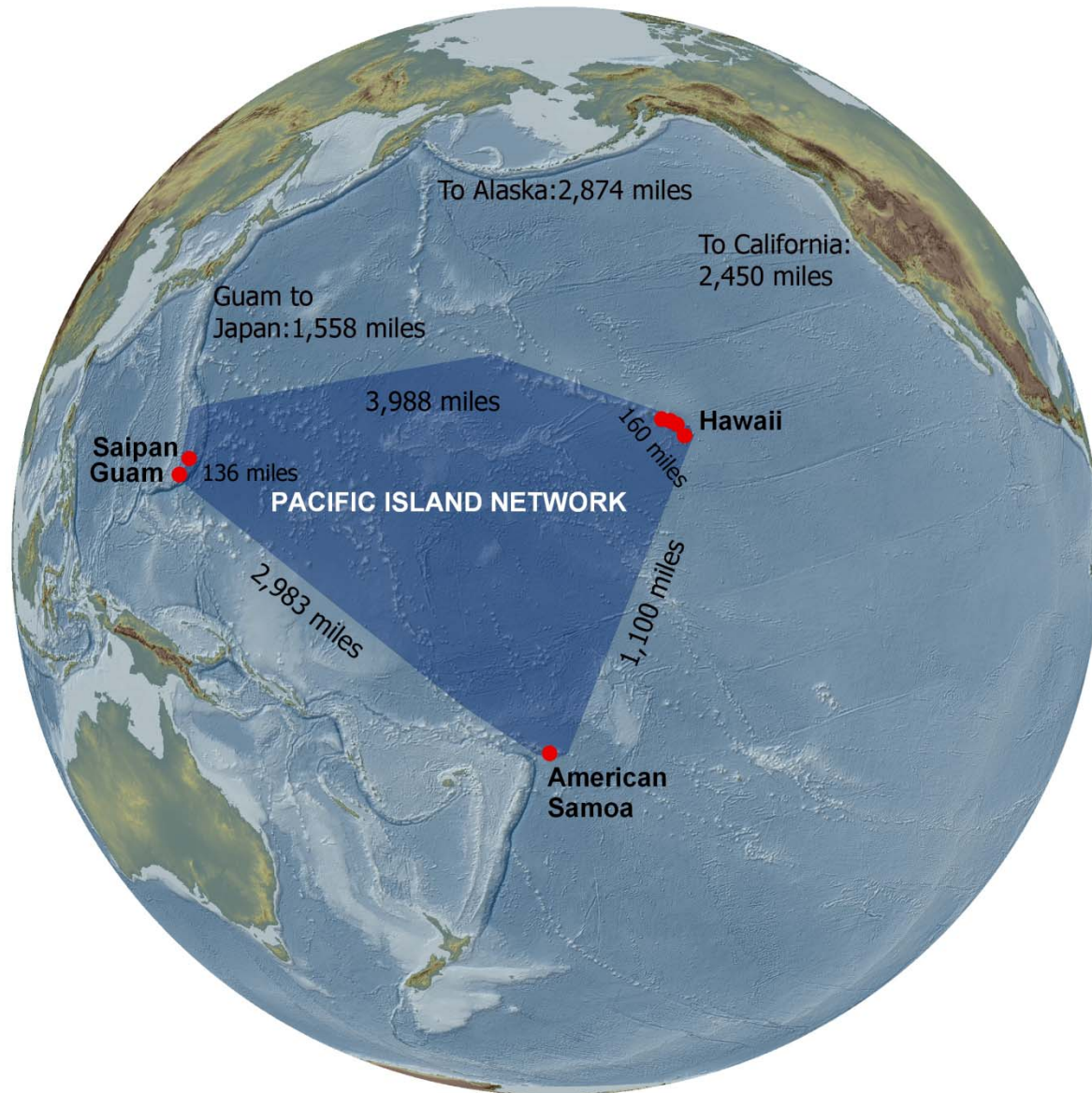
- Sites are monitored quarterly.
- ½ the sites are fixed sites and are consistently sampled during each sampling event. This data gives managers an idea of temporal trends in aquatic resources.
- ½ the sites are temporary sites selected randomly prior to each sampling event using ArcGIS. This data gives managers an idea of the status of aquatic resources.
- Water samples (triplicate) are collected for later lab nutrient analysis of Total Nitrogen, Total Phosphorus, and Nitrate+Nitrite concentrations.
- Physical parameters are recorded using a YSI 6600 sonde. Physical parameters include temperature, specific conductivity, pH, salinity, turbidity, dissolved oxygen saturation, and chlorophyll.



Freshwater Animal Communities Monitoring

- Surveys performed annually.
- 16 sites are surveyed. 8 fixed and 8 temporary.
- Each site is a 30m reach.
- Various survey techniques are used.
- Snorkel surveys for fish and shrimp.
- Nets used to catch, identify, and measure smaller shrimp species.
- Quadrat method used to count, identify, and measure snails.
- Habitat characterization includes flow measurements, discharge, geomorphic channel units, riparian canopy cover, and pebble counts.

Challenges: Remoteness

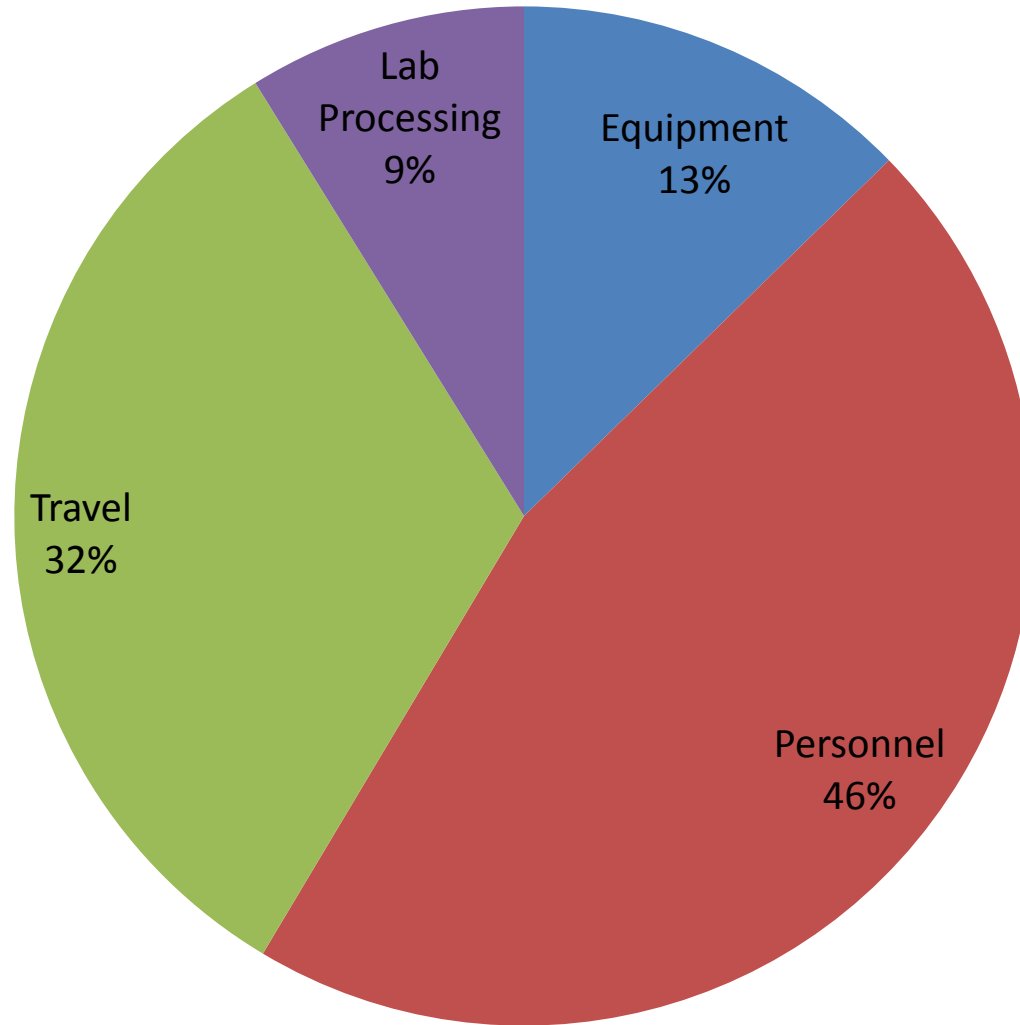


Remote=Costly

- Island units necessitate flying *everywhere*.
- Flights are limited and expensive.
- Multiple park units on different islands requires extended effort.
- Many field sites are located in the backcountry, which may require long hikes.
- This leads to complicated and costly logistics.



What does it cost to maintain the stream monitoring portion of program?



Freshwater Streams Equipment

Water Quality Monitoring

- Instrumentation: sonde probes, repairs = **\$2,000**
- WQ field supplies: Filters (\$968), filter holders (\$2,910), syringes (\$485), waterproof paper/labels (\$700), sample bottles (\$2,140), standards (\$440). Total = **\$6,675**
- Acid washing equipment: HCl (\$113), distilled water (\$72), gloves and baking soda (\$72), distiller and accessories (\$379). Total = **\$636**
- Calibration solutions = **\$5,582**
- Batteries and Camera equipment = **\$1,545**
- Safety gear = **\$220**
- Shipping = **\$1,500**
- Misc. equipment = **\$50**
- **GRAND TOTAL = \$18,208**

Freshwater Animal Communities

- Waterproof paper = **\$240**
- Batteries and Camera Equipment = **\$1,500**
- Safety gear = **\$970**
- Snorkel gear and wetsuits = **\$750**
- Shipping = **\$150**
- Misc. equipment = **\$80**
- Boat use = **\$200**
- **GRAND TOTAL = \$3,890**

Lab Processing

Water Quality

- Water sample lab processing = \$8,181

Freshwater Animal Communities

- Lab analysis of Guam shrimp = \$8,000

Personnel

Water Quality

- KALA: Time effort=3 days
Personnel effort = 2 people
per diem = \$25/day
Cost = \$1,770 x 4 times/yr = **\$7,080**
- HALE: Time effort = 5 days
Personnel effort = 2 people
Per diem = \$25/day
Cost = \$2,688 x 4 times/yr = **\$10,752**
- NPSA: Time effort = 8 days
Personnel effort = 2 people
Per diem = \$75/day
Cost = \$5,447 x 4 times/yr = **\$21,788**
- WAPA: Time effort = 3 days
Personnel effort = 2 people
Per diem = \$80/day
Cost = \$2,020 x 4 times/yr = **\$8,080**
- **GRAND TOTAL = \$37,948**

Freshwater Animal Communities

- KALA: Time effort= 10 days
Personnel effort = 5 people
Cost = **\$18,050**
- HALE: Time effort = 10 days
Personnel effort = 3 people
Cost = **\$5,900**
- NPSA: Time effort = 11 days
Personnel effort = 5 people
Per diem = \$75/day, \$25/day (camping)
Cost = **\$11,472**
- WAPA: Time effort = 10 days
Personnel effort = 3 people
Per diem = \$80/day
Cost = **\$9,252**
- **GRAND TOTAL = \$44,824**

Travel

Water Quality

- KALA: =airline flight (\$860), baggage fee (\$200)= \$1,060 x 4 times/yr = **\$4,240**
- HALE: airline flights (\$480), rental car (\$160), gas (\$30), baggage fees (\$80).
Total = \$750 x 4 times/yr = **\$3,000**
- NPSA: airline flights (\$3,164), lodging (\$1,722), baggage fees (\$50), rental car (\$300), gas (\$50)= \$5,296x 4 times/yr
= **\$21,184**
- WAPA: airline flights (\$2,720), rental car (\$135), gas (\$30) = \$2,885 x 4 times/yr = **\$11,540**
- **GRAND TOTAL = \$40,804**

Freshwater Animal Communities

- KALA: airline flights (\$1,280), baggage fees (\$250).
Total = **\$1,530**
- HALE: airline flights (\$770), rental car (\$450), gas (\$30), baggage fees (\$80). Total = **\$1,330**
- NPSA: airline flights (\$4,746), lodging (\$3,537), rental car (\$825), gas (\$40). Total = **\$9,148**
- WAPA: airline flights (\$2,720), lodging (\$2,862), rental car (\$400), gas (\$50), baggage fees (\$80). Total = **\$6,112**
- **GRAND TOTAL = \$18,120**

Total Per Sample Costs

- Water Quality
 - 372 samples/year
- Total Cost = \$105,141
- \$282.64 per sample

Cost Efficient Strategies

- Technicians are based in KALA, WAPA, and NPSA that are employed ½ time by I&M and ½ by their respective parks. This minimizes travel costs for quarterly water quality monitoring.
- Technicians are trained in all aspects of both the water quality and the freshwater animal communities protocols to maximize efficiency, minimize travel costs, and save time.
- Equipment is shared, if possible, between protocols. Cameras, certain safety gear, batteries are used to support both protocols.

Co-Location

- Water quality sites and freshwater animal communities monitoring sites are co-located meaning they are sampled at the same site on the stream.
- By co-locating sites, crews do not have to hike to different sites to sample water quality and perform a freshwater animal communities survey. This saves personnel time and effort.



Co-Visitation

- Sites are also co-visited meaning sampling occurs during the same sampling event.
- By co-visiting, travel costs are reduced and additional personnel time and effort is saved by “killing two birds with one stone.”

Cost Reductions:

Water Quality + Freshwater Animal Communities

Equipment

- Sharing equipment when possible = -\$1,200

Total = \$17,008 (vs \$18,208)

Cost Reductions:

Water Quality + Freshwater Animal Communities

Personnel

- KALA: Time effort=14 hrs (vs 3 days)
Techs in park= \$910 x 4 times/yr = **-\$3,440**
Co-location/co-visitation = **-\$910**
Total Cost = **\$2,530** (vs \$7,080)
- HALE: Time effort = 5 days
Co-location/co-visitation= - \$2,688
Total cost= **\$8,064** (vs \$10,752)
- NPSA: Time effort = 6 days (vs 8 days)
Techs in park = \$3,511 x 4 times/yr = **-\$7,744**
Co-location/co-visitation = **-\$3,511**
Total Cost = **\$10,533** (vs \$21,788)
- WAPA: Time effort = 14 hrs (vs 3 days)
Techs in park= \$720 x 4 times/yr = **-\$5,200**
Co-location/co-visitation= **-\$720**
Total cost = **\$2,160** (vs \$8,080)
- **GRAND TOTAL SAVINGS= -\$28,563**
GRAND TOTAL = \$9,385 (vs \$37,948)

Cost Reductions:

Water Quality + Freshwater Animal Communities

Travel

- KALA: monitoring performed by in-house staff = -\$4,240
Total = \$0 (vs \$4,240)
- HALE: co-visitation = -\$750
Total = \$2250 (vs \$3,000)
- NPSA: Techs in park = -\$18,784
Co-visitation = -\$600
Total = \$1,800 (vs \$21,184)
- WAPA: monitoring performed by in-house staff = -\$11,540
Total = \$0
- GRAND TOTAL SAVINGS = -\$35,914
- GRAND TOTAL COST = \$4,170

Total Per Sample Cost

- Water Quality

372 samples/year

Total Cost = \$38,784 (vs \$105,141)

Total Savings = -\$66,357 (-63%)

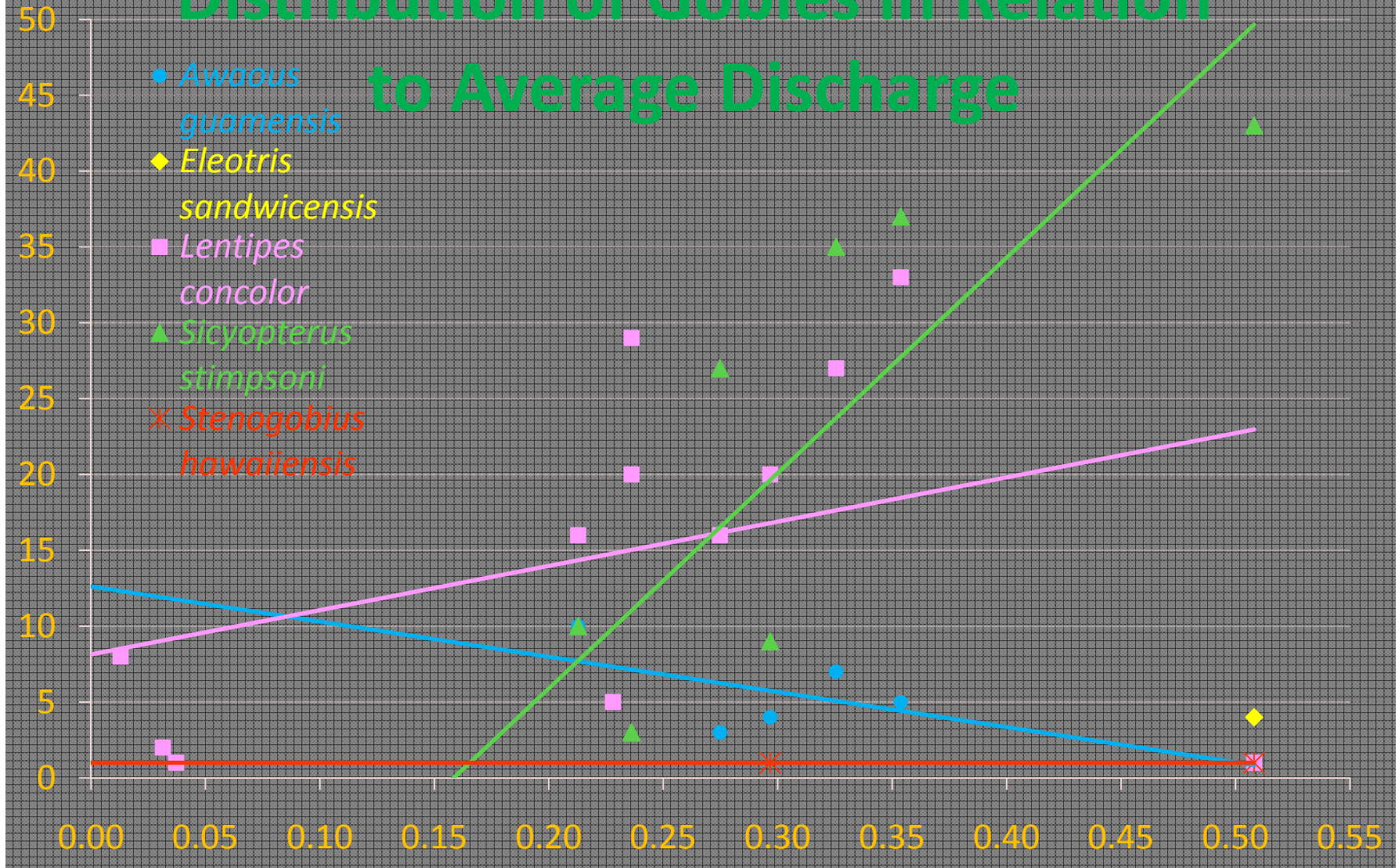
\$104.26 per sample

Total savings = -\$178.38/sample (-58%)

Wait...there's more...

- By co-locating and co-visiting water quality and freshwater animal communities monitoring efforts, direct correlation of biological data to physical and chemical environmental data has increased the interpretability results to management.

Distribution of Gobies in Relation to Average Discharge



Total count of native gobies at each station plotted against the average discharge at that station. Y-axis is total numbers and X-axis is m^3 per sec. Lines are linear regressions of the points: *A. Guamensis* (blue), *L. concolor* (pink), *S. stimpsoni* (green) and *S. hawaiiensis*

Mahalo Nui Loa!

