
The Recent History of
Stream Bioassessments in Hawaii
Reuben H. Wolff
U.S. Geological Survey
USGS

Overview

- Definitions
- Earlier Bioassessments
  - Timbol and Maciolek
  - HSA
- Who's who in Hawaiian Stream Ecology
- Overview of Bioassessment Protocols Applied in Hawaii
  - State
  - Federal
    - ✓ NAWQA
    - ✓ EMAP
- Development of a multi-metric index of biotic integrity using benthic invertebrates

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Survey:

The collecting, processing, and analyzing of representative parameters of an aquatic community to determine the community structure and function (USEPA Region 5)

Biomonitoring:

The measurement of biological parameters in repetition to assess the current status and changes in time of the parameters measured (USFWS)

Bioassessment:

An evaluation of the condition of a water body using biological surveys and other direct measurements of the resident biota in surface waters (Gibson et al. 1996)

Biocriteria:

Numerical values or verbal standards that define a desired biological condition (reference biological condition) for a water body. (Karr 1999)

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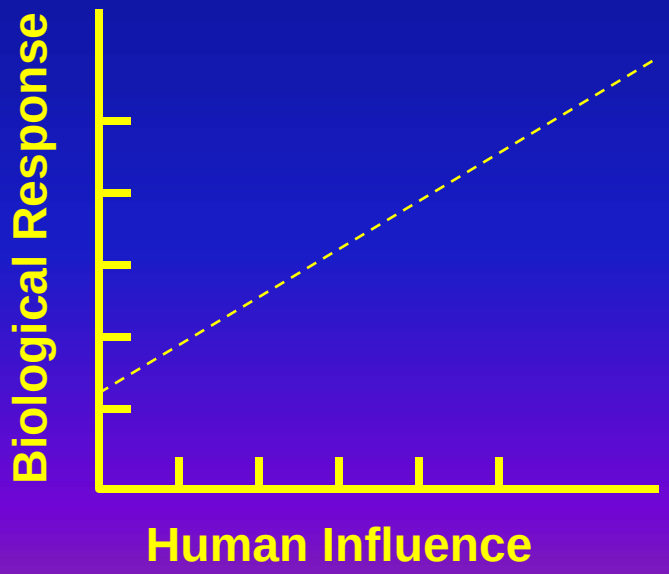
Biological Integrity

A balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural, unimpaired habitat of the region (Karr and Dudley, 1981)

Biological integrity is equated with pristine conditions or those conditions with minimal disturbance, and it is used as the baseline for the IBI;

An integral component of water resource programs at state and federal levels (U.S. Environ. Prot. Agency, 1990).



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Federal

Wild and Scenic Rivers Act (16 USC 1271-1287) - Public Law 90-542, approved October 2, 1968, (82 Stat. 906) establishes a National Wild and Scenic Rivers System and prescribes the methods and standards through which additional rivers may be identified and added to the system.

National Environmental Policy Act of 1969 (NEPA), (Pub. L. 91-190, 42 U.S.C. 4321-4347) the foundation of modern American environmental protection within a comprehensive national policy. Intended to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment.

Federal Clean Water Act, 1972, is to achieve “fishable and swimmable” waters by restoring and maintaining the chemical, physical, and biological integrity of the Nation’s surface waters (33 U.S.C. §1251).

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State

The **Hawaii State Water Code** (Hawaii Revised Statutes (HRS), Chapter 342D) states that the waters of the state are held for the benefit of citizens who have a right to have the waters protected for their use.

Hawaii Administrative Rules (HAR) Chapter 11-54, Water Quality Standards designate uses, set water quality criteria and establish an antidegradation requirement for all state waters.

Section 303(d) of the federal **Clean Water Act** to generate a list of surface waters that are exceeding or will likely exceed state Water Quality Standards. (aka the List of Impaired Waters)

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Stream Bioassessments in Hawaii

Built upon the accumulation of years of knowledge

- **Observations by Hawaiians**
- **Naturalists / Linnean Taxonomists**
  - **Surveys / Collections**
- **Biologists / Ecologists**

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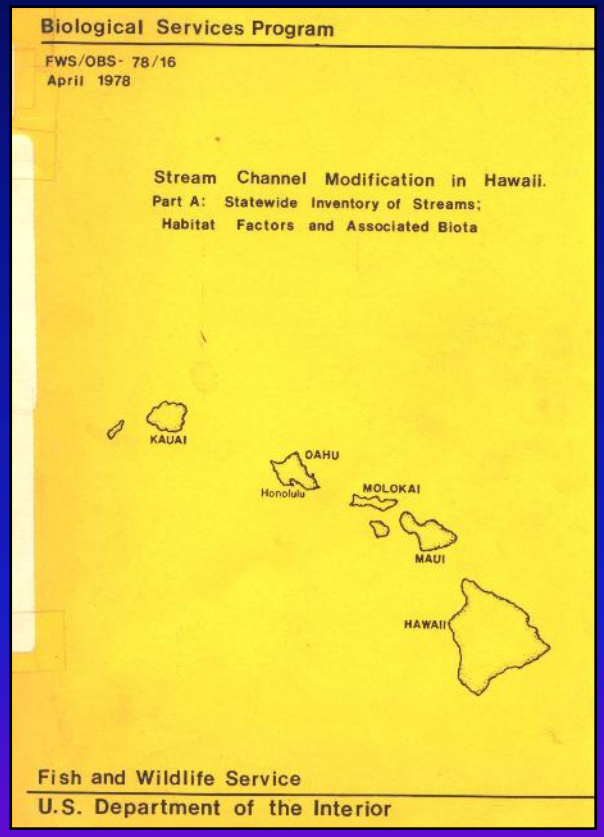
1978: Amadeo Timbol and John Maciolek

Stream Channel Modification in Hawaii. Part A: Statewide Inventory of Streams: Habitat Factors and Associated Biota



Ecological Quality:

I **Pristine-Preservation**: High environmental and biological quality.

II **Limited Consumptive**: Moderate to high quality water or natural values.

III **Exploitive-consumptive**: Moderate to low natural and/or water quality (well exploited, modified or degraded.

IV **Construct-Alter**: Low environmental and biological quality.

Indicator Species:

Alamoo - Lentipes concolor
Nopili - Sicydium stimpsoni (*Sicyopterus stimpsoni*)
Nakea - Awaous stamineus (*Awaous guamensis*)

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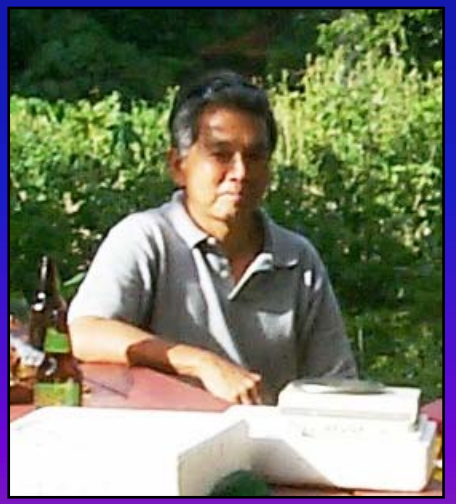
Bob Kinzie
Mike Kido
Dan Polhemus
Bob Nishimoto
Michael Fitzsimons



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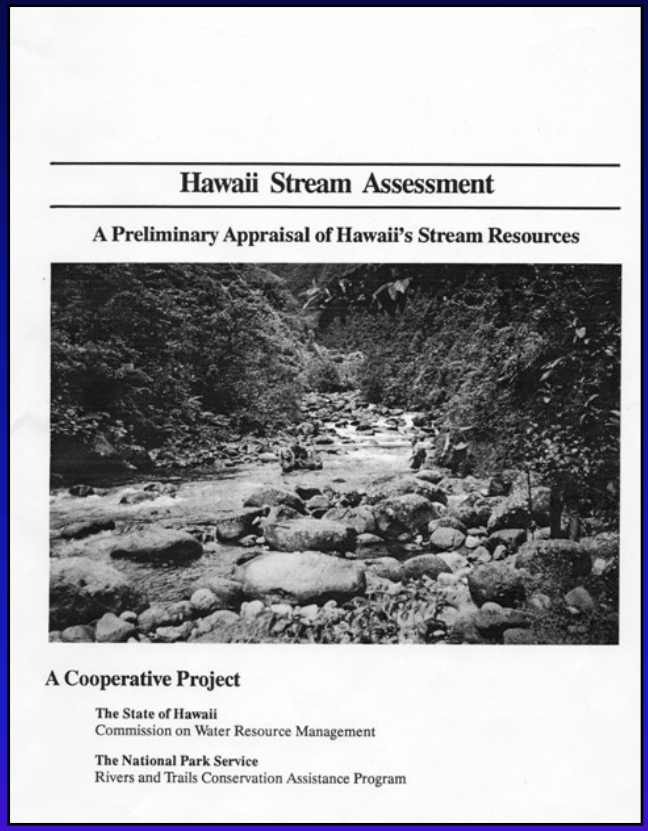
1990: Hawaii Stream Assessment

The primary task of the HSA was to identify streams appropriate for protection.

- In response to the National Wild and Scenic Rivers Act
- Initiated by the State Commission on Water Resource Management
- National Park Service's State and Local Rivers and Trails Conservation Assistance Program.
- Consolidated a vast amount of published information from diverse sources.



Established assessment criteria to identify streams containing ecosystems with potentially high quality aquatic resources

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Hawaii Stream Assessment
Aquatic Resources

Native Species Group 1 (NG1): Sensitive native species.

- Alamoo - *Lentipes concolor*
- Nakea - *Awaous stamineus* (*guamensis)*
- Nopili - *Sicyopterus stimpsoni*
- Hihiwai - *Neritina granosa*

Native Species Group 2 (NG2): The other seven native species considered more common.

Introduced Species Group One (IGI): Included harmful, non-native stream animals.

Convict cichlid, Chinese catfish, Corbicula, Mosquito fish, Malaysian prawn, Smallmouth bass, Guppy (Topminnow) Tilapia, Swordtails

Introduced Species Group Two (IG2): Relatively harmless non-native stream animals.

*Aquatic insects were not considered only because their taxonomy and distribution are poorly understood.

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Hawaii Stream Assessment

Aquatic Resources Ranking Biocriteria

Outstanding

Either A or B

A. Any of these criteria

Lentipes concolor is common in any reach of the stream; Evidence of spawning by any of the NG1 gobies; An abundance of any of the four rare NG1 species anywhere in the stream; Presence of all of the four NG1 species in the stream.

B. All of these criteria

Two or more representatives of NG1 and NG2 each, representing high native species diversity.

One or fewer IGI introduced species

No dams, diversions, or channelization.

Substantial

Both A and B

A. At least three total representatives from NGI and NG2.

B. One or fewer introduced species IG1.

Moderate

Presence of at least one native species from NG1.

Presence of at least one NG2.

Without: No native species present.

Unknown: Insufficient biological information available for the stream.

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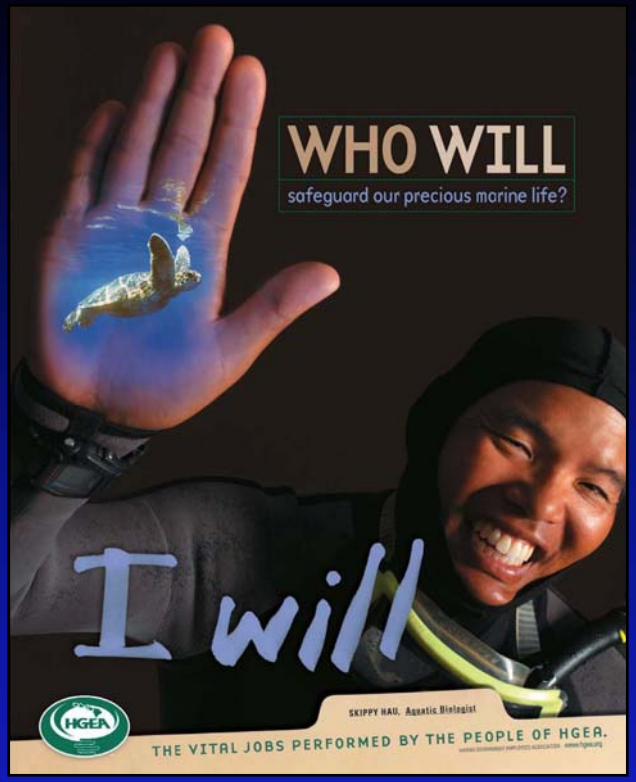
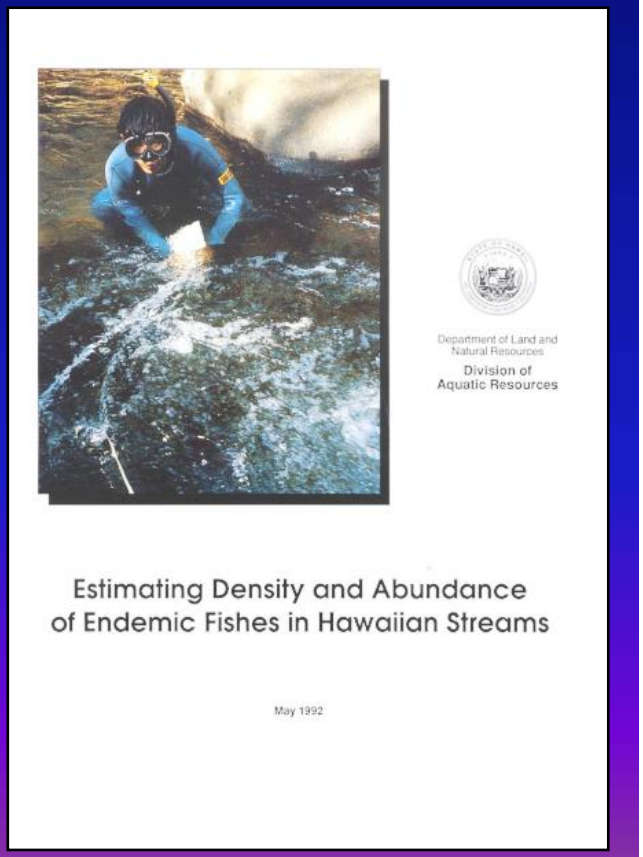


Hawaii Division of Aquatic Resources

The mission of the Division of Aquatic Resources is to manage, conserve and restore the state's unique aquatic resources and ecosystems for present and future generations.



Gathers various types of data for use in monitoring, assessing, managing, and protecting the freshwater aquatic resources of the State.

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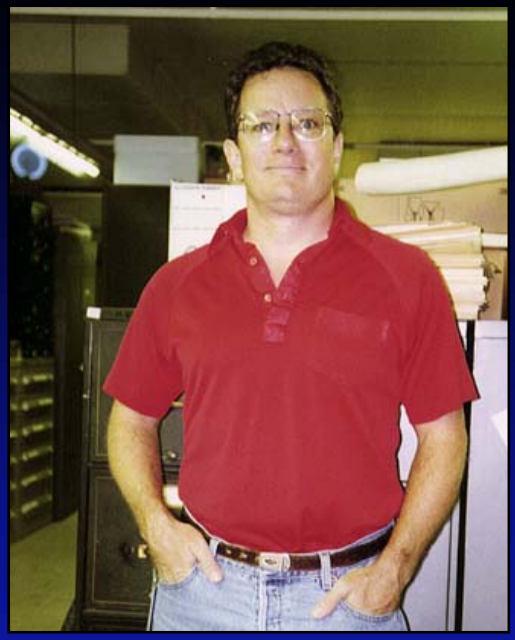
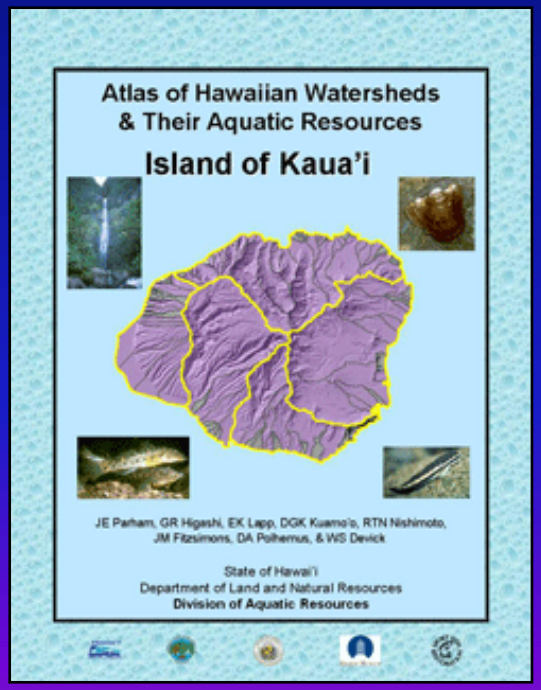
DAR Freshwater Database

Survey data from the States' perennial and intermittent streams, reservoirs, lakes, ponds, ditches, and diversions.

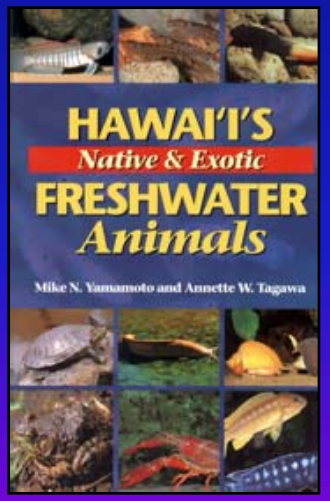
The data dates back to the early 1960s and includes data from the Hawaii Stream Assessment (HSA).





Atlas of Hawaiian Watershed & their Aquatic Resources

Dr. James E. Parham
Glenn R. Higashi
Darrell G.K. Kuamo'o



Yamamoto and Tagawa

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Bishop Museum

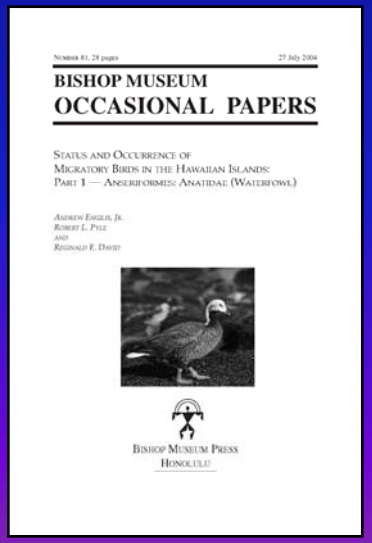
Hawaii Biological Survey Databases

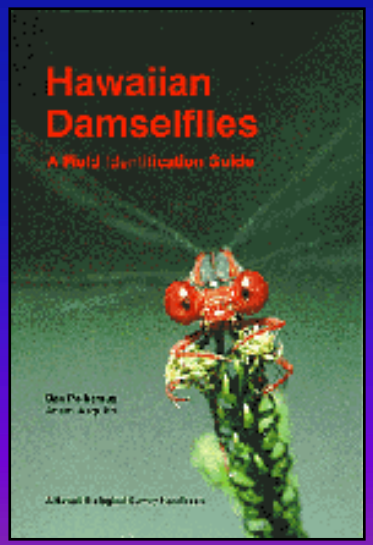
- Northwestern Hawaiian Islands
- Entomology
- Botany
- Mollusk
- Vertebrate
- Fish
- Marine Invertebrates

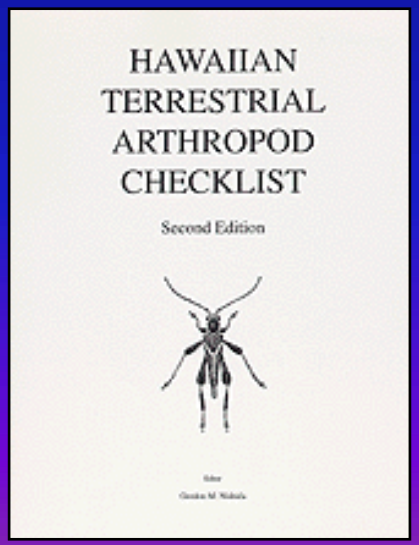
Waipio Stream Team

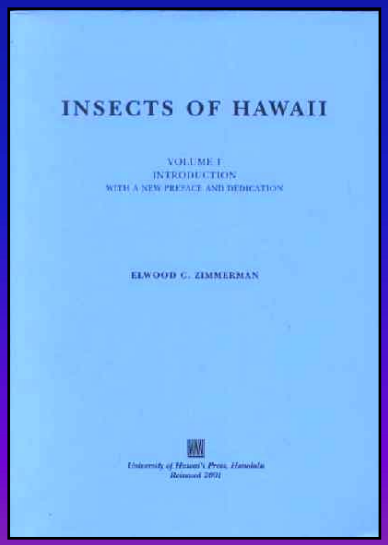
A collaboration of scientists and students

Numerous Surveys and Publications









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University of Hawaii

1979, Biology of a Hawaiian fluvial gastropod Neritina granosa Sowerby

1982, Life crawls upstream

1982, Population biology in small Hawaiian streams

1993, Reproductive biology of an endemic, amphidromous goby Lentipes concolor in Hawaiian streams

1996, Reproductive biology of Awaous guamensis, an amphidromous Hawaiian goby

2000, Goby recruitment to two streams on the north shore of Kauai

2006, Effects of water removal on a Hawaiian stream ecosystem

USGS

Other Research

Devick, W.S., Fitzsimons, J.M., and Nishimoto, R.T., 1992, Conservation of Hawaiian freshwater fishes.

McRae, M.G., 2001, Microhabitat use in an assemblage of native and introduced stream fishes in Wailoa Stream, Island of Hawaii.

McIntosh, M.D., Benbow, M.E., and Burky, A.J., 2002, Effects of stream diversion on riffle macroinvertebrate communities in a Maui, Hawaii, stream.

Parham, J.E., 2002, Spatial models of Hawaiian streams and stream fish habitats.

Sherwood, A.R., and Kido, M.H., 2002, Watershed-scale comparisons of algal biodiversity in high-quality proximate Hawaiian stream ecosystems.

Fitzsimons, J.M., Parham, J.E., Benson, L.K., McRae, M.G., and Nishimoto, R.T., 2005, **Biological assessment of Kahana Stream, island of Oahu, Hawaii: an application of PABITRA survey methods**.

And Many Others…

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Hawaii Department of Health

Environmental Planning Office (EPO)

The mission of the Department of Health is:

- To protect and improve the health and environment for all people in Hawaii
- To prevent pollution and promote and preserve a clean, healthy and natural environment
- **Ensure that federal mandates are satisfied**

List of Impaired Waters: Section 303(d) of the Federal Clean Water Act

Hawaii Administrative Rules
Water Quality Standards

§11-54-4 Basic water quality criteria applicable to all waters.
§11-54-5 Uses and specific criteria applicable to inland waters.

USGS

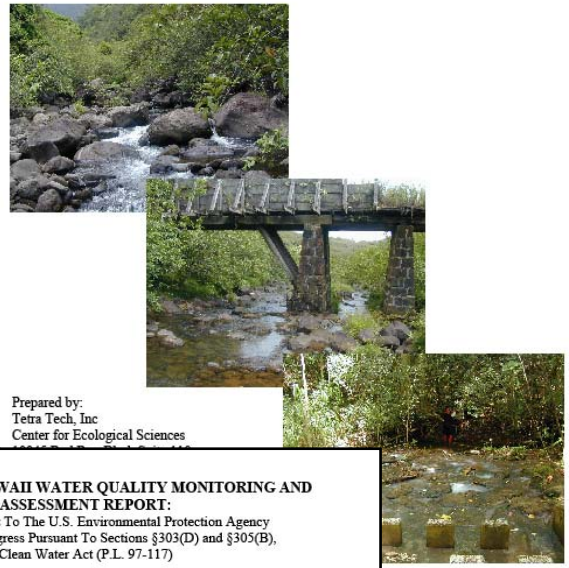
Kawa Stream Bioassessm

Susan Burr
Environmental Planning Office
Hawaii Department of Health
February 2001

Final
Kaneohe Str
Bioassessme

Final
Waikele Str
Bioassessm

STREAM CONDITION ALONG A DISTURBANCE GRADIENT ON KAUAI: STRENGTHENING HAWAIIAN STREAM ASSESSMENT



Prepared by:
Tetra Tech, Inc
Center for Ecological Sciences

TOTAL MAXI
DAILY LOA

KAWA STREAM
KANEOHE, HI

Final Technical R
March 2002

FINAL
2004 LIST OF IMPAIRED WATE
PREPARED UNDER CLEAN WATE

Keakonahua Stre

Prepared by Linda Koch, June Harrigan-Lu
Hawaii State Department o
Environmental Planning

June 16, 2004

2006 STATE OF HAWAII WATER QUALITY MONITORING AND ASSESSMENT REPORT:
Integrated Report To The U.S. Environmental Protection Agency
and The U.S. Congress Pursuant To Sections §303(D) and §305(B),
Clean Water Act (P.L. 97-117)

January 11, 2008
The Hawaii State Department of Health
Honolulu, Hawaii

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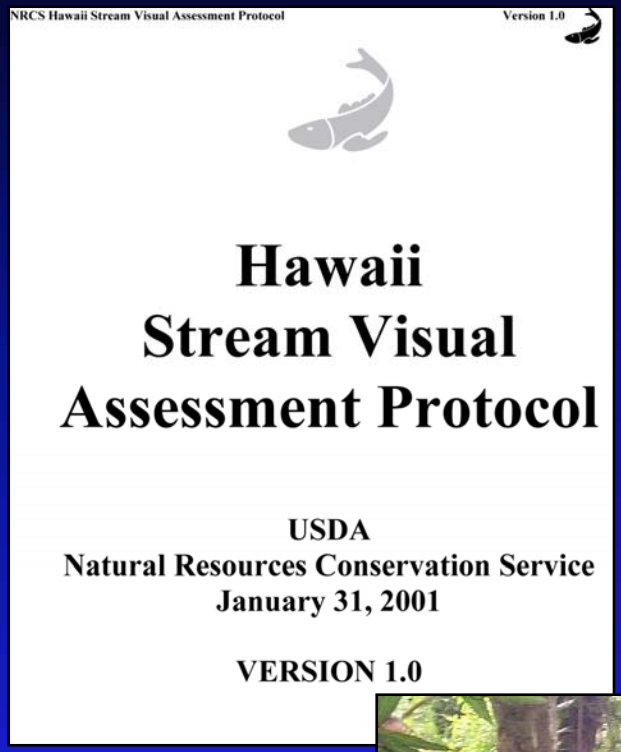
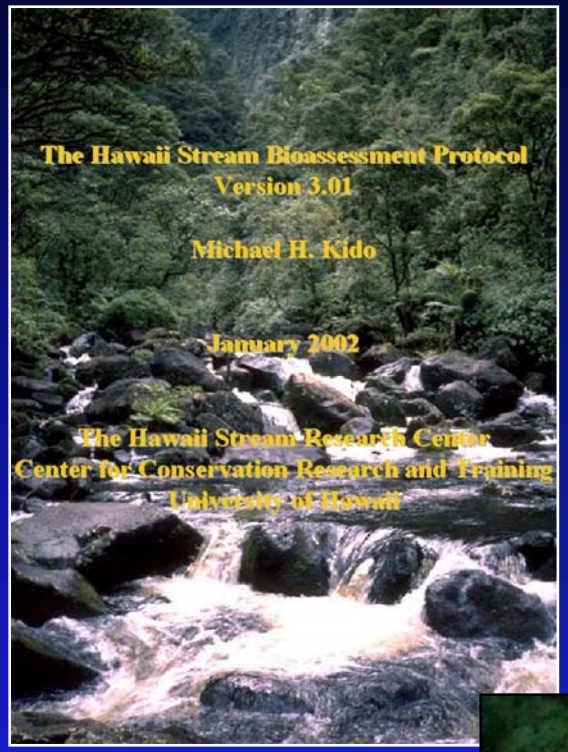
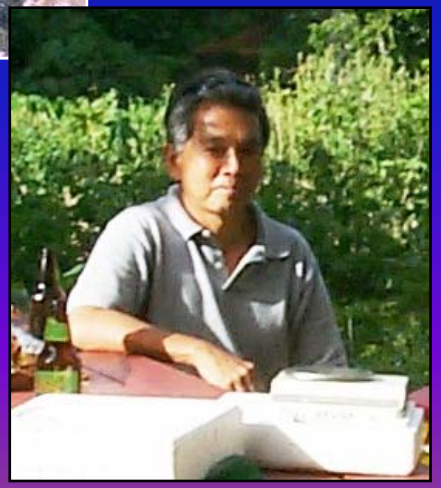
Assessment Protocols Used by the Hawaii Department of Health EPO



HSVAP



HSBP



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Hawaii Stream Visual Assessment Protocol

- Based on the national version of the NRCS Stream Visual Assessment Protocol (NWCC Technical Note 99-1, December 1998).
- Formed the “Hawaii Stream Bioassessment Working Group",
- Modified the protocol to better reflect stream conditions in Hawaii.

Ten Scored Elements (Metrics)

1. Turbidity
2. Plant growth
3. Channel Condition
4. Channel Flow Alteration
5. Percent Embeddedness
6. Bank Stability
7. Canopy/Shade
8. Riparian Condition
9. Habitat Available for Native Species
10. Litter/trash

Scoring

1.8 - 2.0	Very High
1.5 - 1.7	High
1.1 - 1.4	Medium
0 - 1.0	Low

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Hawaii Stream Bioassessment Protocol

- A “first generation” methodology for assessment and monitoring of Hawaiian streams utilizing a standardized “**multimetric**” approach
- Conduct meaningful water quality assessments aimed at restoring and/or maintaining the “biological integrity” of Hawaii’s streams

Hawaii Stream Index of Biotic Integrity (HS-IBI)

1. Number of **Native** amphidromous macrofauna
2. Percent Contribution **Native** Taxa
3. Percent Sensitive **Native** Fish
4. Sensitive **Native** Fish Density
5. Sensitive **Native** Fish Size
6. ***Awaous guamensis*** Size
7. Total **Native** Fish Density
8. Community Weighted Average
9. Number of Alien Taxa
10. Percent Tolerant Alien Fish
11. Percent Diseased / Parasitized Fish

Stream Habitat Assessment

1. Habitat Availability
2. Substrate Embeddedness
3. FPOM / CPOM Characterization
4. Velocity-Depth Combinations
5. Channel Status
6. Channel Alteration
7. Bank Stability
8. Riparian Vegetation Zone Width
9. Percent Riparian Understory Coverage
10. Boulder / Cobble vs. Soil Presence

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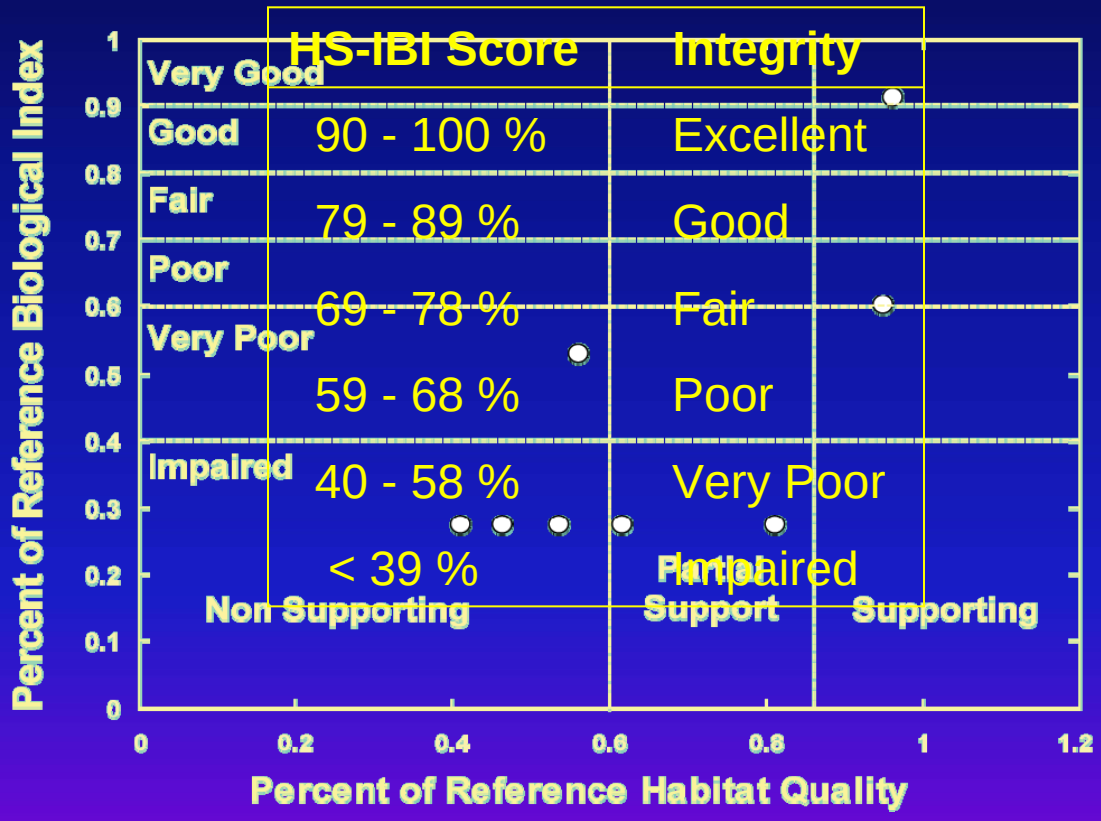
Hawaii Stream Bioassessment Protocol

Index Scoring



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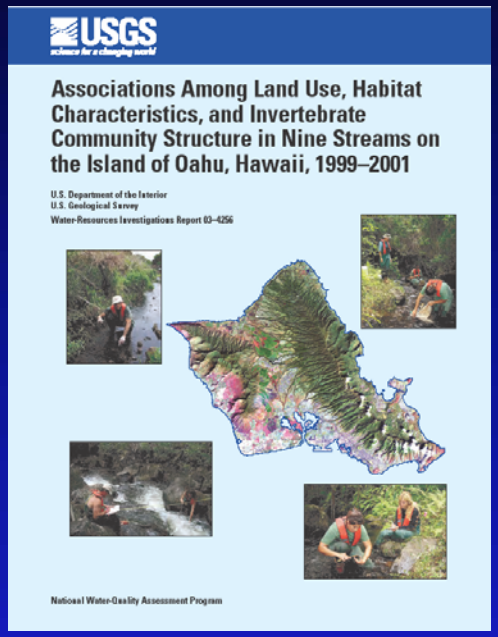
National Water-Quality Assessment Program (NAWQA)
U.S. Geological Survey
1999-2001



Assess the condition of our Nation's streams, rivers, and ground water.

How water-quality conditions may vary locally, regionally, and nationally

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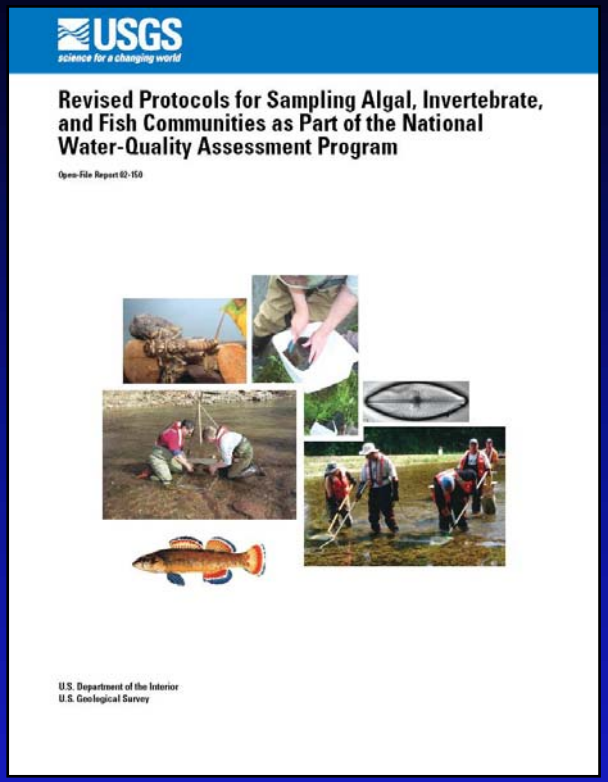
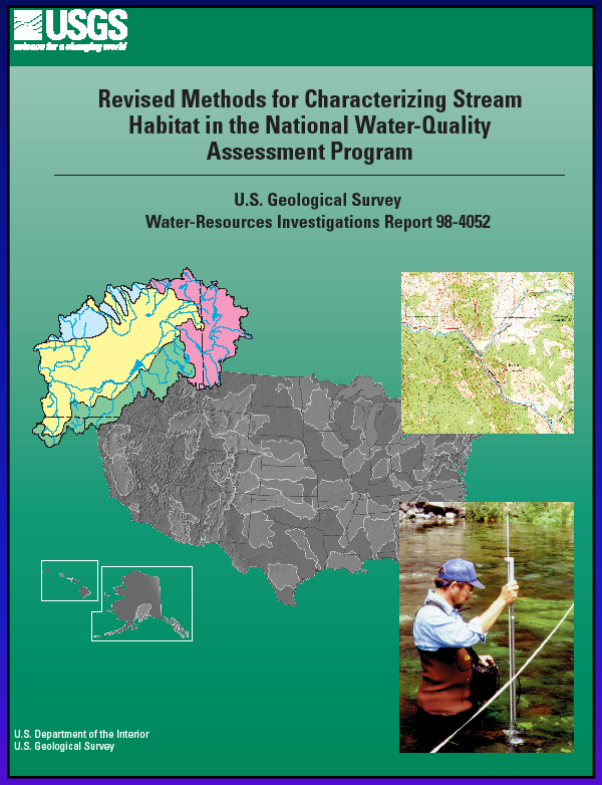
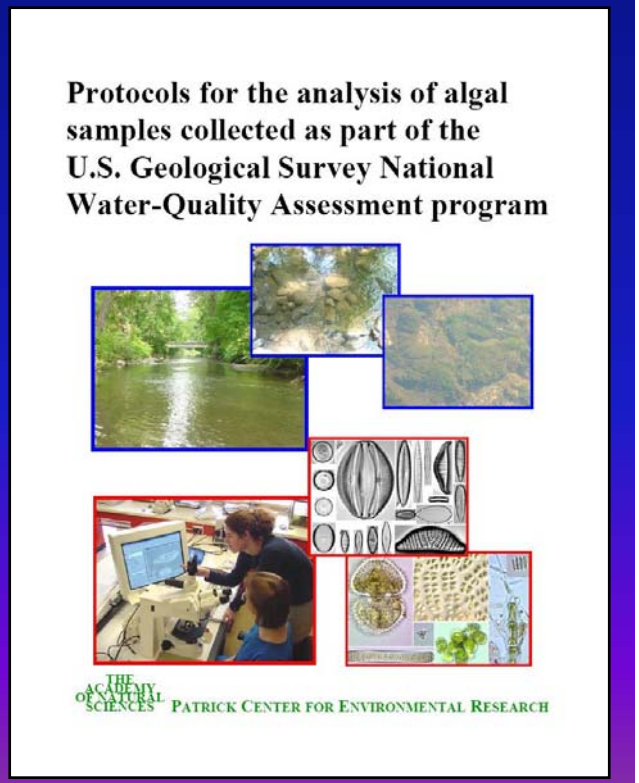
National Water-Quality Assessment Program



Comprehensive Protocols for Sampling and Analyses





- Water Chemistry
- Macroinvertebrates
- Fish
- Algae
- Physical Habitat Characterization
- Fish Tissue and Bed Sediment Contaminants

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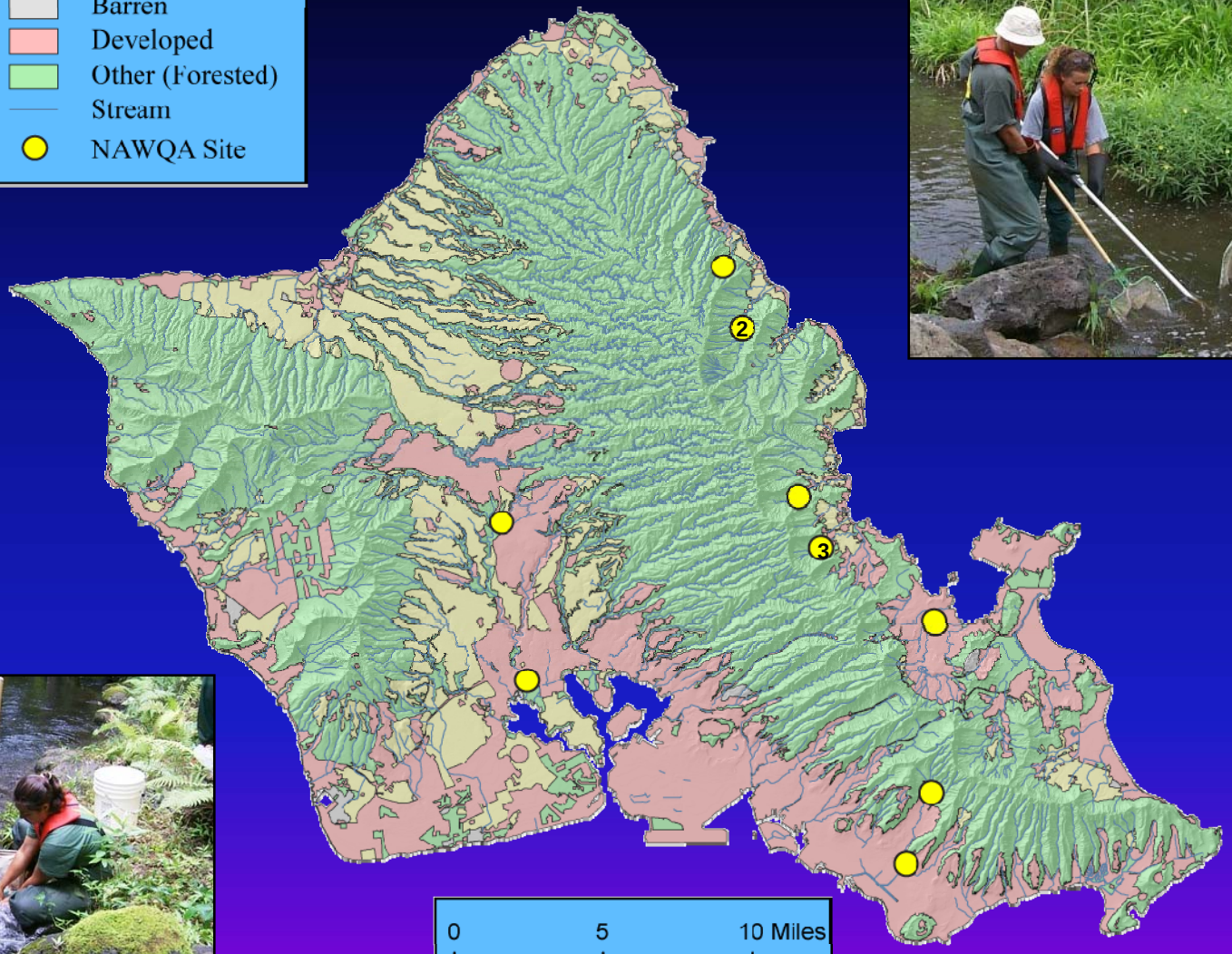
NAWQA Sampling Sites 1999-2001

EXPLANATION

Land Use

- Agriculture
- Barren
- Developed
- Other (Forested)
- Stream
- NAWQA Site



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Environmental Monitoring and Assessment Program
Wadeable Stream Assessment
U.S. Environmental Protection Agency

A probability-based sampling design, the EMAP approach provides a statistically-valid basis for determining aquatic ecological condition.

Sites can be selected from anywhere along perennial streams.

Results can be extrapolated to assess water quality across the watershed or the region.

Oahu EMAP – Cooperative effort of the USGS, HDOH, and USEPA.

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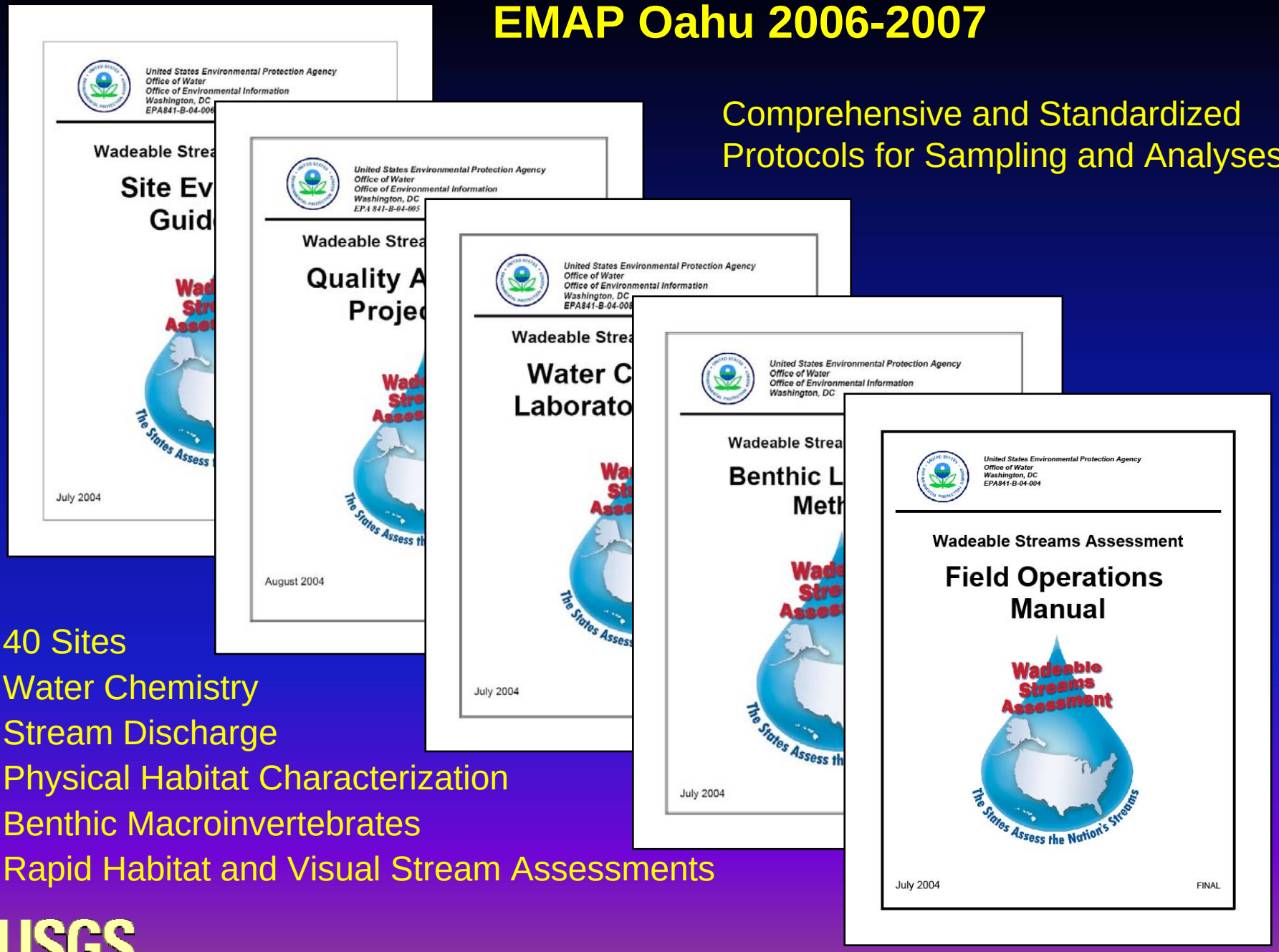
EMAP Oahu 2006-2007

Comprehensive and Standardized Protocols for Sampling and Analyses



- 40 Sites
- Water Chemistry
- Stream Discharge
- Physical Habitat Characterization
- Benthic Macroinvertebrates
- Rapid Habitat and Visual Stream Assessments

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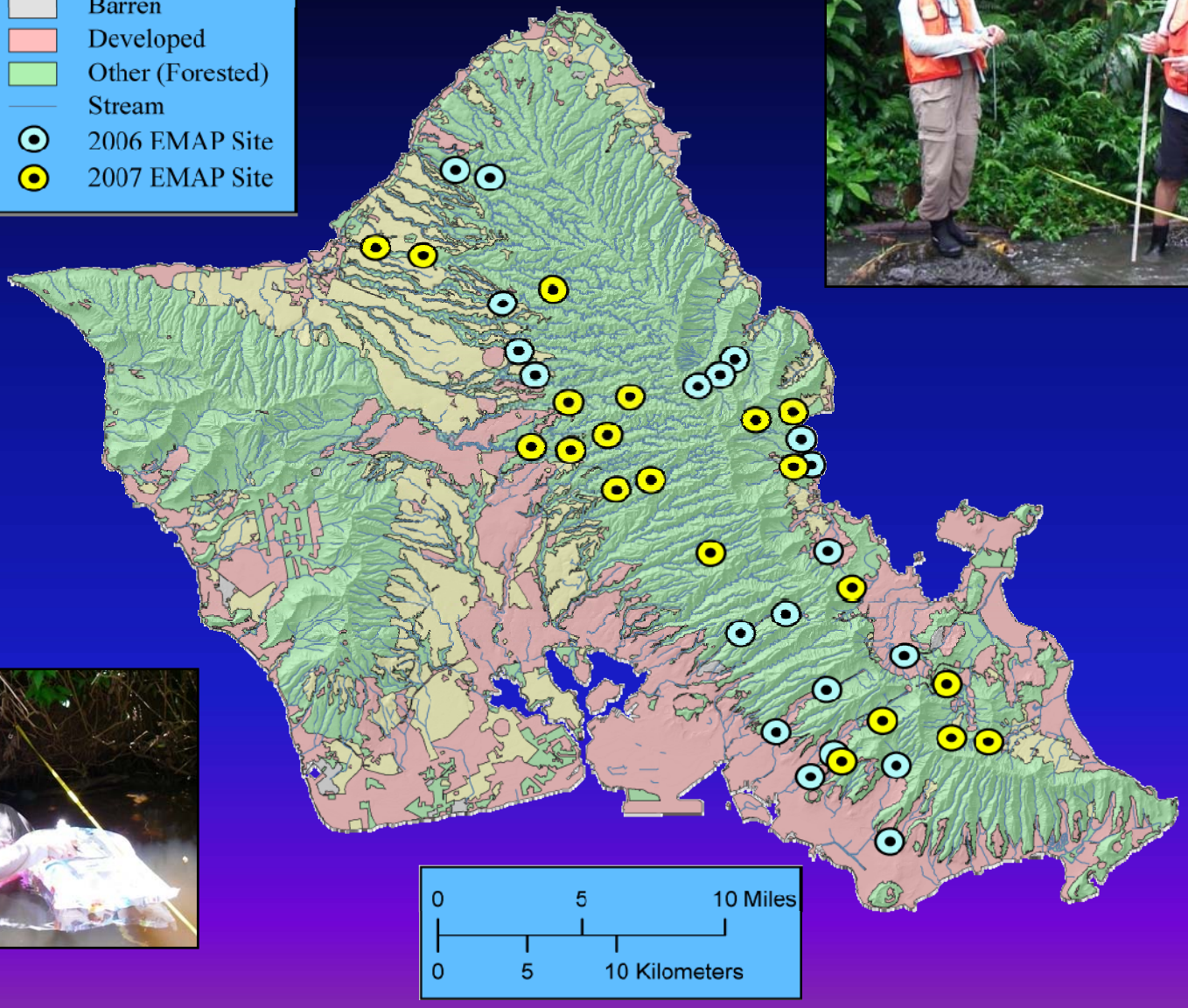
EMAP on Oahu
USGS & HDOH



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Benthic Invertebrates as Indicators of Stream Quality in Hawaii

A goal of the HDOH is to use assessment protocols that include fish, invertebrates, and algae.

The use of diverse groups of organisms in biological monitoring can provide a more robust assessment of stream quality.

- Feasibility Study by USGS in cooperation with the Hawaii Department of Health
- Develop a multi-metric index of biotic integrity using benthic invertebrates (BIBI) in Hawaiian streams
- Identify those components of the invertebrate assemblages that showed the most potential for further investigation

USGS

Hawaiian Benthic Macroinvertebrate IBI

Candidate metrics	Core metrics	Final P-HBIBI
Invertebrate abundance	**X**	**X**
Insect abundance	X	
Trichopteran abundance		
Alien mollusc abundance	**X**	**X**
Dominant taxa abundance		
Amphipod abundance	**X**	**X**
Chironomidae abundance		
Trichopteran-dipteran ratio		
Percentage of trichoptera	X	
Percentage of chironomidae		
Percentage of insecta	**X**	**X**
Percentage of oligochaeta	X	
Percentage of alien mollusca	X	
Percentage of amphipoda		
Number of taxa	**X**	**X**
Native mountain shrimp P/A	**X**	**X**
Crayfish P/A	**X**	**X**
Alien prawn richness	X	
Modified family biotic index		
Margelef's diversity		

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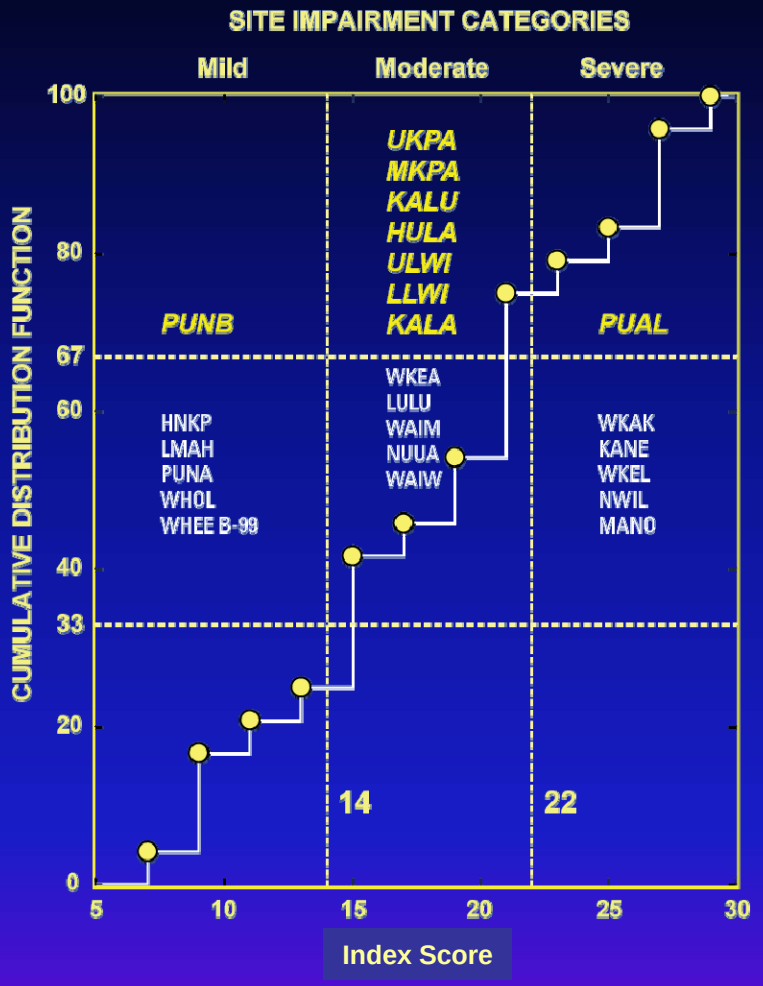
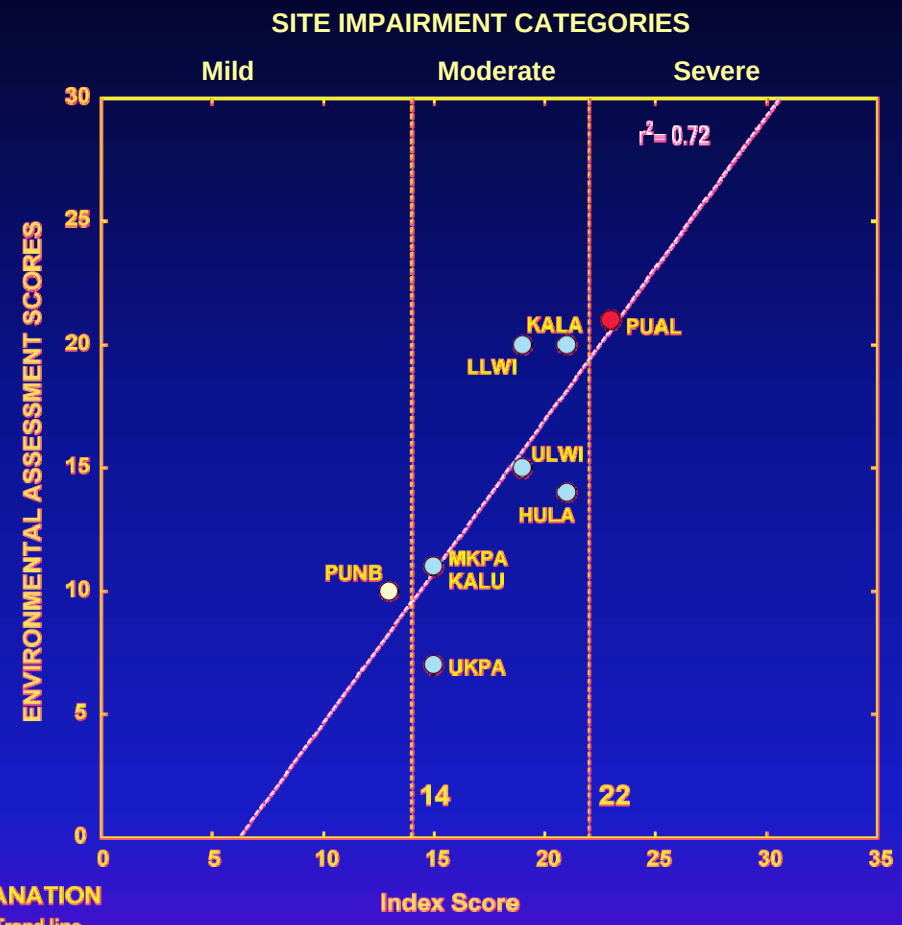
Results





EXPLANATION

Trend line

Cut-off values

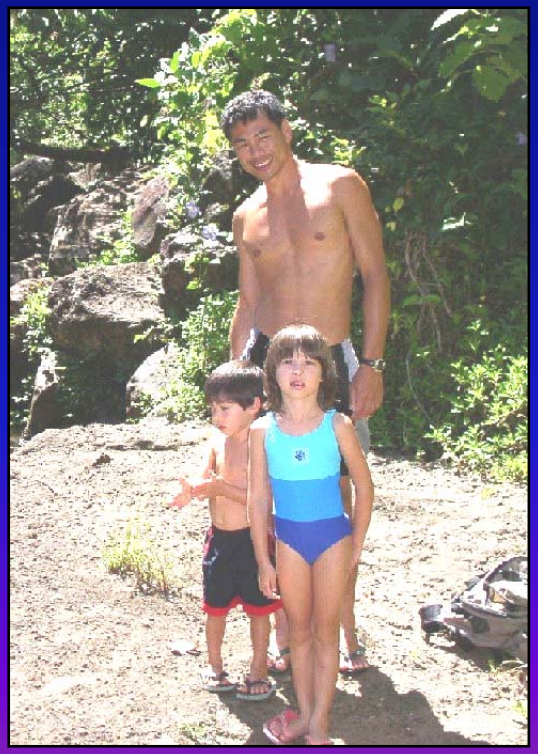
Degree of Impairment

- Mild
- Moderate
- Severe

UKPA Abbreviation of sampling site name

USGS

Thank You



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