Biology of Hawaiian Streams and Estuaries. Edited by N.L. Evenhuis & J.M. Fitzsimons. *Bishop Museum Bulletin in Cultural and Environmental Studies* 3: 305–312 (2007).

The Point Quadrat Method: a Rapid Assessment of Hawaiian Streams

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Abstract

This paper describes the technical guidelines for the collection of data on the abundance and distribution of aquatic animals in Hawaiian streams by using the point quadrat method. This methodology is a standardized visual survey technique involving snorkeling, and it is well suited for the physical and ecological characteristics of Hawai'i streams. The small, steep, dynamic nature of Hawaiian streams with their unique aquatic species are easily observed with this methodology. The in-stream distribution by elevation, behavior, and amphidromous life cycles are easily observed using this technique.

Introduction

The Division of Aquatic Resources (DAR), Hawaii Department of Land and Natural Resources is responsible for managing, conserving, and protecting Hawaii's native stream biota and their habitats. There are 376 perennial streams and a greater number of non-perennial streams and drainage basins statewide. Ideally, surveying the entire length of all these streams would provide baseline data on which to make good management decisions. However, because of limited financial resources, the use of the point quadrat method provides a good characterization of the major stream habitat types and an inventory of native populations with sufficient detail and speed. It must be remembered that this survey methodology, unlike long term monitoring, represents only a snapshot in time (Baker & Foster, 1992). This method is a refinement of previous sampling methodology (modified quadrat) used by DAR biologists to obtain information on goby populations (Baker & Foster, 1992). In 1989, DAR began using the point quadrat methodology developed by DAR field biologists and technicians.

DAR stream surveys using the point quadrat methodology provide data on: species presence, in-stream distribution by discrete location or elevation, relative density and abundance. This method also provides a characterization of habitat types and animal distribution within the stream reaches.

Material and Methods

Personal field gear

The point quadrat methodology requires underwater observation. Minimally, a dive mask and snorkel are all that is necessary, but the addition of other field gear will help to make the surveys more enjoyable, comfortable, and safe. Gear requirements include a full length two-piece wet suit with hood and gloves. The custom-fit wet suit ("Farmer John" style resembling bib overalls plus jacket) protects the observer from cuts, scrapes, and bruises, and from becoming chilled in water with temperatures ranging from about 15–25 °C. The suit should fit comfortably when walking. A separate jacket is best because it can be removed to prevent overheating when hiking into the survey

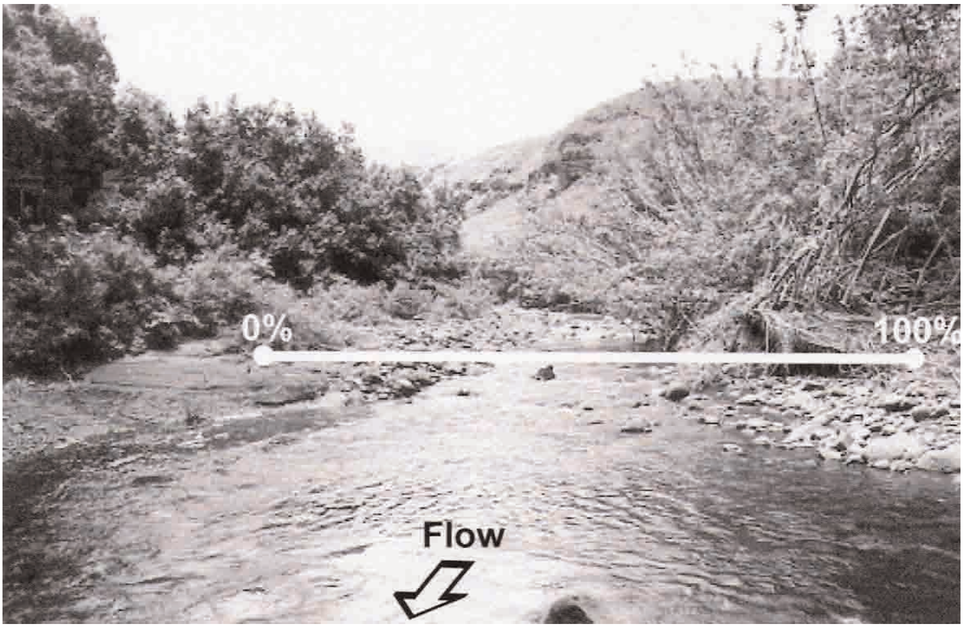

Figure 1. Stream width measurements.

area. Elbow and knee pads provide further protection and may help reduce slipping on wet rocks. A hood, gloves, and hooded long-sleeved dive skin shirt (lycra/polyolefin) are required in cold water to prevent hypothermia. The gloves are also useful to protect hands from rocks with sharp edges and to provide a firmer grip on branches or rocks during hiking and climbing during the survey. Felt-soled flyfishing boots or Japanese spiked *tabis* are superior to hard-soled footwear that slips easily on wet, algae-covered rocks. A rock climbing or kayak helmet with face plate or goggles may be necessary for head and eye protection from falling debris and rock slides when working at high stream elevations in narrow steep-walled valleys or near high waterfalls.

Other field gear

A meshed-back pack is necessary to carry other field gear and will allow the biologist to have both hands free for measuring, writing, hiking, or climbing. A plastic slate with binder clip and rubber bands to secure the survey book when underwater and a No. 2 lead pencil with which to write is a requirement. A folding fiberglass ruler is ideal for measuring the point quadrat site. A USGS quadrangle map of the stream, an altimeter, thermometer, and GPS (global positioning system) unit are all kept in a Pelican® dry box and shared between observers for recording elevation, water temperature, and latitude/longitude position readings at each survey site.

Survey Procedure

In the point quadrat method, visual counts are made at discrete points in the stream by a stationary observer. The observer enters the water quietly, moves upstream to the observation site, and remains motionless until the fishes and other animals have resumed their "normal" behavior. Site selection can be nonrandom (selected by the observer) or random (selected by use of a table of random numbers). The stream width measurement is taken at the bankfull wetted edge level (the edgeheight of the water level on the bank under maximum normal flow conditions or the top elevation of the current active channel where the water touches the stream bank) of the left bank (10%) and ends at the wetted edge bankfullbank full level on the right bank (100%) (Fig. 1). The nonrandom point quadrat method will take the observer to sites thought to contain concentrations of native fish and invertebrates, and may be biased toward the selection of pools and runs. The random approach will take the observer to sites that may or may not be occupied by stream animals, is unbiased in the selection of habitat type, and provides a truer representation of the composition of different habitat types along the stream length. The use of nonrandom or random site selection in the point quadrat method will depend on the kinds of biological questions being asked, such as the presence, absence, instream distribution, relative density of aquatic species, or the characterization of the different habitat types making up a stream reach. The point quadrat method can also involve the use of both random and nonrandom selection of sites during a stream survey. For example, the use of the random numbers may result in the selection of distance across the stream being on a boulder that is out of the water or on a dry section of the streambed. This would provide a null observation with no water. A nonrandom observation could be made to the left or right of the boulder or in another area in close proximity to the random site. The site information on elevation, water temperature, and GPS readings will be the same as the random site observation, and the site number will also be the same except followed by the letter (n), e.g., random site number is 3r and the nonrandom site number is 3n.

Visual counts are accompanied by noting the size of the observation area with measurements taken with the folding fiberglass ruler to include length, width, and depth of the point quadrat site. The observation area should not be larger than 3 feet by 3 feet, and will depend on the field of view. Obstructions such as boulders or fallen logs, and water clarity-depth, turbid water, or bubbles may decrease the area of observation. Previous survey tests (Baker & Foster, 1992) have demonstrated that in viewing larger areas, the observer might miss small fish in the distance and other animals hiding under or in ledges and crevices. Native Hawaiian stream gobies especially are cryptic, and responsive to rapid movement, and thus difficult to detect and observe.

The survey duration should range from 3 to 7 minutes and may be for a shorter duration depending on the site size, depth, water clarity, and laminar flow. A survey team of 3 observers is optimum with a total of 30 observations per stream survey section.

A quadrangle map is used for locating survey area and sites, landmarks, trails, and as a reference for altimeter elevation readings and DAR coding of stream sections (Fig. 2).

The GPS reading is also recorded when available and is important in determining the position on the stream.

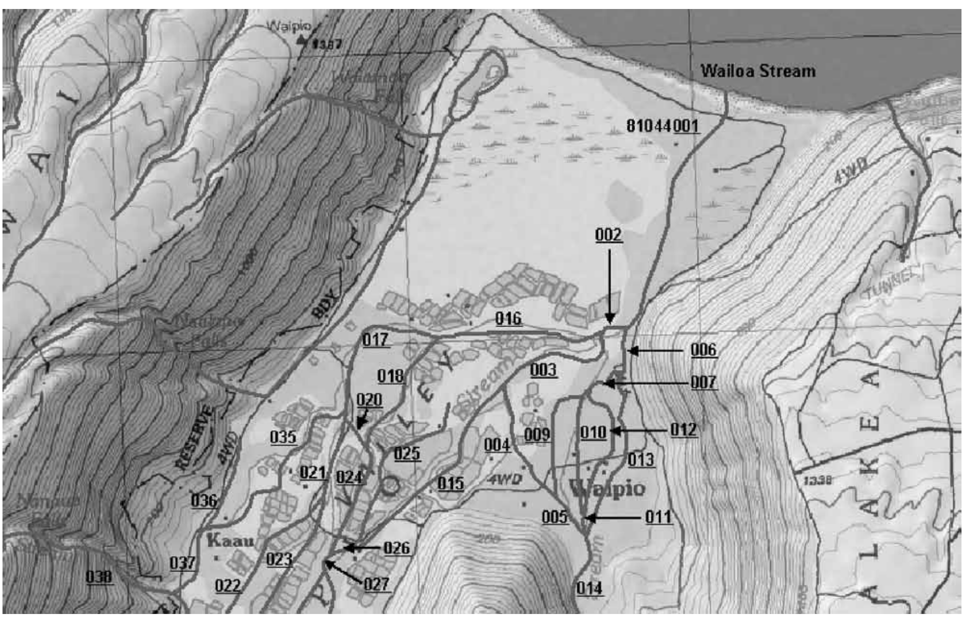

Figure 2. USGS quadrangle map with tributary and stream sections coded.

Table 1. **Aquatic habitats of Hawaiian streams** [after Baker (1992)]

Habitat Type	Depth (m)	Current (m/sec)	Turbulence
Pool	variable	< 0.2	no
Side Pool	< 0.5 usually	nil usually	no
Plunge Pool	< 2.0 usually	< 0.20	yes
Run	variable	0.20 – 0.75+	no
Riffle	< 0.5	> 0.75	yes
Cascade	2.0 usually	> 2.0	much

Upon arrival at the site, observers take the following measurements by using the equipment in the Pelican™ dry box. Elevation will be taken in feet with the altimeter, temperature in centigrade with the digital thermometer, and the GPS unit will provide latitude/longitude readings in decimal degree units. The GPS readings may not always be obtainable especially under a heavy vegetative canopy, in narrow steep-walled valleys, or next to high cliffs. The next observer takes the Pelican™ box and walks along the stream bank to his or her site while, keeping out of the water as much as possible so as not to disturb the bottom and make the water turbid for the observer downstream. After completing his measurements, the next observer takes the box to his site.

At the site, the observer waits for the fish to go back to their normal behavior before beginning the count. The observer notes the species (fish, crustacean, mollusk, etc.) present in the survey site, their number, size, and sex if identifiable.

DAR's aquatic habitat classification is based upon the five habitats delineated by Baker & Foster in 1992. The classification suggested here is an extension and modification of those habitats based on our stream experience on all five of the major Hawaiian Islands (Hawai‘i, Maui, Moloka‘i, O‘ahu, and Kaua‘i). The objective is to enable surveyors to recognize important differences in the habitat types efficiently without requiring them to invest a large amount of time evaluating a large number of details. The habitat types are based on a combination of depth, current speed, and turbulence (Table 1). A definitive description of the habitat types is provided below:

Pool: Area within streams that have reduced current velocity (<20 cm/sec), and which often has water deeper than that of surrounding areas.

Side pool: Small, shallow, slow current habitats very similar to shallow pools. The main difference is that it is situated well off the main stream channel.

Plunge pool: Pool that is situated at the base of a waterfall.

Run: An area of swiftly flowing water, without surface agitation or waves, and in which the slope of the surface water is roughly parallel to the overall gradient of the stream reach (Helm *et al.*, 1985).

Riffle: Shallow rapids where the water flows swiftly over completely or partially submerged obstructions to produce surface agitation, but standing waves are absent (Helm *et al.*, 1985).

Cascade: Extremely swift, turbulent habitats which are generated by a steep slope.

No water: A "No water" classification is included because when using a random survey the site selection could possibly be on top of a boulder sticking out of the water or dry stream bed.

Dirty water: Is included to accommodate situations where visibility is limited due to rain or other causes making the water cloudy or dirty.

Substrate types are noted by percent coverage of the point quadrat site and recorded according to the definitions of Wentworth's (1922) scale of particle classification (Cummins, 1962; Minshall, 1984; Helm *et al.*, 1985) (Table 2). The detritus classification is not part of the Wentworth scale, but was added for sites where there was no strong flow and leaf litter, branches, and other vegetative matter covered the bottom.

Comments are included to note any important facts about the survey site, e.g., located just below a tributary on the left, first site or last site of survey, etc. This information will also be included in the survey database.

Random number and site number are recorded to provide additional information about the distance up stream from the previous site and the site location across the width of the stream. This information can also be useful in locating the site when a GPS coordinate is unattainable due to vegetative canopy or in steep walled areas.

Table 2. **The classification of mineral substrates by particle size**, **according to the Wentworth Scale** [After Cummins (1962), Marshall (1982)]

Size Category	Particle Diameter (mm)	Particle Diameter (in)	Reference
Boulder	>256	>10	head-size and larger
Cobble	64–256	2.5–10.0	fist-size
Gravel	2–64	0.08–2.50	thumb-size
Sand	0.062 –2.000	0.002–0.080	sand-size
Silt	>0.062	>0.002	smaller than pin head

Databasing stream survey information

The DAR stream survey form (Fig. 3) contains the following general information on the stream: name of stream, DAR code, observer, date, temperature, elevation, and start and stop time for the site observations. The DAR code is a straight eight-digit number (00000000) that is used to identify streams for incorporation of the point quadrat survey data into the Division's freshwater Access database. The spatially nested hierarchy is used for all the survey types in the database and is based on island chain, island, hydrographic unit, watersheds, stream segments and sites (Fig. 4).

- The first digit identifies the ISLAND (Island) **0**0000000
  2 Kaua'i
  3 O'ahu
  4 Moloka'i
  6 Maui
  8 Hawai'i

- The second digit identifies the HYDROGRAPHIC UNIT (Hgu_code) 0**0**000000 within each island. These units are regional drainage areas established in the 1970s by U.S. Geological Survey (USGS) and Hawaii Division of Water & Land Development (DOWALD).

- The third through the fifth digits identify the WATERSHEDS 00**000**000. Expansion to 3-digits to incorporate intermittent streams and drainage basins will be included at a later date. The coding of the intermittent streams and drainage basins will probably start from the last number where the perennial streams left off for that island and continue clockwise around the island.

- The sixth through the eighth digits identifies the stream's individual SEGMENTS (Segments) 00000**000**.

Discussion

Hawaiian streams are characterized by being small and rugged in nature, with irregular bottoms, and not easily accessible. Hawaiian fishes and crustaceans quickly move into holes and crevices between rocks and boulders or dive into the loose sand and gravel when disturbed. Because of the behavior of stream animals and the irregularity of the bottom topography, collections by seining or backpack electroshocking are not likely to provide reliable assessments of species presence, distribution, density, and relative abundance. However, visual surveys are the one method that has proven to be reliable, efficient, and effective in the assessment of all Hawaiian stream animals. The point quadrat method, in particular, is most effective.

STREAM SURVEY FORM

SURVEY TYPE: RANDOM NONRANDOM OBSERVER: ____________

HSA CODE: ____-____-______.______ TEMPERATURE: ____________ (°C)

NAME: ________________________ ELEVATION: ____________ (ft.)

DATE: ____/____/____ (Mo. Day Yr.) TIME: __________ (START) AM PM TO __________ (STOP) AM PM

SUBSTRATE TYPE (%):

SEDIMENT ________ SAND ________ GRAVEL ________

COBBLE ________ BOULDERS ________ BEDROCK ________

DETRITUS ________

HABITAT TYPE: SURVEY AREA (l" x w" x h"): ____________

POOL SIDE POOL PLUNGE POOL RUN RIFFLE CASCADE

NO WATER DIRTY WATER

SPP: SIZE ♂ ♀ ?

COMMENTS:

Random No.: ____ , ____ Site No.: ______

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Figure 3. DAR stream survey form.

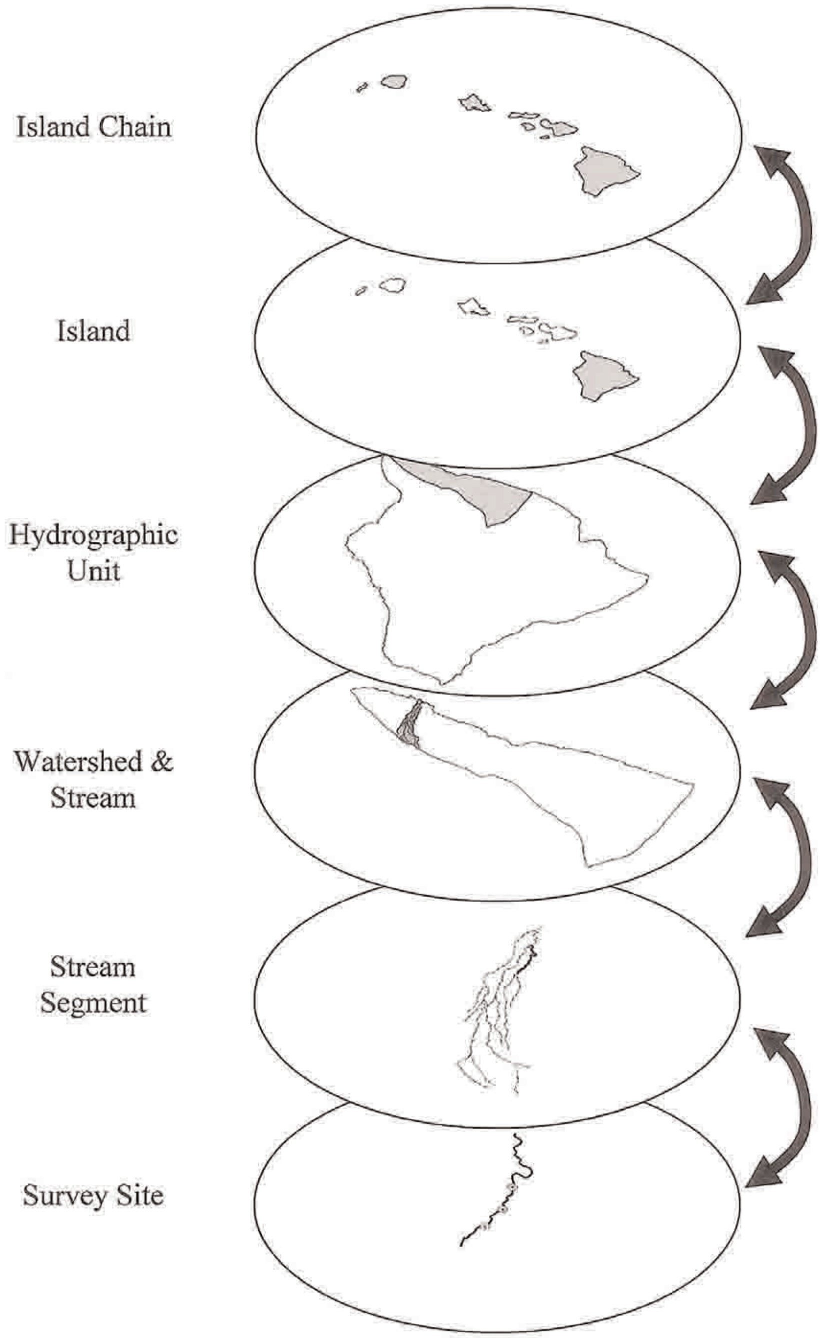

Figure 4.The spatially nested hierarchy used in the Division of Aquatic Resources Survey Database.

The choice between random and nonrandom point quadrat methods depends on the kinds of biological questions being asked. Because island streams have different types of habitats according to elevation or distance inland, it is convenient to place randomly selected sites with lower, middle, and upper stream reaches. This type of sampling (selecting a large area non-randomly and selecting sampling sites within it randomly) is referred to as "stratified random point quadrat method" (Fitzsimons *et al.*, 2005). This method has become the DAR standard for surveying Hawaiian streams.

The point quadrat method, however, should not be used to provide population density estimates but only to provide species presence, distribution, relative abundance, and density at that period in time during which the survey was taken.

The point quadrat survey data play an important part in the management of aquatic resources by DAR by providing baseline data on native biota, and it is a method to quickly assess the aquatic fauna, flora, habitat types, and species/habitat relationships within a stream ecosystem. The incorporation of these data into DAR's freshwater Access database along with other survey types-larval trapping, drift net sampling, etc. and the integration of this database into a Geographic Information System (GIS) isare providing a powerful management tool for setting permanent instream flow standards for all Hawaiian streams. The protection of native stream biota and their habitat is essential to maintain healthy streams, a neglected but essential ecosystem connecting the forest and the ocean.

Acknowledgments

We are grateful to J. Michael Fitzsimons for comments on the manuscript. J.M. Fitzsimons, J.E. Parham, and D.G.K. Kuamoʻo provided input into the development and fine tuning of this stream survey method. This report is supported in part by funds from the Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii (Dingell-Johnson/Wallop-Breaux Sport Fish Restoration Program.

Literature Cited

Baker, J.A. & S.A. Foster. 1992. *Estimating density and abundance of endemic fishes in Hawaiian streams.* Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii. 50 p.

Cummins, K.W. 1962. An evaluation of some techniques for the collection and analysis of benthic samples with special emphasis on lotic waters. *American. Midland Naturalist* **67**: 477–504.

Fitzsimons, J.M. & R.T. Nishimoto. 1991. Behavior of gobioid fishes from Hawaiian freshwaters, p. 106–124. *In:* Devick, W.S. (ed.), New Directions in Research, Management, and Conservation of Hawaiian Freshwater Stream Ecosystems: *Proceedings of the 1990 Symposium on Stream Biology and Fisheries Management*, Division of Aquatic Resources, Departmentt. of Land and Natural Resources, State of Hawaii, Honolulu.

Fitzsimons, J.M. & R.T. Nishimoto. 1999. Application of fish behavior to stream monitoring on tropical Pacific Islands, p. 797–804. *In*: Seret, B. & J.-Y. Sire (eds.), *Proceedings of the 5th Indo-Pacif. Fish Conference, Noumea, 1997.* B. Société Française d'Ichtyologie, Paris.

———, **R.T. Nishimoto, & J.E. Parham**. 2005. Methods for analyzing stream ecosystems on oceanic islands of the Tropical Pacific, p. 103–136. *In:* Mueller Dombois, D., K. Bridges & C. Daehler (eds.), *Biodiversity Assessment of Tropical Islands Ecosystems: PABITRA Manual for Interactive Ecology and Management*.

Helm, W.T., P. Brouha, M. Aceituna, C. Armour, P. Bisson, J. Hall, G. Holton, & M. Shaw. 1985. Aquatic habitat inventory, glossary of stream habitat terms. *Western Division, American Fisheries Society*. 33 p.

Higashi, G.R. & M.N. Yamamoto. 1993. Rediscovery of "extinct" *Lentipes concolor* (Pisces: Gobiidae) on the island of Oʻahu, Hawaiʻi. *Pacific Science* **47(2)**: 115–117.

Kuamoʻo, **G.K.**, **G.R. Higashi & J.E. Parham**. 2005. Structure of the Division of Aquatic Resources surveys database and use with a geographical information system. *Proceedings of the 2005 Symposium on the Biology of Hawaiian Streams and Estuaries.* State of Hawaii, Division of Aquatic Resources, Hilo.

Minshall, **G.W**. 1984. Aquatic insect-substratum relationships, p. 358–400. *In*: Resh, V.H. & Rosenberg, D.M. (eds.), *The ecology of aquatic insects*. Praeger Scientific. 625 p.

Nishimoto, **R.T. & J.M. Fitzsimons**. 1999. Behavioral determinants of the instream distribution of native Hawaiian steam fishes, p. 813–818. *In*: Seret, B. & J.-Y. Sire (eds.), *Proceedings of the 5th Indo-Pacif. Fish Conference, Noumea, 1997.* B. Société Française d'Ichtyologie, Paris.

Parham, **J.E**. 2002. Spatial models of Hawaiian streams and stream fish habitats. Ph.D. Dissertation Louisiana: Louisiana State University. 144 p.

Rosgen, **D. & H.L. Silvey**. 1998. *Field guide for stream classification*. Wildland Hydrology Consultants, Pagosa Springs. 193 p.

Wentworth, **C.K**. 1922. A scale of grade and class terms for clastic sediments*. Journal of Geology* **30**: 377–392.

Yamamoto, **M.N. & A.W. Tagawa**. 2000. *Hawaiʻi's native & exotic freshwater animals.* Mutual Publishing, Honolulu. 200 pp.