

Hawai'i Stream Index of Biological Integrity (HSIBI) Calculations - Example

The table below contains data collected from Mānoa-Pālolo Stream collected on May 24, 2019 at the Kaimukī High School stream site located at: Latitude (bottom) – 21.28639, Longitude (bottom) – -157.81888, Latitude (top) – 21.28728, Longitude (top) – -157.81799, Elevation (bottom) – 18 ft, Elevation top – 19 ft.

Method	Origin	Organism Type	Species	Common Name	Count	Size Range (cm)	Biomass Estimate (lbs)	Approx. HSIBI
pa'ēpa'ē	Native	Vertebrate	<i>Stenogobius hawaiiensis</i>	'O'opu naniha	13	4 to 8	60.00	34.60
pa'ēpa'ē	Native	Vertebrate	<i>Eleotris sandwicensis</i>	'O'opu 'akupa	8	5 to 13		
pa'ēpa'ē	Native	Vertebrate	<i>Kuhlia sandwicensis</i>	Āholehole/Hawaiian flagtail	32	3 to 13		
pa'ēpa'ē	Native	Invertebrate	<i>Macrobrachium grandimanus</i>	'Ōpae oeha'a	1	5		
pa'ēpa'ē	Non-native	Vertebrate	<i>Andinoacara rivulatus</i>	Green terror	1	16		
pa'ēpa'ē	Non-native	Vertebrate	<i>Amphilophus labiatus</i>	Red devil cichlid	3	12 to 16		
pa'ēpa'ē	Non-native	Vertebrate	<i>Amatitlania nigrofasciata</i>	Convict cichlid	3	5 to 7		
pa'ēpa'ē	Non-native	Vertebrate	<i>Sarotherodon melanotheron</i>	Black chin tilapia	2	5 to 10		
pa'ēpa'ē	Non-native	Vertebrate	<i>Poecilia sphenops</i>	Mexican Molly	17	3 to 6		
pa'ēpa'ē	Non-native	Vertebrate	<i>Hypostomus watwatta</i>	Suckermouth catfish/Plecostomus	205	18 to 30		

Hawai'i Stream Index of Biological Integrity (HS-IBI) Data Form

Name: John Smith Date: May 30, 2019

School: Jarrett Middle School Teacher's Name: James Clark

Sampling Date: May 24, 2019 Stream: Mānoa-Pālolo Stream

Study Site Location Name: Kaimukī High School Elevation (bottom): 18 ft.

Latitude (bottom): 21.28639 Longitude (bottom): -157.81888

Background

The Hawai'i Stream Index of Biological Integrity (HS-IBI) utilizes five ecological categories (taxonomic richness, sensitive species, reproductive capacity, trophic-habitat capacity, and tolerance capacity) and 11 metrics to distinguish a stream's biological condition on a scale ranging from undisturbed to severely impaired. A framework comprised of five "integrity classes" (excellent-good-fair-poor-impaired) is provided, which can be used to translate a stream's HS-IBI score into a verbal and visual portrait of its biological condition. The HS-IBI are appropriate for application in all perennial streams in Hawai'i and may be adapted for use in streams on other tropical Pacific islands where native species assemblages persist in near-pristine stream environments.

[Source: Kido, M.H. 2013. A native-species based Index of Biological Integrity for Hawaiian Stream Environments. Environmental Monitoring and Assessment 185 (5): 4063-4075.]

Procedure

Using the data collected from your study site, follow the directions provided throughout the data sheet for each of the five ecological categories to assign a subscore of 1, 3, or 5 for each metric. Use Table 1 on Page 2 to identify native and alien taxa. Exclude Cane toad (tadpoles) and Softshell turtle from your data if applicable. On Page 8, find the sum of your calculated subscores to determine your final HS-IBI score as a percentage. Note that the lowest final score you can get is 11 or 20% and the highest score you can get is 55 or 100%. Table 14 on Page 9 can be used to determine the "Integrity class" of your study site based on your final score.

Table 1. Native and alien stream fauna

Common Name	Species	Origin
Āholehole	<i>Kuhlia sandvicensis</i>	Native
Hapawai	<i>Neritina vespertina</i>	Native
Hīhīwai	<i>Neritina granosa</i>	Native
‘O‘opu ‘akupa	<i>Eleotris sandwicensis</i>	Native
‘O‘opu ‘alamo‘o	<i>Lentipes concolor</i>	Native
‘O‘opu nākea	<i>Awaous stamineus</i>	Native
‘O‘opu naniha	<i>Stenogobius hawaiiensis</i>	Native
‘O‘opu nōpili	<i>Sicyopterus stimpsoni</i>	Native
‘Ōpae kala‘ole	<i>Atyoida bisulcata</i>	Native
‘Ōpae ‘oeha‘a	<i>Macrobrachium grandimanus</i>	Native
Apple snail	<i>Pomacea</i> spp.	Alien
Asiatic clam	<i>Corbicula fluminea</i>	Alien
Banded jewel cichlid	<i>Hemichromis elongatus</i>	Alien
Blackchin tilapia	<i>Sarotherodon melanotheron</i>	Alien
Bristlenose catfish	<i>Ancistrus</i> sp.	Alien
Chinese Catfish	<i>Clarius fuscus</i>	Alien
Convict cichlid	<i>Amatitlania nigrofasciata</i>	Alien
Guppy	<i>Poecilia reticulata</i>	Alien
Japanese swamp shrimp	<i>Neocaridina denticulata sinensis</i>	Alien
Malaysian trumpet snail	<i>Melanoides tuberculata</i>	Alien
Molly	<i>Poecilia sphenops</i>	Alien
Red swamp crayfish	<i>Procambarus clarkii</i>	Alien
Smallmouth bass	<i>Micropterus dolomieu</i>	Alien
Swordtail	<i>Xiphophorus helleri</i>	Alien
Suckermouth catfish	<i>Hypostomus</i> sp.	Alien
Tahitian prawn	<i>Macrobrachium lar</i>	Alien

CATEGORY A. TAXONOMIC RICHNESS

Metric 1: “Number of native amphidromous macrofauna” assesses species richness in its simplest form as direct counts of the number of native aquatic species found in study site. Use **EITHER** Table 2a or Table 2b, **NOT BOTH**, to determine points for Metric 1. If your study site was either at Kaimukī High School or Mānoa-Pālolo Confluence, use Table 2b. For any other location, use Table 2a.

Table 2a. Native species present (Non-estuary)

Number of non-estuary native species	Points
Reference Table	
If your “Number of non-estuary native species” is	Then use this subscore
3-4	5
1-2	3
0	1

Table 2b. Native species present (Estuary)

Number of estuary reach native species	Points
4	3
Reference Table	
If your “Number of estuary reach native species” is	Then use this subscore
5-6	5
2-4	3
0-1	1

Metric 2: “Percent contribution of native taxa” is a form of species richness measure and is equivalent to Simpson’s Diversity Index.

Table 3. Use the table below to list the percent of native taxa at your site

% of native taxa	Points
$\frac{\text{native species}}{\text{total species}} \times 100$ $\frac{4}{10} \times 100$	1
Reference Table	
If your “% of native taxa” is	Then use this subscore
75-100%	5
50-74%	3
≤49%	1

Metric 3: “Number of alien taxa” is correlated with decreasing habitat quality and increasing human disturbance. Taxa refers to different types of organisms (often species) and not counts of individuals.

Table 4. Use the table below to list the number of alien taxa at your site.

Number of alien taxa	Points
6	1
Reference Table	
If your “Number of alien taxa” is	Then use this subscore
0-1	5
2-3	3
>3	1

CATEGORY B. SENSITIVE “SENTINEL” SPECIES

Metric 4. “Percent sensitive native fishes” are species highly sensitive to environmental degradation and thus are reliable indicator species for assessments of biotic integrity. In Hawaiian Streams, sensitive native species are *Lentipes concolor*-‘o‘opu ‘alamo‘o and *Sicyopterus stimpsoni*-‘o‘opu nōpili.

Table 5. Use the table below to list the percent of sensitive native fish at your site

% of sensitive native fishes	Points
$\frac{\text{sensitive native species}}{\text{total species}} \times 100$ $\frac{0}{10} \times 100$	1
Reference Table	
If your “% of sensitive native fish” is	Then use this subscore
≥50%	5
49-20%	3
≤19%	1

Metric 5. “Sensitive native fish density” is used to verify absolute densities of *Lentipes concolor* (‘o‘opu ‘alamo‘o) and *Sicyopterus stimpsoni* (‘o‘opu nōpili), as it may not always coincide with high proportionate abundance of sensitive species found in Metric 4.

Table 6. Use the tables below to list the sensitive native fish density at your site. Assign a subscore of 1 unless instructed otherwise (most sites on O‘ahu have a very low sensitive native fish density).

Sensitive native fish density (fish/m ²)	Points
	1
Reference Table	
If your “ Sensitive native fish density (fish/m ²)” is	Then use this subscore
≥0.46	5
0.20-0.45	3
≤0.19	1

CATEGORY C. REPRODUCTIVE CAPACITY

Metric 6. “Sensitive native fish size” in a sample population is used as an overall indicator of community health, as size is relatively influenced by both environmental (e.g. food availability / quality, pollution, stressors, etc.) and population / community factors (e.g. predation, competition, disease, etc.).

- * **Sensitive native** species are *Lentipes concolor*-‘o‘opu ‘alamo‘o and *Sicyopterus stimpsoni*-‘o‘opu nōpili
- * **Sensitive native** fish size is measured in total length (mouth to end of tail)
- * Exclude post-larval size classes (fish that are ≤3.0 cm in total length)

Table 7. Use the table below to list the percent of sensitive native fish ≥6.0 cm at your site. Assign a subscore of 1 unless instructed otherwise (most O‘ahu sites have very low sensitive native fish density).

Sensitive native fish size (% ≥ 6.0 cm in total length)	Points
$\frac{\text{sensitive native species} \geq 6.0 \text{ cm}}{\text{total sensitive species}} \times 100$	1
Reference Table	
If your “ Sensitive native fish size (% ≥ 6.0 cm in total length)” is	Then use this subscore
$\geq 50\%$	5
49-25%	3
$\leq 24\%$	1

Metric 7. “*Awaous stamineus* (‘o’opu nākea) size.” As a moderately tolerant species to environmental degradation, ‘o’opu nākea often overlaps in distribution within / between streams with the two sensitive species in Metrics 5 and 6, but is also found in streams with higher levels of human disturbance. As a generalist feeder (omnivore), ‘o’opu nākea size is also a useful indicator of food availability and habitat quality.

- * *Awaous stamineus* size is measured in total length (mouth to end of tail)
- * Exclude post-larval size classes (fish that are ≤ 3.0 cm in total length)

Table 8. Use the tables below to list the percent of *Awaous stamineus*-‘o’opu nākea ≥ 8.0 cm at your site. Assign a subscore of 1 if no ‘o’opu nākea were found, as 0 % is still in the lowest subscore category.

<i>Awaous stamineus</i> size (% ≥ 8.0 cm in total length)	Points
$\frac{\text{Awaous stamineus} \geq 8.0 \text{ cm}}{\text{Total Awaous stamineus}} \times 100$	1
Reference Table	
If your “ <i>Awaous stamineus</i> size (% ≥ 8.0 cm in total length)” is	Then use this subscore
$\geq 50\%$	5
49-25%	3
$\leq 24\%$	1

CATEGORY D. TROPHIC / HABITAT CAPACITY

Metric 8. “Total native fish density” uses native fishes (and invertebrates) as an indicator of stream biotic integrity and supports metric 5, where higher densities correlate with more natural ecological functioning, environmental quality, lower number of alien species, and reduced human disturbance.

Table 9. Use the tables below to list the total **native** fish density at your site. Assign a subscore of 1 unless instructed otherwise (most sites on O‘ahu have a very low total native fish density).

Total native fish density (total native fish/m ²)	Points
	1
Reference Table	
If your “Total native fish density (total native fish/m ²)” is	Then use this subscore
≥0.75	5
0.74-0.36	3
≤0.35	1

Metric 9. “Community weighted average” is a numerical expression that reflects the relative sensitivity of various taxa to habitat degradation and the relative individuals in each taxon in a sample. The CWA is calculated as the sum of the proportionate numerical abundances of individual taxa in the sampled population multiplied by their respective weighting values.

***Note:** Score other non-migratory native species such as ‘ama‘ama (*Mugil cephalus*) and awa‘awa (*Elops hawaiiensis*) with a “4” only at the following sites—Mānoa-Palolo Confluence, Kaimuki High School, and King Street.

Table 10a. CWA weighting values for stream species

Species	Common Name	Weighting value
<i>Lentipes concolor</i>	‘O‘opu ‘alamo‘o	1
<i>Sicyopterus stimpsoni</i>	‘O‘opu nōpili	1
<i>Neritina granosa</i>	Hīhīwai	2
<i>Atyoida bisulcata</i>	‘Ōpae kala‘ole	3
<i>Macrobrachium grandimanus</i>	‘Ōpae ‘oeha‘a	3
<i>Stenogobius hawaiiensis</i>	‘O‘opu naniha	3
<i>Awaous stamineus</i>	‘O‘opu nākea	4
<i>Eleotris sandwicensis</i>	‘O‘opu ‘akupa	4
<i>Kuhlia sandwicensis</i>	Āholehole	4
<i>Macrobrachium lar</i>	Tahitian prawn	9
Alien species (other than <i>M. lar</i> / Tahitian prawn)		10

Table 10b. Calculated CWA Example

Species	Count	Weighting value
Tahitian Prawn	2	9
Bristlenose catfish	2	10
Rainbow guppy	3	10
‘O‘opu nākea	2	4
$\text{CWA} = \frac{2(9) + 2(10) + 3(10) + 2(4)}{9} = 8.44$		
<p style="font-size: 1.2em; margin: 0;">Score = 3 pts</p>		

Table 10c. Use the tables below to list the community weighted average (CWA) at your site

Community weighted average (CWA)	Points
$\frac{13(3)+8(4)+32(4)+1(3)+1(10)+3(10)+3(10)+2(10)+17(10)+205(10)}{285}$	3
Reference Table	
If your “Community weighted average (CWA)” is	Then use this subscore
1.0-4.0	5
4.1-9.0	3
9.1-10	1

CATEGORY E. TOLERANCE CAPACITY

Metric 10. “Percent tolerant alien fish” describes the introduced species of fish that have established populations in Hawaiian Streams, even those that have been heavily disturbed by humans. These include all alien species listed in Table 1. Their presence is detrimental to native fishes because of direct predation, increased competition for resources, increased habitat degradation, and vectors of disease and parasites.

Table 11. Use the tables below to list the percent of tolerant alien species at your site

% tolerant alien species	Points
$\frac{\text{number of alien species}}{\text{total number of species}} \times 100$ $\frac{231}{285} \times 100$	1
Reference Table	
If your “% tolerant alien species” is	Then use this subscore
0%	5
1-4%	3
≥5%	1

Metric 11. Percent diseased / Parasitized Fish evaluates the stream biological condition at the level of the individual, where habitat quality is correlated with the incidence of lesions and parasites on fishes and benthic invertebrates.

Table 12. Use the table below to list the percent of diseased or parasitized fish at your site. Assign a subscore of 5 unless instructed otherwise (most sites have a low % of diseased or parasitized fish)

% diseased or parasitized fish	Points
	5
Reference Table	
If your “% diseased or parasitized fish” is	Then use this subscore
≤1%	5
2-10%	3
≥11%	1

Table 13. Determine the final HSIBI score by adding points from Metrics 1-11, then calculate percentage:

Metric 1	3	Metric 7	1	Final HS-IBI score as a %: [(Total ÷ 55) x 100]
Metric 2	1	Metric 8	1	
Metric 3	1	Metric 9	1	
Metric 4	1	Metric 10	3	[(19 ÷ 55) x 100] = 34.60%
Metric 5	1	Metric 11	5	
Metric 6	1	Total:	19	

Table 14. Circle the integrity class of your stream site using your calculated Final HS-IBI % score

% HS-IBI	Integrity Class	Attributes
90.0 - 100	Excellent	Comparable to reference (near-pristine) conditions with minimal human disturbance exemplified by having the full complement of native macrofauna grouped into functional ecological guilds that maintain specific structure, diversity, and abundance characteristics at expected locations along the stream continuum from mountain-to-sea; meets native species density/size-class expectations including those for sensitive fish species (<i>S. stimpsoni/L. concolor</i>) at all elevations; no disease, deformities, or parasites observed on individuals; no alien species (except <i>M. lar</i>) present in any location along the stream continuum.
79.0 - 89.9	Good	Lowered biotic integrity as evidenced by reduced densities of expected native macrofauna; however, native species generally present in the assemblage at expected locations along the stream continuum; sensitive fish species (<i>S. stimpsoni/L. concolor</i>) densities/size classes below expectations; minimal evidence of disease, deformities, or parasites observed on individuals (<1 % numerically); no alien aquatic species present in middle-to-upper elevation reaches (except <i>M. lar</i> in low densities); however, small populations may be present at lower elevations often associated with ditches and other water diversion infrastructure.
69.0 - 78.9	Fair	Some native macrofauna absent depending upon elevation with expected species assemblage pattern disrupted; total native gobiid and sensitive fish species (<i>S. stimpsoni/L. concolor</i>) densities/size classes well below expectations at all elevations; alien aquatic species common compared to natives, but generally confined to lower elevations; individuals with external symptoms of disease, deformities, or parasites present, but not very common (2 to 10 % numerically).
40.0 - 68.9	Poor	Few (if any) native macrofauna present with sensitive native species absent and species densities/size classes never meeting expectations; tolerant native species (<i>A. stamineus /E. sandwicensis</i>) generally only found in lower elevation/estuarine stream reaches; aliens dominant particularly high tolerance species (e.g., Poeciliidae); individuals with external symptoms of disease, deformities, or parasites common (>10 % numerically).
< 39.9	Impaired	Stream apparently devoid of life; native macrofauna absent regardless of elevation; if tolerant alien species present, only in very low abundances; nearly all individuals with external symptoms of disease, deformities, and/or parasites.

Modified table from Kido, 2012.