



# VISAYA

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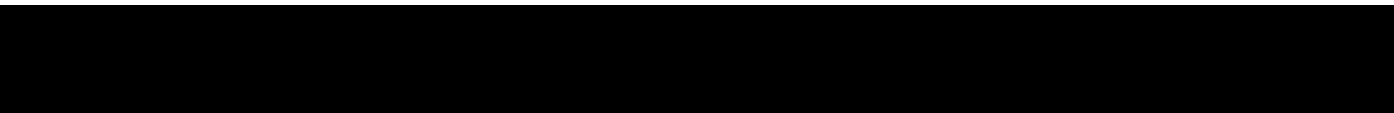
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**THE USE OF MOLLUSCS AS BIOLOGICAL INDICATORS  
IN ASSESSING CLIMATE AND ENVIRONMENTAL CHANGE**

Daniel R. Goodwin

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# The Use Of Molluscs As Biological Indicators In Assessing Climate And Environmental Change

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## ABSTRACT

Current methods involved in the study and bioassessments of wetlands, watersheds, streams, rivers, and estuaries use BMIs as key players in analyzing and determining environmental change and or damages; normally BMIs are organisms >.5mm in size. The use of the species: *Neritina (Theodoxus) vespertinus* (Sowerby, 1849) one of Hawai'i's more common stream/river species that usually occupy fresh and brackish water environments is reported in this paper.

**KEYWORDS:** Molluscs, Bioassessments, Streams, Indicators, BMIs, Hawaiian Islands.

## I. INTRODUCTION

The use of mollusks as biological indicators and controls in monitoring climate and environmental change are currently being used in most Bioassessment programs. In Hawai'i; the species: *Neritina (Theodoxus) vespertinus* (Sowerby, 1849) or in the Hawaiian language: "Hapa "Wai" is one of the more commonly found BMIs in most of Hawai'i's streams. The term "Hapa" in Hawaiian means "Half" and the term "Wai" means famine. The "Wai"; Hihi 'Wai, or *Neritina granosum* (Sowerby, 1825) = *Neritina granosa* (Sowerby, 1825) a rarer species found mostly in year-around flowing streams; Hapa "Wai, the *Neritina (Theodoxus) vespertinus* (Sowerby, 1849); Pipi "Wai, *Neritina (Theodoxus) cariosus* (Wood, 1828) = *Theodoxus cariosa* (Wood, 1828) another uncommonly found species (mostly found in brackish water) was eaten during months with little or no food supply or eaten during the

months of "Famine". Another species found in river or stream mouths, and estuaries is: *Theodoxus neglectus* (Pease, 1861) = *Theodoxus neglecta* (Pease, 1861). This fluvial species is sometimes associated with *Nerita picea* (Recluz, 1841)—which in turn at a glance resembles *Neritina (Theodoxus) neglectus*. They are also known as the freshwater "Opihi" shell or "Whistle Shells". The species mentioned above are one of three diadromous species of mollusks in the Hawaiian islands—migrating between freshwater and saltwater and completing their circle of life. The term "Hapa" means half, which signifies the species half life in freshwater and half life in saltwater. The species also resemble a shell species significant of a combination of a freshwater snail and saltwater species of mollusk. The species is used as a biological indicator in bioassessments of riparian stream studies—and one of the BMIs (Benthic Macroinvertebrates) found in most of Hawai'i's stream environments. A BMI is

usually a organism greater in size than .5mm. Most BMIs consists of insect larvae—the snail or mollusk species: *Neritina (Theodoxus) vespertinus* would consist of the larvae or veliger greater than .50mm in size—more than likely a juvenile specimen with protoconch and first one half nuclear whorl. The abbreviation listed below is some of the acronyms used in bioassessments or papers reporting climate or environmental change (Table – 1). Both natural and man made stressors influence this change. Global warming has a great deal of influence on seasonal and temperate changes, and the man made influence is from exceedence of TMDLs (Total Maximum Daily Load), sedimentation, turbidity, nutrients, and trash (Table – 2). Looking at both stressors—both are considered influence by man. Global warming is the product of man and the other stressors mentioned above. The streams play in the environmental change is not alone, but rather a key player in the eco-system, as it empties into estuaries, bays, harbors, and the ocean. The degree of damage doesn't stop at the stream, but causes stressors on yet another environment; “Our Precious Oceans”. The State of Hawaii uses two main protocols; The Hawaii Stream Bioassessment Protocol (HSBP), University of Hawai'i (U of H) and Hawaii Stream Visual Assessment Protocol (HSVAP), Natural Resources Conservation Service, United States Department of Agriculture (USDA).

## SYSTEMATICS

**Family:** Neritidae

**Genus:** *Theodoxus* Montfort, 1810

**Type species:** (o.d.) *Theodoxus luteianus* Montfort, 1810 (= *Nerita fluviatilis* Linnaeus, 1758 ICZN Op. 335, 1955)

***Theodoxus vespertinus* Sowerby, 1849 =**

**Hawaiian name: “Hapa Wai”**

**Locality:** All major Hawaiian Islands

**Remarks:** Freshwater and Brackish water species

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**Remarks:** Freshwater and Brackish water species

## Synonyms:

*Neritina solidissima* Sowerby, 1849

*Neritina sandwichensis* Reeve, 1855

*Neritina tahitensis* Lesson, Tinker, 1952

## Synonymy:

*Neritina vespertina* Sowerby, 1842-1887 (1849)

*Theodoxus vespertinus* Sowerby, 1842-1887 (1849)

*Neritina tahitensis* Lesson, Tinker, 1958; Quirk and Wolfe, 1974

*Neritina vespertinus*, Sowerby, 1839.

*Neritina tahitensis* Lesson, Tinker, Wilkie Spencer, 1958.

*Theodoxus vespertinus*, Kay, 1979; Kay, E. Alison and Olive Schoenberg-Dole. 1991; Goodwin, 1989, 1992, 2006; Moretzsohn and Kay, 1995; Cowie et. al., 1995; Yamamoto and Tagawa, 2000

**Description:** Appearance: Elongated Horseshoe, some mature specimens ariculate (Having wing like appendages), and olive green in coloration. The species is medium size, medium-light weight shell, protoconch is slightly elevated, aperture semi-oval, parietal shield or columella completely covers the base from anterior end to posterior end, lip slightly flaring with an slight edge, parietal shield or columella light olive in coloration. The evaluation of six specimens produced the following character sets, variances, and SD: 21.64mm in length, 5.53 in variance, and 2.35 SD; 17.09mm in width, 10.29 in variance, and 3.21 SD; and 6.94mm in height, 0.77 in variance, and 0.88 SD.

## II. RESULTS AND CONCLUSION

The dispersal or degree of fluctuation (SD) is important in determining the influence of stressors on the BMIs.

Standard Deviation (Mean Standard Deviation) or

$$SD: \sigma^2 = \frac{\sum fi (Xi - \mu)^2}{N}$$

A close watch on their conchological and anatomical changes are indicators of change on them, from influence of environmental changes and or damages. Recently in the Islands, during our rainy or wet season, we had extensive flooding—resulting in high sedimentation, turbidity, nutrients, trash and other pollutants emptying in our streams, rivers, estuaries, and oceans. The recent flooding even caused wastewater treatment plants to overflow—causing hundreds of thousands of gallons of raw and untreated

sewage to enter or precious oceans. The results are devastating, damage to the environment and risk of disease from the raw sewage. A list of TMDLs and Factors are reported in Tables 1 & 2. Water Chemistry samples taken:  $\text{NH}_4\text{-H} + \text{NO}_2\text{-H} + \text{NO}_3\text{-H}$ ; Ammonia, Nitrites, and Nitrates are taken routinely. Survey of streams with higher levels of  $\text{NH}_4\text{-H}$  or ammonia and  $\text{NO}_2\text{-H}$  or nitrites had less nutrients, resulting in lesser amount of macroalgae. Stream with higher levels of  $\text{NO}_3\text{-H}$  or nitrates had a higher amount of macroalgae. The streams with macroalgae had a higher yield of *Neritina (Theodoxus) vespertinus*. A recent visual survey of the stream in March 2006 resulted in more turbid water, lower nutrient levels resulting in minimal amounts of macroalgae, and no visual observation of any of the molluscan BMIs. Continual RSB should be conducted on a regular basis.

Streams should be monitored and cleaned of trash (some trash as batteries will leak acid into the surrounding grounds and seeps into the streams water, possible trash that includes pesticides and other heavy metals). The debris and trash can severely clog the stream during high rainfall resulting in overflowing stream and water into residential areas.

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**Table - 1: Abbreviations used in this Paper**

- 1) BMI = Benthic Macroinvertebrates
- 2) EMAP = Environmental Monitoring and Assessment Program (Methods Format Guidance), United States Environmental Protection Agency (EPA)
- 3) ERD = Ecosystem Research Division, U. S. Environmental Protection Agency (EPA)
- 4) HAS = Hawaii Stream Assessment, Department of Health, State of Hawai'i
- 5) HSBP = Hawaii Stream Bioassessment Protocol, University of Hawai'i
- 6) HSVAP = Hawaii Stream Visual Assessment Protocol, NRCS, USDA
- 7) IBI = Index of Biotic Integrity
- 8) NaCl = Salinity
- 9) NRCS = Natural Resources Conservation Service
- 10) ppt = parts per thousand
- 11) ppm = parts per million
- 12) RSB = Rapid Stream Bioassessment, United States Environmental Protection Agency (EPA)
- 13) TMDL = Total Maximum Daily Load
- 14) USDA = United States Department of Agriculture

**Table - 2: List of TMDLs (Total Maximum Daily Load) of Significant Interest**

Number	Type of TMDL
1	Severity of pollution <ol style="list-style-type: none"> <li>a. number of pollutants listed and degree that levels of pollutants exceed standards</li> </ol>
2	Uses of the waters
3	Type and location of waterbodies
4	Degree of public interest
5	Vulnerability of particular waters
6	Importance of particular waters
7	Agency limitations <ol style="list-style-type: none"> <li>a. including funding</li> </ol>
8	TMDLs currently under development

**Table - 3: List of Factors in 2005/2006 effecting the Decline in *Theodoxus vespertinus* population**

Number	Type or Source of Factors
1	Turbidity higher than 25 percent visibility
2	Turbidity lingering—even after a dry period with no or little rainfall
3	Limited macroalgae population
4	High percentage of sediments covering the floor of the stream (Sedimentation)
5	Limited nutrient levels
6	Increased amount of trash
7	Heavy metals
8	Pesticides
9	other TMDLs
10	Other pollutants
11	Water Chemistry
12	Collecting or harvesting
13	Predation

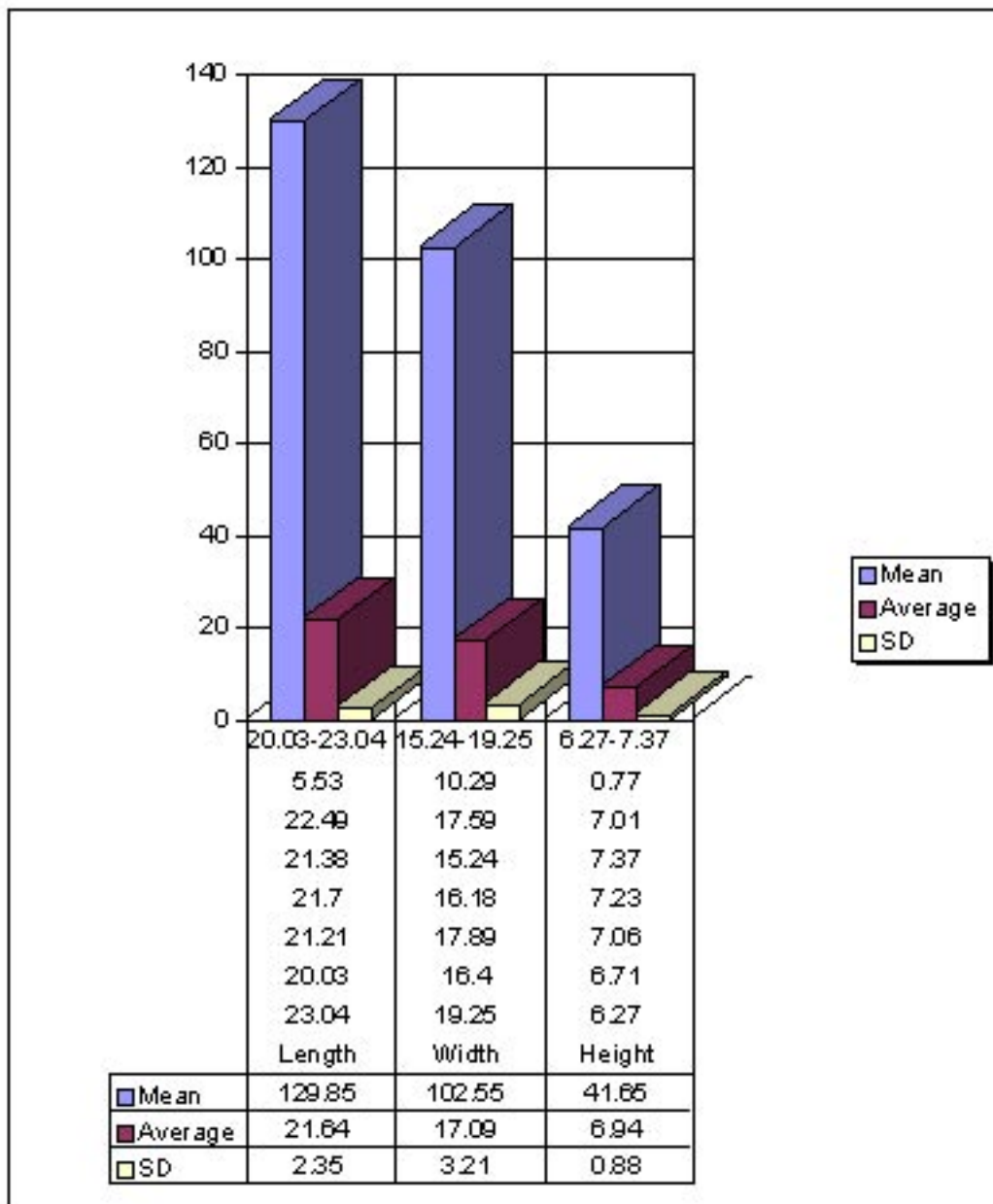


Chart – 1 Character sets of six specimens collected from Kalihi Stream in 1991

Kalihi Stream, Wet Season, date: February 2006





*Neritina (Theodoxus) vespertinus* (Sowerby, 1849)  
25.07 mm in length; 25.11 mm in width.



1



2



3



4

*Neritina (Theodoxus) vespertinus* (Sowerby, 1849)

25.07 mm in length; 25.11 mm in width.

1. Anterior view.
2. Posterior view.
3. Operculum; Top view.
4. Operculum; Bottom view.

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