



# VISAYA

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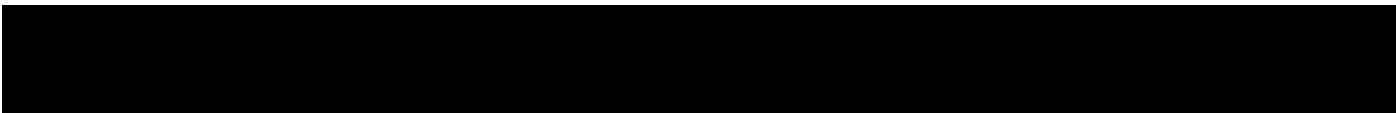
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**THE DISCOVERY OF *NERITINA (THEODOXUS) CARIOSA* (WOOD, 1828)  
ON THE ISLAND OF MAUI, HAWAII (GASTROPODA: NERITIDAE)**

Daniel R. Goodwin

December 02, 2006



# The Discovery of *Neritina (Theodoxus) cariosa* (Wood, 1828) on the Island of Maui, Hawaii (Gastropoda: Neritidae)

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## ABSTRACT

This research paper was first written during my undergraduate studies in 1989 as partial fulfillment for the degree; other papers during my graduate studies that have not been published formally will follow; as with some research papers the findings were not officially published. This paper is an update to my research paper from 1989 embracing the discovery of *Neritina (Theodoxus) cariosa* (Wood, 1828) from the Island of Maui, Hawaii.

## I. INTRODUCTION

### Fluvial Gastropods of the Island of Maui

The search for river oriented (fluvial) gastropods, turned out to be a long and tedious task. After searching numerous streams, rivers, and ponds, and with the excessive exposure from the general public there, the diadromous mollusks were scarce, if not completely absent. I approached several very interesting people in the immediate area, and of course going through the most populated area of the island of Maui, I expected to draw some attention of certain local people with the hope that they could share any knowledge of *Neritina (Theodoxus) cariosa* (Wood, 1828) or other species of the same genera. Most of

the elders of the island, might know the whereabouts of some of the *Neritid* species. The past generations of Hawaiians used to eat the species of *Neritina granosum* (Sowerby, 1825) = *Neritina granosa* (Sowerby, 1825), known to Hawaiians as: Hihi'wai or 'Wai, *Neritina (Theodoxus) cariosa* (Wood, 1828) = *Neritina (Theodoxus) cariosus* (Wood, 1828) (Kay, 1979) known to Hawaiians as: Pipi'wai and *Neritina (Theodoxus) vespertinus* (Sowerby, 1849), known to the Hawaiians as: Hapa'wai. They called the diadromous gastropod "Hihi'wai" or "Wai" which means Famine, and when food was scarce, the Hawaiians use to eat the Hihi'wai or Wai as food and to supplement their diets. There is limited amount of Hawaiians in today's generation that knows about the delicacy, and a handful that might know where this gastropod is found. My theory is, where *Neritina granosa* Sowerby, 1825 lives, so does the *Neritina (Theodoxus) cariosa*. The species *Neritina granosa* is usually found in higher elevations of the streams, up to 400 yd (130 m) or so (Maciolek, 1979?). Since this species is said to be diadromous, and their veligers (larvae) flow down stream and into the open ocean, I think it might be a good chance of finding the specimens I am looking for of the other species of *Neritids*. I was unsuccessful with the local people as to the whereabouts of any of the species of *Nerit-*

*ids*. I have concluded that it would be a few if any people today, that actually knows what “Hihi’wai” is, or what the other species are. I started my expedition in the city of Kihei, going through seven different streams and ponds, with no luck. It seems where there is the absolute presence of man, it is noticed that there is some ecosystem damage from pollutants and rubbish. I started back to Kahului city, one of the main towns of the island, and tried to start on some of the streams there, but high waves at the lower elevations (winter season wave action), kept me from going into the water to do my studies. I came up with far off idea and theory, and ventured to an area some 57 (91.73 km) mi southeasterly around the coastline to the city called, Hana.

We found an area next Kapi’a Stream in Hana and setup camp on the northeastern side of the stream. On the second day, after breaking camp, I ventured 25 yd (22.5 m) from my campsite to a riverbed that I’ve seen the day before on the way here. It was nice and early and before the first sign of the morning sun. I started in the freshwater area of the stream and ventured as far upstream that I could go, where the running water was very limited, and no signs of any ponds or other water caption areas. I already knew that this stream would probably not produce any *Neritina granosa*. But I continued to study the pond site at the mouth of the stream, about 15-17 meters inland. I noticed while looking at the siding of the streambed and the numerous porous black lava rock formations--I noticed tiny small olive and dark brown colored types of gastropods. I’ve examined a few, after taking them out of the tiny holes in the formation. It was baby or juvenile *Neritina Theodoxus vespertinus* (Sowerby, 1849) all taking shelter from the outside world or until they can reach a size that they cannot be prayed upon as food. The stream known as Kapi’a Stream and the immediate area of Kaki’o, just 3 mi (4.83 km) out of downtown Hana Town. I continued in the range I was and lifted a large smooth black lava rock out of the water, beneath it I was rewarded with my first three specimens of *Neritina (Theodoxus) cariosa*. I now knew that I was on top of an area that could be quite promising.

## The Discovery of Four Species of Neritidae

Since going through the lava rock area of the stream at the 15-17 m zone, we have collected 27 specimens in which to examine for scientific study, of which four specimens were collected dead with a small pin hole on the underside of the shell, usually against the columella shield. Twenty-three specimens were collected live, with their operculum intact (Graph 1). I started further up the stream in the 17-25 m zone, and uncovered specimens of *Neritina (Theodoxus) vespertinus*. At the mouth of the streambed and 15 m upstream, I have discovered specimens of *Neritina (Theodoxus) neglecta* (Pease, 1861). I had a pretty good amount of research material for study except for *Neritina granosa*. On the way back to Kahului airport, I stopped at a small shack, like a gift shop stand. The lady operating it, seem pretty friendly and was mature enough to answer my very unorthodox questions of the whereabouts of *Neritina granosa* or the Hawaiian Hihi’wai. She told me that they were far up a stream and that came down into their Taro patches (farm) (Taro is a starchy staple food of the Hawaiian people). She handed me a bag of *Neritina granosa* that she had reserved somehow for a rainy day...today was the rainy day. Now with my four species of *Neritids* I concluded my research expedition on Maui, with plans to return in the near future for additional scientific studies.

## II. SUBJECTS, MATERIALS, AND METHODS

### The Environment of the Neritidae Found

The environment of the *Neritina (Theodoxus) cariosa* (Wood, 1828) was found. The species is defined as a brackish water species; experiments by housing them in freshwater resulted in high mortality rates. The environment in Kapi’a stream was about 15-17 m upstream, salinity about 5 to 30 ppt (parts per thousand), NH-3 (Ammonia) about <1.0 ppm (parts per million), NH-4 (Nitrite) about <1.0 ppm, NO2 (Nitrates) about 4 to 8 ppm, O2 (oxygen saturation) about 5 to 7 ppm and temperatures of 70-75 degrees Fahrenheit (21.11 to 23.88 degrees Celsius). Limited research has been conducted on the family of fluvial characteristics and diadromous factors. Re-

search on the island of Oahu has been unsuccessful as far, most probable because of ecosystems disruptions and urban populations. Research on the island of Kauai, Molokai, Lanai, and Niihau has not been studied. I believe a theory of ecosystem disruption in my scientific method of observation and research. The windward islands (northwestern Hawaiian Islands) of Nihoa, Necker, Gardner Pinnacles, Laysan, Lisianski, Midway, and Kure Atoll, might be a probability. Future studies on these islands will determine the extreme range of the endemic Neritid species. Many members of the Hawaiian Malacological Society of Honolulu, have stated that they have not seen Neritidae species in about 10-15 years. Most of the species has been lost in research by lack of interest and most probably the unavailability of references to be cited and studied. This paper will assist the scientific community in updating highlighted areas of interest, and open an area for future reference and study.

### Valuable Scientific Knowledge Uncovered

As I continued my search for *Neritina cariosa* and its close relatives, I began to work the area closer to the ocean's splash zone, which spills water into the stream by means of tidal change and wave actions. I discovered another species of Neritidae: *Theodoxus neglecta* (Pease, 1861). This species is another absent species stated previously. *Neritina (Theodoxus) neglecta* is what its name sounds like "neglectus or neglected". This species is found occasionally with its close look a like cousin; *Nerita picea* Recluz, 1841, which resembles *Neritina (Theodoxus) neglecta* by shape of the shell, color and appearance. It is been said that while picking the species *Nerita picea*, that they would accidentally pick-up a few *Neritina (Theodoxus) neglecta*. The local people in Hawaii still relish eating the *Nerita picea* or known in the Hawaiian language as "Pipipi", as part of their diet. While accidentally ingesting a *Neritina (Theodoxus) neglecta* rather than a "Pipipi", they claim that it was a bad area for picking or that the Pipipi was feeding on something bad. It's not so, although the badly tasting *Neritina (Theodoxus) neglecta* is of a completely different nature and genera. Even most shell enthusiasts and amateur malacologists

pass them by while looking for them. The specimens collected of *Neritina (Theodoxus) neglecta*, was collected over a pretty wide range, from the wave-line (0 m mark) to 15 m upstream (See Area 1, Map 1). The range of *Neritina (Theodoxus) vespertinus* seems to have a range of 17 to 25 m upstream (See Area 3, Map 1), and the range for *Neritina granosa*, from past references cited and my personal knowledge of the species, it is conclusive to say they have the largest range of all the fluvial or diadromous species in Hawaii. *Neritina (Theodoxus) cariosa* has the least amount of range distribution of all of the fluvial species. The range of *Neritina (Theodoxus) cariosa* is limited from about 15 to 17 m upstream; an area of only 1.3 m. Range has quite a bit to do with the Neritidae's existence, as temperature, salinity, and quality of the water.

### SYSTEMATICS

Family **NERITIDAE** Rafinesque, 1815

Genus *Neritina* Lamarck, 1816

Type species: (o.d.): *Nerita pulligera*  
Linnaeus, 1766

Sub-genus: *Theodoxus* Montfort, 1810

Type species: (o.d.): *Theodoxus luteianus*  
Montfort, 1810

*Neritina (Theodoxus) cariosa* (Wood, 1828) =  
*Theodoxus cariosus* (Wood, 1828)

Hawaiian name: Pipi'wai

Type environment: Brackish water ponds and high salinity areas of streams and rivers.

Range: Hawaiian Islands; Kauai, O'ahu, Molokai, Maui, and Hawai'i. I found no records of the establishment of the species on Nii'hau and the islands of the northwestern archipelago.

### III. RESULTS AND CONCLUSIONS

#### Conclusive Evidence

*Neritina (Theodoxus) cariosa*, is one of the more sensitive species of the Neritidae family. It has lim-

ited range of distribution in the streams and ponds, because of salinity and temperature factors. *Neritina cariosa* is limited in Kapi'a stream, probably because of the streams close width of about 3-4 m, an average depth of 1 m, and limited rocks and stones in which they can hide from the outside environment. More rocks and stones within the stream at the 15 to 17 m (Map 1; Chart 3), average sizes of 15.68 mm in length and 14.89 mm in width (Table 1 & Chart 1), and average living temperature of 70° - 75° F (21.11° - 23.88° C). *Neritina (Theodoxus) cariosa* seems to prefer waters of salinity ranges of 1 to 30 ppt, brackish with limited visibility. It's also conclusive to say that with the number of young shells examined, that the younger shells lack the triangular wings and dorsal hump. They develop the dorsal hump when they reach maturity. They have been observed feeding on algae on sides of the stones and on the bottom of the stones. These Neritinas are diadromous and also herbivores feeding on plant-like substances. No conclusive evidence was observed of their night activities, but I pretty much think that like most of the other Nerites they are active at night and slower moving during the daylight hours. More expeditions to other islands will be conducted to determine their distribution throughout the Hawaiian Islands, and more on the biology of these brackish water Prosobranchia species.

### Aquaculture Possibilities

We all know that the purpose of aquaculture is to either prevent genus' and species of animals or plants, presently endangered of extinction or increase the present growth rate and reproduction of a said species, better than if they were living in the wild. Successes in aquaculture today has been demonstrated, from species of abalone, clams, oysters, shrimps and prawns, lobsters, maine fishes, seaweeds and algae, numerous species of freshwater fishes, and many more species not mentioned here. These aquaculture successes have opened the doors to the hopeful cultivation of other species of animals and plant life. In Hawaii, we currently have two main aquaculture farms that are successful. Farms are not mentioned to protect their interests. My theory for mollusks in aquaculture especially for genus *Neritina* is the

use of balanced amount of salinity in the water and controlled temperature by a tidal action or continual flow of saline water into the brackish water pond to keep the salinity and temperature balanced. Backyard aquacultures have been tried, in Taro (Hawaiian staple starch food) farms, which was located near a saltwater pond or river opening. Their success was limited without the use of scientific methods and technology. We now have the technology and machinery to modernize the facilities with machines to regulate and control and or duplicate the environment that certain species thrive in. I am convinced with our present success in temperature-controlled, nutrient and chemistry-controlled water, we are quite close to aquaculture of *Neritids*.

### Ecosystem and Conservation

The main disruption the *Neritids* face toward the destruction of *Neritina cariosa* would be the contamination and pollution of our waterways and streams. Water pollution is a major problem in most of the world and including the United States of America, and hard standards of dumping our wastes, are necessary to prolong the ecosystem of our waterways today. It is most probable that the genera we are talking about in other countries and the disruption to the ecological environment, places the extinction of species or are very near too. A good thing to keep in mind is "Take what you need and not what you want!" Conserve and save for tomorrow.

### IV. REFERENCES

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TABLE - 1 *Neritina (Theodoxus) cariosa* (Wood, 1828) Live taken specimens, collected from Kapi'a Stream, Hana, Maui; August 16, 1989.

Specimen No.	Length	Width	Remarks
No. 1	21.00	21.05	Adult
No. 2	20.00	20.00	Adult
No. 3	16.00	13.50	Adult
No. 4	11.40	10.50	Adult
No. 5	13.00	13.00	Adult
No. 6	12.70	11.30	Adult
Variance Total 81.44		Variance Total 101.72	

Range	11.40-21.00	10.50-21.05
Mean	94.10	89.35
Average	15.68	14.89
SD	9.02	10.09

Table - 2 Percentages of Three *Neritid* species

Species	Percentage Range
<i>N. cariosa</i>	5%
<i>N. neglecta</i>	52%
<i>N. vespertinus</i>	43%

\* Note - *Neritina granosa* values are not utilized in the above figures.

Chart - 1

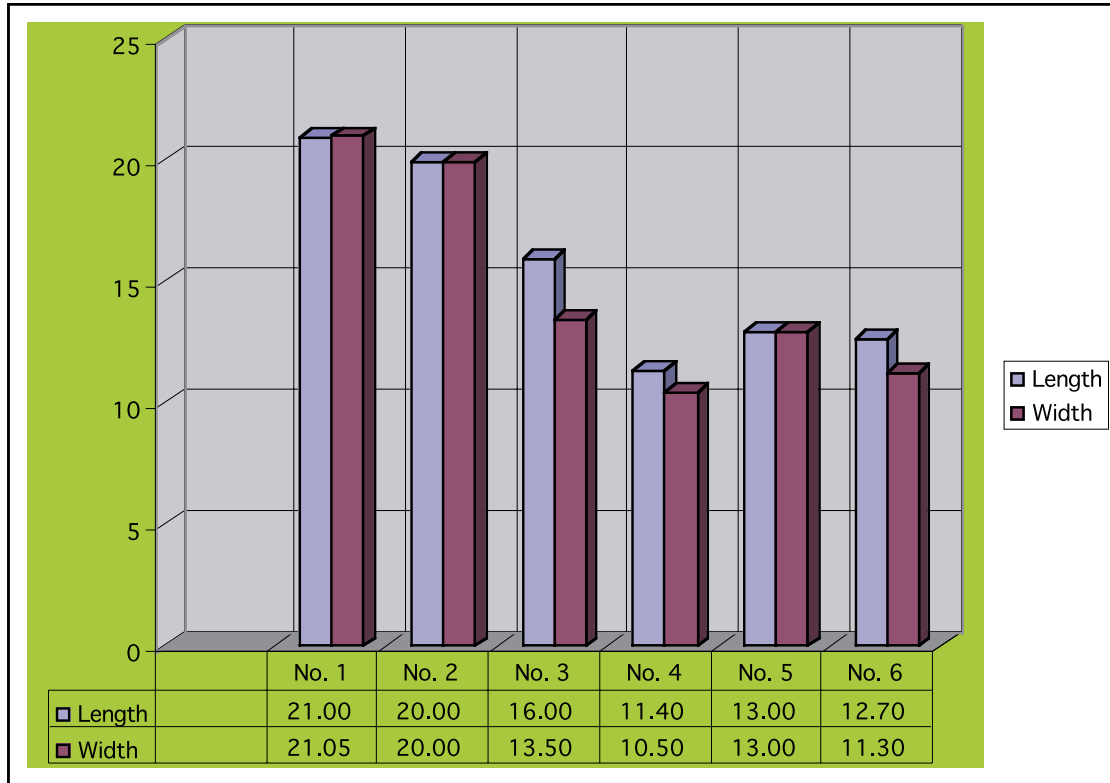


Chart – 2 Population Percentages of three fluvial species

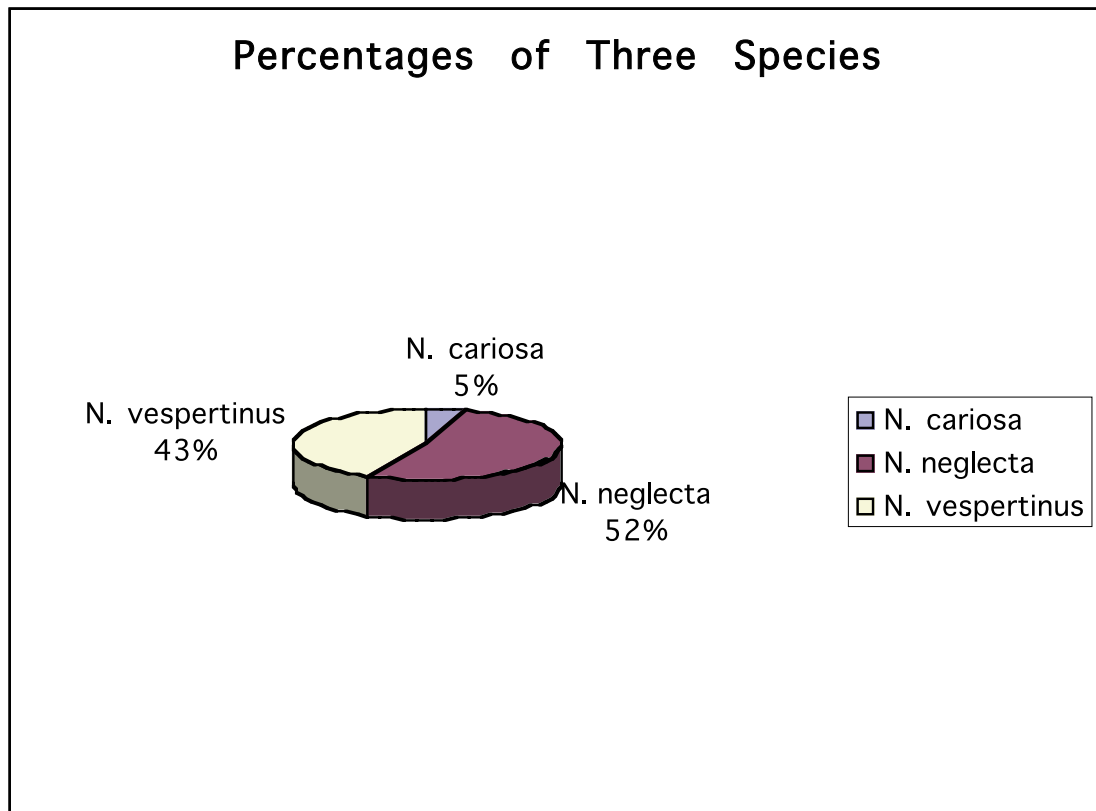




Chart – 3 Area Distribution of three fluvial species

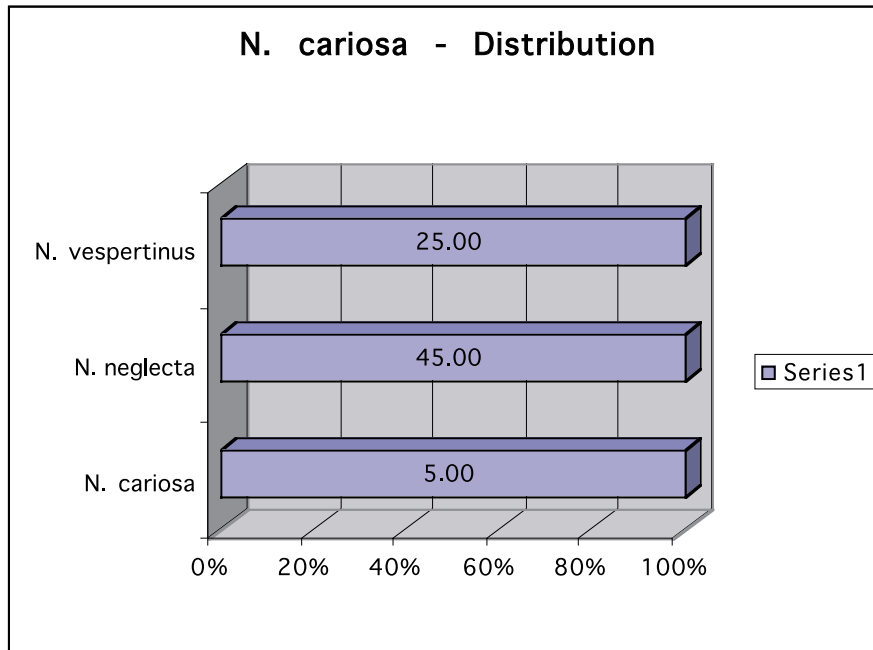
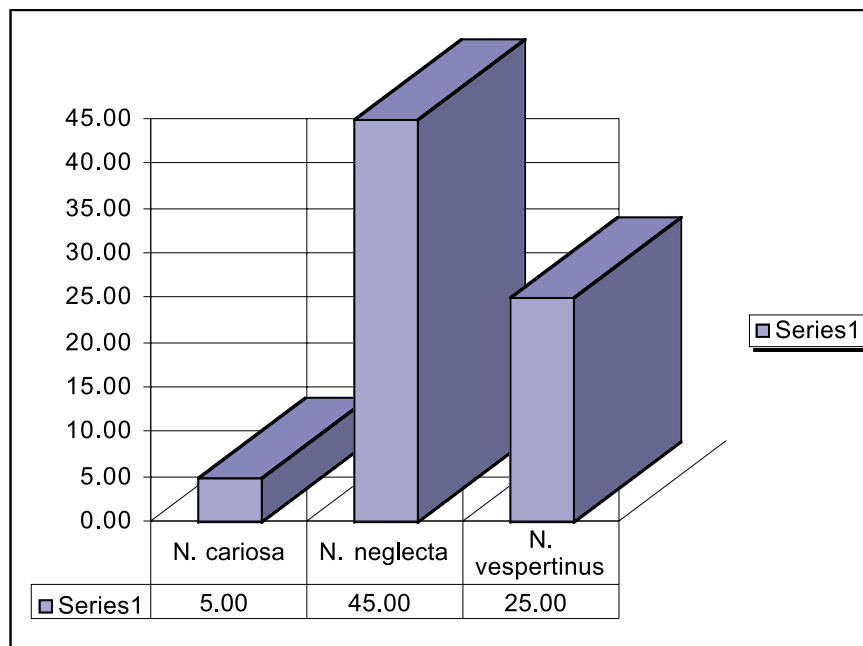


Chart – 3A Area Distribution of three fluvial species (Continued)



**Footnotes:**

*Neritina (Theodoxus) cariosa* – Range of 45-50 yd up stream. Reflecting a total (limited) living area of 5 yd; as noted above.

*Neritina (Theodoxus) neglecta* – Range of 50-75 yd up stream. Reflecting a total living area of 25 yd; as noted above.

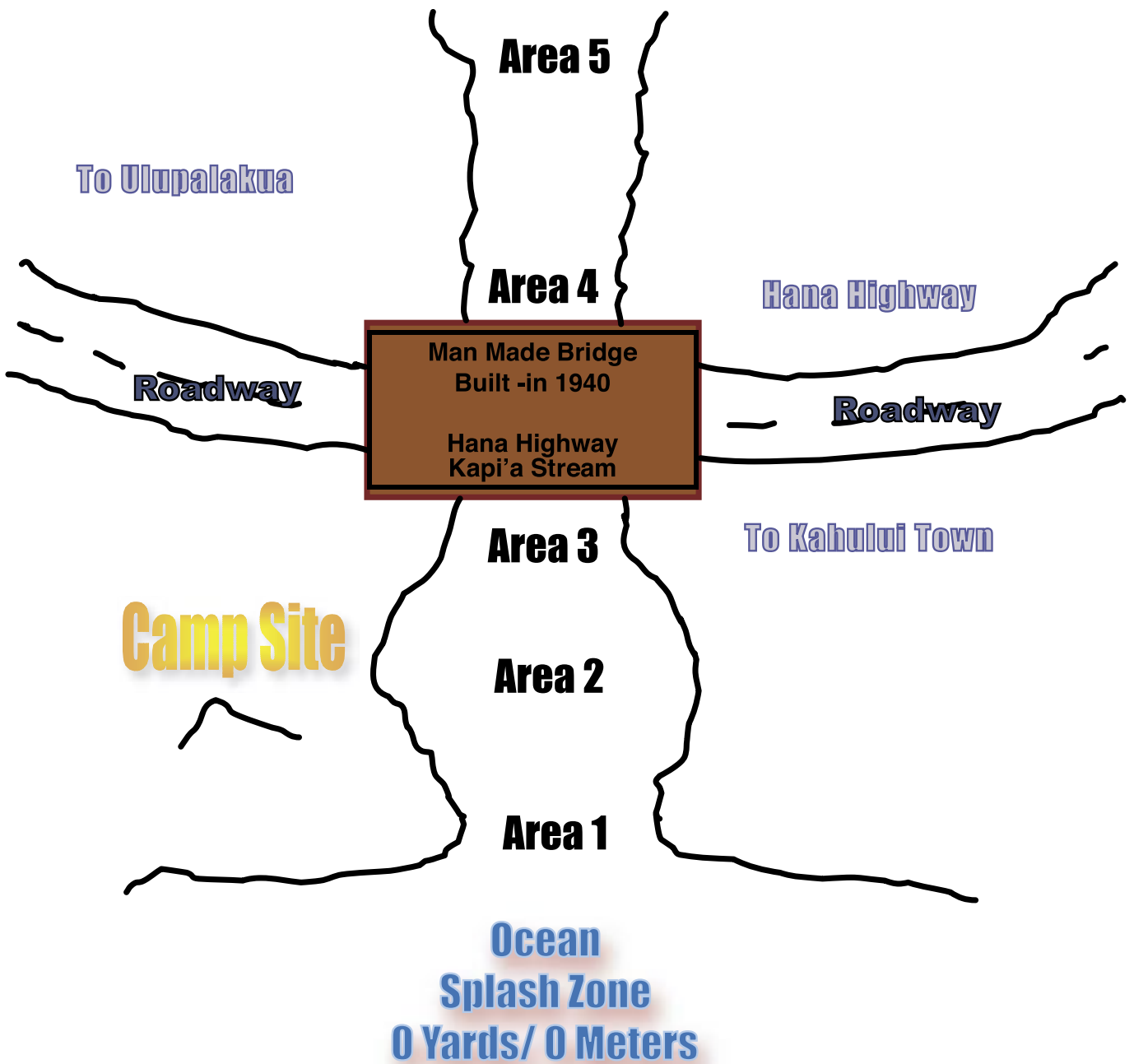
*Neritina (Theodoxus) vespertinus*—Range of 0-45 yd up stream. Reflecting a total living area of 45 yd; as noted above.

*Neritina granosa*—No specimen examined from Kapi’a Stream. (Usual range of distribution is stated from 150-1200 yd (400 m); depending on the class of the stream.



MAP - 1

**Upstream  
To Mountain**





**Plate 1**

*Neritina (Theodoxus) cariosa* (Wood, 1828)

Length: 20.39 mm. Width: 22.69 mm. Height: 9.07 mm. Maui, Hawaii, USA.



**Plate 2**

*Neritina (Theodoxus) cariosa* (Wood, 1828)

Length: 21.04 mm. Width: 25.54 mm. Maui, Hawaii, USA.

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