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MARITIME INVERTEBRATE STUDY

Fire Island, New York

Prepared for
Internship
Prof. Blanchard, PhD
Mr. James Ebert, FINS

Prepared by
Rachel B. Fried
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INVENTORY

Fire Island

MARITIME INVERTEBRATE STUDY

Fire Island, New York

FIRE ISLAND BEACHES MARITIME INVERTEBRATE COMMUNITY
A Study of Species (Arthropoda) Richness and Abundance

Objective: To create an inventory of terrestrial maritime invertebrates (arthropoda) representing species richness and species abundance to be consistent on two separate beaches within the Fire Island National Seashore. The two areas chosen have been closed to vehicles for one year and have been selected due to previous sightings of the endangered Piping plover, *Charadrius melodus*. The plover is known to breed on these coastal beaches in the high beach near the dunes and forage for insects along with crustaceans and marine worms in the open sandy habitat on outer beaches. It has been suggested that the plover's diet, with respect to arthropods only, may be hypothesized from the data collected. Due to the its ecological standing, its nesting grounds and diet, the significance of the Piping plover for this project is limited to the suggestion of place and subject. It is hypothesized that two beaches with similar physical characteristics will support the same ecological communities, regardless of location.

Hypothesis: The species richness and abundance of Lighthouse Beach, Fire Island New York (Lighthouse) will equal those of Watch Hill Beach, Fire Island New York (Watch Hill).

Ho: $H_1 = H_2$

Null Hypothesis: The species richness and abundance of Lighthouse will not equal those of Watch Hill.

Ha: $H_1 \neq H_2$

State Variables	Forcing Functions	Control Functions
Species Richness	Precipitation	Method of collection:
Species Abundance	Wind	sticks, cups

METHOD

An inventory of invertebrates was created by collecting samples from the following two 1 mile area that have been closed to vehicles for a minimum of 1 year: Lighthouse Beach and Watch Hill Beach of Fire Island, New York. Both beaches are part of the Fire Island National Seashore and are administered by the National Park Service, U.S. Department of the Interior. The inventory will provide information useful in creating an ecological model of the maritime beach invertebrates to be applied to contiguous beaches with similar environmental characteristics.

Sampling techniques included sticky stick traps and buried soapy water containers. Sticky sticks are tongue depressors coated with a sticky substance that has a sweet odor and traps flying or crawling insects. The intended use was primarily to catch flying insects. Soapy water containers for this collection were 8 oz. quorpak jars that were approximately 1/3 filled with soapy water and buried up to the rim in the sand within each sampling area. Of the respective 1 mile areas, an invisible grid marking

three (3) one (1) meter columns was constructed to provide a loose structure for random sampling on each beach. The one (1) meter columns ran from the beach face of the dune to approximately 1 meter above high tide mark, or the berm. From one (1) meter above the high tide mark to the top of the dune as described above, there were three (3) sticks per column making total maximum samples fifteen (15) per site per week, or fifteen (15) per event. Although sticky sticks were collected for each event, identification of insects from this method of collection proved impossible for this observer. Inconclusive identifications will be included in the discussion later on in this report. Columns began approximately 1/4 mile away from the 1 mile border (border of restriction of vehicles). Sample locations were visited two (2) times per week. One day for collection preparation and one day for collection and labeling. Time lapse between set up and collection rarely exceeded twenty-four (24) hours. A log of weather conditions was maintained for each collection day. Sampling locations were suggested by Jim Ebert, Fire Island National Seashore, as potential Piping plover foraging ranges. Samples were returned to C.W. Post Campus in Brookville, Long Island, where they were transferred to small vials and immersed in denatured ethyl-alcohol for preservation. Identifications were confirmed by Professor Orland Blanchard, Jr. PhD of Long Island University.

BEACH ENVIRONMENT

The barrier beaches of Long Island's south shore face the Atlantic Ocean, and consist of dunes and sandy stretches of an outwash plain. Sand particles are 20-2000 mm in diameter and consist of mostly quartz and relatively inert minerals. Small rivers flow through the salt marshes behind the beaches as well as through forests of oak, maple, and hickory behind the second dunes. The beachfront is a harsh environment due to the wind, salt and lack of fresh water. The species who can withstand the stress of this environment are generally burrowing species, such as, crustacea, molluska, and other arthropods. Other species that are found in this environment are temporary inhabitants. Shore birds are an example of a temporary species. The birds feed at the water's edge and forage on the sand dunes and overwash areas. The Piping plover is an example of such an inhabitant. The Piping plover, *Charadrius melodus*, is a small whitish plover, its upper parts are sandy colored and match the dry sand of the beach. It has a lot of white on its head with a narrow black band above its forehead that reaches from one eye to the other eye. The white parts have black patches and usually has an incomplete or very narrow ring around its neck. Its legs are orange-yellow, its bill is black with a yellow tip, but all black in winter. As it flies over sandy beaches it utters a clear melodious whistle or a two-noted peep-lo when running over the sand. The bird is so protectively colored that when it crouches it seems to disappear in the sand. The plover is usually found by itself or gathered in small flocks. Plovers usually appear on Fire Island on the Fire Island seashore around late February to early March, nest April-May, and migrate by September. The young hatch and are flying approximately thirty (30) to thirty-five (35) days later. Parents protect eggs and young by attracting

attention to themselves as they often feign a broken wing. Plovers have very deliberate feeding habits; they usually run short distances, pause, stare at the sand, tilt their heads slightly to one side and then pick up their prey. Prey include arthropoda: fly larvae, beetles, crustacea, and marine worms; mollusks, and other marine animals and their eggs. Piping plovers breed on coastal beaches from Newfoundland and southeastern Quebec to North Carolina. These birds primarily winter on the Atlantic Coast from North Carolina to Florida, although some migrate to the Bahamas and the West Indies. Plovers were common along the Atlantic Coast during much of the 19th Century, but nearly disappeared due to excessive hunting for trade. The current population decline following the Bird Treaty Act in 1928 and the pact in the 40's is due to increased development and recreational uses of beaches since the end of World War II. A survey done in 1986 calculated the Atlantic population to be about 700 pairs. Commercial, residential, and recreation development have decreased the amount of coastal habitat available for the piping plover to nest and feed. The contributing factors to the decline of the plover are the indirect results of development. Human disturbance is the leading factor such as vehicular traffic including off road vehicles (ORV's) that crush eggs and nests or young. Although ORV's move sand only a few tens of centimeters away from its own tire tracks and the total sand flux is almost insignificant, they do cause weak links in the dune line contributing to the weaknesses made by overwash and flooding thus limiting nesting activity of the plover.

Excessive foot traffic and like disturbance may force the parents to vacate the nest, thus exposing eggs and young to natural threats such as, predators and the heat of the sun. Interruption of feeding may stress juvenile birds during critical periods in their development. Domestic animals, dogs especially, harass the birds. Development near beaches attract gulls, raccoons, skunks, and fox all of whom prey on the bird eggs, chicks, and adults alike. Stormtides may also contribute to destroying nests. On January 10, 1986, the piping plover became a protected species under the Endangered Species Act. Along the Atlantic Coast it is designated a threatened species.

Locally, the plovers make their nesting grounds behind the dunes of some Fire Island Beaches, as those selected for the sampling areas for this project.

Plant communities of the beachfront are of those species that can withstand the harsh conditions and actually thrive on continual natural disturbance of their roots. The grasslands of the natural barrier island system perpetuated by overwashes are the only virtual grassland in the Eastern United States.

Dunes are formed by drifting sand guided by the wind's force. Shifting dunes are stabilized on these barrier beaches. Mild summer waves carry the sand to the berm, while wind carries the sand to the dune. While winter and stormtides may completely reclaim the berm, the dune erosion replenishes the berm. The berm functions as a moderator or reservoir of sand

for the dunes as well as for the beach. The flora associated with the dunes impede the rate of sand movement and function as a stabilizing force. The plants have acclimated to the harsh winds off the water and the salt spray and sand carried from the water. Behind the dunes there is heavier vegetation including perennial shrubs, trees and vines: gnarled holly, sassafras, tupelo, shadblow; oaks, maples, beech; catbrier, wild grape and an abundance of poison ivy.

The dunes are enormously valuable and exceptionally fragile. A stable ecology on the coastal islands depends primarily on the maintenance and perpetuation of the dune system. On secondary dune lines those lying landward of the frontal dunes there is a succession of vegetation that proceeds from grasses to forest communities as stated above and promotes large-scale trapping of sand thus stabilizing dune systems and enabling permanent features to be made of the dunes.

Ecosystem stability landward of the frontal line dunes is directly dependent on the dunes capacity to stop storm waves from running across the beach and the dunes ability to maintain or hold the shore intact. The environment is continually affected by wave action, storms, boat wakes, dredging activity, clamming, and/or algal blooms. (No measurements available or could be located to quantify the relative affect of each of these sources, independently or together.)

Nearshore profile gradient is affected by the downslope movement of sand seaward of the dune. The slope of the frontal dunes on Watch Hill are greater than that of Lighthouse. However, the sandy stretch of Watch Hill was less congested than that of Lighthouse. Congested, being less traffic, less debris, and as the sampling results will indicate, less inhabited by crawling arthropods. (see findings)

ARTHOPODA

There are over 850,000 species of arthropods. Arthropoda have chitinous exoskeletons and segmented bodies. The anterior third of their bodies have appendages that are jointed and stiff. Each possesses specialized articles, with a minimum of one pair that become either antennae or mouth parts. Molting is an imperative process for growth and is controlled by the endocrine gland. The distinction between aquatic, semiaquatic and terrestrial arthropods is arbitrary. Terrestrial insects frequently become trapped in aquatic environments and have modifications that enable survival. However, those insects that primarily exist in the aquatic environment are generally dorsoventrally flattened and equipped with their sensory structures, such as eyes and antennae, dorsally located. The food gathering apparatus is often ventrally situated so that the insect may move through the interstices of coarse sediments and cling to exposed surfaces in rapidly flowing waters. The modification of a fringe of hair to the hind legs is common to coleoptera as is the modification to front legs for burrowing. Burrowing is important for collecting nutrients within the interstices of sand.

Although adult stages are relatively similar, body development is unique to the environment. Specific larval types adapt to diverse ecological conditions. Almost all insects are represented in the water, especially during development. In the water respiration occurs in both closed and open systems, the developing insect can take oxygen from the water through its body surface (collembola) or adaptive extensions, such as gills. In an open system air passes from the atmosphere or air passages of plants through insects openings, such as spiracles directly to air tubes. Some larvae have blood gills, they practice intestinal breathing through a rythmical body movement. Most have tracheal gills.

Insects displace air in order to stay afloat. Its uppermost layer is a fine elastic skin that enables the insect to suspend itself. Springtails stay afloat in water by expanding the leaping organ.

The hair is probably the most important organ for the insects. Hair is an organ for touch, smell, sight, etc. It allows the insect to cling, and it serves as a bracing device. It is a covering that permits air storage and keeps the insect dry. It also encircles the breathing apertures and hinders the entrance of water and dirt particles from entering. It is also a cleaning device, a feeding implement, a buoyancy device and a mode of transportation.

The requirements for a sustainable habitat for insects includes:

- * Inorganic substances, C, N, CO₂, H₂O, etc.;
- * Organic compounds, proteins, carbohydrates, lipids, humic substances;
- * Autotrophs and other producers
- * Phagotrophs, heterotrophic organisms
- * Saprotrophs, microconsumers to breakdown complex compounds, absorb some of the decomposition products and release inorganic substances to be used by the autotrophs together with organic residues to provide energy sources or to function as inhibitor, stimulator, or regulator for other biotic components of the ecosystem.

Arachnida have abdominal book lungs and demonstrate a most recent derivation from gills of aquatic or marine ancestors. Arachnida are especially abundant and include the spiders and mites who have invaded most terrestrial habitats, but have secondarily invaded aquatic habitats, except for the many plant and animal parasites among the mites and scavengers among the opilionids, and predatory arachnids.

Of the araneae, only one species is typically found on marine shores and is considered truly aquatic. Numerous species of different families live on ocean shores below the high tide mark on ocean shores. Some live in rocks during high tide. Spiders use silk to make a retreat, many spiders enclose their prey in silk and digest the silk once they are ready to feed. Some feed immediately on captured prey, others wrap

their prey in silk and when ready secrete digestive juices from their midgut or possibly a poison gland to penetrate the wounds of their victims and rapidly digest valuable proteins that are then pumped in before new digestive juices emerge.

All species lacking teeth suck up liquid nutrients from their prey and leave only the empty exoskeleton usually hanging in their silk dens or dropped in perfect condition. Many simply bite into the leg of the prey and pump digestive juices into the body and suck out the digested soft parts. Spiders prey may be several times its size. Such is the case of the Latrodectus which may prey on the Scarabidae (June Beetle), which is several times its size. Theraphosidae, orb weavers, agelenid funnel weavers, and wolf spiders chew up their prey roll it into a ball in water before discarding, and often discard the ball in water containers.

Acarina feed on plants, detritus, stored products, and are typically plant and animal parasites. They are found in air, terrestrial habitats, in soil, in litter, on and inside plant stems, inside the nests of bees, ants, wasps, birds and mammals, in barns, in storage bins and other dwellings and survive as ecto- and endoparasites of invertebrates including reptiles, birds and mammals. Over 100 species are marine. The fact that mites are so small provides them with many advantages, such as access to many small spaces, and to survive in harsh environments with little nourishment. Hygrosopic structures allow the mites to detect and absorb any available water and even humidity. They may burrow below the beach surface and remain for an extended period of time and surface when they detect rain. At this time they may search out nutrient sources. Only one mite was identified in the samples taken. It is possible that the mite migrated via a bird or neighboring pet, or that one simply surfaced after a dry spell. This is speculation on the part of the researcher.

Amphipods or scuds are mostly marine bottom dwellers, sometimes found within soft substrate. They lie on their flattened sides and are scavengers of detritus. They feed by scraping sand grains.

Collembola are most common in interstitial littoral habitats. They are detritus feeders. They have been observed biting the lipoprotien layer of the film or bacterial populations beneath it. On the fourth abdominal segment there is a furcula, which is the insects jumping organ.

Coleoptera are the largest order of insects. 30,000 occur in the United States. They vary in length from less than a millimeter to 76 mm. Most distinctive is the structure of the wings of beetles. Most have four wings; the front wings provide a protective covering and are usually thickened and hardened, while the hind pair, covered by the front pair, are membranous and used for flight. The mandibles are well developed and used for chewing. Some beetles are predaceous and some are scavengers and they feed on all sorts of plant and animal material. Many beetles are aquatic or semi-aquatic.

Decapoda, specifically crabs, of the class crustacea, vary in aquatic habitat. Some are free-swimmers, some burrow in mud, and many are found on aquatic vegetation. The crabs dwelling onshore may be found in the detritus, often feeding. The carapace of a decapoda covers the thorax and five (5) pairs of appendages of which the first pair is claw-like. The crabs have a reduced abdomen as compared to the lobster and crayfish that share the same order.

Hemiptera are the "true" bugs. Some have a distinctive wing structure. The wings are partly thickened and partly membranous, while the hind wings are entirely membranous. The mouth parts are the piercing-sucking type. Many bugs have scent glands and give off a distinct unpleasant odor. Many are aquatic species. The bugs feed on plant juices, some are predaceous, some attack animals and man and suck their blood. A few hemiptera transmit disease.

Formicidae are present in almost every terrestrial environment. There is extensive data existing on ants, for the purpose of this report the formicidae description will be limited to the following:

The Majority of ants nest in the ground, although some are winged, not only queens, they form elaborate tunnels and chambers and broods have been observed shifting chambers as conditions change. Formicidae feed on the flesh of other animals, fungi, sap, nectar, and similar substances. Some ants bite, sting, and eject an unpleasant smelling substance. The specific species described above were selected for hypothesis testing as they are specifically terrestrial although some are winged and capable of flight.

MATRIX MODEL

In order to discuss the connectedness of the species identified from sampling the observer has organized a matrix similar to those of J.E. Cohen as cited by Frederic Briand in Ecology, 64(2), 1983, pp.253-263.

Fire Island Beach Matrix

	2	3	4	5	6	7
1	x	x	x	0	0	0
2	0	x	0	0	0	x
3	0	0	0	x	x	x
4	0	x	0	x	x	x
5	0	x	0	x	x	x
6	0	x	0	0	x	x
7	0	x	0	0	0	x

This food web matrix is indicative of feeding relationships within the beach community. The horizontal numbers identify the predators and the vertical numbers the prey or nutrient.

x indicates the column number corresponding species preys on the corresponding identity of the number of the row. 0 indicates no relationship.

- 1 organic debris, detritus
- 2 primary producers
- 3 terrestrial maritime invertebrates
- 4 plants
- 5 fish
- 6 birds
- 7 carnivores; fox, raccoons, dogs

This is a roughly constructed community, and as stated earlier the beach environment is harsh and relatively unstable. This model represents a predator-prey relationship.

This model does not factor in such variables as natural degradation and human encroachment. However, it does identify competing predators thus demand of prey, and the number of trophic interactions. If we accept the matrix as accurate, and we will, then we identify the interactions of Organic debris and primary producers; Organic debris and maritime invertebrates; Primary producers and plants; Maritime invertebrates and fish; Maritime invertebrates and birds; and Maritime invertebrates and carnivores. The competing predators appear to be the primary producers and maritime invertebrates; maritime invertebrates and plants; maritime invertebrates, fish, birds, and carnivores appear to be competing for three food sources, while maritime invertebrates, birds and carnivores compete for another food source and maritime invertebrates and carnivores compete for an additional food source. From this matrix it would appear that birds and carnivores rank high in competition. In interpreting this model it is important to recognize that we are identifying different trophic and competing trophic levels without specifying the species that are being grouped and which may not in fact be actual competitors to the other groups. For example, birds that do not fish are not in competition with other fish eaters. This would decrease the actual number of competing individuals. The accuracy of competition is low. The relatedness of invertebrates and carnivores is probably one of a parasitic or scavenger nature. For the purpose of this analyses, the observer only wishes to show relatedness of groups within the beach environment. There are a number of interactions represented within the matrix to show relatedness.

FINDINGS

Refer to the attached tables, it is apparent that some species are represented more often than others. It is further recognized that the most common occurrence of species is closest to the dune. Except for the trapping of decapoda on Lighthouse and none on Watch Hill, all identified species are represented on both beaches. It should be noted, that collembola are not truly counted. A value of 4 or 2 has been assigned since it was impossible for this observer to physically count the individuals. This number was randomly selected to make valid comparisons to other species totals.

Although volumes were not counted, the assignment of 4 and 2 should be assumed to represent a reasonable number for calculation and comparison. The largest populations according to individuals collected are the collembola and amphipods. Collections often contained both collembola and amphipods, leading the observer to suspect a relationship between the two. This relationship was not explored hypothetically or statistically. Weather conditions did not appear to have a significant affect on the populations, although rain did interrupt collections. Collections under rain, harsh winds impeded collections and individuals were disregarded. The greatest quantities of individuals, collembola and amphipods, were collected in September. As there were no collections in August to compare them to this is supposed to be the result of maturation, although no conclusive study or data is supplied here to support this supposition. Lighthouse did support a difference in collection at the dune as opposed to the high beach or high tide collections. This is depicted on the graph titled, Concentrations by dunes, high beach or high tide. The Watch Hill concentrations were not as significantly depicted, nor the actual number of individuals collected prove a significant difference. It is evident that collection of individuals was lowest at high beach for both locations.

HYPOTHESIS TESTING

Hypothesis: The species richness and abundance of Lighthouse Beach, Fire Island New York (Lighthouse) will equal those of Watch Hill Beach, Fire Island New York (Watch Hill).

Ho: $H_1 = H_2$

Null Hypothesis: The species richness and abundance of Lighthouse will not equal those of Watch Hill.

Hn: $H_1 \neq H_2$

Random sample from population of all individuals located at either Lighthouse or Watch Hill

- 1 acarina
- 2 araneae
- 3 amphipoda
- 4 decapoda
- 5 collembola *assigned values to correspond with other quantities, actual values far exceed other numbers
- 6 hemiptera
- 7 coleoptera
- 8 formicidae

	1	2	3	4	5	6	7	8	Total
Lighthouse	2	14	135	5	104	12	16	21	309
Watch Hill	1	1	112	0	104	10	7	10	245

A distribution equation will be used to describe and

summarize the observed species abundance relationship within the beach community. However, the results are of little value in determining the underlying interactions responsible for the observed abundance relationship among the species.

Diversity is dependant on not only the number of species in each collection but also on the relative abundance of each species. A community with all the species of about equal population density is more diverse than another community of the same number of species, but with some species common and others rare (as in this collection). The distribution of individuals among species is called evenness. We find a low evenness in both the Lighthouse and Watch Hill communities. Due to similar physical characteristics the researcher predicts the same low evenness for the Watch Hill community. It is understood that actual samples have already been collected to test the hypothesis. Although diversity is defined as both the number of species and the evenness of abundance, often is the observance that the number of species is a greater and more valid measure of diversity. Some statisticians say that the number of species is the only true objective measure of diversity.

The Shannon-Weaver measure of diversity assumes that a random sample is taken from an infinitely large population, and that all the species in the community population are represented in the sample. For qualifying purposes, winged arthropods other than those mentioned earlier have been excluded from calculations due to the researchers qualifying of community as those that are described as terrestrial within the community.

See attached calculations

RESULTS

$$\begin{aligned}H_1' &= .6208 \text{ natural bels} \\EH_1' &= .6095 \\varH_1' &= .0031\end{aligned}$$

$$\begin{aligned}H_2' &= .4905 \text{ natural bels} \\EH_2' &= .4762 \\varH_2' &= .0031\end{aligned}$$

Since H' has been estimated for two collections the two diversities can be compared with a t-test.

See attached calculations

The result of the t-test are the following:

$$\begin{aligned}T &= 1.656 \\df &= 549.\end{aligned}$$

According to these results, there is a much greater than 5% probability that the hypothesis has been nullified.

Therefore, H_n : $H_1 \nless H_2$

DISCUSSION

The results and hypothesis testing are filled with weaknesses. Sample collections were not consistent and did not yield a significant number of individuals to accurately perform statistical analysis. It is possible that

inappropriate equations were performed in order to test the hypothesis. This means that the equation may not have been performed as intended. Perhaps populations should have been deleted from the performance of the t-test. Perhaps there was a misinterpretation of the equations.

There were several individuals left out of the totals. These individuals were collected on the sticky sticks. The removal of the individuals from the sticks was not successful. Wings, legs, etc. were ripped from the individuals increasing the difficulty of identification. Although identifications could be made of some species, accurate counting was impossible for this observer. The only species identified off the sticks that did not appear in the bottle collections, was a hymenoptera, suspected to be a bumble bee. Another weakness is the lapse in collection from the month of August.

Although the hypothesis proved null, it is the belief of this observer that populations are consistent and that species diversity may be equal whereas species abundance may not. The only populations that are consistent are collembola, arthropoda, araneae, and decapoda. These populations although not represented significantly at Watch Hill if at all are consistent with beach habitat and species descriptions.

CONCLUSION

Long Islands Coastlines have historically been preferred nesting habitat for piping plover *C. melodus*. The past thirty (30) years of residential encroachment in conjunction with expanding marine commerce have forced species to endangered status in New York State. At the present rate of development, the continued presence of the piping plover is a bleak hope.

The root of the problem is increasing human encroachment in prime plover habitat. Elimination of human activity is impractical, but a combination of monitoring, education, and physical protection can minimize adverse impacts. Implementation of appropriate management techniques can minimize the disturbance of recreational activities, commercial activities including dredging, and even predators on the sensitive nesting sites of the Piping plover. Habitat monitoring is just one example of such a technique. We know that dredging deposits and sludge on the coast buries amphipoda and collembola and other habitat dwellers thus decreasing the available food source.

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An Introduction to Quantitative Ecology

TOTAL PER SITE

Lighthouse

LIGHTHOUSE 7/8/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA						1	5			
3	IB										
4	IC					4					
5	IIA						8				1
6	IIB							1			1
8	IIC			1		4	1		1		
9	IIIA			1							
10	IIIB		1								
11	IIIC			1							
12	IVA										
13	IVB			4					1		
14	IVC			1		4			2	1	
15	TOTAL	0	1	8	0	12	10	6	4	1	2

LIGHTHOUSE 7/13/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA	1	2					1	3		3
3	IB			1				1	3		
4	IC		1	1		4					
5	IIA						1		2		
6	IIB			1		4					
8	IIC					4			1		
9	IIIA							1	2		6
10	IIIB		1					1			
11	IIIC		1								
12	IVA								2		
13	IVB		2					1	2		
14	IVC		1			4					
15	TOTAL	1	8	3	0	16	1	5	15	0	9

LIGHTHOUSE 7/27/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA		1						1		2
3	IB			1		4				1	
4	IC			1		4					
5	IIA	1	1			4		1		1	
6	IIB		1	2			1				2
8	IIC			1		4					
9	IIIA							2	2		5
10	IIIB		2	1					1		
11	IIIC			1				2			
12	IVA								1		
13	IVB										
14	IVC										
15	TOTAL	1	5	7	0	16	1	5	5	2	9

[illegible][illegible]

LIGHTHOUSE 9/10/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA			3					1	1	
3	IB			1		4					
4	IC										
5	IIA			2		2					
6	IIB				1	2			1		
8	IIC										
9	IIIA			1		2			1		
10	IIIB			1		4			1		
11	IIIC										
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	0	8	1	14	0	0	4	1	0

LIGHTHOUSE 9/12/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA			1		2			1		
3	IB										
4	IC										
5	IIA			1					1		1
6	IIB					4					
8	IIC					4					
9	IIIA					4			1		
10	IIIB			1		4			2		
11	IIIC					2			1		
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	0	3	0	20	0	0	6	0	1

LIGHTHOUSE 9/14/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA										
3	IB			13					12		
4	IC										
5	IIA			17					10		
6	IIB			3	1	4			1		
8	IIC			3		2					
9	IIIA			1		2			4		
10	IIIB				1	2			1		
11	IIIC				2	4					
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	0	37	4	14	0	0	28	0	0

LIGHTHOUSE 9/16/93

1	A	B	C	D	E	F	G	H	I	J	K
	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA			30					7		
3	IB										
4	IC										
5	IIA			16					7		
6	IIB			2		2			2		
8	IIC			1		2					
9	IIIA			15					13		
10	IIIB			5		4			1		
11	IIIC										
12	IVA								1		
13	IVB										
14	IVC					4					
15	TOTAL	0	0	69	0	12	0	0	31	0	0

TOTAL PER SITE

Watch Hill

WATCH HILL 6/18/93

1	A	B	C	D	E	F	G	H	I	J	K
	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	T1 = IA			2				1	1		1
3	T2 = IB			1		4					
4	T3 = IC										
5	T4 = IIA					4			2		6
6	T5 = IIB					4					
8	T6 = IIC					4					
9	IIIA										
10	IIIB										
11	IIIC										
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	0	3	0	12	0	1	3	0	7

WATCH HILL 7/13/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA II	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA					2					
3	IB							1	4		
4	IC					4		1	1		
5	IIA							1	3		1
6	IIB								1		
8	IIC					4			2		
9	IIIA					2		1			
10	IIIB					4					
11	IIIC		1					1	1		
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	1	0	0	16	0	5	12	0	1

WATCH HILL 8/9/93

[illegible]

WATCH HILL 9/10/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA II	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA										
3	IB			7		4			28		
4	IC										
5	IIA										
6	IIB					4					
8	IIC										
9	IIIA			1		4					
10	IIIB										
11	IIIC										
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	0	8	0	12	0	0	28	0	0

WATCH HILL 9/12/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA			1		2			1	4	
3	IB								1		
4	IC			1							
5	IIA					4					
6	IIB					4			4		
8	IIC			2		4		1			
9	IIIA					4			2		
10	IIIB					4					
11	IIIC					4					
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	0	4	0	26	0	1	8	4	0

WATCH HILL 9/14/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA II	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA			8		2			4		
3	IB										
4	IC	1		25					5		
5	IIA					4					
6	IIB					4			1		
8	IIC			1		4			1		
9	IIIA			6		4			2		
10	IIIB			1		4					
11	IIIC					4					
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	1	0	41	0	26	0	0	13	0	0

WATCH HILL 9/16/93

1	A	B	C	D	E	F	G	H	I	J	K
	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA			13					12		
3	IB			3		4					
4	IC			18		4			4		2
5	IIA										
6	IIB			3					3		
8	IIC			1		4					
9	IIIA			18					6		
10	IIIB										
11	IIIC										
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	0	56	0	12	0	0	25	0	2

TOTALS PER EVENT

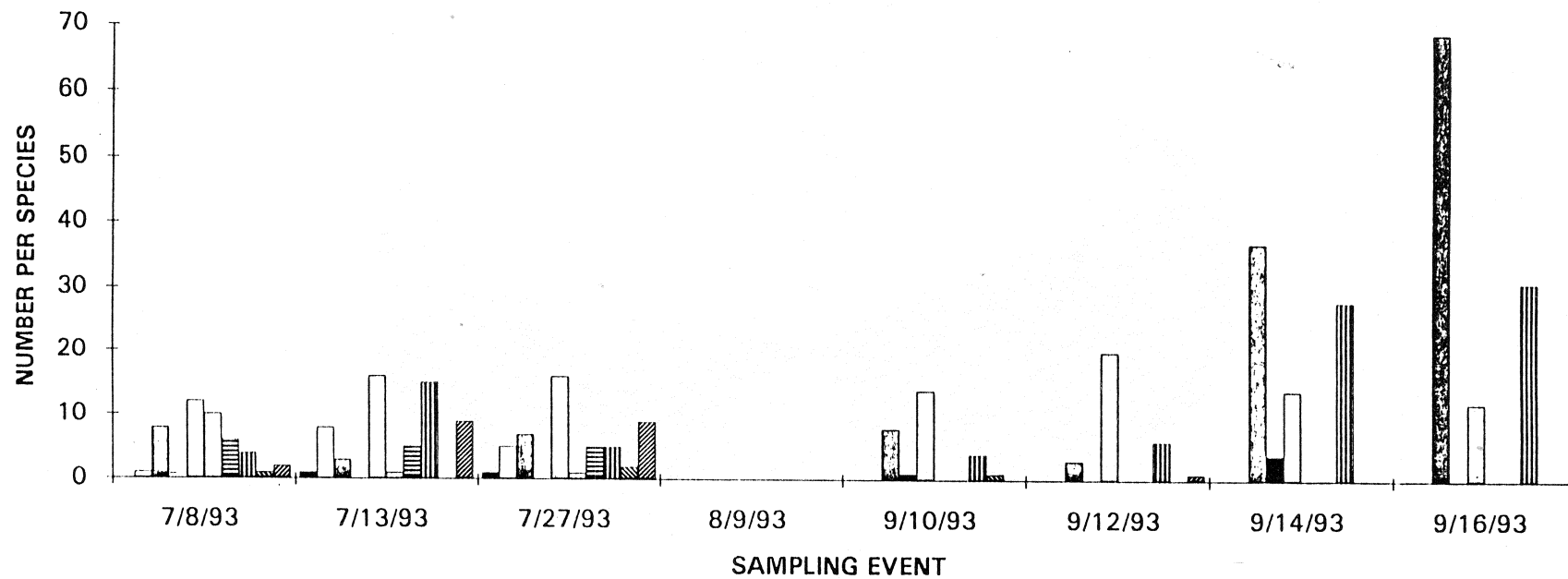
Lighthouse

Lighthouse Beach, Fire Island

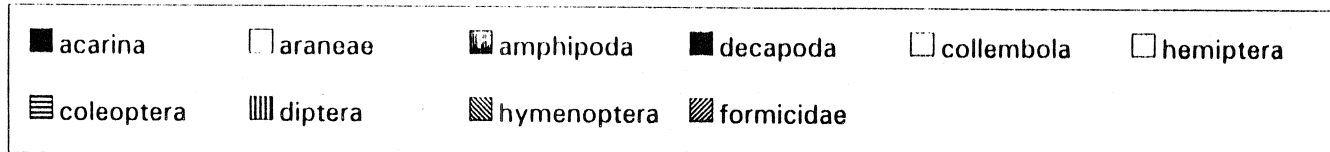
Dates	acarina	araneae	amphipoda	decapoda	collembola	hemiptera	coleoptera	diptera	hymenoptera	formicidae	TOTAL
7/8/93	0	1	8	0	12	10	6	4	1	2	44
7/13/93	1	8	3	0	16	1	5	15	0	9	58
7/27/93	1	5	7	0	16	1	5	5	2	9	51
8/9/93	0	0	0	0	0	0	0	0	0	0	0
9/10/93	0	0	8	1	14	0	0	4	1	0	28
9/12/93	0	0	3	0	20	0	0	6	0	1	30
9/14/93	0	0	37	4	14	0	0	28	0	0	83
9/16/93	0	0	69	0	12	0	0	31	0	0	112
Totals	2	14	135	5	104	12	16	93	4	21	406

NOTE: A VALUE OF 4 PER 100 COLLEMBOLA HAS BEEN ASSIGNED TO MAKE VALID COMPARISONS TO TTHR SPECIES.

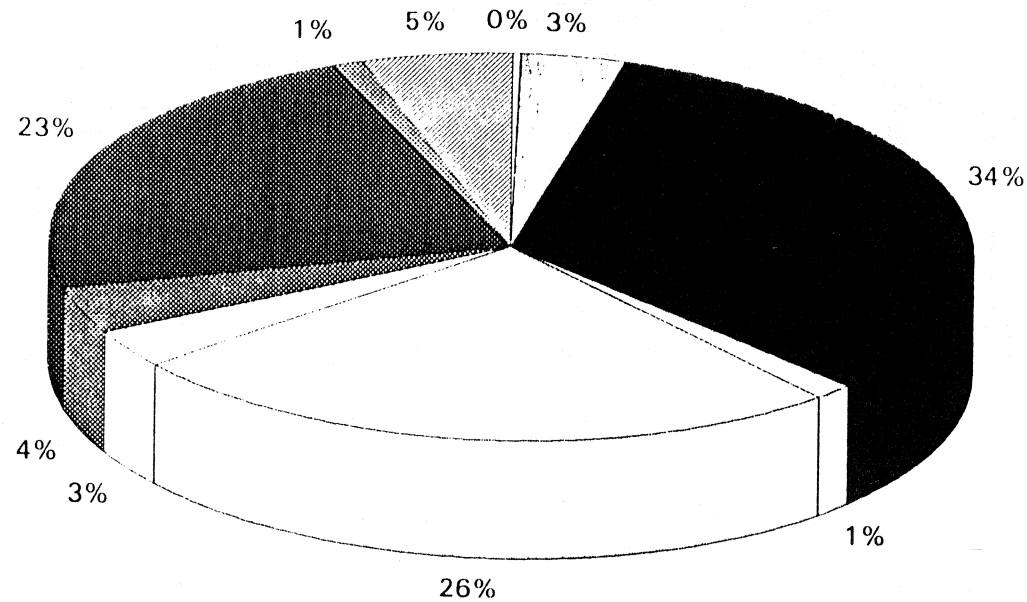
LIGHTHOUSE



KEY



LIGHTHOUSE



KEY

☐ Acarina	☐ Araneae	☐ Amphipoda	☐ Decapoda	☐ Collembola	☐ Hemiptera	☐ Coleoptera	☐ Diptera
☐ Hymenoptera	☐ Formicidae						

TOTALS PER EVENT

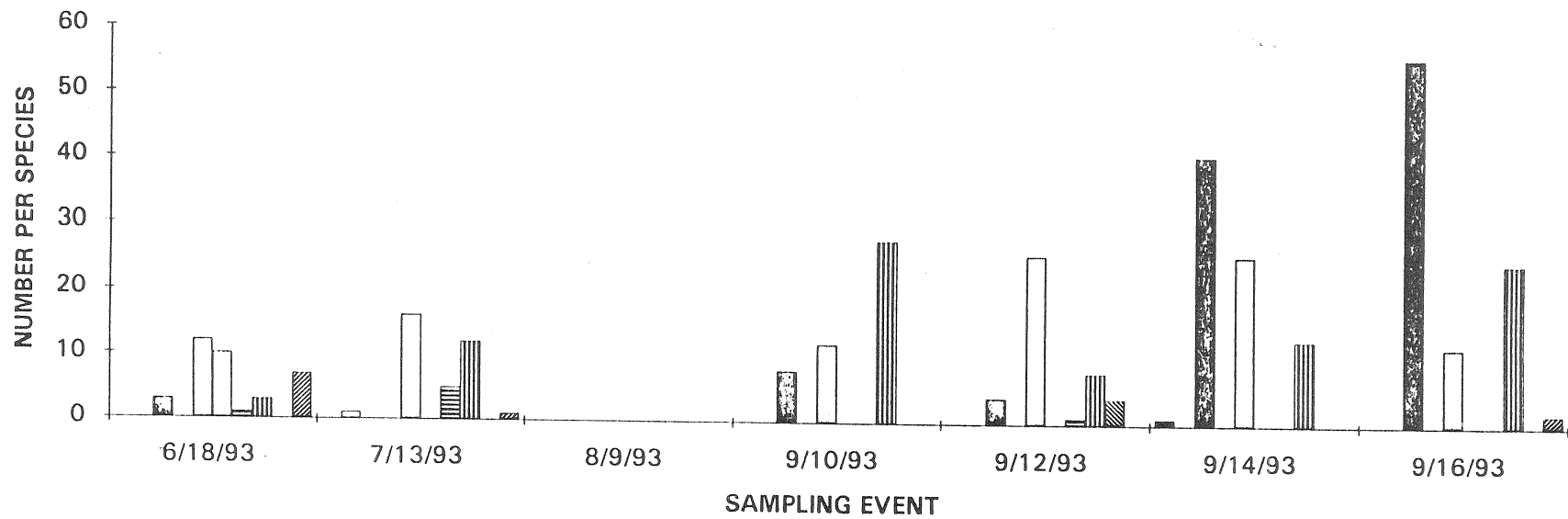
Watch Hill

Watch Hill Beach, Fire Island

Dates	acarina	araneae	amphipoda	decapoda	collembola	hemiptera	coleoptera	diptera	hymenoptera	formicidae	TOTAL
6/18/93	0	0	3	0	12	10	1	3	0	7	36
7/13/93	0	1	0	0	16	0	5	12	0	1	35
8/9/93	0	0	0	0	0	0	0	0	0	0	0
9/10/93	0	0	8	0	12	0	0	28	0	0	48
9/12/93	0	0	4	0	26	0	1	8	4	0	43
9/14/93	1	0	41	0	26	0	0	13	0	0	81
9/16/93	0	0	56	0	12	0	0	25	0	2	95
Totals	1	1	112	0	104	10	7	89	4	10	338

NOTE: A VALUE OF 4 PER 100 COLLEMBOLA HAS BEEN ASSIGNED TO MAKE VALID COMPARISONS TO OTHER SPECIES.

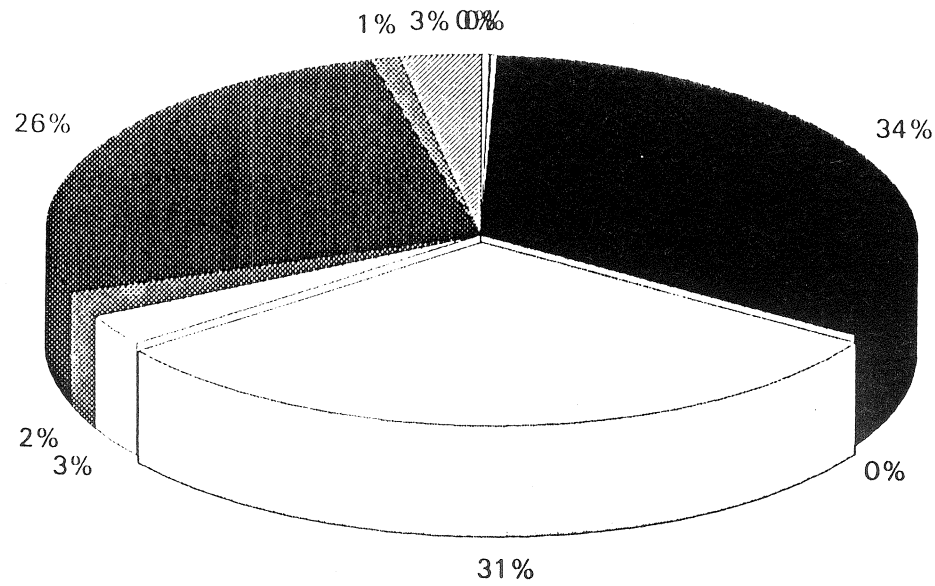
WATCH HILL



KEY



WATCH HILL



KEY

☐ Acarina	☒ Araneae	☒ Amphipoda	☐ Decapoda	☐ Collembola	☐ Hemiptera
☒ Coleoptera	☒ Diptera	☒ Hymenoptera	☒ Formicidae		

CALCULATIONS

Hypothesis Testing

$$H' = - \sum_{i=1}^S p_i \log p_i$$

S = number of known species

p_i = proportion of the total number of individuals consisting of the i th species

$$\text{acarina } H'_1 = - \frac{2}{309} \log \frac{2}{309} = (.00647 \log .00647) = .0142$$

$$= 0.0142$$

$$\text{craneae } H'_1 = - \frac{14}{309} \log \frac{14}{309} = (.045 \log .045) = 0.0604$$

$$\text{amphipod } H'_1 = - \frac{135}{309} \log \frac{135}{309} = (.437 \log .437) = .1572$$

$$\text{decapoda } H'_1 = - \frac{5}{309} \log \frac{5}{309} = (.0162 \log .0162) = .0290$$

$$\text{cellembula } H'_1 = - \frac{104}{309} \log \frac{104}{309} = (.336 \log .336) = .1592$$

$$\text{hemiptera } H'_1 = - \frac{12}{309} \log \frac{12}{309} = (.0383 \log .0383) = .0548$$

$$\text{coleoptera } H'_1 = - \frac{16}{309} \log \frac{16}{309} = (.0518 \log .0518) = .0666$$

$$\text{formicidae } H'_1 = - \frac{21}{309} \log \frac{21}{309} = (.0680 \log .0680) = .0794$$

$$\boxed{\text{estimated } H'} = \left[- \sum p_i \log p_i \right] = \left[\frac{S-1}{2N} \right] + \left[\frac{1 - \sum p_i^{i-1}}{12N^2} \right] + \left[\frac{p_i^{i-1} + p_i^{i-2}}{12N^3} \right] + \dots$$

$$\sum H' = \frac{.6208 - (8-1)}{2(309)} = \frac{\sum H' = .6208 - 7/618}{2(309)} \approx .6095$$

natural log's

ln H₁₁

$$H'_2 = - \sum_{i=1}^s p_i \log p_i$$

$$\begin{aligned} \text{acarina} \quad H'_2 &= - \frac{1}{245} \log \frac{1}{245} = .0098 \\ \text{araneae} \quad H'_2 &= - \frac{1}{245} \log \frac{1}{245} = .0098 \\ \text{amphipoda} \quad H'_2 &= - \frac{112}{245} \log \frac{112}{245} = .1554 \\ \text{collembola} \quad H'_2 &= - \frac{104}{245} \log \frac{104}{245} = .1580 \\ \text{hemiptera} \quad H'_2 &= - \frac{10}{245} \log \frac{10}{245} = .0567 \\ \text{coleoptera} \quad H'_2 &= - \frac{7}{245} \log \frac{7}{245} = .0441 \\ \text{formicidae} \quad H'_2 &= - \frac{10}{245} \log \frac{10}{245} = .1581 \end{aligned}$$

$$H'_2 = .4905 \text{ natural uels}$$

$$\begin{aligned} \sum H'_2 &= \left[- \sum p_i \log p_i \right] - \left[\frac{s-1}{2N} \right] + \left[\frac{1 - \sum p_i^{-1}}{12N^2} \right] + \left[\frac{p_i^{-1} + p_i^{-2}}{12N^3} \right] + \dots \\ \sum H'_2 &= .4905 - \left[\frac{7-1}{2 \cdot 245} \right] \approx .4762 \text{ natural uels} \end{aligned}$$

Variance

$$\text{Var}(H'_1) = \left[\sum_{i=1}^s p_i \log^2 p_i \right] - \left[\sum_{i=1}^s p_i \log p_i \right]^2 + \left[\frac{s-1}{2N^2} \right] + \dots$$

* only first two terms used, other terms produce negligible #s.

$$\begin{aligned} & \left[(.0065 \ln^2 .0065) + (.0453 \ln^2 .0453) + (.4369 \ln^2 .4369) + (.0162 \ln^2 .0162) + (.3366 \ln^2 .3366) \right. \\ & \left. + (.0388 \ln^2 .0388) + (.0518 \ln^2 .0518) + (.0680 \ln^2 .0680) \right] - \left[(.0065 \ln .0065) + (.0453 \ln .0453) + (.4369 \ln .4369) + (.0162 \ln .0162) + (.3366 \ln .3366) + (.0388 \ln .0388) + (.0518 \ln .0518) + (.0680 \ln .0680) \right]^2 \div 309 \end{aligned}$$

$$\begin{aligned} \text{Var}(H'_1) &= \left[.1651 + .4337 + .2996 + .2755 + .3991 + .4091 + .4541 + .4916 \right] - \left[.0327 + .1422 + .3618 + .0668 + .3383 + .1241 + .1533 + .1826 \right]^2 / 309 \\ &= 2.928 - 1.966 \end{aligned}$$

$$\text{Var } H'_1 = \frac{2.928 - 1.966}{309} = .0031 \text{ variance}$$

Wald-Hill $\text{Var } H'_2 = [.0040 \ln^2 \pi + .0040 \ln^2 \pi + .4571 \ln^2 \pi + .4244 \ln^2 \pi + .0408 \ln^2 \pi + .0286 \ln^2 \pi + .0408 \ln^2 \pi] - [.0040 \ln \pi + .0040 \ln \pi + .4571 \ln \pi + .4244 \ln \pi + .0408 \ln \pi + .0286 \ln \pi]^2 \div 245$

$$\text{Var } H'_2 = [.1219 + .1219 + .2801 + .3118 + .4176 + .3613 + .4176] - [.6221 + .0221 + .3578 + .3637 + .1305 + .1017 + .1305] \div 245$$

$$\text{Var } H'_2 = \frac{2.0322 - 1.2733}{245} = \frac{.7589}{245} \approx .0031$$

Variance $H'_2 = .0031$

H'	$L = H'_1$	$W = H'_2$
H'_1	.6208	.4905
H'_2	.6095	.4762
$\text{Var } H'$	.0031	.0031

t-test

$$t = \frac{H'_1 - H'_2}{\left[\frac{\text{Var}(H'_1) + \text{Var}(H'_2)}{2} \right]^{1/2}} = \frac{.6208 - .4905}{\left(\frac{.0031 + .0031}{2} \right)^{1/2}} =$$

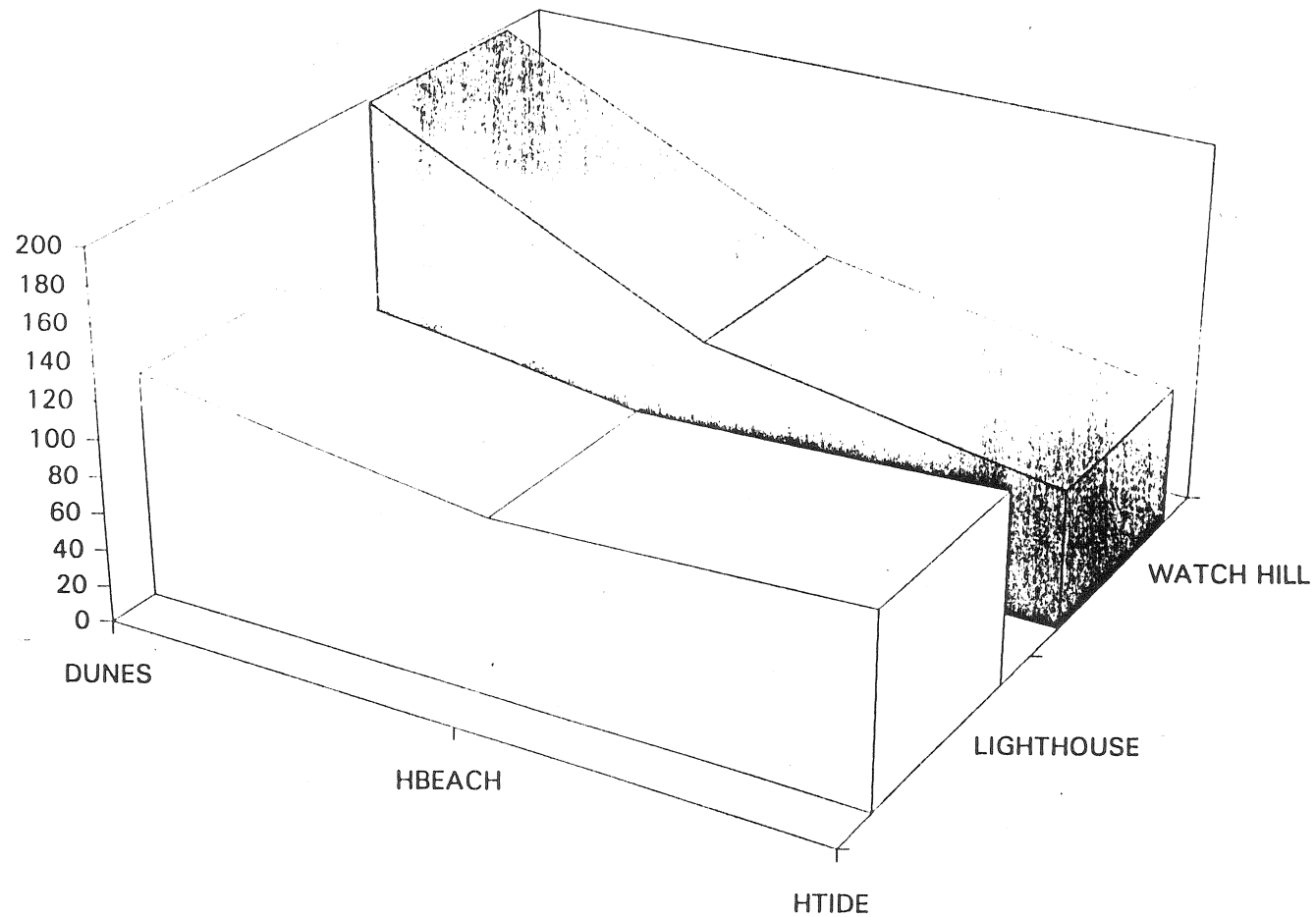
$$\frac{.1303}{\sqrt{.0062}} = \frac{.1303}{.0787} = 1.656$$

$$df = \frac{\frac{\text{Var}(H'_1) + \text{Var}(H'_2)}{2}}{\frac{\text{Var}(H'_1)^2 + \text{Var}(H'_2)^2}{N_1^2 + N_2^2}} = \frac{[.0031 + .0031] \div 2}{\frac{.0031^2}{309} + \frac{.0031^2}{24500000070}} = \frac{.000384}{\frac{.00000071}{309} + \frac{7.0 \times 10^{-08}}{24500000070}} = \frac{.00000031 + .00000035}{.000000070} = \frac{.00000066}{.000000070} = 549.0$$

550 degrees of freedom

CONCENTRATIONS

CONCENTRATIONS BY DUNES, HIGH BEACH OR HIGH TIDE



Note: individuals limited to those found within the permanent sampling columns I, II, III.

SAMPLING EVENT TOTALS BY COLUMNS AND PROXIMITY-dunes, high beach, high tide

WH 6/18/93	I	II	III	TOTAL		LH 7/8/93	I	II	III	TOTAL
DUNES (A)	5	4	0	9		DUNES (A)	6	9	1	16
HBEACH (B)	5	4	0	9		HBEACH (B)	0	2	1	3
HTIDE (C)	8	0	0	8		HTIDE (C)	4	7	1	12
WH 7/13/93	I	II	III	TOTAL		LH 7/13/93	I	II	III	TOTAL
DUNES (A)	2	5	3	10		DUNES (A)	10	3	9	22
HBEACH (B)	5	1	2	8		HBEACH (B)	5	5	2	12
HTIDE (C)	4	4	3	11		HTIDE (C)	6	5	1	12
WH 9/10/93	I	II	III	TOTAL		LH 7/27/93	I	II	III	TOTAL
DUNES (A)	0	0	5	5		DUNES (A)	4	8	9	21
HBEACH (B)	39	4	0	43		HBEACH (B)	6	6	4	16
HTIDE (C)	0	0	0	0		HTIDE (C)	5	5	3	13
WH 9/12/93	I	II	III	TOTAL		LH 9/10/93	I	II	III	TOTAL
DUNES (A)	8	4	6	18		DUNES (A)	5	0	0	5
HBEACH (B)	1	8	4	13		HBEACH (B)	5	4	4	13
HTIDE (C)	1	7	4	12		HTIDE (C)	0	4	6	10
WH 9/14/93	I	II	III	TOTAL		LH 9/12/93	I	II	III	TOTAL
DUNES (A)	14	4	12	30		DUNES (A)	4	3	5	12
HBEACH (B)	0	5	5	10		HBEACH (B)	0	4	7	11
HTIDE (C)	31	6	4	41		HTIDE (C)	0	4	3	7
WH 9/16/93	I	II	III	TOTAL		LH 9/14/93	I	II	III	TOTAL
DUNES (A)	25	0	24	49		DUNES (A)	0	27	7	34
HBEACH (B)	7	6	0	13		HBEACH (B)	25	7	4	36
HTIDE (C)	28	5	0	33		HTIDE (C)	0	7	6	13
	I	II	III	TOTAL		LH 9/16/93	I	II	III	TOTAL
DUNES (A)	5	4	0	9		DUNES (A)	37	23	28	88
HBEACH (B)	5	4	0	9		HBEACH (B)	0	6	10	16
HTIDE (C)	8	0	0	8		HTIDE (C)	0	5	4	9

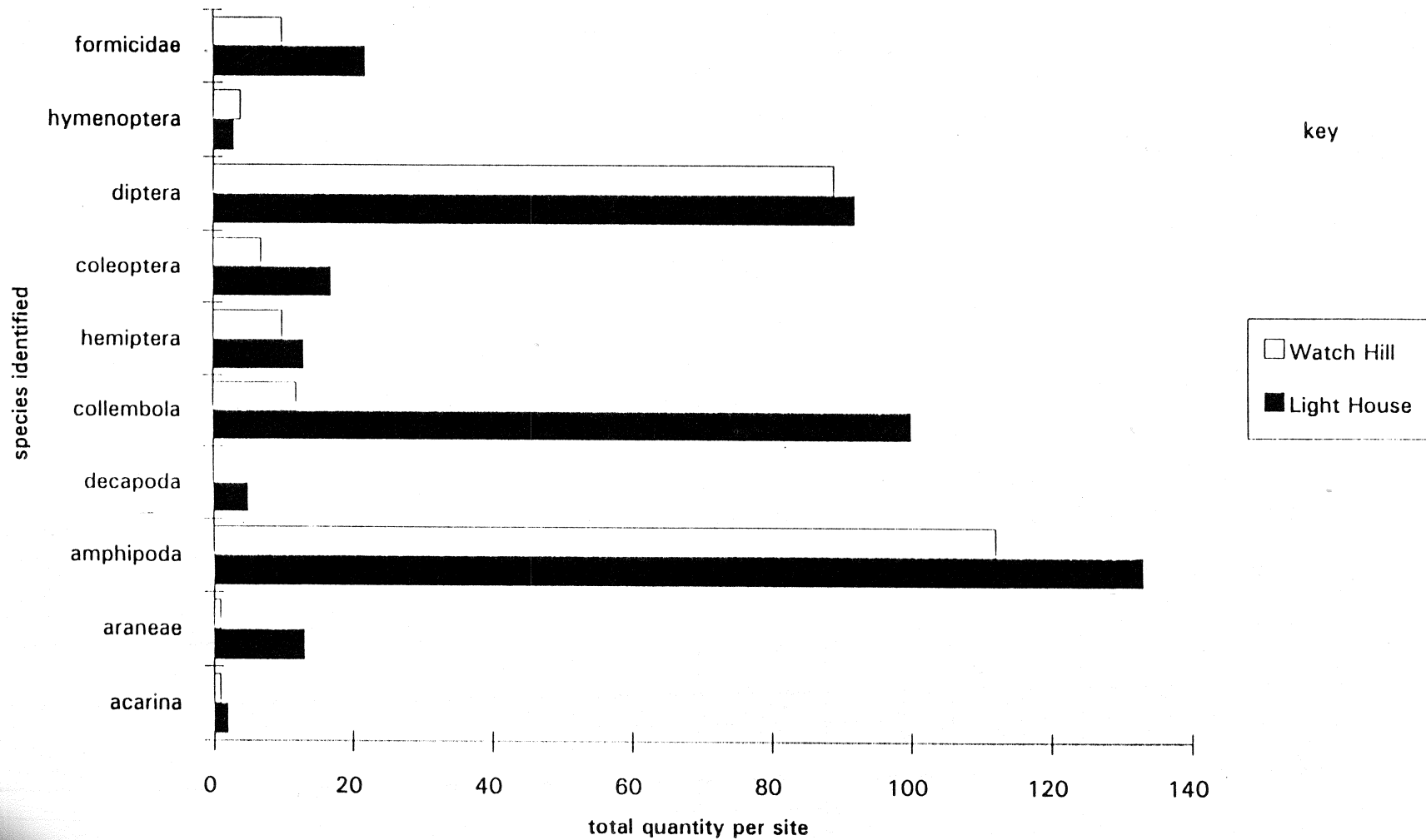
Individuals limited to those found within the permanent sampling columns I, II, III

COMPARISONS

Lighthouse vs. Watch Hill

Lighthouse vs Watch Hill per Species

WH VS LH	acarina	araneae	amphipoda	decapoda	collembola	hemiptera	coleoptera	diptera	hymenoptera	formicidae	total
Light House	2	13	133	5	100	13	17	92	3	22	400
Watch Hill	1	1	112	0	12	10	7	89	4	10	246



AVERAGES

Average per spec	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Formicidae	
LIGHTHOUSE	0.29	2	19.2	0.71	14.8	1.7	2.28	3	
WATCH HILL	0.17	0.17	18.7	0	17.3	1.2	1.16	1.66	
	Light house	Watch Hill							
Species	10	9							
Total individuals	409	246							
Avg per event	58	41							
Total events	7	6							

TOTAL PER SITE

Lighthouse

LIGHTHOUSE 7/8/93

1	A	B	C	D	E	F	G	H	I	J	K
	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA						1	5			
3	IB										
4	IC					4					
5	IIA						8				1
6	IIB							1			1
8	IIC			1		4	1		1		.
9	IIIA			1							
10	IIIB		1								
11	IIIC			1							
12	IVA										
13	IVB			4					1		
14	IVC			1		4			2	1	
15	TOTAL	0	1	8	0	12	10	6	4	1	2

LIGHTHOUSE 7/13/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA	1	2					1	3		3
3	IB			1				1	3		
4	IC		1	1		4					
5	IIA						1		2		
6	IIB			1		4					
8	IIC					4			1		
9	IIIA							1	2		6
10	IIIB		1					1			
11	IIIC		1								
12	IVA								2		
13	IVB		2					1	2		
14	IVC		1			4					
15	TOTAL	1	8	3	0	16	1	5	15	0	9

LIGHTHOUSE 7/27/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA		1						1		2
3	IB			1		4				1	
4	IC			1		4					
5	IIA	1	1			4		1		1	
6	IIB		1	2			1				2
8	IIC			1		4					
9	IIIA							2	2		5
10	IIIB		2	1					1		
11	IIIC			1				2			
12	IVA								1		
13	IVB										
14	IVC										
15	TOTAL	1	5	7	0	16	1	5	5	2	9

LIGHTHOUSE 8/9/93

[illegible]

LIGHTHOUSE 9/10/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA			3					1	1	
3	IB			1		4					
4	IC										
5	IIA			2		2					
6	IIB				1	2			1		
8	IIC										
9	IIIA			1		2			1		
10	IIIB			1		4			1		
11	IIIC										
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	0	8	1	14	0	0	4	1	0

LIGHTHOUSE 9/12/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA			1		2			1		
3	IB										
4	IC										
5	IIA			1					1		1
6	IIB					4					
8	IIC					4					
9	IIIA					4			1		
10	IIIB			1		4			2		
11	IIIC					2			1		
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	0	3	0	20	0	0	6	0	1

LIGHTHOUSE 9/14/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA										
3	IB			13					12		
4	IC										
5	IIA			17					10		
6	IIB			3	1	4			1		
8	IIC			3		2					
9	IIIA			1		2			4		
10	IIIB				1	2			1		
11	IIIC				2	4					
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	0	37	4	14	0	0	28	0	0

LIGHTHOUSE 9/16/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA			30					7		
3	IB										
4	IC										
5	IIA			16					7		
6	IIB			2		2			2		
8	IIC			1		2					
9	IIIA			15					13		
10	IIIB			5		4			1		
11	IIIC										
12	IVA								1		
13	IVB										
14	IVC					4					
15	TOTAL	0	0	69	0	12	0	0	31	0	0

TOTAL PER SITE

Watch Hill

WATCH HILL 6/18/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	T1 = IA			2				1	1		1
3	T2 = IB			1		4					
4	T3 = IC								2		6
5	T4 = IIA					4					
6	T5 = IIB					4					
8	T6 = IIC										
9	IIIA										
10	IIIB										
11	IIIC										
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	0	3	0	12	0	1	3	0	7

WATCH HILL 7/13/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA II	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA					2					
3	IB							1	4		
4	IC					4		1	1		
5	IIA							1	3		1
6	IIB								1		
8	IIC					4			2		
9	IIIA					2		1			
10	IIIB					4					
11	IIIC		1					1	1		
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	1	0	0	16	0	5	12	0	1

WATCH HILL 8/9/93

[illegible]

WATCH HILL 9/10/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA II	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA										
3	IB			7		4			28		
4	IC										
5	IIA										
6	IIB					4					
8	IIC										
9	IIIA			1		4					
10	IIIB										
11	IIIC										
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	0	8	0	12	0	0	28	0	0

WATCH HILL 9/12/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA I	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA			1		2			1	4	
3	IB								1		
4	IC			1							
5	IIA					4					
6	IIB					4			4		
8	IIC			2		4		1			
9	IIIA					4			2		
10	IIIB					4					
11	IIIC					4					
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	0	0	4	0	26	0	1	8	4	0

WATCH HILL 9/14/93

	A	B	C	D	E	F	G	H	I	J	K
1	AREA II	Acarina	Araneae	Amphipoda	Decapoda	Collembola	Hemiptera	Coleoptera	Diptera	Hymenoptera	Formicidae
2	IA			8		2			4		
3	IB										
4	IC	1		25					5		
5	IIA					4					
6	IIB					4			1		
8	IIC			1		4			1		
9	IIIA			6		4			2		
10	IIIB			1		4					
11	IIIC					4					
12	IVA										
13	IVB										
14	IVC										
15	TOTAL	1	0	41	0	26	0	0	13	0	0

WATCH HILL 9/16/93

1	AREA I	A	B	C	D	E	F	G	H	I	J	K
2	IA				13					12		
3	IB				3		4					
4	IC				18		4			4		2
5	IIA											
6	IIB				3					3		
8	IIC				1		4					
9	IIIA				18					6		
10	IIIB											
11	IIIC											
12	IVA											
13	IVB											
14	IVC											
15	TOTAL	0	0	0	56	0	12	0	0	25	0	2