# The Ecology of the Japanese Shore Crab (*Hemigrapsus* sanguineus de Haan) and its niche relationship to the Green Crab (*Carcinus maenas*) along the Coast of Connecticut, U.S.A.

**Tara Casanova**
**Southern Connecticut State University**
**Biology Department**
**New Haven, Connecticut**

## Abstract

The Japanese Shore Crab (*Hemigrapsus sanguineus* de Haan) was first introduced to Atlantic waters on September 24, 1988. Since then, *Hemigrapsus sanguineus* has spread at an alarming rate and has become well established on the Atlantic coast. It's affect on and possible distribution competition with the native crab species is unknown. This study will focus the relative abundance distribution and population density of *Hemigrapsus sanguineus* at two study sites on the Connecticut shoreline. Habitat selectivity concerning rock size and crab class size correlation will be studied as well.

## Introduction

The intentional or accidental introduction of exotic species into North America is a great threat to the integrity of natural communities of plants and animals and to the preservation of endangered species (Carlton 1995). Most studies of exotic introduction have focused on terrestrial and fresh water systems where one or a few successful exotic species have had a catastrophic effect on native species (Carlton and Geller 1993). The effects of exotic species in marine systems have not been as well studied but are of such a magnitude that they may well be leading to profound ecological changes in the structure ocean communities (Carlton and Gelleer 1993). Quantitative studies that document the effect of marine invasions on resident communities, using experiments and long term data to distinguish effects of introductions are rare (Grosholz and Ruiz 1995).

The lack of data on the effect of marine exotic species is somewhat surprising considering the potential for the movement of marine species beyond their natural range. Many marine species have highly mobile larvae that are tolerant of a wide range of environmental conditions. Most marine habitats have rich zoo-plankton assemblages rich in their highly mobile larval form. These larvae are commonly taken up in ballast water used in most cargo ships and easily transported from port to port around continents and across the oceans.

Long Island Sound has a long history of maritime commerce and it is likely that it's species composition changes yearly because of the release of exotic species that are taken up in this manner. There are more species in Long Island Sound this year than last. The same is very likely true for most estuaries, ports and harbors around the country and around the world who support maritime commerce that brings ocean-going ships loaded with plankton-rich ballast water from a foreign port (Carlton 1985). New Species to American waters have become established because of ballast water release (e.g. Zebra mussel), and it appears that these numbers are steadily growing. Every hour an average of more than 2 million gallons of ballast water rich in foreign plankton are released in U.S waters (Carlton *et al.* 1995). This is the method by which the non-indigenous Japanese Shore Crab *Hemigrapsus sanguineus* de Haan was believed to have been introduced to the east coast of North America.

The Japanese Shore Crab *Hemigrapsus sanguineus* is now well established and rapidly expanding it's range along the Atlantic coast of the United States from Chesapeake Bay to Cape Cod (Carlton 1995). *Hemigrapsus sanguineus* was first recorded in the United States on 24 September 1988 during an invertebrate biology course field trip at Townsends Inlet, Cape May County, New Jersey [39° 07'06''N 70° 43'00"W] (Williams and McDermott 1990). Twenty months later (28 May 1990) an immature female [carapace width (CW) x carapace length (CL) = 12.8 x 10.8 mm] was recovered (McDermott 1991). This second finding suggested that the first record of the species in New Jersey was representative of a population established in U.S. waters. This discovery provides a unique opportunity to document a major introduction to U.S. waters (McDermott 1991).

*Hemigrapsus sanguineus* is now extremely abundant on the Connecticut coastline. *H. sanguineus* is thought to exploit the different but overlapping habitats on cobble and boulder shores in rocky intertidal habitats (Fukui 1988). In areas where *Carcinus maenas* (the native Green Crab), used to be abundant *H. sanguineus* is the dominant species and few *Carcinus maenas* are found. Changes in abundance may be the result of inter-specific competition between the two species for food and/or habitat

The focus of this study is to determine the relative abundance of *H.sanguineus* at two specific sites on the Connecticut coastline: Outer Island, Stony Creek, Connecticut. and Hammonasset State Park in Madison, and the possible inter-specific competition between *H. sanguineous* and *C. maenas* by studying their population density and distribution along the rocky inter-tidal zone.

**Study Sites**

Two study sites were selected based on their central locality along the Connecticut shore and their large percentage of rocky inter-tidal shoreline, which *Carcinus maenas* and *Hemigrapsus sanguineus* seem to prefer (Map 1). The first site will be located on Outer Island which is the southernmost island of the Thimble islands located in Stony Creek, Connecticut (Map 2). The island is approximately 5km$^2$ located in central Long Island Sound and has been extensively used for field studies (The Center for Education and Research at Outer Island 1995) (Map 3).

The second site will be located in Hammonasset State Park in Madison, Connecticut (Map 4) The park contains approximately 900 km$^2$ of varying marine habitats. Meig's point at the eastern tip of the park, is a classic rocky inter-tidal habitat with a variety of cobble and boulder substrate (Map 5).

**Methods**

Three linear transects were laid out at each sampling site delineating each tidal zone: the high inter-tidal zone, middle inter-tidal zone and low inter-tidal zone. Each transect ran parallel to the water line. Both at Outer Island and Hammonasset State Park each transect was divided into quadrants measuring 1m x 1m (Fig.-3&4).

At Outer Island the rock sizes along each transect were congruent enough to place each sampling area (quadrant) at 6m intervals (incorporating the 1m taken up by each of the five quadrants). The full sampling area at Outer Island was one congruent niche habitat. At Outer Island each transect measured a distance of 30m. Each quadrant at Outer Island in the high inter-tidal zone was designated as H1-H5 respectively. Each quadrant in the middle inter-tidal zone was designated M1-M5 respectively; and each low inter-tidal quadrant was designated L1-L5 respectively. There were a total of 15 stations (quadrants) at Outer Island (Figure 3).

At Hammonasset each transect measured a distance of 60 meters. Each quadrant at Hammonasset State Park in the high inter-tidal zone was designated as H1-H10 respectively. Each quadrant in the middle inter-tidal zone was designated M1-M10 respectively; and each low inter-tidal quadrant was designated L1-L10 respectively. There were a total of 30 stations (quadrants) at Hammonasset State Park.
Quadrant placing was calculated through the measurement of rock sizes along each transect. This was necessary for the rock area along each 60m for each zone was not congruent therefore creating different niche habitats for each collective rock grouping along the transect. Each individual rock grouping was measured for distance in meters and calculated for the amount of transect space that it occupied. After the distance for each rock grouping was calculated along each transect, individual rocks for each grouping were measured and the average rock size was calculated for each niche habitat. This was significant to measure possible rock size/crab size class correlation's within the rocky inter-tidal zones.

The location of these stations were marked with stakes and by marking specific boulders with paint. Pictures of the boulder arrangement were taken at the beginning of each sampling period to account for possible movements of the boulders (Appendix 1). Five plots at each station were randomly for each sampling period at Hammonasset State Park, where at Outer Island each quadrant was sampled at each sampling period.

Sampling at each station was conducted where all the boulders within the quadrant to the underlying gravel within a depth of approximately 5 cm. were turned over to hand capture both *Hemigrapsus sanguineus* and other native crab species including *Carcinus maenas*. After sampling, boulders and cobbles were piled up again as before. The underlying gravel was noted as well. Crabs were placed in labeled jars upon capture brought back to the lab and preserved in a 10% formalin solution until analyzed. The abundance for each species recovered from each quadrant was determined.

Each crab species was identified and measured to the nearest 0.1mm with Vernier calipers. Each crab species was recorded in relative size categories: less than 9mm were considered juveniles, 9.1mm-18.0mm – small, and 18.1+mm – large. Crabs were then sexed and ovigerous females were determined. Population density and distribution as well as niche selection (correlation with rock size) was determined.

Initially quadrants were to be sampled at both high and low tide. Sampling the high tide would have been done through the use of S.C.U.B.A., upon initiating these methods it was deemed unsafe therefore the quadrants were sampled only during an outgoing tide.

## Results

### Outer Island

At Outer Island results of the data set for 8/21/98 seemed to show a shift from the largest density of Japanese Shore Crabs at both the mid tidal and low tidal zones; where the highest numbers were found at the first quadrant then sloping somewhat steadily to the 5th quadrant. (Chart 4) Both the mid tide and low tide numbers were remarkably similar and of high densities where the high tidal zone had substantially fewer numbers. However, the data set from 10/18/98 shows a change from the highest density of crabs at only the mid tide area at a substantial difference from the other tidal zones which increased since August. The high tidal zone increased in number and the low tidal zone decreased in number (Chart 15). The reason for this could be that in October the waters cool to a temperature that is unfavorable to *Hemigrapsus sanguineus* therefore the crabs moved to a higher tidal zone. This is based upon only one year's data. Further studies would need to be carried out to conclude this.

Green crabs were only found at Outer Island (Table 2 and Table 5). On 8/21/98 Green Crabs were found at both the mid and low tidal zones (Charts 5,6, &7). These numbers were extremely low: only 9 at mid tide and 3 at low tide (Table 2). On 10/18/98 Green crabs were found only at the mid tidal zone and in even fewer numbers: 4 at M5 (Chart 16). Again the reason for this could be water temperature.

The comparison between the density of Green Crabs at each site for each sample period is almost non-existent (Charts 8-11 & Charts 17-20). This demonstrates the extreme inter-specific competition between Japanese Shore crabs and Green crabs at this Study Site (Outer Island). Further studies need to be done to determine the nature of this competition.

Size class distribution for *Hemigrapsus sanguineus* varied at Outer Island between sampling periods as well. Male crabs within the size class 0-9mm. were at their highest concentration at the mid tide for both sampling dates. They were also found in great densities although not as high as the mid tidal range at the low tidal zone for each sampling period. Their numbers although low for both sampling periods in the high tidal zone did increase slightly from the August sample set to the October sample set (Charts 21&22). Females in the same class size were found in substantially low numbers (Tables 7&8) for both sampling periods with no significant differences between data sets. Both male and female crabs within the medium size class range (9.1-18.0mm.) were abundant at the mid and low tidal range in August but their numbers decreased almost by half in October and increased slightly in the high tidal zone. Very few larger crabs were found for either sample set and their numbers were uniform along all tidal zones (Charts 21 & 22).

Hammonasset State Park

At Hammonasset State Park there were no Green Crabs found. At Hammonasset the data sets for both sampling periods 9/27/98 & 11/25/98 were remarkably similar, even from quadrant to quadrant. Japanese Shore Crabs were found in the highest densities at the mid tidal zones for both sample periods. They were also abundant in the low tidal zones and least abundant in the high tidal areas where the densities again decreased by almost half (Charts 26 &30).

Size class distribution for small (0-9.0mm.) and medium (9.1-18.0mm.) males and females were found in generally the same densities and followed the same trends with slight differences between quadrants for the 9/27/98 sample set (Table 11). The general trend for these categories was the highest density from the low tidal zone to the lowest density at the high tidal zone. Large males and females (18+mm.) varied up and down but in very low densities along each transect with small if any differences (Chart 31).

The size class distribution changed drastically for the 11/25/98 sample set (Table 12). The highest density of Japanese Shore Crabs was both the medium (9.1-18.0mm.) males and females with the small (0-9.0mm.) males and females dropping drastically by almost 2/3 their number in September. The trend was now a shift to the mid tidal range for all size classes except the large (18+mm.) males concentrating at the lower tidal zone. Large (18+mm.) females again were in small numbers with no preference for any tidal zone (Chart 32).

Rock Size

Rock sizes varied greatly for each sampling site (Table 13). Where Outer Island was very congruent in terms of niche habitat along each individual transect except for one quadrant (H3) (Chart 33), Hammonasset State Park had extreme variances along each transect creating different viable habitat hence separate niche habitats (Chart 34).

When analyzing the rock size data and plotting against the Japanese Shore Crab size class distribution, rock size only seemed to correlate with size class distribution with the small to medium males and females at Outer Island with smaller rock sizes (approx. 80-100mm.) (Charts 35 & 36). When the rock sizes were greater than 100mm. rock sizes had little or no effect on the selectivity of the crabs at Hammonasset (Charts 37 & 38).

## Discussion

### Population density

The highest population densities for the Japanese Shore Crab were shown to select for the low and mid tidal range at both sampling sites for the earlier sampling periods then shifted towards the mid tidal range where numbers were extremely high and lower tidal zone numbers decreased. This could be a result of the colder water temperatures in the later months therefore the highest size class densities for all sampling areas (the small to medium males and females) would shift to the higher zones because of possible lack of tolerance for the colder water temperatures. The larger class sizes of both male and females showed little or no specificity of zonation at any sampling period. This could be a result of a higher tolerance for temperature changes as crabs mature and grow larger. There were no significant differences between larger crab sizes and sex, however with the smaller class sizes males seemed to be the dominant sex.

Rock size distribution

There were small correlation's between smaller size classes and rock sizes varying between 80-100mm. Here small trends were noticed. As rocks became larger there was absolutely no correlation.

Inter-specific competition

There is no question that since the introduction of the Japanese Shore Crab *Hemigrapsus sanguineus* it has overcome other indigenous and native crabs within the rocky inter-tidal zone. Only very few Green Crabs *Carcinus maenas* and no other crab species were found at Outer Island. Hammonasset has no other crab species at any sampling area or period ;the components of this competition is still unknown. Highest densities of the Japanese Shore Crab *Hemigrapsus sanguineus* were found in areas of very high concentrations of amphipods although whether they have been using these amphipods as a food source is unknown. Stomach samples that were analyzed were inconclusive because the stomach contents were digested before the preservation process could take place (at the lab) therefore stomach content data was not determined. Continuing studies are underway and crabs are now being preserved upon capture to prevent this problem. Future stomach content analysis should be more conclusive with this change in sampling procedure.

This study will be used as preliminary data for my Master's thesis and has given me a working knowledge of the most efficient and productive sampling procedures and techniques for research of this nature. This research will be the first of this kind on the

Japanese Shore Crab *Hemigrapsus sanguineus* and will provide baseline data for the determination of the impact of this crab on native crab populations and possible management strategies for this crab in the future.

**Acknowledgements**

I would like to thank the S.C.S.U. Foundation, the Haakonsen family, and Elizabeth Hurd, for giving me the opportunity to carry out my research and giving me a basis for furthering my education in pursuit of a graduate degree. With the increasing influx of non-indigenous species to Long Island Sound, and many areas all over the world, non-native species studies are becoming more and more important in terms of managing our native species populations and resources. This is an area of study to which I will pursue a Ph.D. degree and your help has given me this experience to do so.

It was an honor and a privilege to carry out this study in Harry Haakonsen's name for he was a dear friend and mentor to me and I will always treasure the memories I have of him and the knowledge that he has passed on to me.

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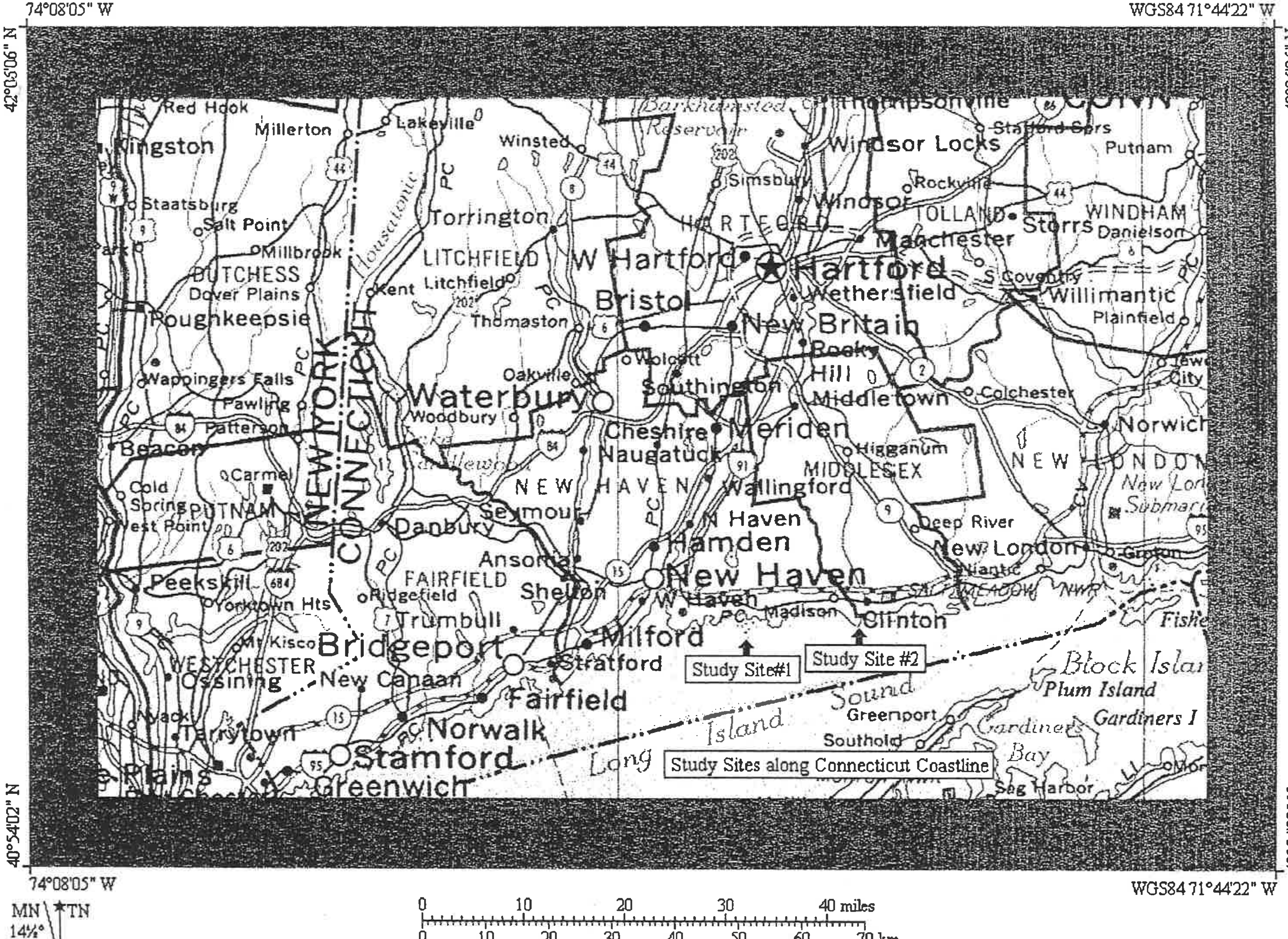


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Map 1

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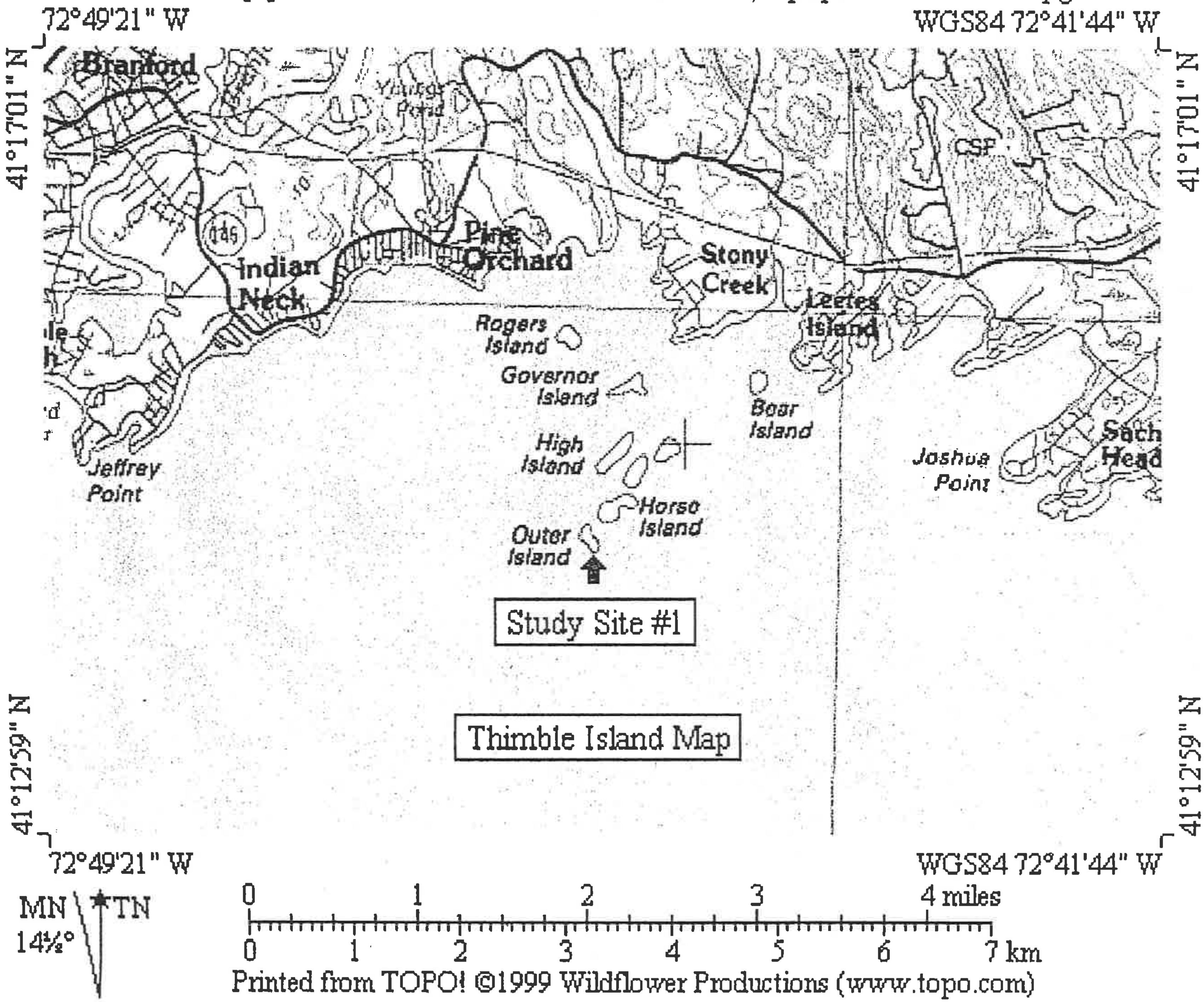


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Map 2

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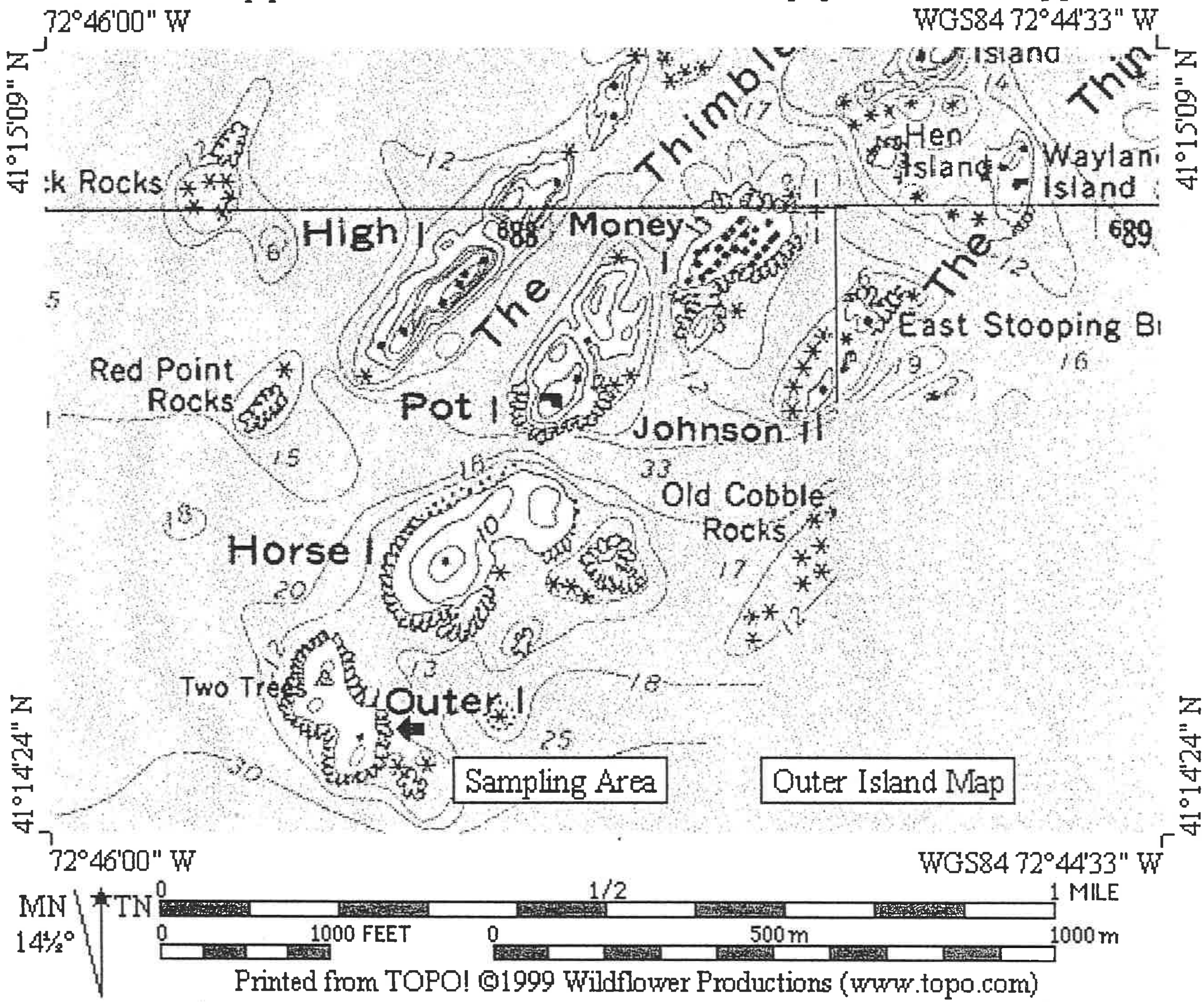


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Map 3

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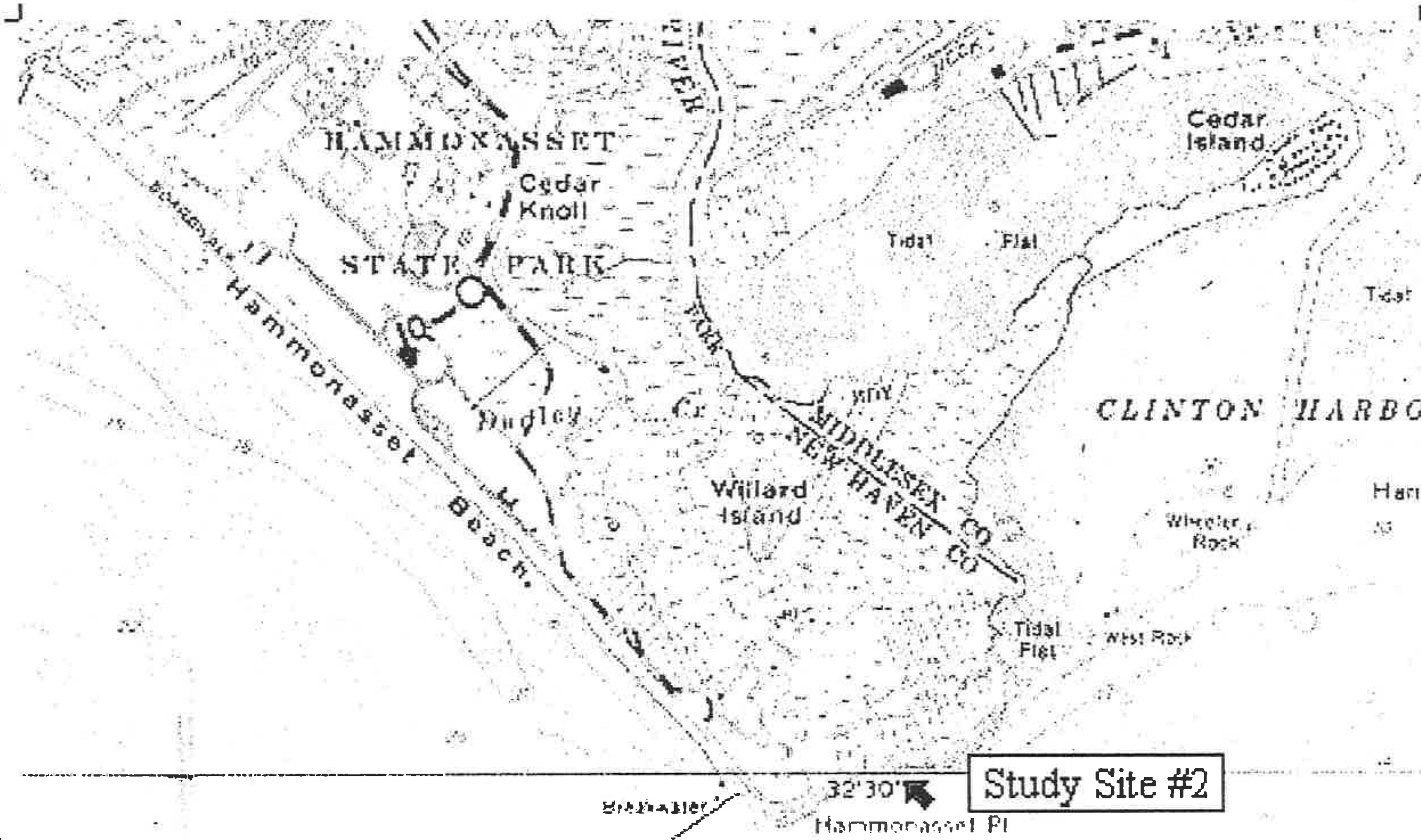
72°34'13" W | WGS84 72°31'19" W

41°16'10" N | 41°16'10" N




41°14'38" N | 41°14'38" N

Hammonasset State Park Map

72°34'13" W | WGS84 72°31'19" W

MN TN 14½°

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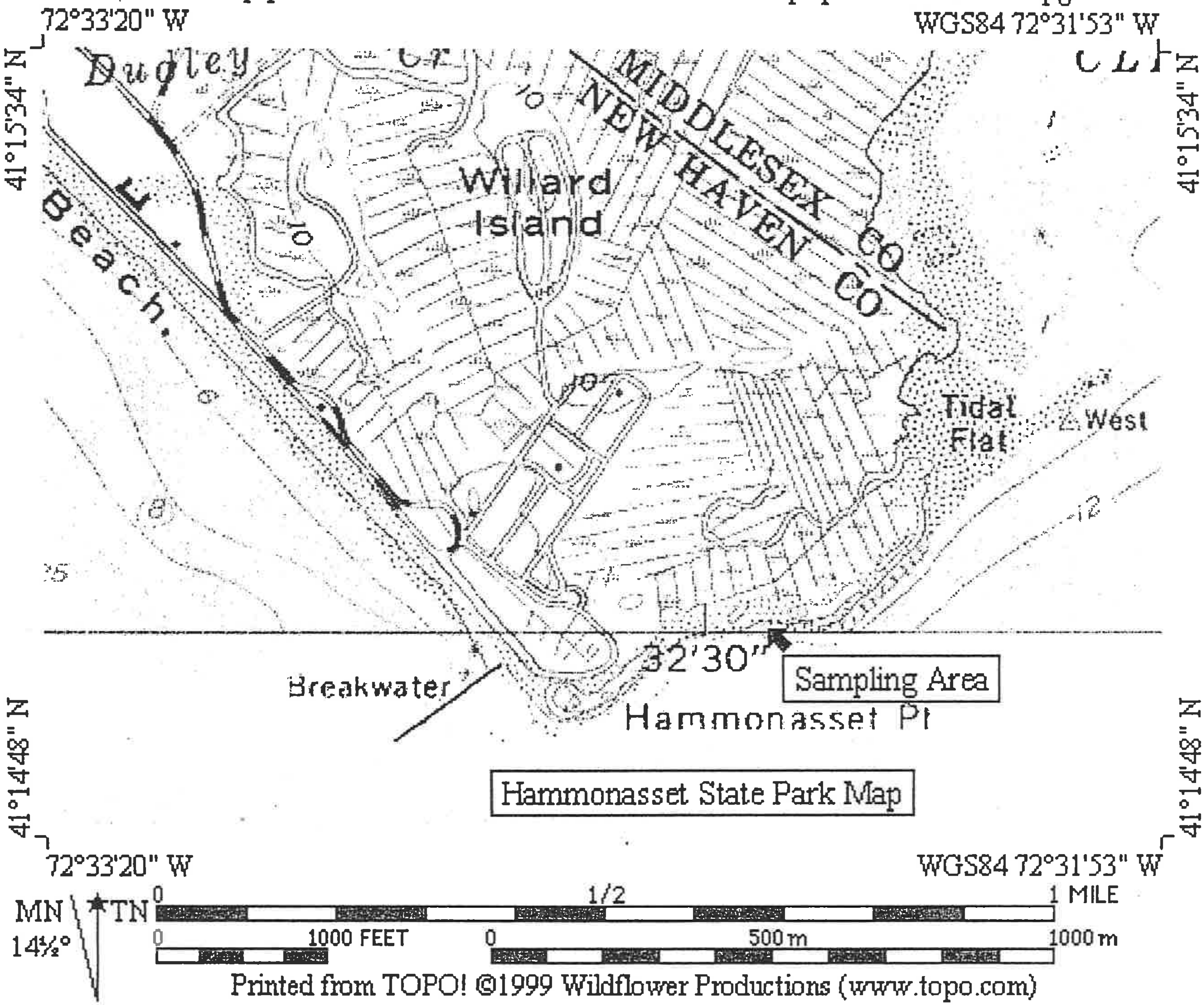


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Map 5

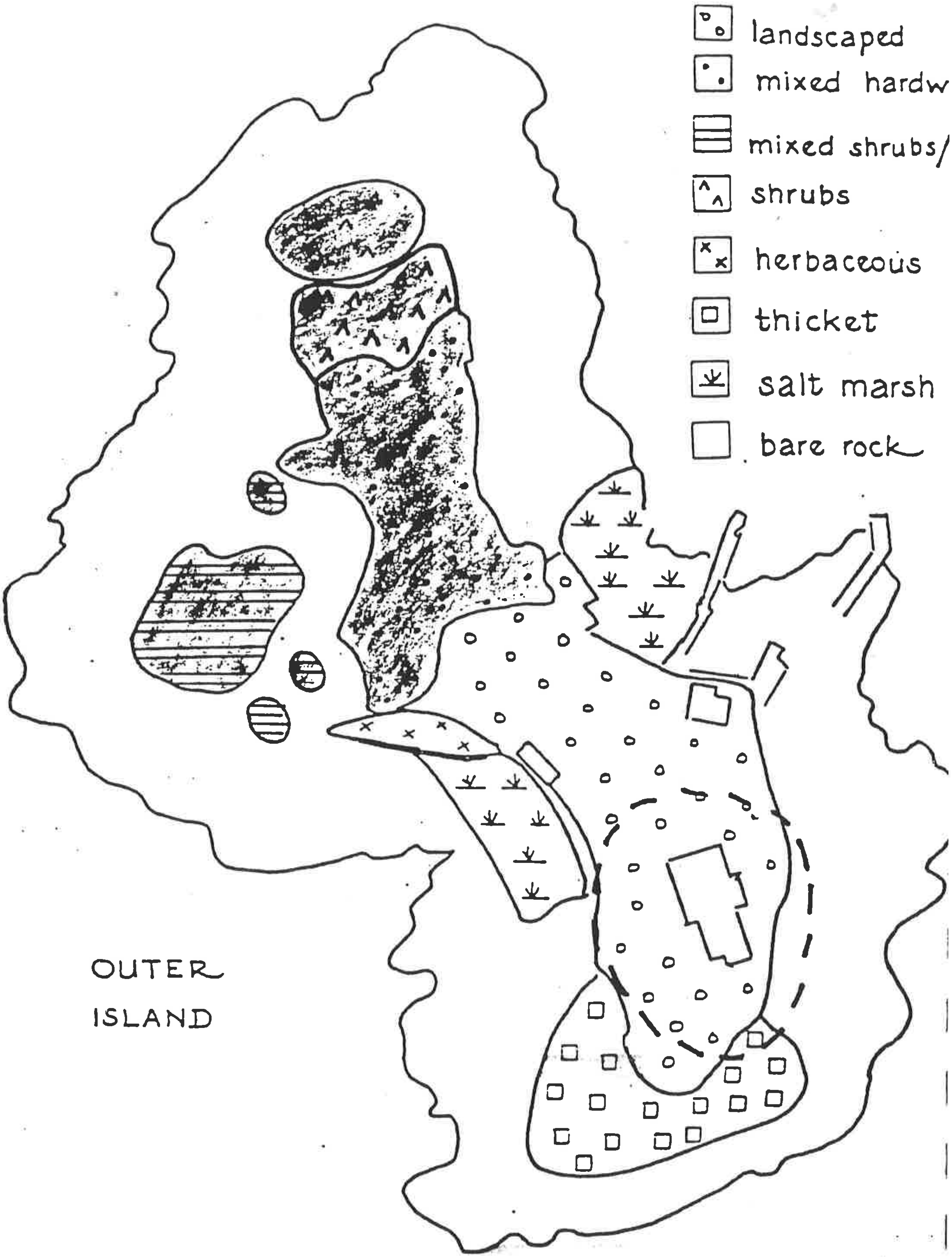
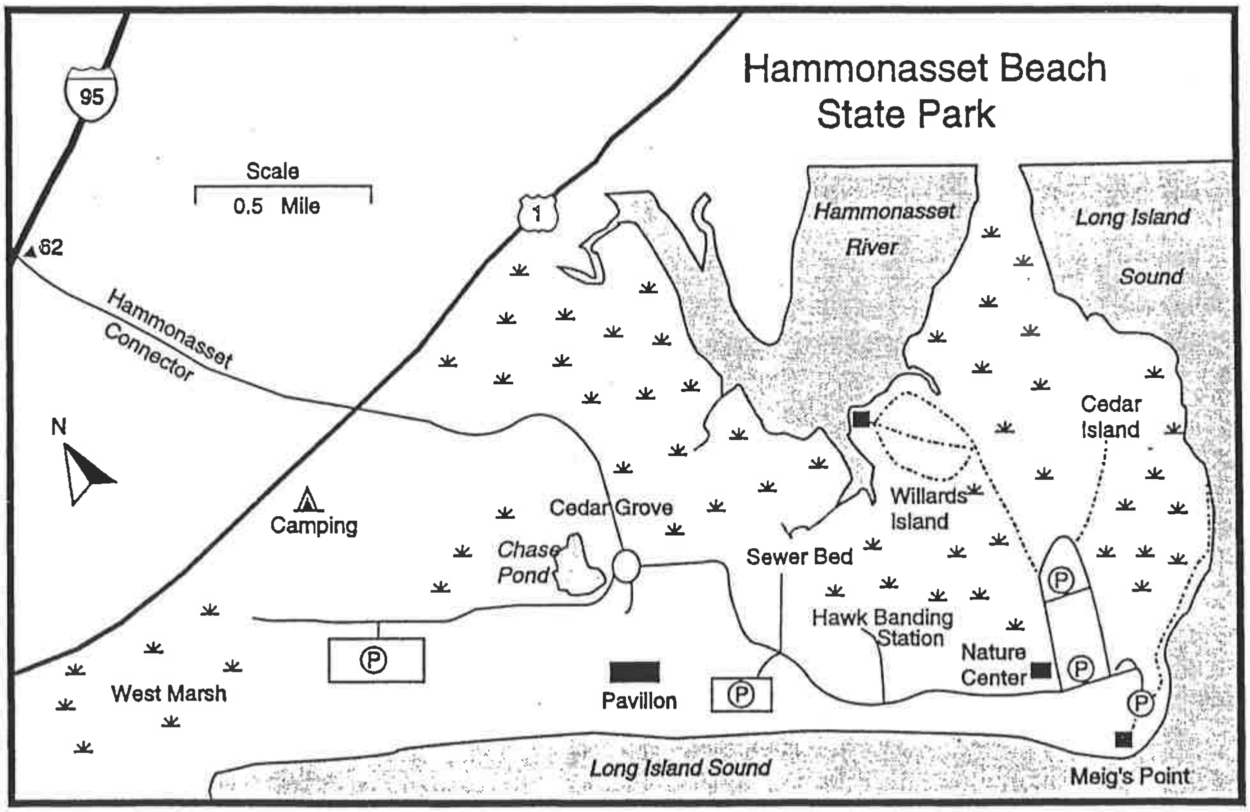
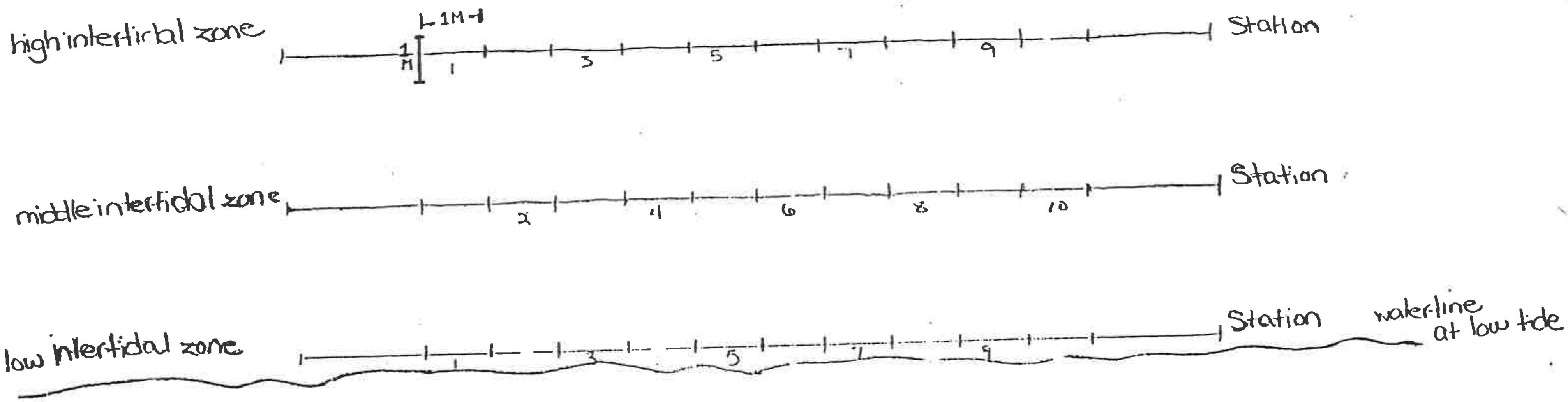

landscaped
mixed hardw
mixed shrubs/
shrubs
herbaceous
thicket
salt marsh
bare rock
OUTER
ISLAND

Figure 1



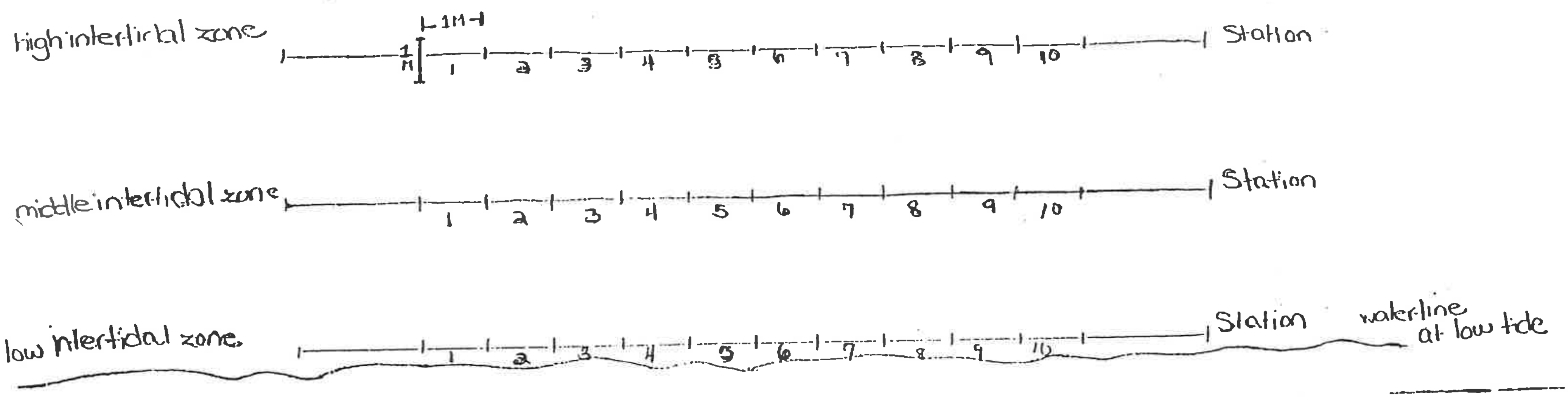

Demographic Map of Hammonasset
Figure 2




Study Site #1 Outer Island

Figure 3

Map of Study Site with Quadrant Layout and Station Delineations




Study Site #2 Hammonasset State Park

Figure 4

Map of Study Site with Quadrant Layout and Station Delineations

**Outer Island 8/21/98 Crab Totals**

| Quadrant | Crab | Total # | Male | Female | Unknown | Total size | Avg. size |
|---|---|---|---|---|---|---|---|
| H5 | JSC | 11 | 8 | 3 | 0 | 137. | 12.45 |
| H4 | JSC | 0 | 0 | 0 | 0 | 0 | 0 |
| H3 | JSC | 11 | 7 | 4 | 0 | 114.5 | 10.41 |
| H2 | JSC | 0 | | 0 | 0 | 0 | 0 |
| H1 | JSC | 0 | | 0 | 0 | 0 | 0 |
| Total | | 22 | | | | | |
| | | | | | | | |
| M5 | JSC | 148 | 116 | 32 | 0 | 1340 | 9.1 |
| M4 | JSC | 114 | 98 | 16 | 0 | 944 | 8.28 |
| M3 | JSC | 71 | 65 | 5 | 0 | 514.5 | 7.2 |
| | GC | 1 | 1 | 0 | 0 | 3 | 3 |
| M2 | JSC | 91 | 78 | 13 | 0 | 865.5 | 9.5 |
| M1 | JSC | 61 | 49 | 12 | 0 | 182.5 | 2.99 |
| | GC | 8 | 8 | 0 | 0 | 40.5 | 5.1 |
| Total JSC | | 485 | | | | | |
| Total GC | | 9 | | | | | |
| | | | | | | | |
| L5 | GC | 3 | 1 | 2 | 0 | 26.5 | 8.8 |
| | JSC | 0 | 0 | 0 | 0 | 0 | 0 |
| L4 | JSC | 152 | 102 | 50 | 0 | 1620.5 | 10.7 |
| L3 | JSC | 98 | 84 | 14 | 0 | 851 | 8.68 |
| L2 | JSC | 74 | 53 | 21 | 0 | 874 | 11.8 |
| L1 | JSC | 24 | 21 | 3 | 0 | 246 | 10.25 |
| Total JSC | | 348 | | | | | |
| Total GC | | 3 | | | | | |

Table 1

Outer Island 8/21/98 High Tide Line Japanese Shore Crab Numbers

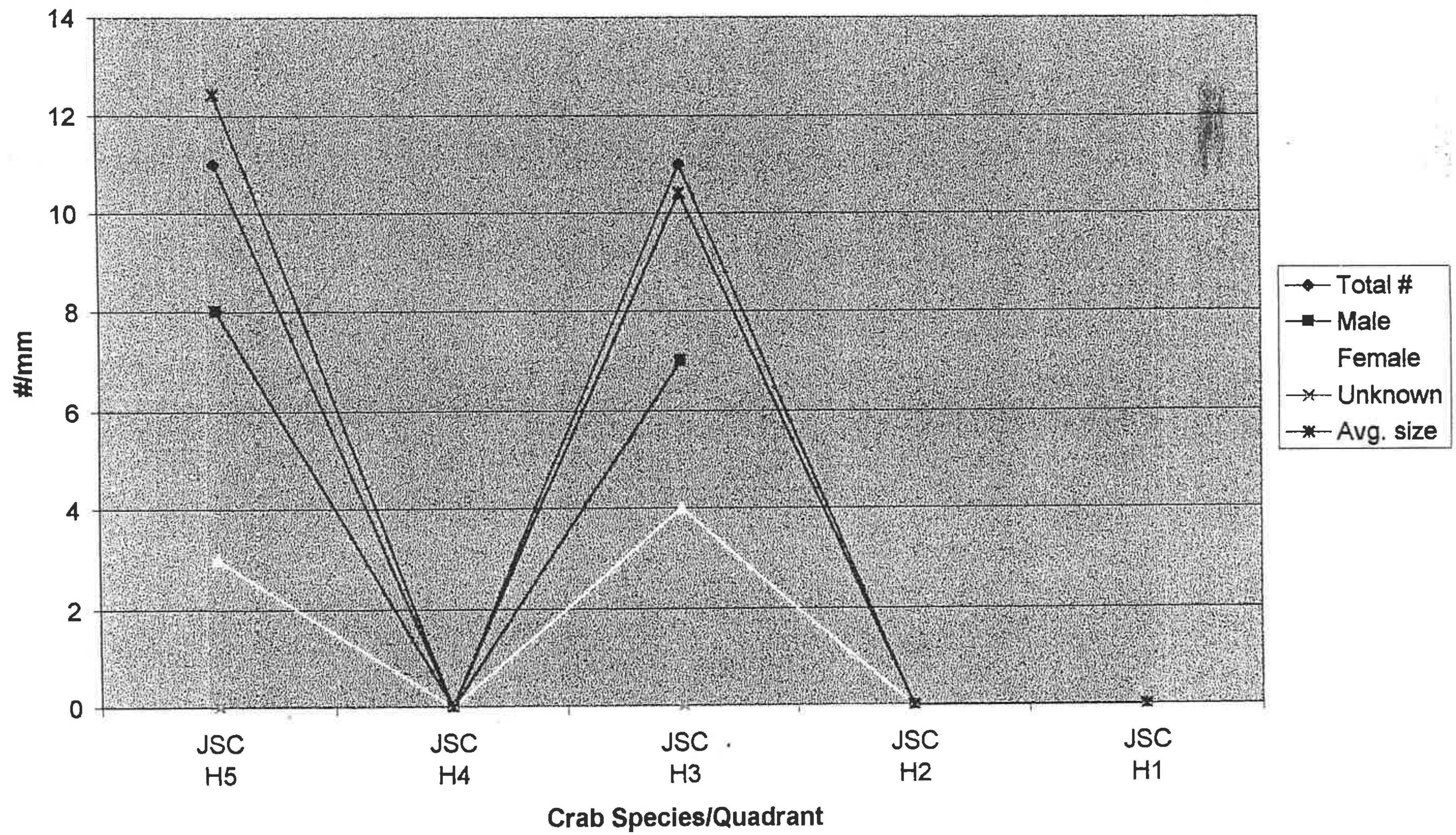
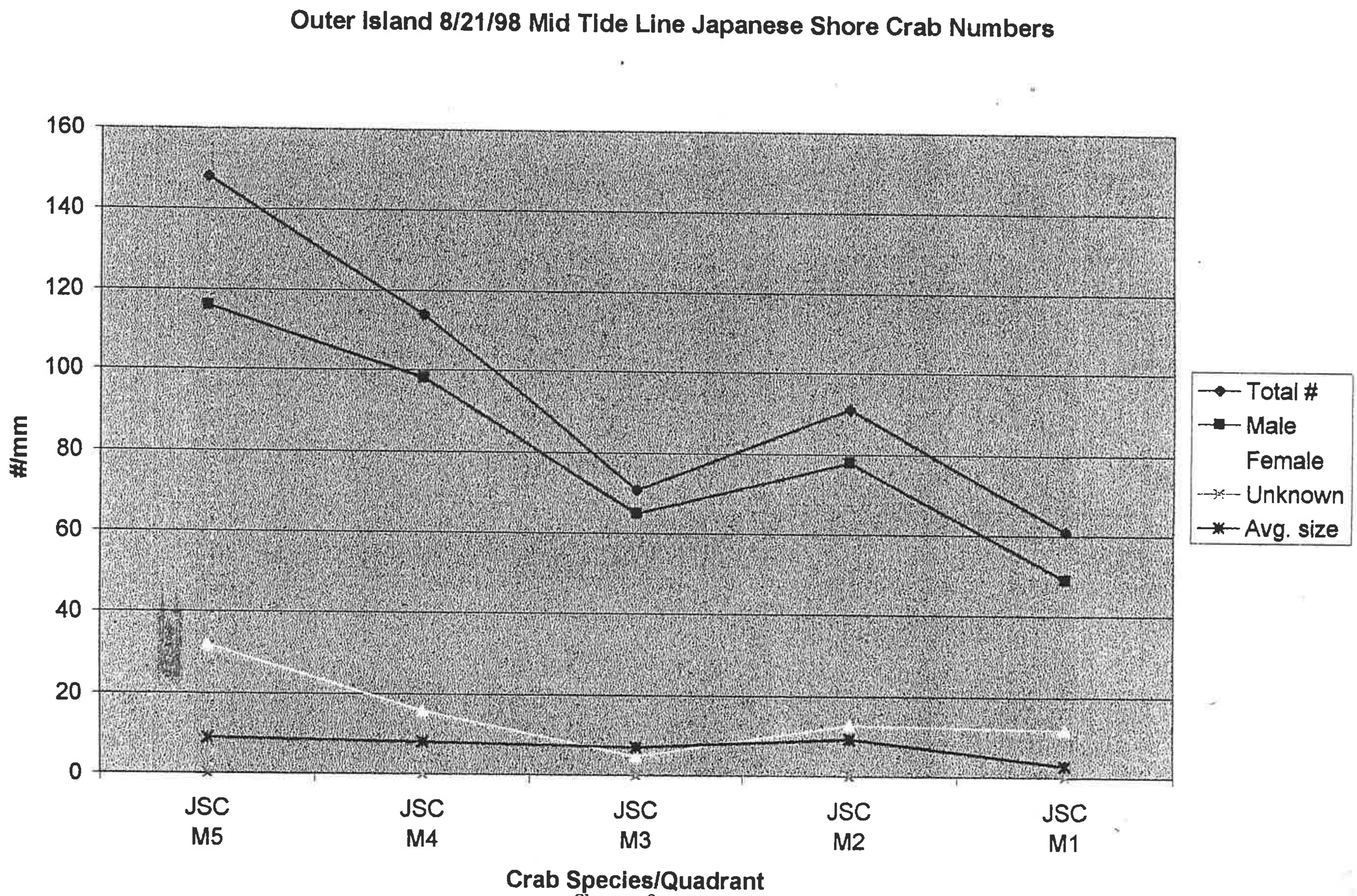



Chart 1


Outer Island 8/21/98 Mid Tide Line Japanese Shore Crab Numbers
160
140
120
100
80
60
40
20
0
#/mm
JSC M5
JSC M4
JSC M3
JSC M2
JSC M1
Crab Species/Quadrant
Total #
Male
Female
Unknown
Avg. size
Chart 2

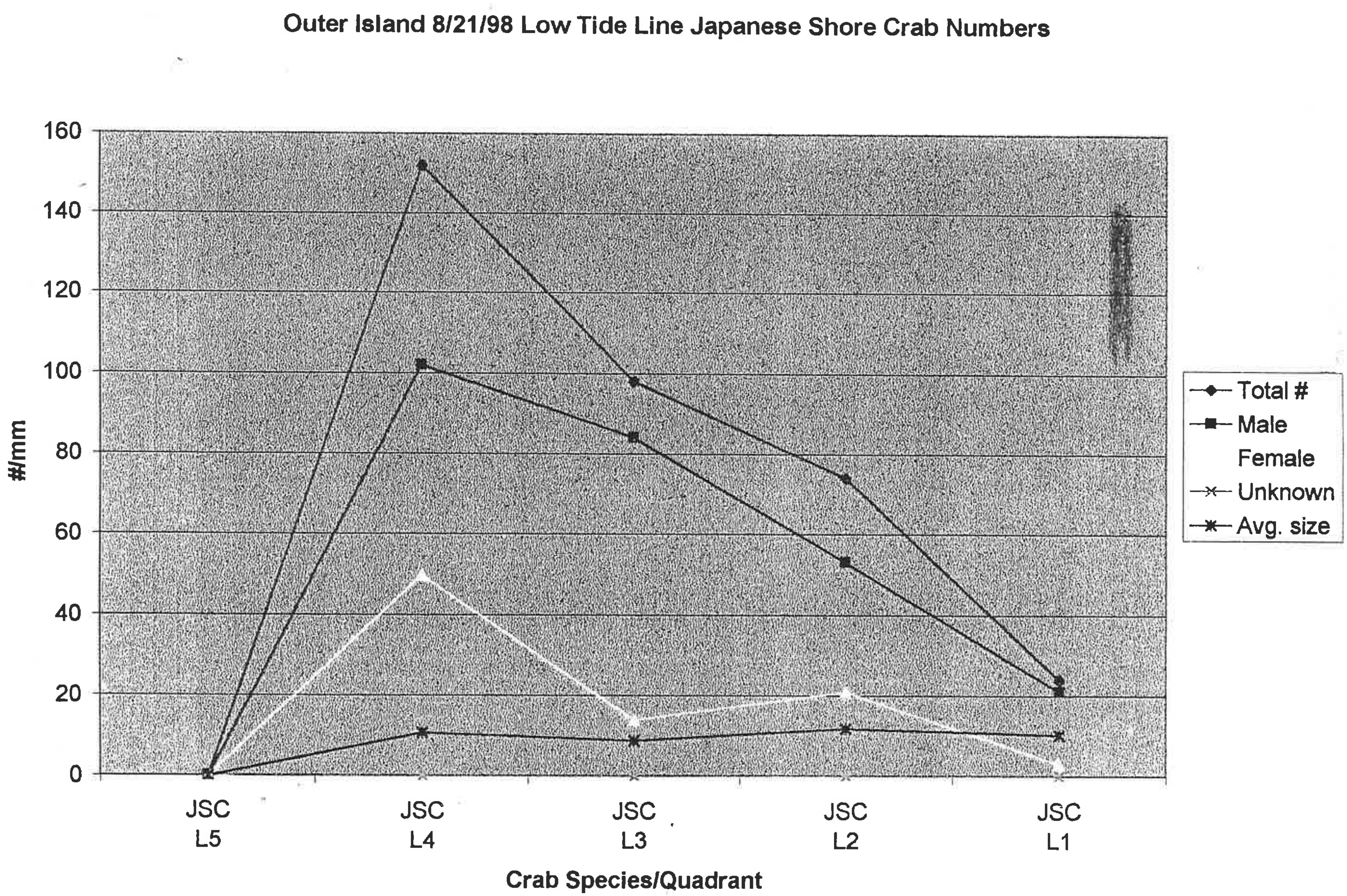

Outer Island 8/21/98 Low Tide Line Japanese Shore Crab Numbers
160
140
120
100
80
60
40
20
0
#/mm
JSC L5
JSC L4
JSC L3
JSC L2
JSC L1
Crab Species/Quadrant
Total #
Male
Female
Unknown
Avg. size

Chart 3

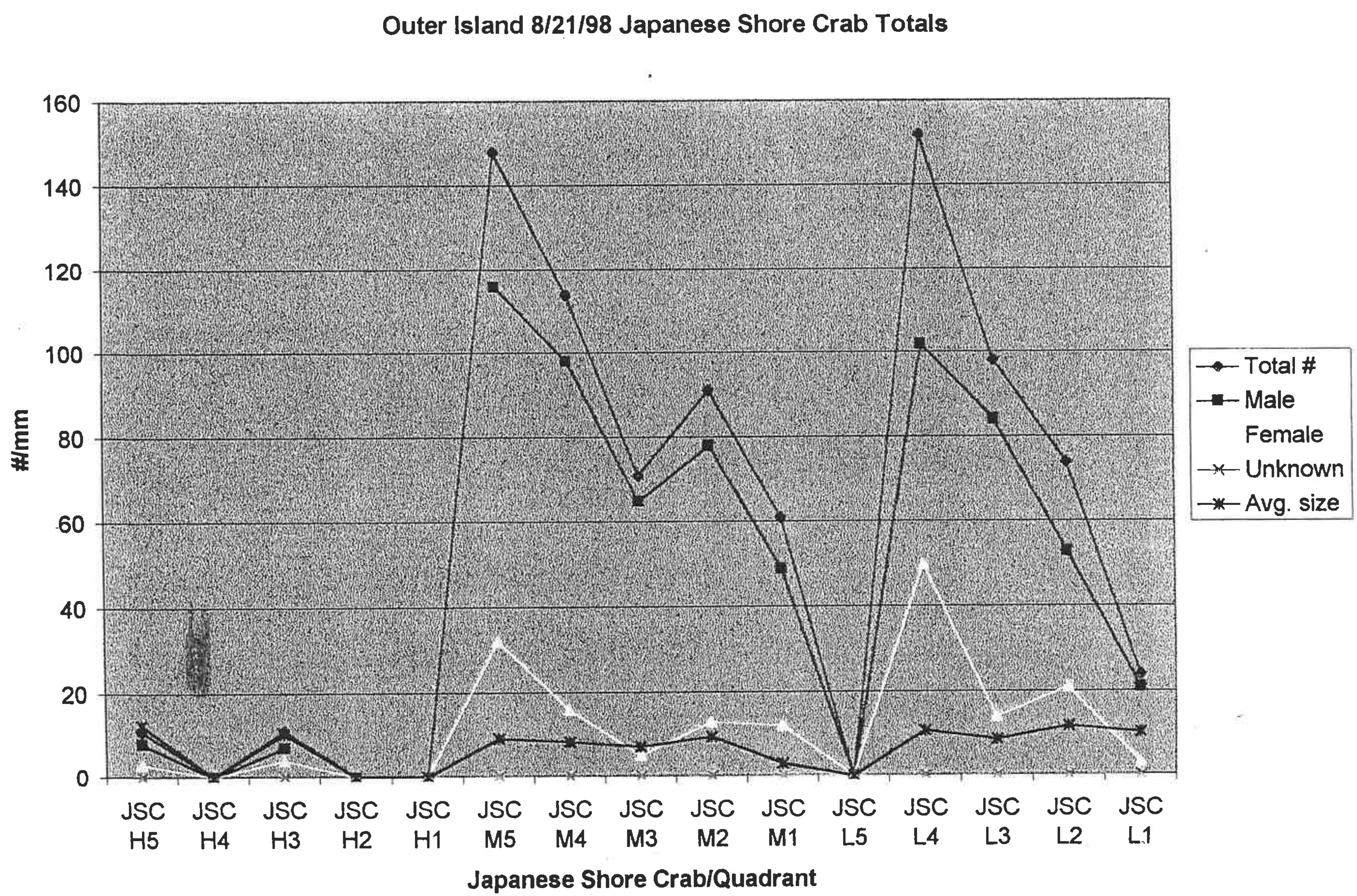

Outer Island 8/21/98 Japanese Shore Crab Totals
160
140
120
100
80
60
40
20
0
#/mm
JSC H5
JSC H4
JSC H3
JSC H2
JSC H1
JSC M5
JSC M4
JSC M3
JSC M2
JSC M1
JSC L5
JSC L4
JSC L3
JSC L2
JSC L1
Japanese Shore Crab/Quadrant
Total #
Male
Female
Unknown
Avg. size

Chart 4

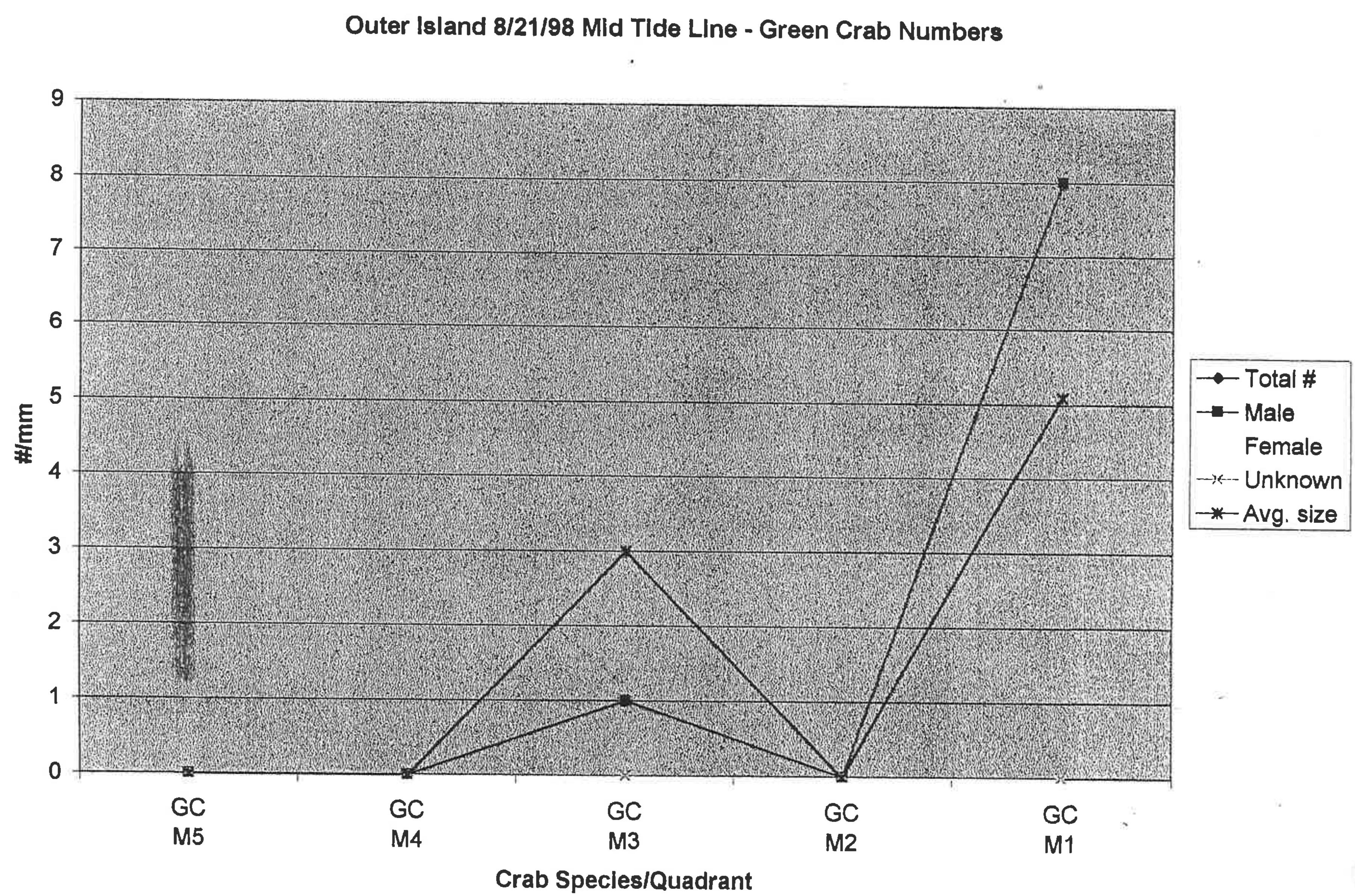
**Outer Island 8/21/98 Green Crab Totals**

| Quadrant | Crab | Total # | Male | Female | Unknown | Avg. size |
|---|---|---|---|---|---|---|
| H5 | GC | 0 | 0 | 0 | 0 | 0 |
| H4 | GC | 0 | 0 | 0 | 0 | 0 |
| H3 | GC | 0 | 0 | 0 | 0 | 0 |
| H2 | GC | 0 | 0 | 0 | 0 | 0 |
| H1 | GC | 0 | 0 | 0 | 0 | 0 |
| Total | | 0 | | | | 0 |

| Quadrant | Crab | Total # | Male | Female | Unknown | Avg. size |
|---|---|---|---|---|---|---|
| M5 | GC | 0 | 0 | 0 | 0 | 0 |
| M4 | GC | 0 | 0 | 0 | 0 | 0 |
| M3 | GC | 1 | 1 | 0 | 0 | 3 |
| M2 | GC | 0 | 0 | 0 | 0 | 0 |
| M1 | GC | 8 | 8 | 0 | 0 | 5.1 |
| Total | | 9 | | | | |

| Quadrant | Crab | Total # | Male | Female | Unknown | Avg. size |
|---|---|---|---|---|---|---|
| L5 | GC | 3 | 1 | 2 | 0 | 8.8 |
| L4 | GC | 0 | 0 | 0 | 0 | 0 |
| L3 | GC | 0 | 0 | 0 | 0 | 0 |
| L2 | GC | 0 | 0 | 0 | 0 | 0 |
| L1 | GC | 0 | 0 | 0 | 0 | 0 |
| Total | | 3 | | | | |

Table 2



Outer Island 8/21/98 Mid Tide Line - Green Crab Numbers
#/mm
0
1
2
3
4
5
6
7
8
9
GC M5
GC M4
GC M3
GC M2
GC M1
Crab Species/Quadrant
Total #
Male
Female
Unknown
Avg. size


Chart 5

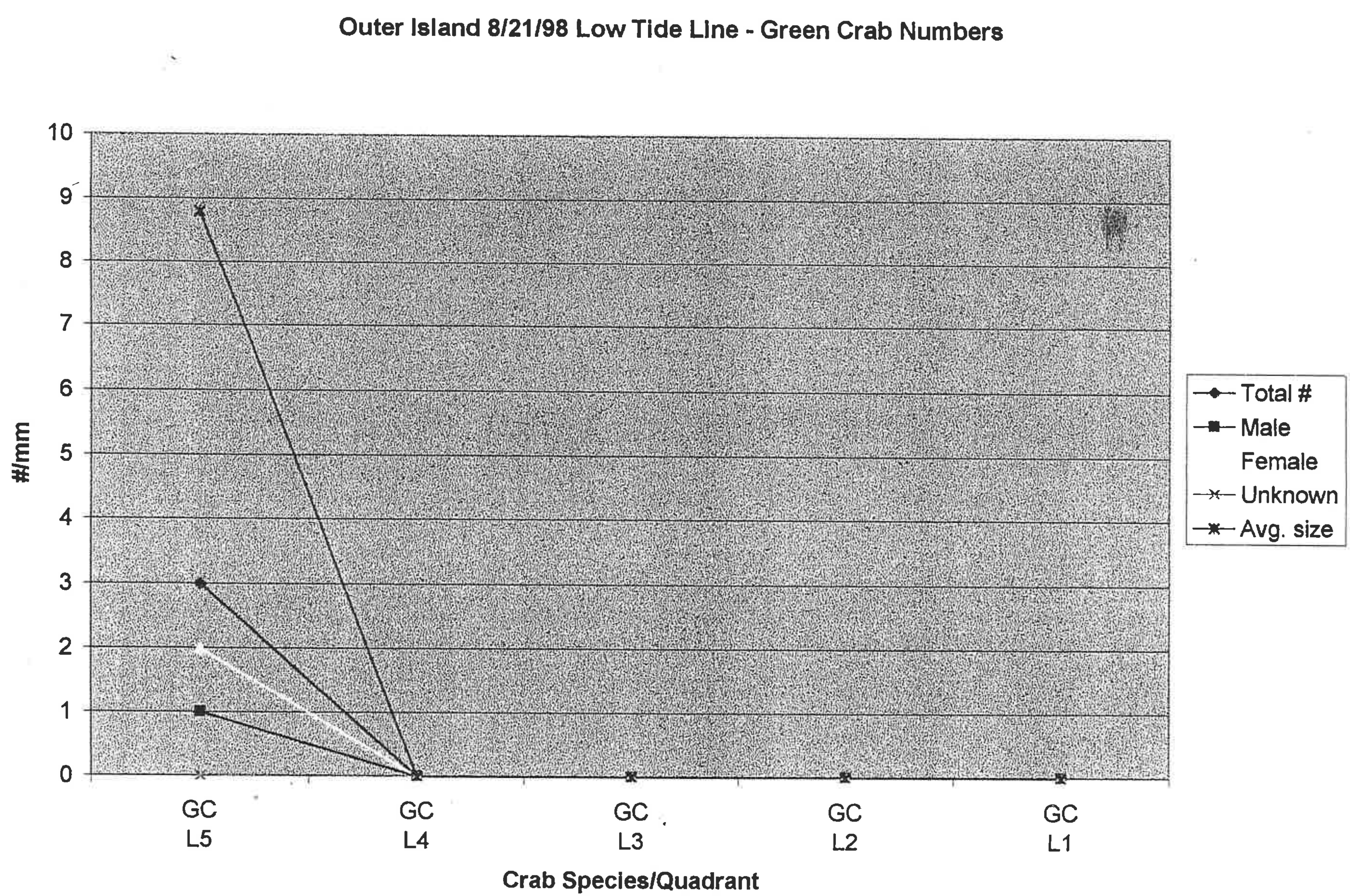

Outer Island 8/21/98 Low Tide Line - Green Crab Numbers
#/mm
10
9
8
7
6
5
4
3
2
1
0
GC L5
GC L4
GC L3
GC L2
GC L1
Crab Species/Quadrant
Total #
Male
Female
Unknown
Avg. size

Chart 6

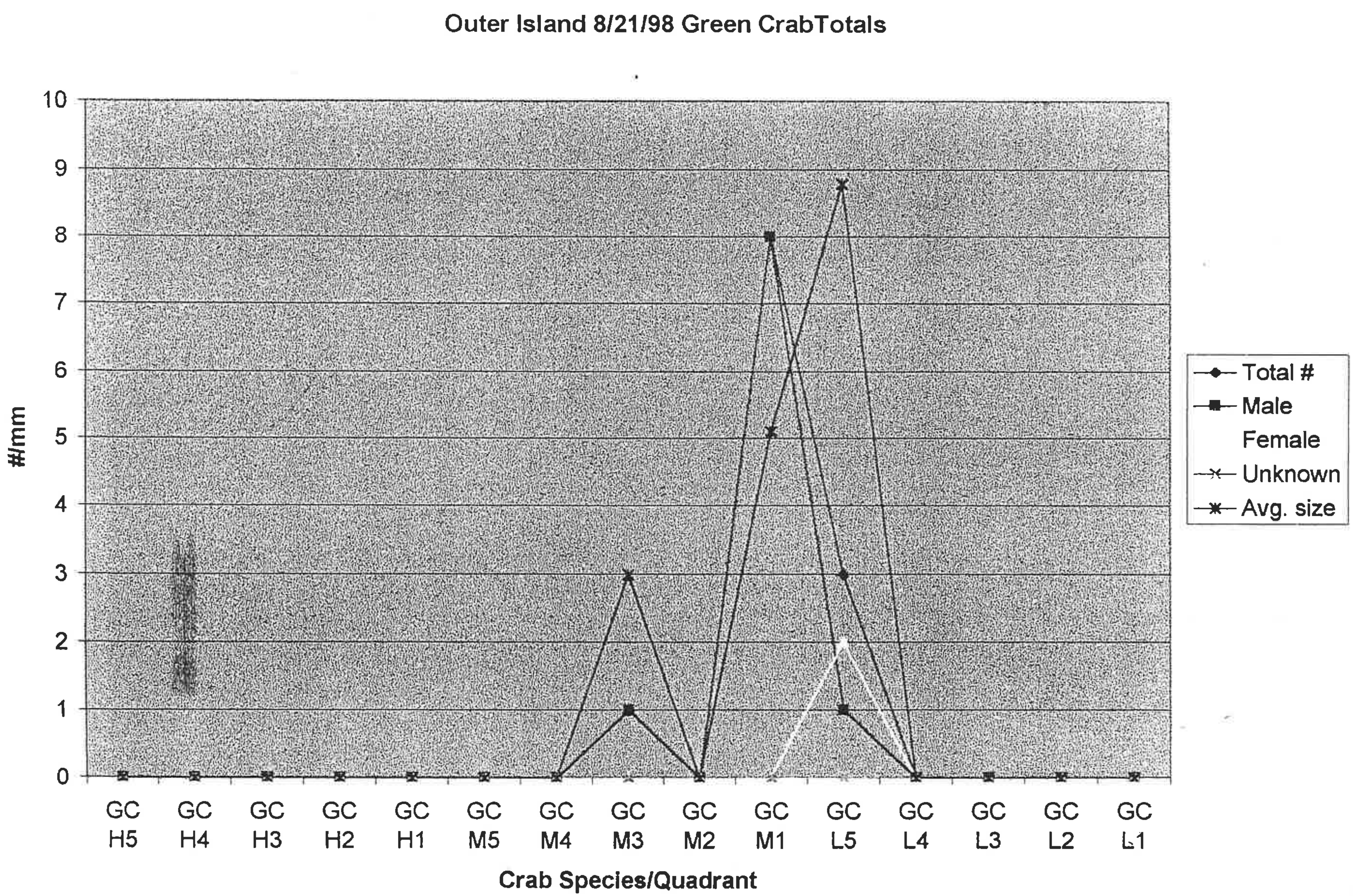

Outer Island 8/21/98 Green CrabTotals
10
9
8
7
6
5
4
3
2
1
0
#/mm
GC H5
GC H4
GC H3
GC H2
GC H1
GC M5
GC M4
GC M3
GC M2
GC M1
GC L5
GC L4
GC L3
GC L2
GC L1
Crab Species/Quadrant
Total #
Male
Female
Unknown
Avg. size

Chart 7

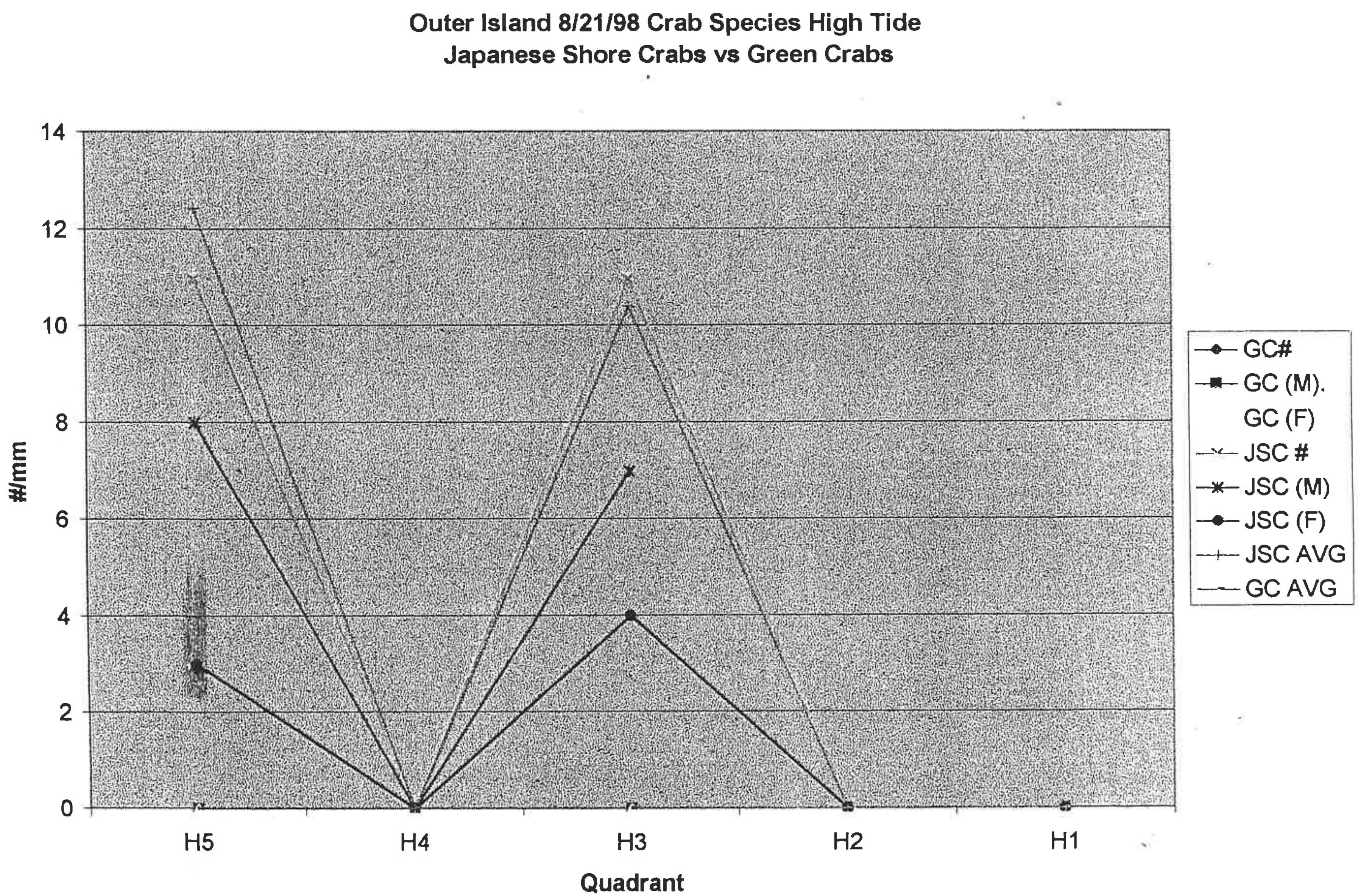
**Outer Island 8/21/98 Green Crab vs. Japanese Shore Crab Totals**

| Quadrant | GC# | GC (M). | GC (F) | GC AVG | JSC # | JSC (M) | JSC (F) | JSC AVG |
|---|---|---|---|---|---|---|---|---|
| H5 | 0 | 0 | 0 | 0 | 11 | 8 | 3 | 12.45 |
| H4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| H3 | 0 | 0 | 0 | 0 | 11 | 7 | 4 | 10.41 |
| H2 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| H1 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| TOTAL | 0 | | | | 22 | | | |

| Quadrant | GC# | GC (M) | GC (F) | GC AVG | JSC# | JSC (M) | JSC (F) | JSC AVG |
|---|---|---|---|---|---|---|---|---|
| M5 | 0 | 0 | 0 | 0 | 148 | 116 | 32 | 9.1 |
| M4 | 0 | 0 | 0 | 0 | 114 | 98 | 16 | 8.28 |
| M3 | 1 | 1 | 0 | 3 | 71 | 65 | 5 | 7.2 |
| M2 | 0 | 0 | 0 | 0 | 91 | 78 | 13 | 9.5 |
| M1 | 8 | 8 | | 5.1 | 61 | 49 | 12 | 2.99 |
| TOTAL | | | | | 485 | | | |

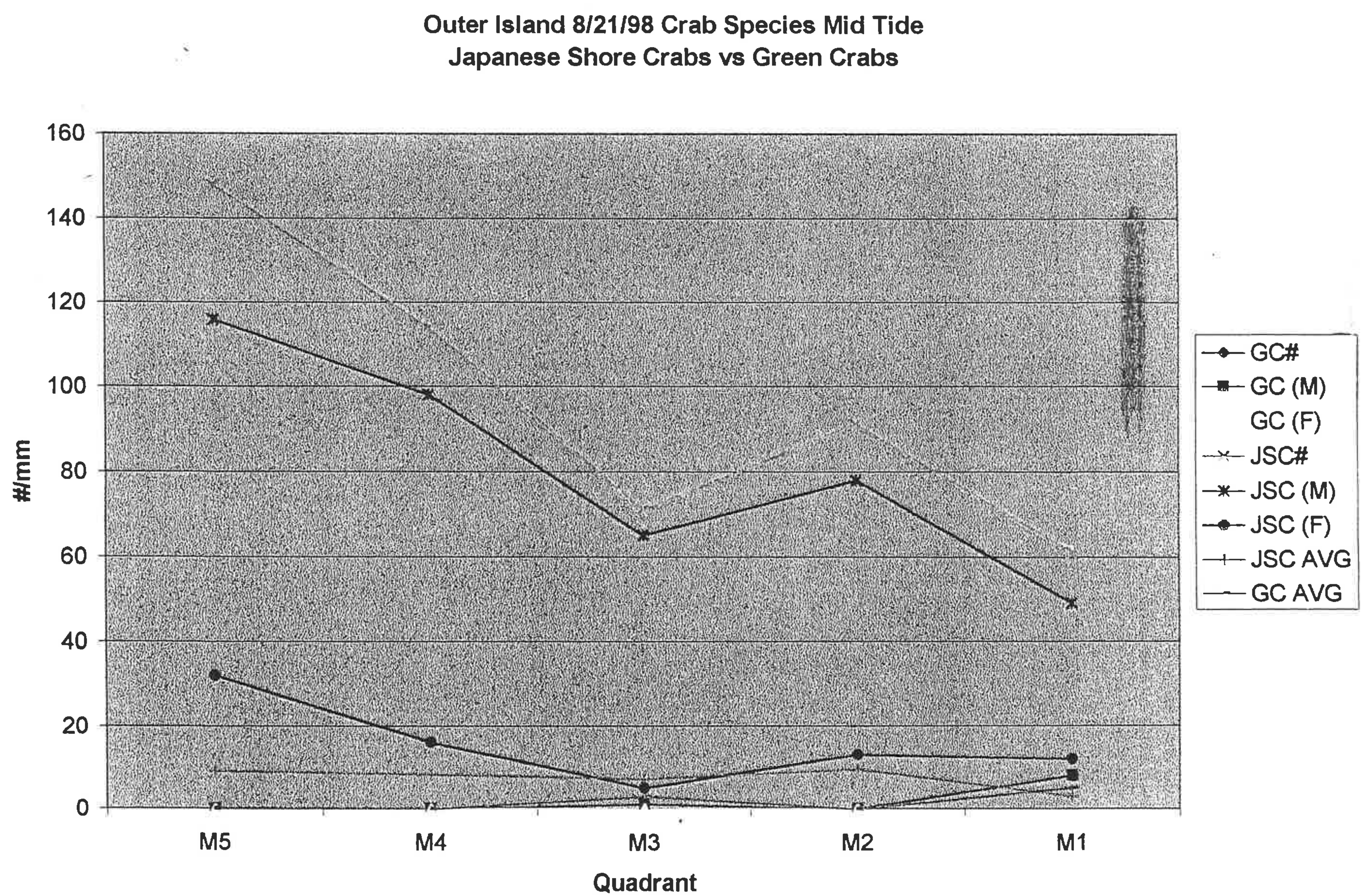
| Quadrant | GC# | GC(M) | GC (F) | GC AVG | JSC # | JSC (M) | JSC (F) | JSC AVG |
|---|---|---|---|---|---|---|---|---|
| L5 | 3 | 1 | 2 | 8.8 | 0 | 0 | 0 | 0 |
| L4 | 0 | 0 | 0 | 0 | 152 | 102 | 50 | 10.7 |
| L3 | 0 | 0 | 0 | 0 | 98 | 84 | 14 | 8.68 |
| L2 | 0 | 0 | 0 | 0 | 74 | 53 | 21 | 11.8 |
| L1 | 0 | 0 | 0 | 0 | 24 | 21 | 3 | 10.25 |
| TOTAL | 3 | | | | 348 | | | |

Table 3



Outer Island 8/21/98 Crab Species High Tide
Japanese Shore Crabs vs Green Crabs
#/mm
14
12
10
8
6
4
2
0
H5
H4
H3
H2
H1
Quadrant
GC#
GC (M).
GC (F)
JSC #
JSC (M)
JSC (F)
JSC AVG
GC AVG


Chart 8



Outer Island 8/21/98 Crab Species Mid Tide
Japanese Shore Crabs vs Green Crabs
160
140
120
100
80
60
40
20
0
#/mm
M5
M4
M3
M2
M1
Quadrant
GC#
GC (M)
GC (F)
JSC#
JSC (M)
JSC (F)
JSC AVG
GC AVG


Chart 9

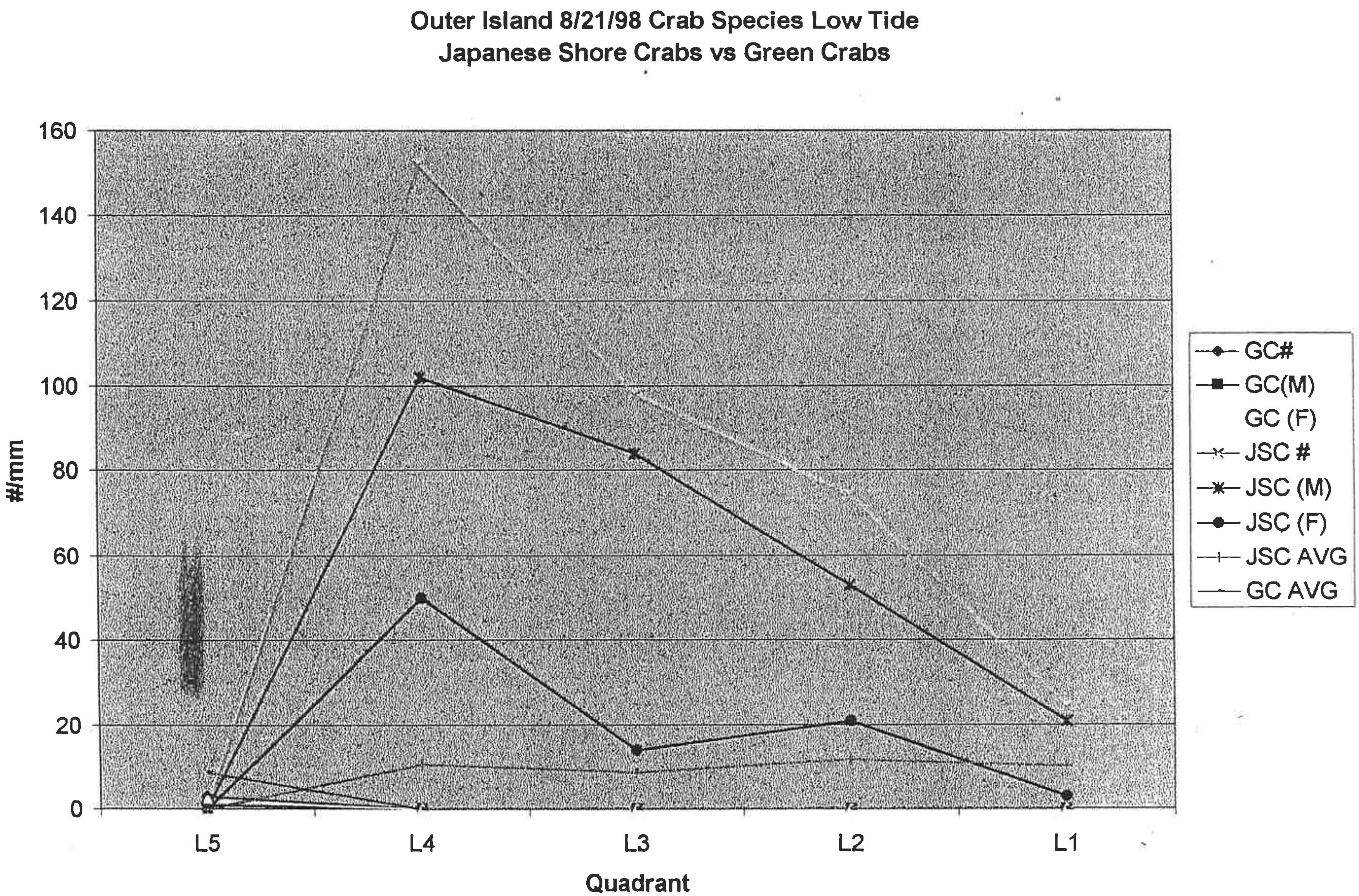

Outer Island 8/21/98 Crab Species Low Tide
Japanese Shore Crabs vs Green Crabs
160
140
120
100
80
60
40
20
0
#/mm
L5
L4
L3
L2
L1
Quadrant
GC#
GC(M)
GC (F)
JSC #
JSC (M)
JSC (F)
JSC AVG
GC AVG

Chart 10

**Outer Isl: d 10/18/98** **Japanese Shore Crab Totals**

| Quadrant | JSC # | JSC (M) | JSC (F) | JSC (U) | JSC AVG |
|---|---|---|---|---|---|
| H5 | 90 | 32 | 58 | 0 | 9.11 |
| H4 | 47 | 20 | 27 | 0 | 7.82 |
| H3 | 26 | 13 | 13 | 0 | 10.7 |
| H2 | 3 | 0 | 0 | 0 | 6.6 |
| H1 | 1 | 0 | 0 | 0 | 4 |
| Total | 167 | | | | |

| Quadrant | JSC # | JSC (M) | JSC (F) | JSC (U) | JSC AVG |
|---|---|---|---|---|---|
| M5 | 58 | 23 | 35 | 0 | 7.8 |
| M4 | 174 | 96 | 78 | 0 | 6.78 |
| M3 | 154 | 87 | 67 | 0 | 5.75 |
| M2 | 152 | 68 | 84 | 0 | 5.43 |
| M1 | 39 | 38 | 1 | 0 | 5.88 |
| Total | 577 | | | | |

| Quadrant | JSC # | JSC (M) | JSC (F) | JSC (U) | JSC AVG |
|---|---|---|---|---|---|
| L5 | 10 | 10 | 0 | 0 | 8 |
| L4 | 90 | 23 | 67 | 0 | 9.42 |
| L3 | 65 | 58 | 7 | 0 | 5.55 |
| L2 | 47 | 39 | 8 | 0 | 7.28 |
| L1 | 66 | 40 | 26 | 0 | 8.28 |
| Total | 278 | | | | |

Table 4

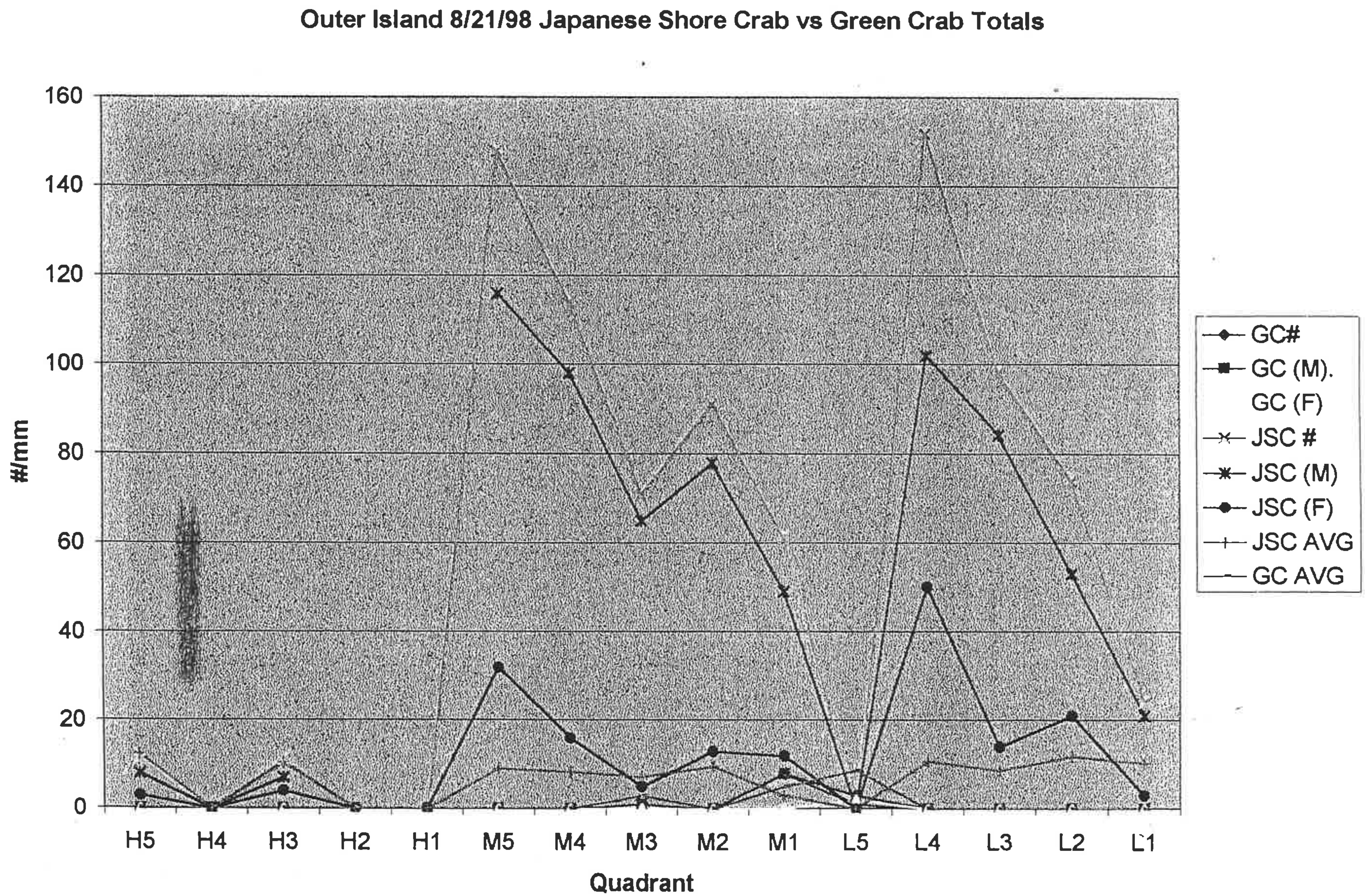
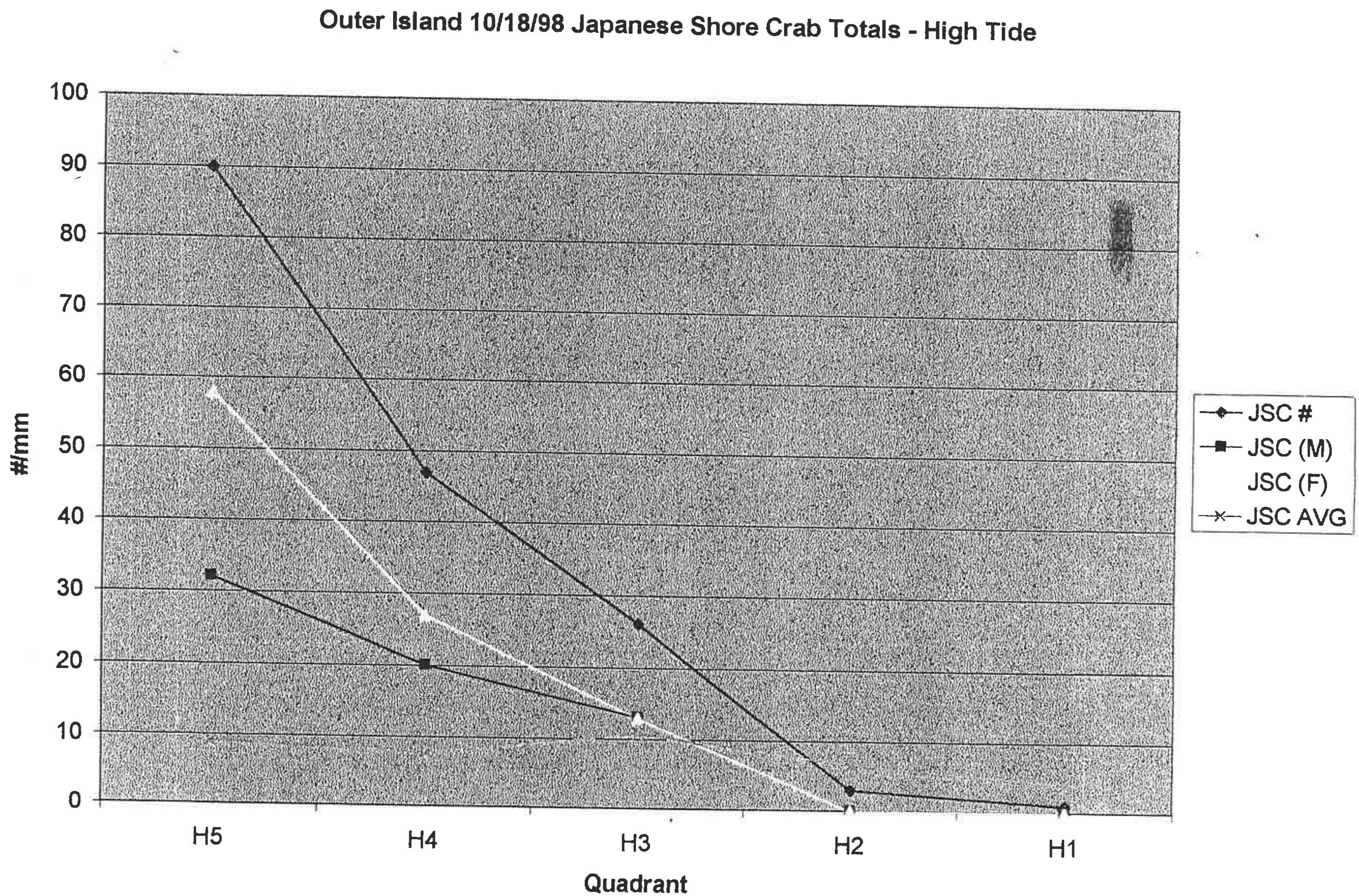
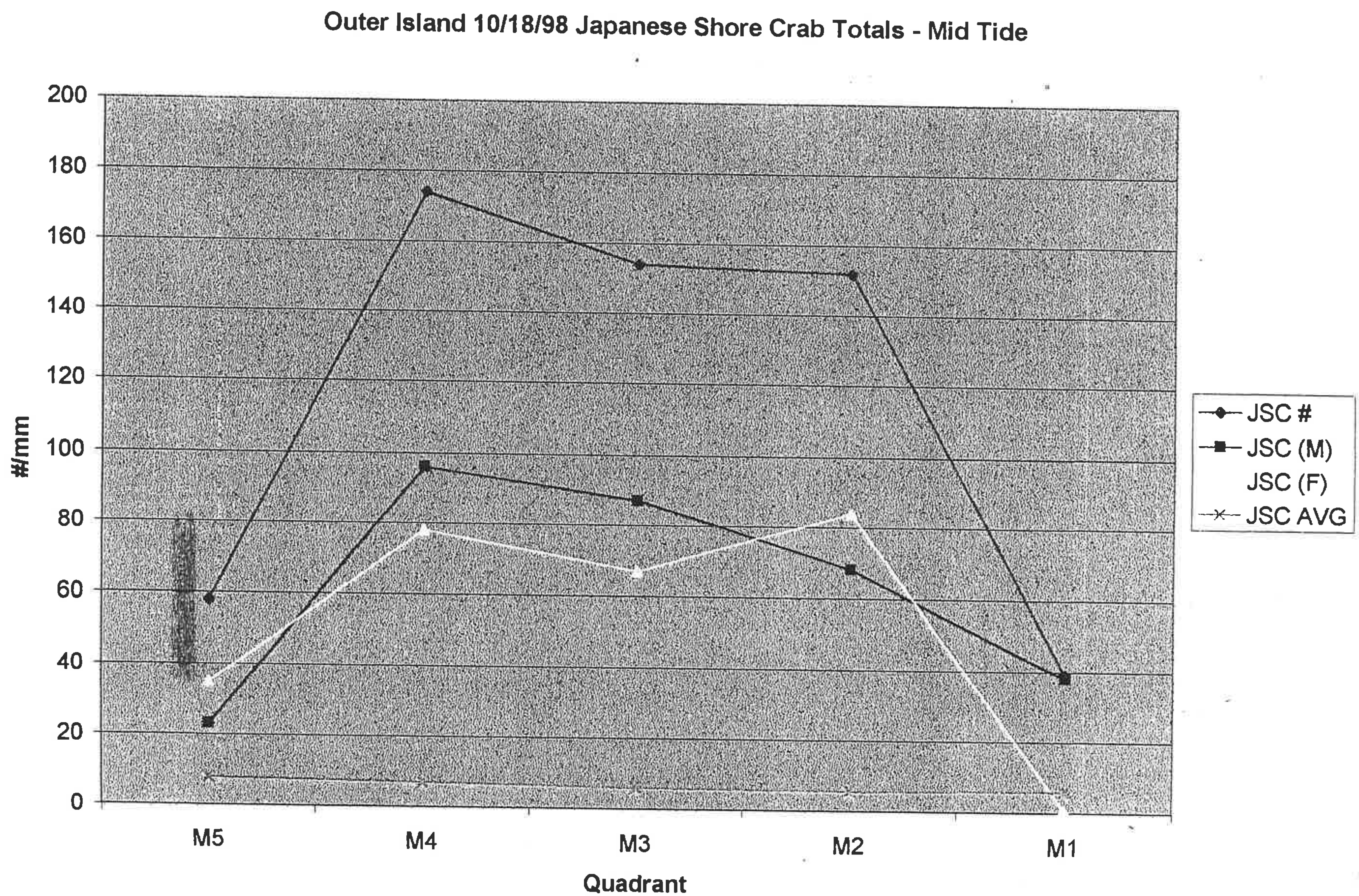

Outer Island 8/21/98 Japanese Shore Crab vs Green Crab Totals
160
140
120
100
80
60
40
20
0
#/mm
H5
H4
H3
H2
H1
M5
M4
M3
M2
M1
L5
L4
L3
L2
L1
Quadrant
GC#
GC (M).
GC (F)
JSC #
JSC (M)
JSC (F)
JSC AVG
GC AVG

Chart 11



Outer Island 10/18/98 Japanese Shore Crab Totals - High Tide
100
90
80
70
60
50
40
30
20
10
0
#/mm
H5
H4
H3
H2
H1
Quadrant
JSC #
JSC (M)
JSC (F)
JSC AVG


Chart 12



Outer Island 10/18/98 Japanese Shore Crab Totals - Mid Tide
200
180
160
140
120
100
80
60
40
20
0
#/mm
M5
M4
M3
M2
M1
Quadrant
JSC #
JSC (M)
JSC (F)
JSC AVG


Chart 13

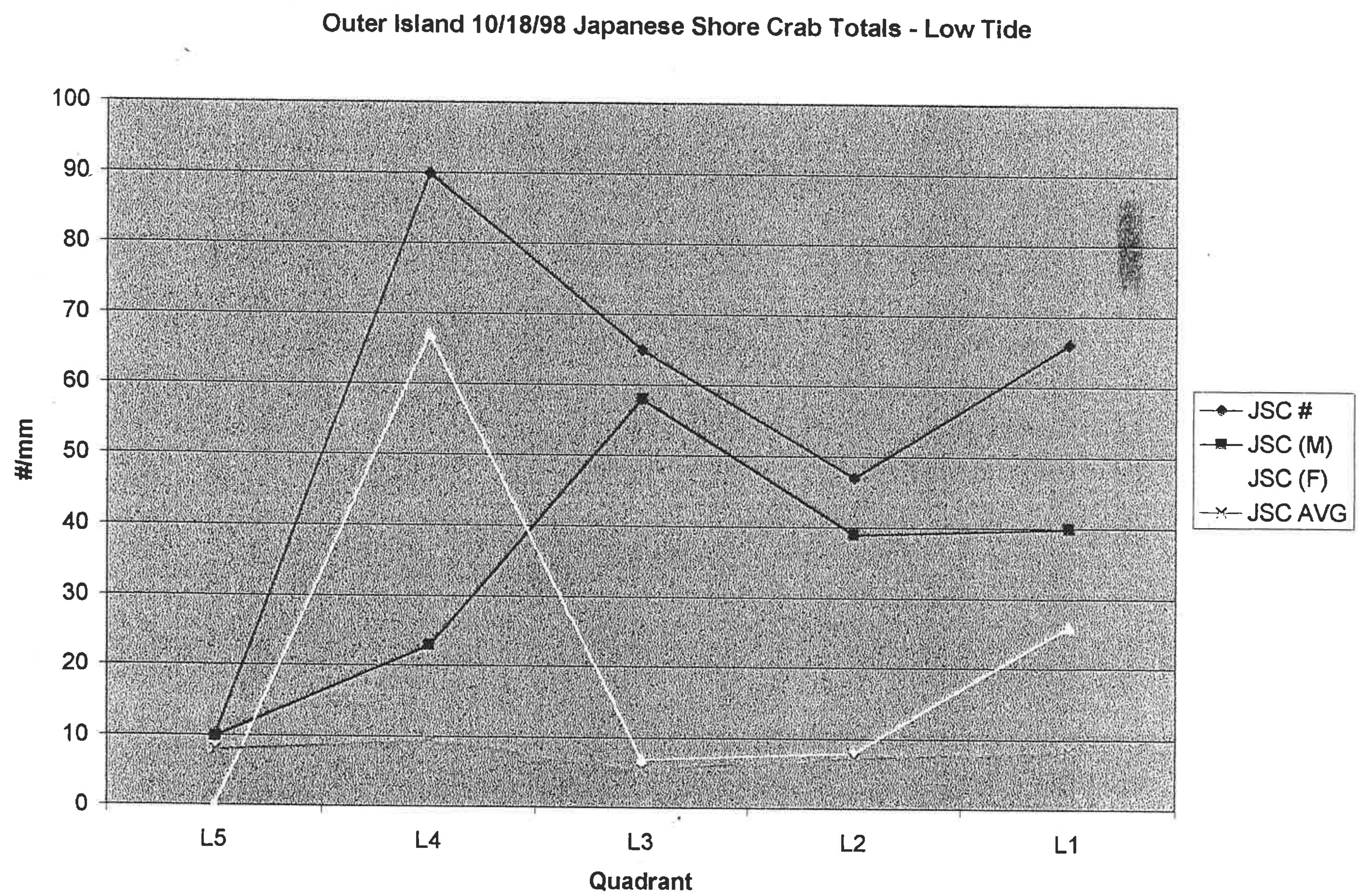

Outer Island 10/18/98 Japanese Shore Crab Totals - Low Tide
100
90
80
70
60
50
40
30
20
10
0
#/mm
L5
L4
L3
L2
L1
Quadrant
JSC #
JSC (M)
JSC (F)
JSC AVG

Chart 14

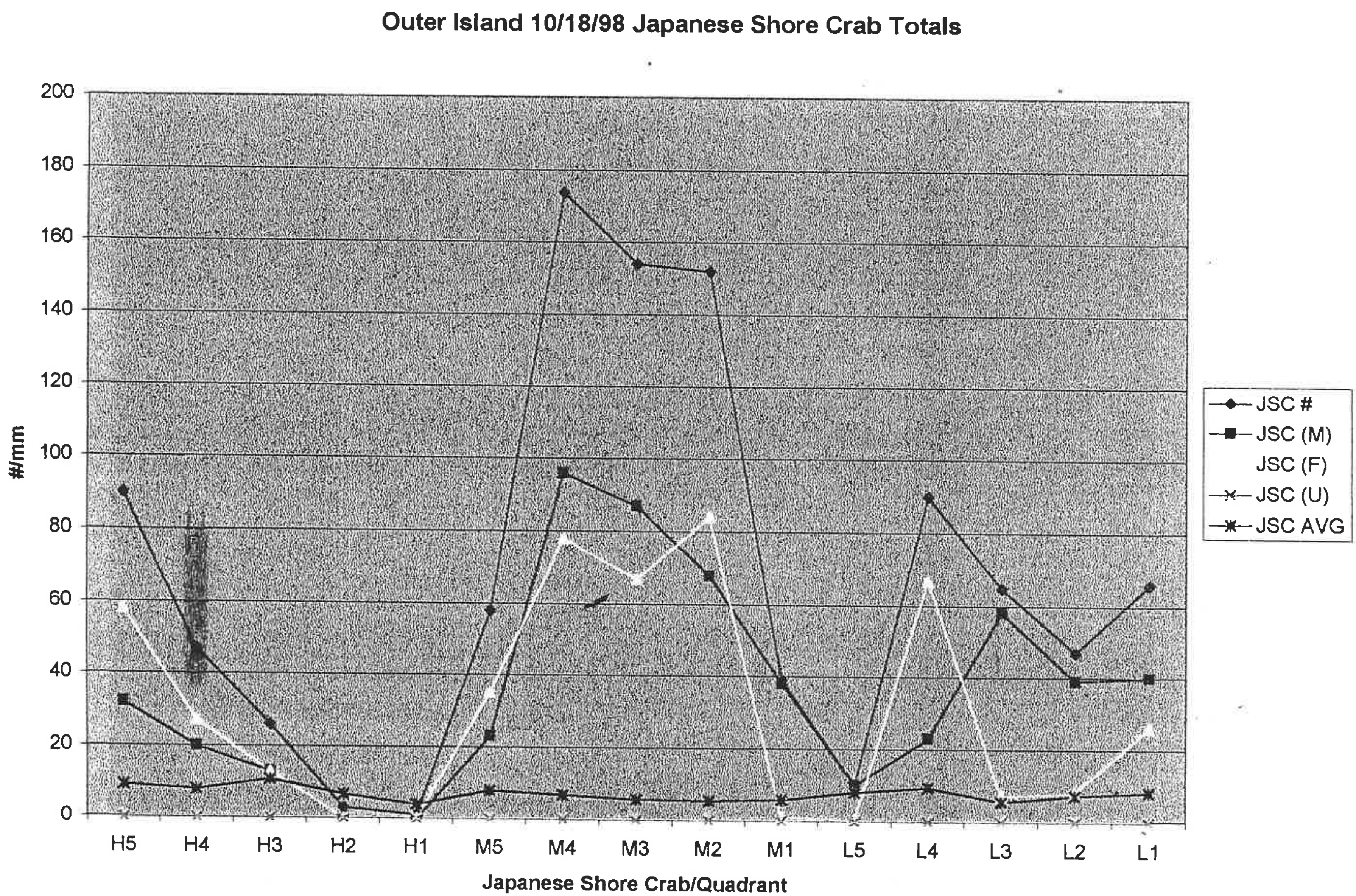

Outer Island 10/18/98 Japanese Shore Crab Totals
200
180
160
140
120
100
80
60
40
20
0
#/mm
H5
H4
H3
H2
H1
M5
M4
M3
M2
M1
L5
L4
L3
L2
L1
Japanese Shore Crab/Quadrant
JSC #
JSC (M)
JSC (F)
JSC (U)
JSC AVG

Chart 15