Size, abundance, and percent pigment in shrimp-like crustaceans throughout the water column near Southwest Reef, Bahamas

Sara Matthews

Abstract

Planktonic organisms are often fed on by visual predators. They have adapted various ways to "camouflage" themselves in the open ocean. Possible adaptations include transparency, small size, and diel vertical migration. In a study using two MOCNESS tows off Southwest Reef, Bahamas, macrofaunal shrimp-like crustaceans were collected through the water column to 900 meters. General trends seen with increasing depths included: decreasing abundance, increasing size and increasing pigmentation. Several explanations are given for these findings.

Introduction

Planktonic crustaceans have several predator-avoidance adaptations for visual predators, including coloration and migratory behaviors. In the open ocean, there are no substrates, with the exception of floating algae, to camouflage against. Since piscine planktivores are visual predators (Zaret and Suffern, 1976), it would be advantageous for prey to be transparent or located at deeper depths during daylight hours. By using diel vertical migration, plankton can feed in the surface waters at night and sink to some depth during the day to avoid predation (Gliwicz, 1986). In addition to migrating and being transparent, planktonic organisms can avoid being seen by being small in size (Verity and Smetacek, 1996).

In this study, shrimp-like crustaceans (herein shrimp) were collected at depths from the surface to 900m to survey the abundance, size, and coloration throughout the water column. The water column was split into eight depth ranges using a MOCNESS to determine a trend for Southwest Reef, Bahamas.

Methods

Two MOCNESS tows were taken at Southwest Reef, Bahamas (N 24°52'.9795, W 77°32'.3854) between May 15 and 21, 2008. Collections with 130 mm mesh were made from 900m up to the surface, with nets closing at 750, 650, 550, 450, 350, 250, and 150 meters. The towing rate was 10 meters per minute, and the opening of each net was 1 m^2. Once at the surface, cod ends were rinsed into containers, keeping collections from each net separated. Macrofauna were separated from other plankton using a spaghetti strainer. Macrofaunal shrimp were enumerated, categorized by color pattern, and measured using calipers. Because the surface sample on the second MOCNESS tow contained high densities of shrimp, the sample was split into one-quarter for determination of abundance and pigmentation: one-tenth of the shrimp from that subset were measured for length. A picture was taken of each representative color group for determining the percentage of the animal that was pigmented. All shrimps that had color were red, orange, or brown except for one individual in the surface tow, which was completely transparent except for its blue eyes. This individual was still included in the data set. Percentage pigment for the group of shrimp at each depth was calculated using the abundance of each color pattern of shrimp (i.e. the most abundant shrimp color pattern weighed heaviest in the overall percentage for that depth). Each variable was plotted against depth to determine trends throughout the water column.

Results

The highest abundance of shrimp was found in the surface tow (0-150m) on the second MOCNESS sample. Shrimp abundance at the surface (extrapolated from a quarter of the sample) totaled over 2600. This was not included in the figures in order to see the detail from the rest of the depths. There are two other peaks of abundance with depth: nets with maximum depths of

250 and 450 meters (Figure 1). These trends were seen in both MOCNESS tows. The remaining depths had less than 30 shrimp for each sample, with the general trend of decreasing abundance with increasing depth.

Shrimp size had a general trend of increasing with depth (Figure 2). There is one unusual peak at 350m, present in both samples. In the second MOCNESS, one shrimp collected at that depth measured 57mm. This individual was omitted in for this figure due to the large increase in variance in size for that depth. The same trend is seen with and without it.

Percent of pigment on shrimp generally increased with depth (Figure 3). One exception to this trend was the 750-900m catch in the second MOCNESS sample. In this net, only one of 9 shrimp was mostly pigmented, whereas in the first MOCNESS deep net only one shrimp was collected and was 100% pigmented. The low abundance in both samples causes these numbers to be drastically different.

Discussion

Shrimp abundance peaked with the surface tow on the second MOCNESS sample. This is an expected result, as it included the entire mixed layer including the thermocline. These are the areas of highest phytoplankton due to the sunlight available. Shrimp-like crustaceans that eat phytoplankton would be expected at depths of high phytoplankton densities. These high numbers are continued into the samples from 150-250m. With a decrease seen below 250m and one more peak at depths 350-450m, one would expect another nutritional source at that depth (i.e. marine snow). The abundance of marine snow is variable throughout the year and at different depths (Walsh and Gardner, 1992; Lampitt et al., 1993), so a separate study would need to be conducted to support this. Rex et al. (2006) related the decreasing faunal abundance with the rate of nutrient input: there is a decrease of nutrients with increasing depth and distance from the coast. Also, this might be the depth at which animals using diel vertical migration travel down to during the day. Although vertical migration has been studied at relatively shallower depths (16 meters in a temperate lake, Zaret and Suffern, 1976; 50 meters depth off Rhode Island, Herman, 1963), Ohman (1990) found migrating copepods and chaetognaths migrating to the bottom of part of the Puget Sound at 150 meters. Herman (1963) also mentioned that vertical migration happens in shallow and deep waters, so animals may be migrating from deeper depths up to a depth between 350-450m. On the other hand, those individuals found between 350-450m might not migrate all the way to the surface at night.

Shrimp size increased as depth increased. This is possibly a form of visual predator avoidance (Verity and Smetacek, 1996). Alternatively, it could show that the adult population has a different migration pattern than larvae or juveniles. Herman (1963) showed that *Neomysis americana* adults off Rhode Island only showed migration patterns when reproductive, while larvae or juveniles have regular migration patterns throughout the year. Since species were not determined, no further conclusions on this can be made from this data set, unless species can be identified from pictures.

Percentage of shrimp pigment increased with increasing depth. This is most likely explained by the light penetrating the water column. Red light is absorbed first in the water, making those individuals with red pigments look black to surrounding animals. This helps with camouflage where there is not a lot of light penetrating.

General trends of decreasing abundance, increasing size, and increasing pigmentation are seen with increasing depth. All of these can be attributed to predator-avoidance adaptations from visual predators, such as fish. Other explanations for these results are yet to be uncovered, as there may be many. Experimental studies on visual predators and descriptive inquiries from other parts of the world could help support the claims of this paper.

Literature Cited

Herman S.S. (1963) Vertical migration of the opossum shrimp, *Neomysis americana* Smith. Limnology and Oceanography 8(2):228-238.

Gliwicz M.Z. (1986) Predation and the evolution of vertical migration in zooplankton. Nature 320:746-748.

Lampitt R.S., W.R. Hillier, and P.G. Challenor. (1993) Seasonal and diel variation in the open ocean concentration of marine snow aggregates. Nature 362:737-739.

Ohman M.D. (1990) The demographic benefits of diel vertical migration by zooplankton. Ecological Monographs 60(3):257-281.

Rex M.A., R.J. Etter, J.S. Morris, J. Crouse, C.R. McClain, N.A. Johnson, C.T. Stuart, J.W. Deming, R. Thies, and R. Avery. (2006) Global bathymetric patterns of standing stock and body size in the deep-sea benthos. Marine Ecology Progress Series 317:1-8.

Verity P.G., and V. Smetacek. (1996) Organism life cycles, predation and the structure of marine pelagic ecosystems. Marine Ecology Progress Series 130:277-293.

Walsh I.D., and W.D. Gardner. (1992) A comparison of aggregate profiles with sediment trap fluxes. Deep-Sea Research 39:1817-1834.

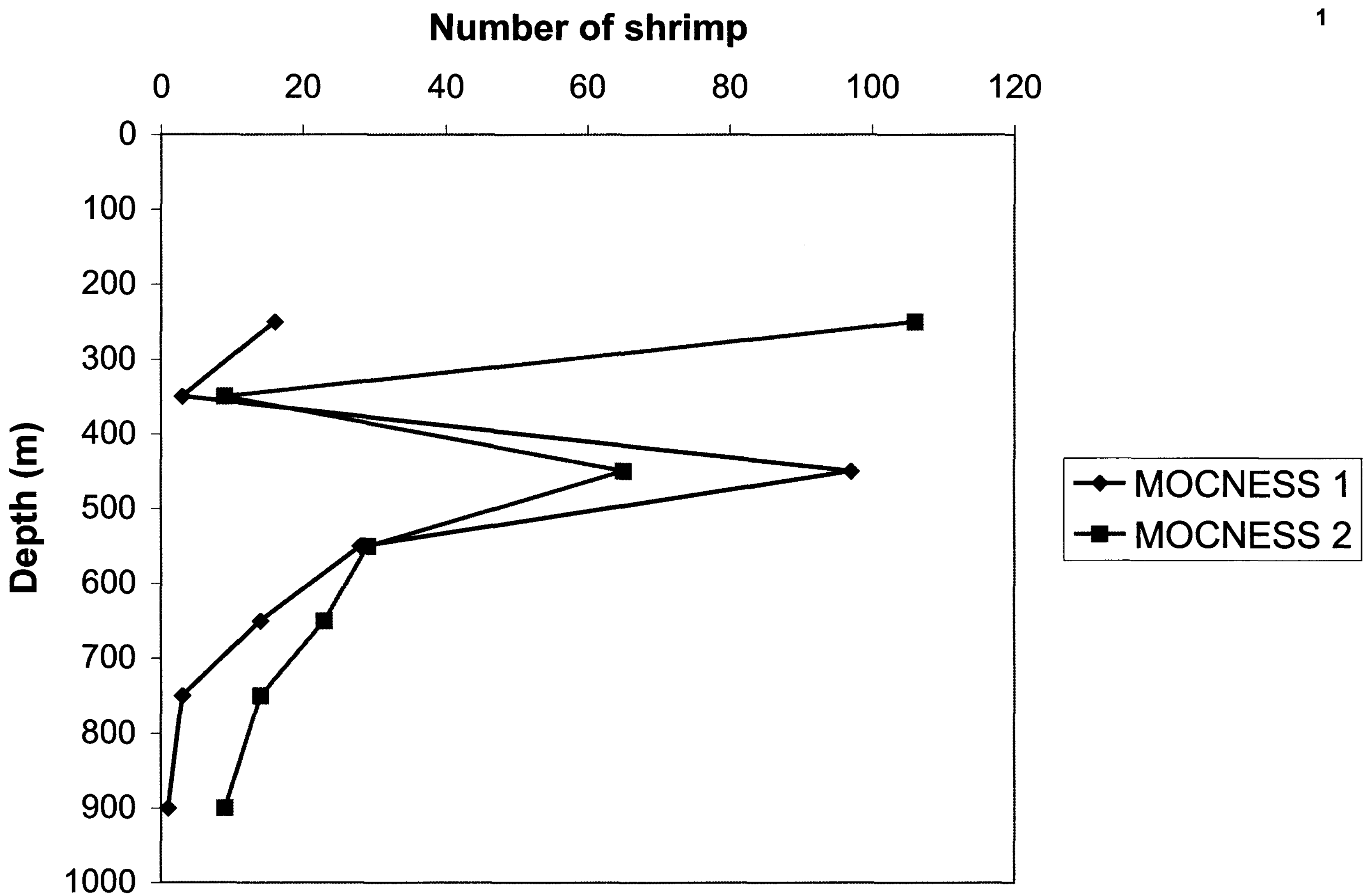
Zaret T.M., and J.S. Suffern. (1976) Vertical migration in zooplankton as a predator avoidance mechanism. Limnology and Oceanography 21(6):804-813.

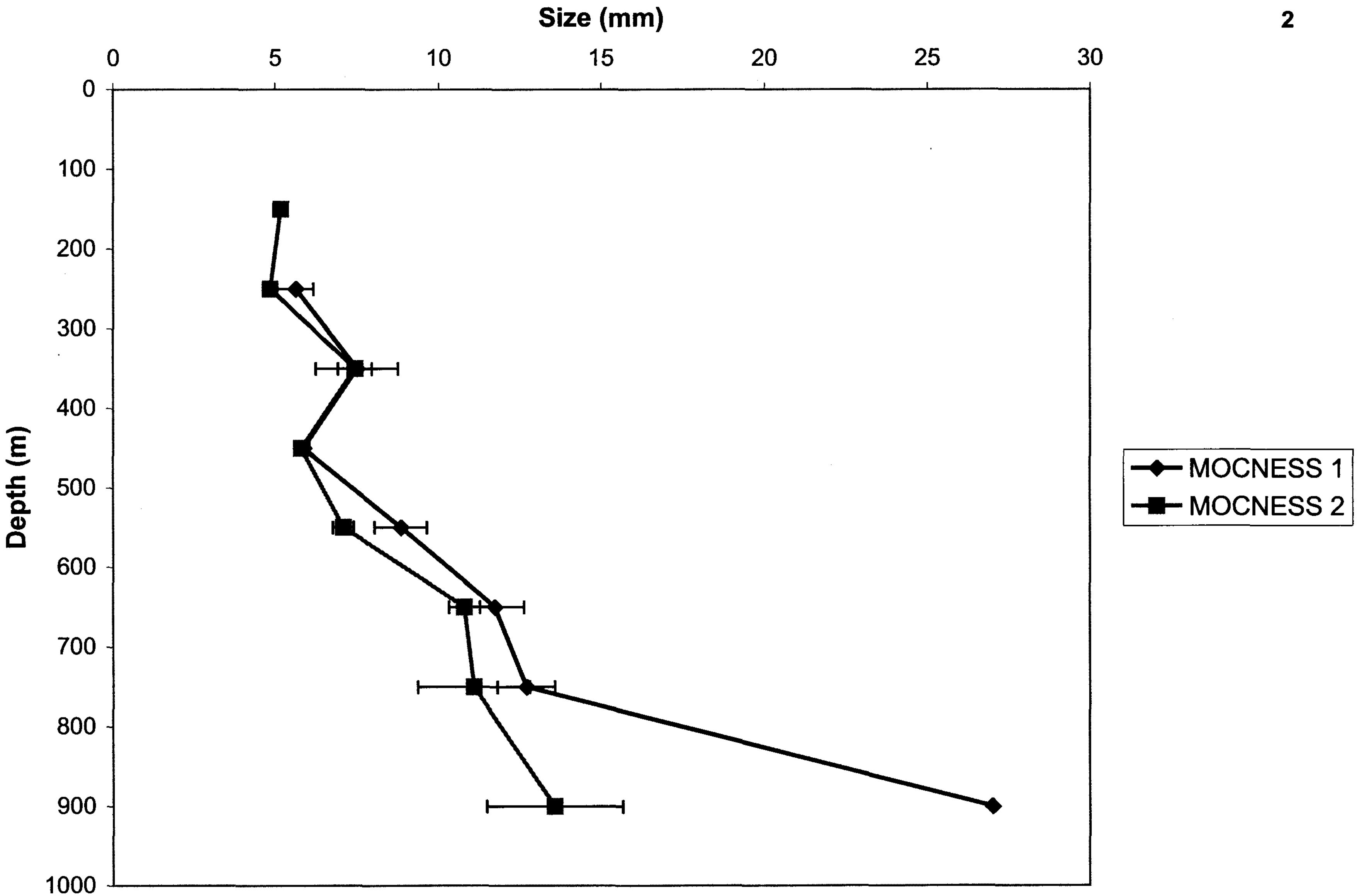
Figure Captions

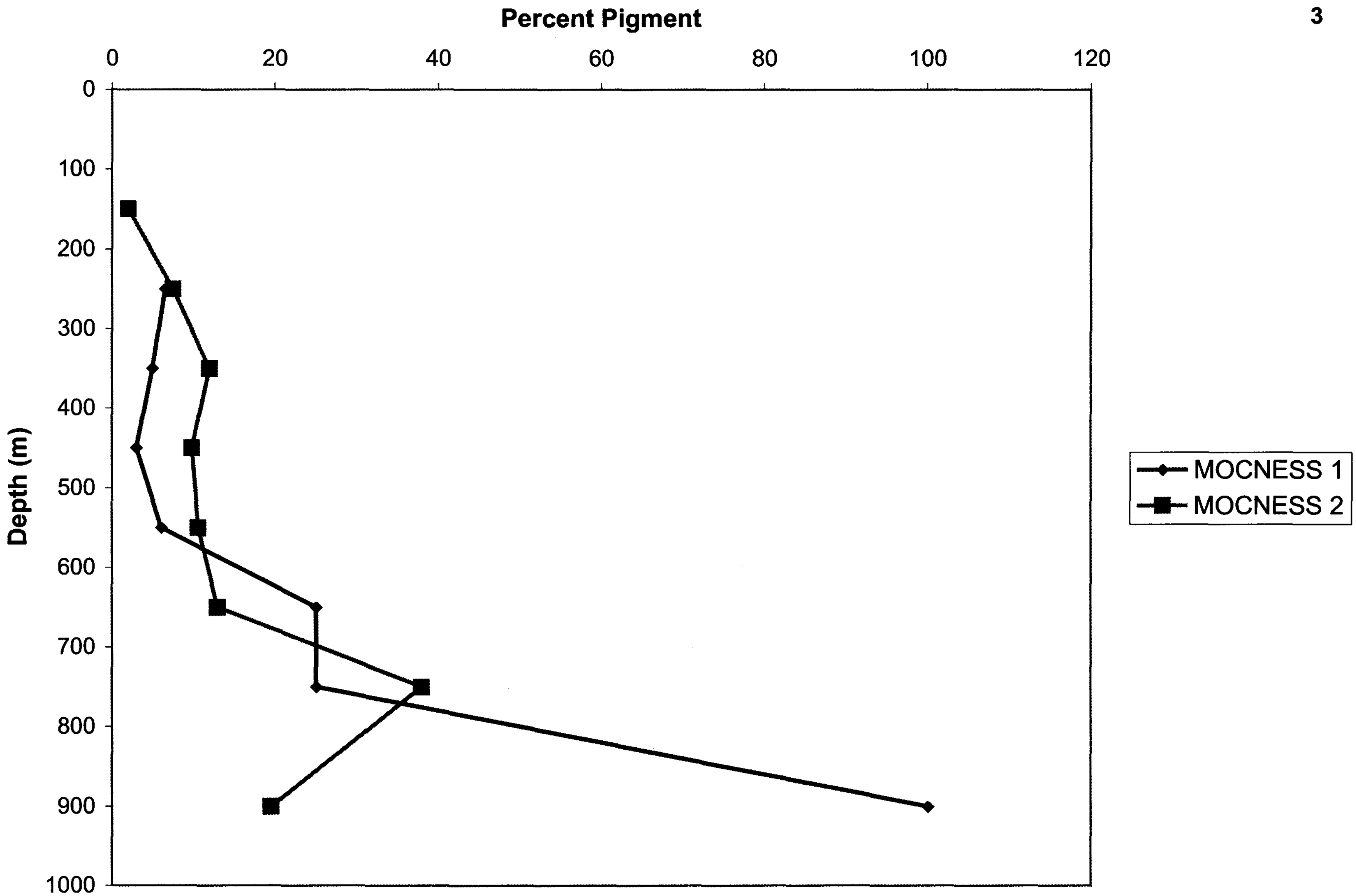
Figure 1: Abundance of shrimp through the water column plotted with their maximum depth for each net.

Figure 2: Size of shrimp through the water column plotted with their maximum depth for each net. Unusual individual from 350m not included (length: 57mm). Error bars represent standard error.

Figure 3: Percent of shrimp pigmented red, orange, and brown through the water column plotted with their maximum depth for each net.


Number of shrimp
0
20
40
60
80
100
120
Depth (m)
0
100
200
300
400
500
600
700
800
900
1000
MOCNESS 1
MOCNESS 2


Size (mm)
0
5
10
15
20
25
30
Depth (m)
0
100
200
300
400
500
600
700
800
900
1000
MOCNESS 1
MOCNESS 2


Percent Pigment
0
20
40
60
80
100
120
0
100
200
300
400
500
600
700
800
900
1000
Depth (m)
MOCNESS 1
MOCNESS 2