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The Vertical and Horizontal Distribution of Deep-Sea Crustaceans of the Order Euphausiacea (Malacostraca: Eucarida) from the northern Gulf of Mexico with notes on reproductive seasonality.

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By

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Table of Contents

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ABSTRACT

The vertical and horizontal distributions of Euphausiacea in the northern Gulf of Mexico, including the location of the *Deepwater Horizon* oil spill, were analyzed from 340 trawl samples collected between April-June, 2011. This study is the first comprehensive survey of euphausiid distributions from depths deeper than 1000 m in the Gulf of Mexico and included stratified sampling from five discrete depth ranges (0-200 m, 200-600 m, 600-1000 m, 1000-1200 m, and 1200-1500 m). In addition, this study encompasses the region heavily impacted by the *Deepwater Horizon* oil spill. Data presented here could potentially be used in ecosystem models investigating trophic effects of the spill because euphausiids are the preferred prey of a variety of higher trophic organisms. Lastly, these data represent the first quantification of euphausiid assemblages in this location after the *Deepwater Horizon* event and can serve as a basis of comparison against which to monitor recovery of the euphausiid assemblage after exposure to *Deepwater Horizon* hydrocarbons and dispersant in the water column.

Keywords: Euphausiacea, Deep Sea, Gulf of Mexico, *Deepwater Horizon* Oil Spill, Vertical Migration, Micronekton, Reproductive Seasonality

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

Importance of Euphausiacea:

Earth's oceans cover approximately 72% of the planet's surface and contain about 97% of the Earth's total water (NOAA, 2012). They are a vast and diverse habitat for over 200,000 known species and vital to all known life forms (Drogin, 2009). In spite of knowing how important our oceans are, it is estimated that only about 5% of Earth's oceans have been explored (NOAA, 2012). What is known as the "deep sea" has been explored even less. The deep sea includes all depths deeper than 200 meters (Charette and Smith, 2010). The Gulf of Mexico extends to a depth of around 4,000 m and therefore includes the epipelagic zone (0-200 m), the mesopelagic zone (200-1000 m) and the bathypelagic zone (1000-4000 m) (Turner, 1999). Pelagic refers to the water column, which is the habitat of the species in this study.

Euphausiacea is an order of crustaceans that can be found in oceans all over the world, including the Gulf of Mexico (Atkinson *et al*., 2009). The order consists of two families, the Bentheuphausiidae and the Euphausiidae. The family Bentheuphausiidae consists of only one species – *Bentheuphausia amblyops*. The family Euphausiidae consists of the remaining 85 species (Baker *et al.*, 1990). Although this may appear to be a small number of species, euphausiids can have large biomasses due to their high abundances. One species, *Euphausia superba*, has an estimated biomass of nearly 379,000,000 tonnes in the Southern Ocean alone (Atkinson *et al*., 2009).

Up until 1883, Euphaciacea and Mysidacea were grouped together in the order Schizopoda. This order was then divided into two orders by Johan Erid Vesti Boas because of morphological differences (Gordon, 1955). Molecular studies (Jarmin, 2001;

D'Amato, 2008) and Euphausiacea's distinctive physical characteristic of the gills being exposed below the carapace (Cassanova, 2003) support the idea that the order Euphausiacea is monophyletic (all the species within it are derived from a single ancestor).

Euphausiids are pelagic animals that actively swim, ranging from mesozooplankton (0.2 μm-2 mm), macrozoplankton (2-20 mm), and micronekton (20-200 mm) (Omori and Ikeda, 1985, Sutton, 2013). They are a vital part of the food web as they consume phytoplankton and zooplankton (Kinsey and Hopkins, 1994, Atkinson *et al*., 2009) and are in turn consumed by larger organisms including seabirds (Deagle *et al*., 2007), fishes (Jayalakshmi *et al*., 2011), whales (Schramm, 2007), and humans (Baker *et al*., 1990). Many of the organisms that prey upon euphausiids, such as tuna, are commercially important species (Jayalakshmi *et al*., 2011).

Euphausiacea are also important because most of them undergo diel vertical migrations, in which they remain in deeper waters during the day to avoid visual predators and ascend into shallower waters at sunset to feed under the cover of darkness (reviewed in Cohen and Forward, 2009). This is important to note because this means that Euphausiacea are potential prey for a variety of different organisms, at multiple depth levels. This also means that they were potentially exposed to oil at various depths after the *Deepwater Horizon* oil spill, and may have served as vectors for the transport of oil or other pollutants throughout the water column and through various trophic levels.

The current study is unique because it analyzes samples collected consecutively from 0 to 1500 m water depth within five discrete depth ranges. Previous studies of euphausiids in the Gulf of Mexico did not extend past 1000 m (Hopkins *et al.*, 1989, Kinsey and Hopkins, 1994, Gasca *et al*., 2001). When Burghart *et al*. (2007) collected samples of Decapoda, Lophogastrida and Mysida from depths greater than 1000 m in the eastern GOM, they found that the bathypelagic zone was dominated by different species, with several novel species also present that were not found in the mesopelagic zone. Burghart *et al*.'s study also demonstrated that several species thought to be relatively rare based on collections shallower than 1000 m, were actually quite common in the deeper depths, emphasizing the need to extend these studies to the Euphausiidae, one of the dominant groups in the Gulf of Mexico (Hopkins *et al.* 1989, Kinsey and Hopkins 1994).

The trawling sites for this study encompass the region most heavily impacted by the *Deepwater Horizon* oil spill. This region had not been studied in a comparable manner with respect to the pelagic ecosystem before the spill; hence there are no baseline data against which to measure the impact of the spill on the crustacean assemblage. The data presented here represent the first quantification of the euphausiid assemblage in this location after the *Deepwater Horizon* event and can be used to monitor recovery of the ecosystem after exposure to *Deepwater Horizon* floating oil, dissolved oil, oil droplets and dispersant in the water column. As such, they represent part of the only available dataset against which results from future GoMRI (Gulf of Mexico Research Initiative) funded cruises can be compared to monitor ecosystem changes in subsequent years.

Characteristics of the Gulf of Mexico:

The Gulf of Mexico (Figure 1) has numerous factors that interact with each other to form unique physical properties. While all of these factors are important, they do not all have major impacts on the characteristics of the Gulf's deep water which is the focus of this study. The Gulf is the world's 9th largest body of water and can be divided into two segments- the shallower water that covers the continental slope and the deeper water that extends out towards the center of the Gulf (Nipper *et al.*, 2004). Each of these two segments cover about half of the Gulf's basin which stretches for roughly 1,600,000 km^2. The Gulf also holds approximately 2,500,000 km^3 of water at any given time and its deepest point, at 4383 m is called the Sigsbee Deep (Nipper *et al.*, 2004).

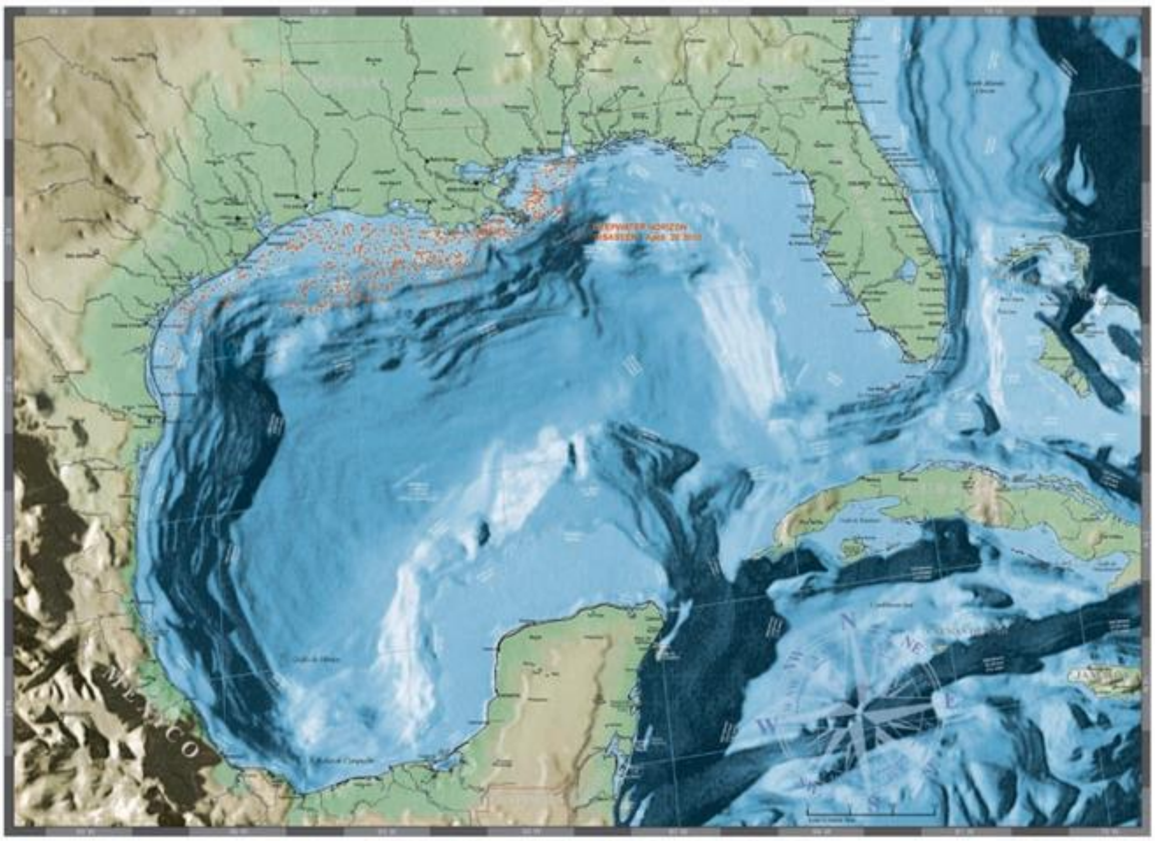

Figure 1. Location and topography of the Gulf of Mexico with respect to the United States, Mexico, and Cuba (Port Publishing, 2015).

The Gulf of Mexico has multiple sources of both fresh and salt water. The largest input source of salt water is the Loop Current (Johns, 2002) and the largest input source of fresh water is the Mississippi River. In total, more than 1.06 x 10^9 $m^3$of freshwater enter and mix with the salt water of the Gulf of Mexico each year. Over half of this fresh water input comes from the Mississippi River (Moody, 1967). However, most of the fresh water from the Mississippi River remains on the continental slope and minimally interacts with the deep water of the Gulf (Jochens and DiMarco, 2008).

The Loop Current is the main circulation feature of the Gulf of Mexico. It is a warm water current that moves north into the Gulf through the Yucatan Channel (which has a sill depth of 2040 m), veers east towards Florida, then turns south and exits the Gulf via the Straits of Florida (which has a sill depth of 730 m) (Bunge *et al.* 2002; Johns, 2002). These sill depths are important because they can affect water transfer into and out of the Gulf (Bunge *et al.*, 2002). The position of the Loop Current can also vary dramatically; it may take a sharp right after entering the Gulf and head straight for the Atlantic Ocean, or it may flow well into the northeastern corner of the Gulf before exiting (Bunge *et al.*, 2002).

While the Loop Current predominantly affects the eastern and northern waters of the Gulf of Mexico (due to its physical location) it can also have an impact on the western waters as well. The Loop Current causes the formation of warm water eddies that are flung off the main current and sent spiraling westward within the Gulf (Sturges, 2000). Some of these clockwise circulating eddies can reach about 400 km wide and extend about 1000 m deep (Oey *et al.*, 2005). Due to the depth of some of these eddies, counterclockwise circulation can sometimes be generated in the deeper parts of the water column. Although much smaller in size and force than the Loop Current itself, these eddies generated by the Loop Current impact the circulation of the water in the Gulf of Mexico (Oey *et al.*, 2005).

MATERIALS AND METHODS

Sample Collection and Analysis

Samples were collected from April through June 2011 on the M/V *Meg Skansi* cruise MS7 in the northern GOM (Figure 2). Samples were collected with a 10-m^2, six-net MOCNESS (Multiple Opening and Closing Net and Environmental Sensing System) trawl with 3-mm mesh nets (Wiebe *et al*., 1976). Table 1 shows the depth ranges that were collected from 0-1500 m. Samples were collected twice during each 24-hour cycle, resulting in one "day" trawl and one "night" trawl at each station. Temperature and salinity measurements were collected with a separate CTD cast because the sensors on the MOCNESS trawl were not calibrated appropriately. A total of 516 samples were collected, but only 340 samples from 45 sites (Appendix I) were included in this study as all oblique nets (net 0s which fished open from 0-1500 m) and all samples that had unreliable flow data were excluded from the analyses. The samples were fixed in 10% buffered formalin in seawater and transported to the Deep-sea Biology lab at Nova Southeastern University, where all the crustaceans in the sample were identified to the lowest taxonomic classification possible, using taxonomic keys from Chase (1940), Crosnier and Forest (1973), Abele and Kim (1986), Baker *et al*. (1990), and Holthuis (1993). The body lengths of 25 individuals of each species in each sample were measured with digital calipers (CO030150 electronic digital caliper, Marathon Management). After taxonomic identification, species were weighed to the nearest 0.01 g (P-114 Balance, Denver Instruments).

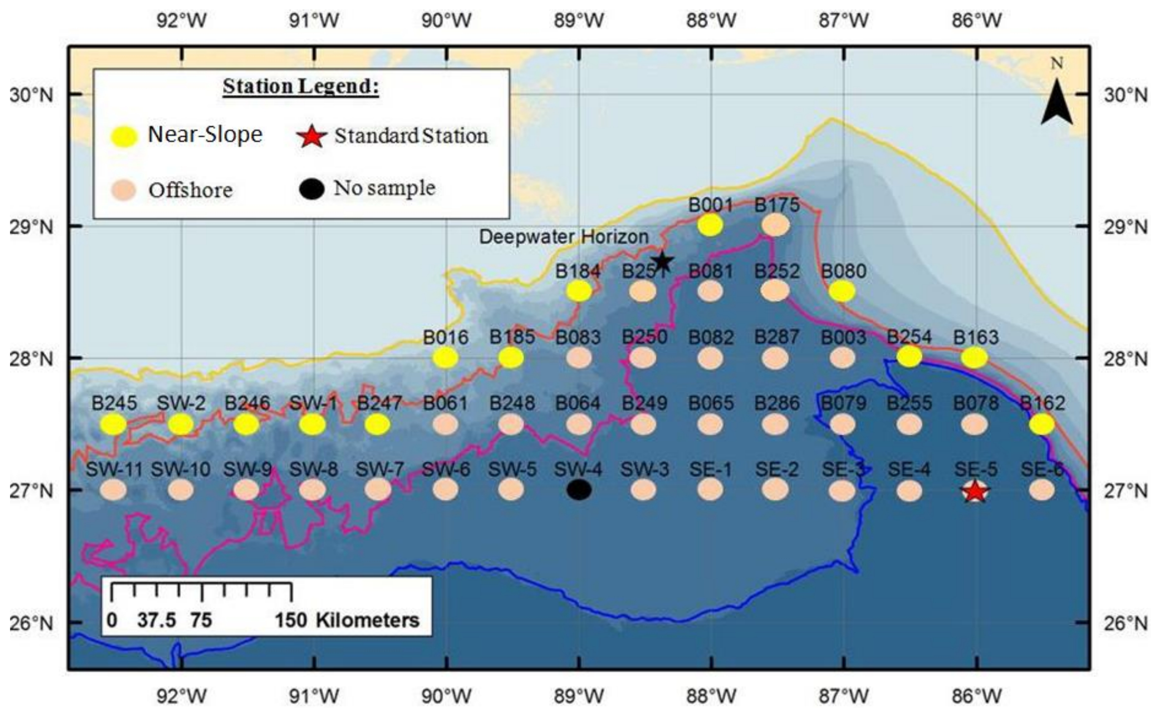

Figure 2. Sampling stations of the M/V *Meg Skansi* cruise from April to June showing near-slope and offshore station divisions. Black star indicates *Deepwater Horizon* oil rig. Red star indicates Standard Station.

Table 1. Depth intervals sampled by the MOCNESS Trawl.

Net Number	Depth Codes
0	0-1500 m
1	1200-1500 m
2	1000-1200 m
3	600-1000 m
4	200-600 m
5	0-200 m

Near-slope Vs Offshore Assemblage Comparison

Stations were divided into two groups and listed as either near-slope or offshore (Figure 2). Those stations that were on or adjacent to the 1000-m isobath, where trawls down to 1500 m were not possible, were categorized as near-slope samples and those that were located on the open ocean side of the isobath where trawls down to 1500 m were possible, were categorized as offshore samples. There were a total of 32 offshore stations (station SW-4 was not trawled) and 13 near-slope stations. Near-slope stations were limited by depth and were trawled up to their maximum depth. The offshore stations were trawled to a maximum depth of 1500 m. Total catch was standardized for each station by dividing by volume of water filtered in order to calculate station to station variance with respect to location.

To compare near-slope assemblages of euphausiids with offshore assemblages, species data from all the trawls in one area were combined; i.e. data from all near-slope trawls were combined to compare with data from all combined offshore trawls. As the volume of water filtered by each net in each trawl varied, these data were standardized by dividing the combined species counts (N) or biomass (g) by the total volume filtered (m^3) in the nets that trawled the specified areas. Normality was tested for by using the Shapiro-Wilk test. The test showed that the data were not normally distributed and therefore, Mann-Whitney *U* tests had to be applied to determine if there were significant differences between individual species' abundances for near-slope vs offshore assemblages.

Euphausiids were ranked in descending order of abundance with the most abundant species having a rank of 1, for both near-slope and offshore assemblages. A Spearman's rank comparison was completed using the equation:

$$\rho = 1 - (6\Sigma d_i^2)/[n(n^2-1)]$$

where n is the number of species and d_i is the difference in paired ranks for each species. Spearman's rho values were compared with table values to determine if there were significant differences between the assemblages of euphausiids within the two study areas.

Biomass data for all crustacean groups were quantified, but species analyses were only carried out on the Euphausiacea. After standardizing the data to N m^{-3} or g m^{-3}, euphausiid species were listed in decreasing order of abundance with regards to depth range and time of collection (day or night). Species richness (S), evenness (J'), and diversity (H') values were calculated for near-slope and offshore assemblages, also with regards to depth range and time of collection. Species richness is the number of species found within a certain area, evenness is a representation of how evenly distributed individuals in an assemblage are amongst all species present, and diversity is a correlation between species richness and evenness (Hill, 1973). Therefore, as species richness increases and evenness increases, so should diversity. Species diversity was calculated by using the Shannon Diversity Index equation:

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

where p_i is the proportion of the assemblage arising from the i^{th} species. Evenness was calculated by using the Pielou's Evenness Index equation:

$$J' = H'/H'_{max} = H'/\log S$$

where H' is the species diversity, H'_{max} is the value representative of all species being equally abundant, and S is the species richness. Independent sample t-tests were then completed on the Shannon Diversity Indices to see if any significant differences were present between near-slope and offshore assemblages with respect to depth range and time.

Gravid Female Data

The number of gravid females present was recorded for the species that had at least one gravid female. These numbers were used to calculate standardized abundances of gravid females per depth range and per month, as well as the percent of the total catch that was represented by gravid females for the specified month.

Vertical Distribution

Species that made up 99% of the euphausiid assemblage were analyzed with respect to their vertical distributions, as there were enough individuals (over 100 per species) present of these species for meaningful analyses. The total abundance (N m^{-3}) was determined for each species, and the percentage of the assemblage at each depth range during the day and at night was calculated. The depth ranges examined were the epipelagic (0-200 m), upper mesopelagic (200-600 m), lower mesopelagic (600-1000 m) and bathypelagic (split between 1000-1200 m and 1200-1500 m).

RESULTS

Temperature and Salinity

Surface temperature values ranged from 24-29 ºC with the coolest temperature occurring in May and the warmest temperature in June. Surface salinities varied slightly from 36.3-36.8 psu. Temperature decreased with depth until 900 m, where it leveled off at around 5 ºC for all stations. Salinity values decreased with depth until 500 m, where they leveled off to 34.9 psu for all stations. A thermocline was present from 25-600 m and a halocline was present from 125-500 m for each month at every station. Figures 3-

5 show representative temperature and salinity profiles for April, May, and June respectively, showing that there was little variation in these physical parameters with respect to location or month.

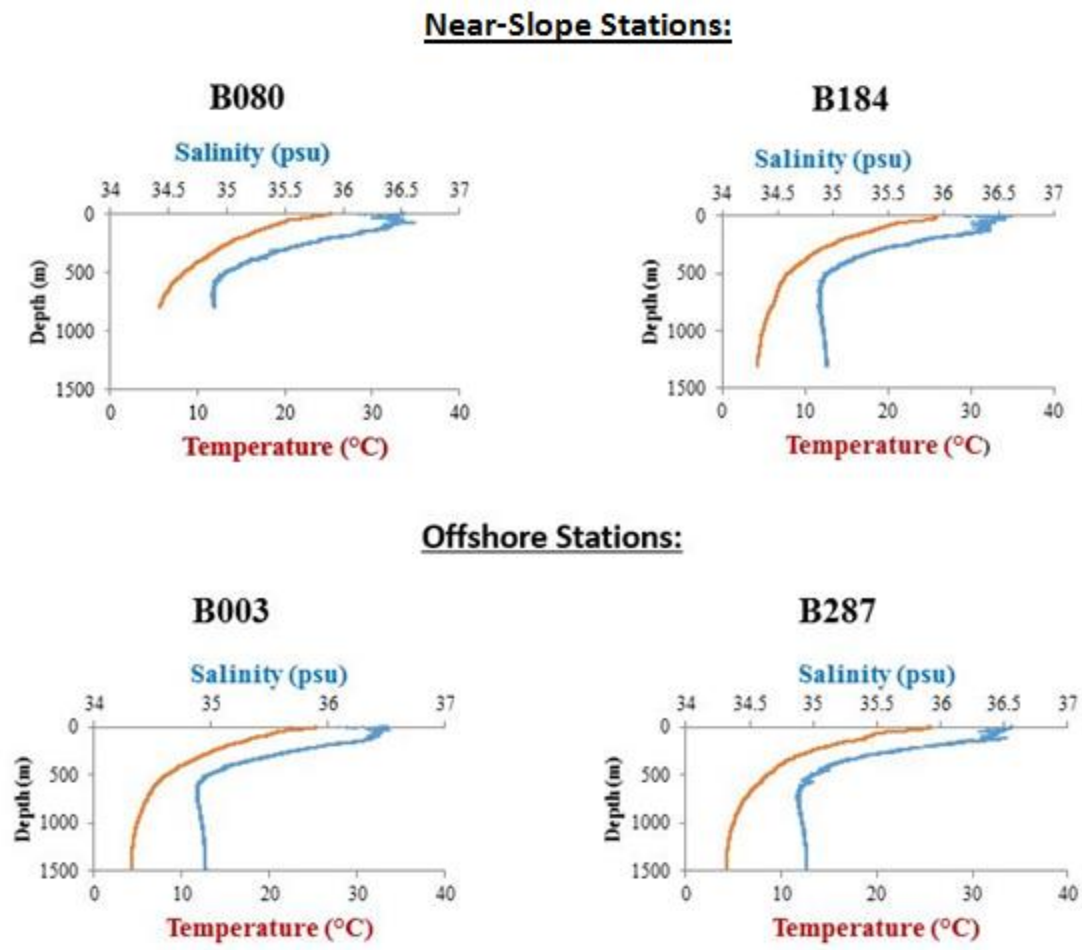

Figure 3. Temperature and Salinity profiles from the month of April during the MS7 *Meg Skansi* cruise.

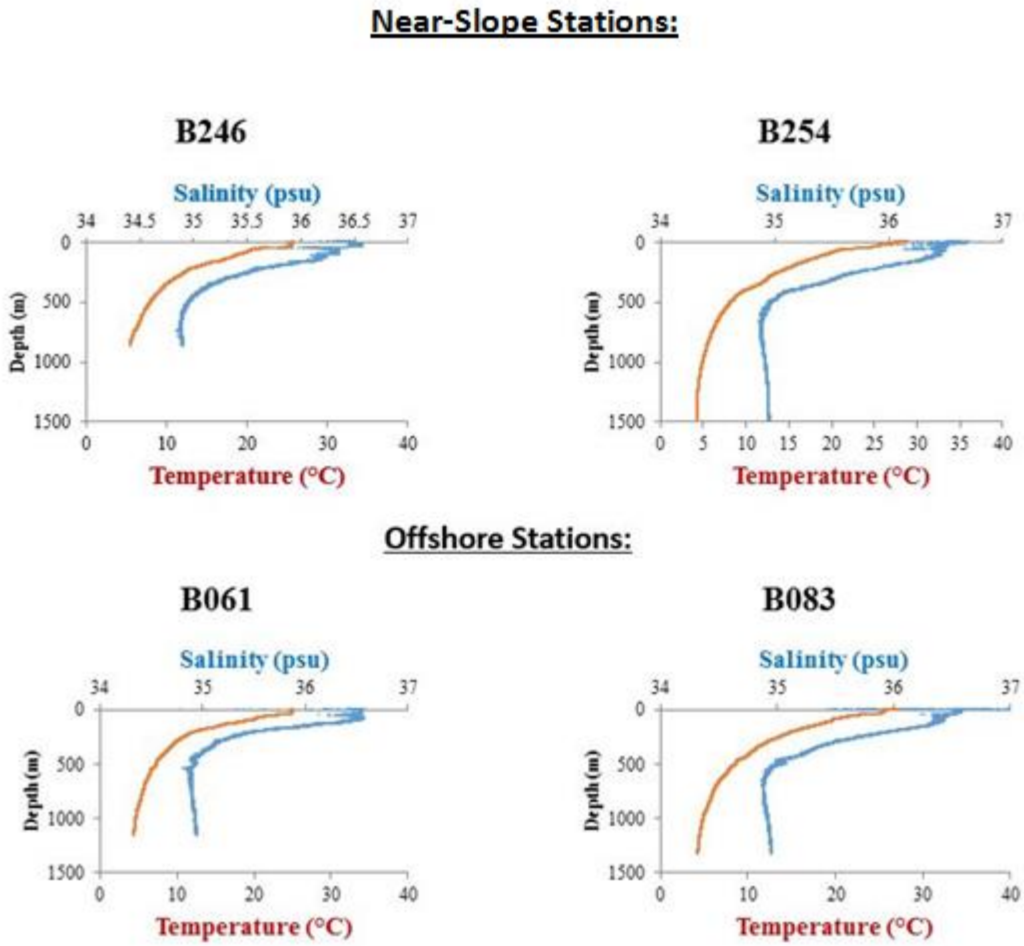

Figure 4. Temperature and Salinity profiles from the month of May during the MS7 *Meg Skansi* cruise.

Near-Slope Stations:

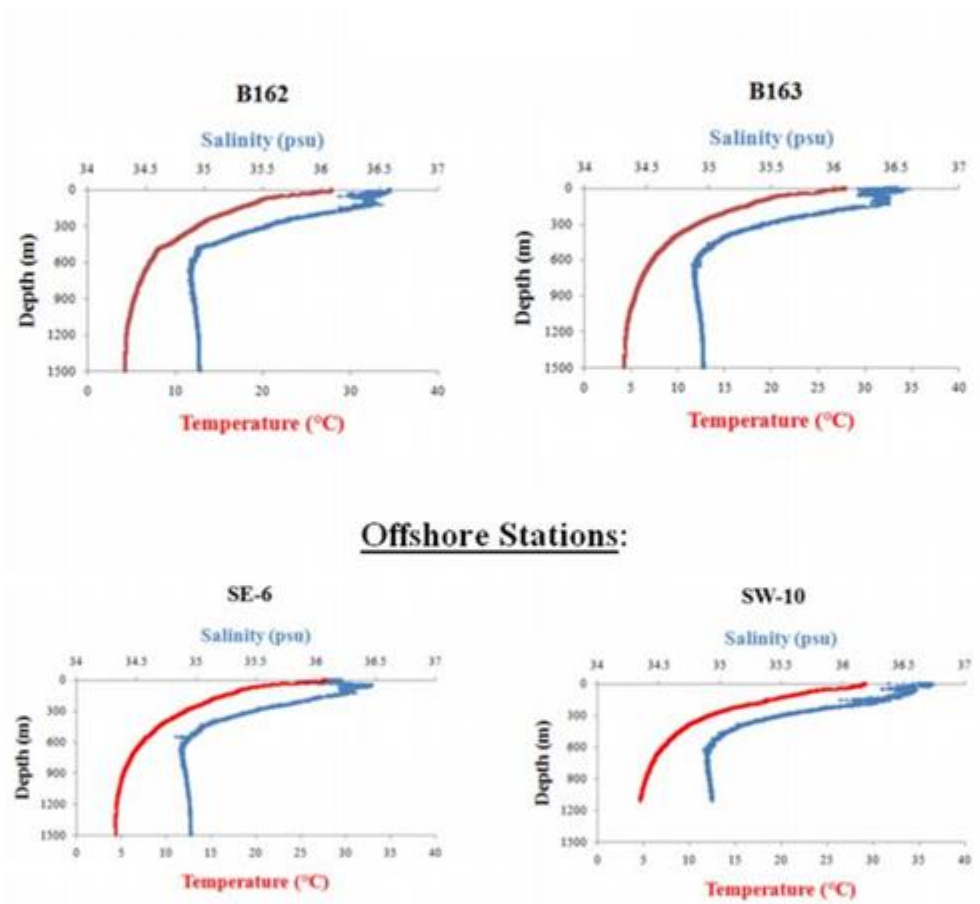

Figure 5. Temperature and Salinity profiles from the month of June during the MS7 *Meg Skansi* cruise.

Total Abundance and Biomass

During the analyses, it became clear that for several groups of euphausiids collected at these sites, the species description did not match known species. For example the key characteristic distinguishing *Nematoscelis atlantica* and *Nematoscelis microps* (James 1970, Roger 1978, Mikkelsen 1987, Baker *et al.* 1990) is the number of setae on the propodus of the first thoracic leg, which should be 5-6 for *N. atlantica*, and

8-9 for *N. microps*. Of the first two hundred individuals that were examined, 91% of them possessed seven setae, so these species were grouped together as *N. atlantica/microps.* Ongoing molecular analyses will determine if this is a new species, or if the original separation was a misidentification of a single species. Furthermore, *Thysanopoda obtusifrons* and *Thysanopoda aequalis* (James 1970, Mikkelsen 1987, Baker *et al.* 1990) are reportedly distinguishable by the structure of their antennular lappets. *Thysanopoda obtusifrons* should have an antennular lappet that covers a third to half of the width of the base of the second segment of the antennular peduncle, while *T. aequalis* should have an antennular lappet that covers the full width of the base of the second segment. This difference was not readily apparent in the samples analyzed in this study so the two species were grouped together as *T. obtusifrons/aequalis*. Lastly, *Thysanopoda acutifrons* and *Thysanopoda orientalis* are two very closely related species and cannot be differentiated unless they are sexually mature adults with petasmae or thelyca (Baker *et al*., 1990). The individuals in these samples were small with very few sexually mature individuals, so these two species were grouped together as *T. acutifrons/orientalis*.

In total, 51,559 euphausiids were collected. Sixteen species made up 99% of the total euphausiid assemblage and were categorized as abundant, while 15 species made up the remaining 1% and were categorized as rare. *Nematoscelis atlantica/microps* was by far the most abundant euphausiid taxon, accounting for 51.2% of all euphausiids present, with *Stylocheiron abbreviatum* (12.4%) being the only other species to account for more than 10% of the total (Figure 6). Each of the rare species included in the bottom 1% accounted for 0.2% or less of the total euphausiid assemblage (Figure 7).

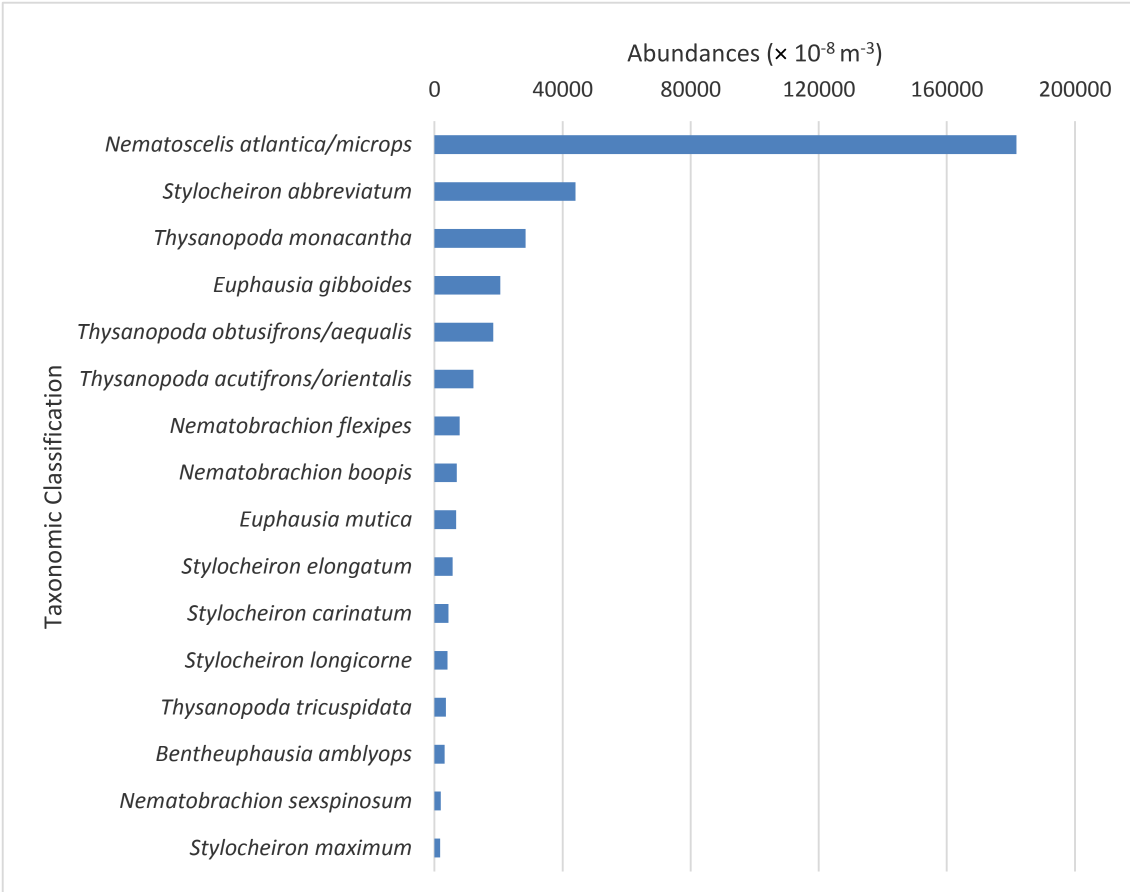

Figure 6. Standardized abundances for the species that comprise the top 99% of all Euphausiacea caught (categorized as abundant species)

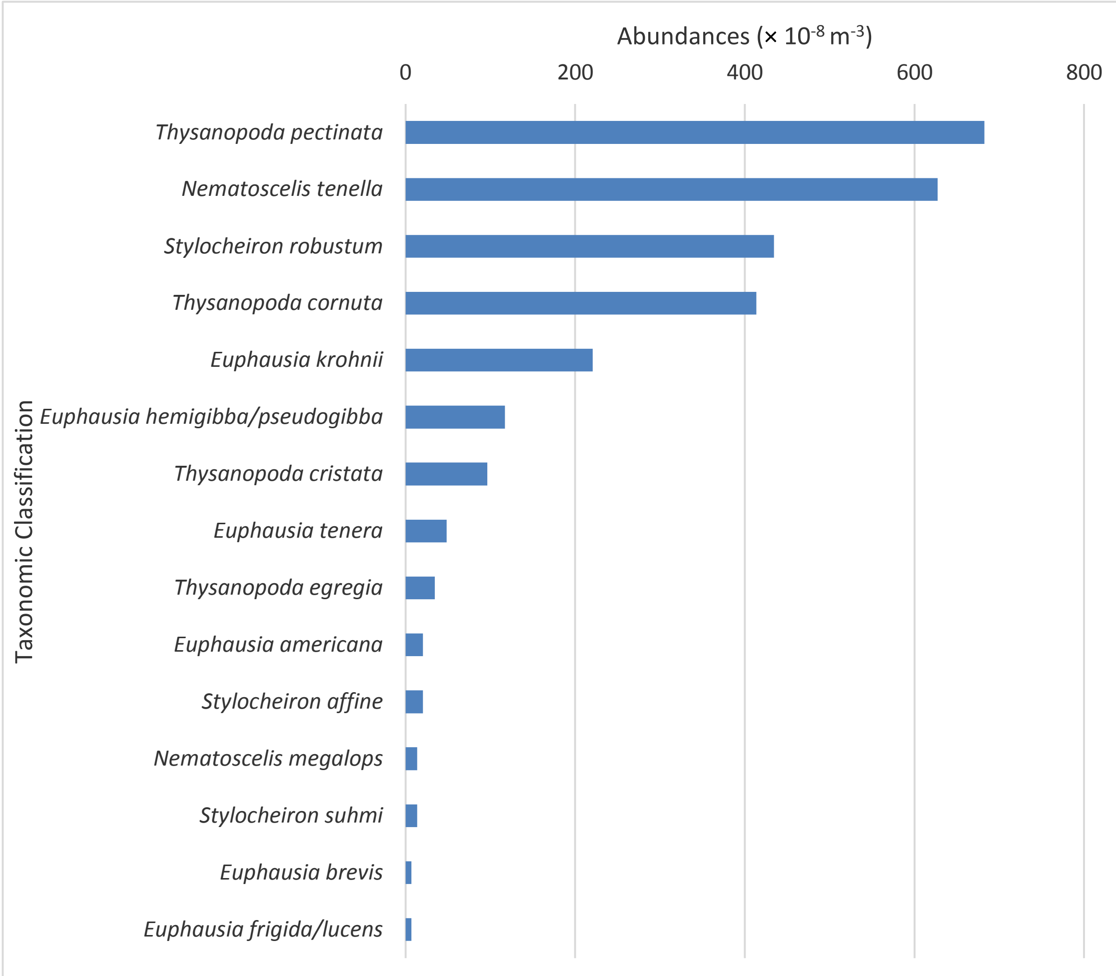

Figure 7. Standardized abundances for the species that comprise remaining 1% of all Euphausiacea caught (categorized as rare). Note: X-axis max value is different from that of Figure 6.

Euphausiids made up 15.8% of the total biomass of all the crustaceans collected during this study (1.837 kg), with *Nematoscelis atlantica/microps*, the most abundant euphausiid, making up 44% of the total euphausiid biomass. *Thysanopoda acutifrons/orientalis* was the 6th-most abundant euphausiid, but due to its larger size compared to the more abundant species, it made up 12.7% of the total euphausiid biomass. Figures 8 and 9 show the biomass of the abundant and rare euphausiid species, respectively.

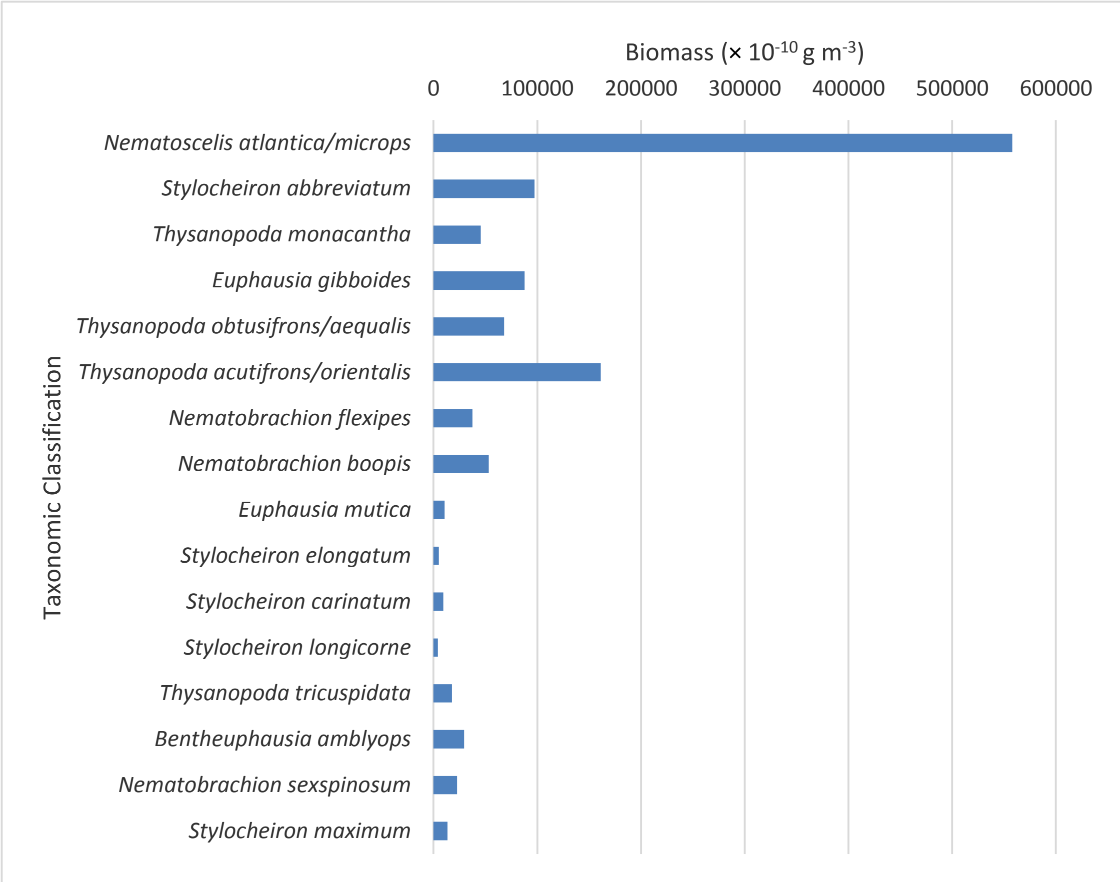

Figure 8. Standardized biomass for abundant euphausiids.

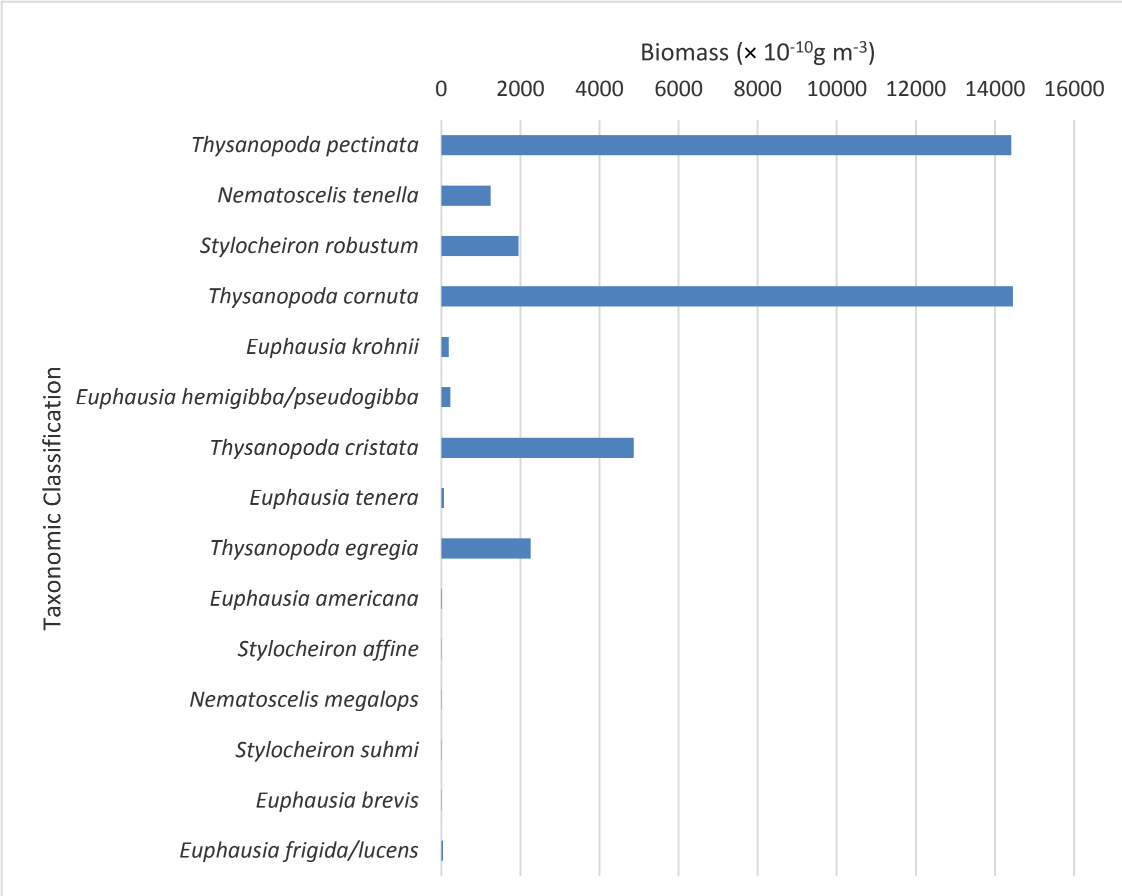

Figure 9. Standardized biomass for rare euphausiids. Note: X-axis maximum value is considerably less than that of Figure 8.

Vertical Distribution

Vertical distribution patterns were determined for the 16 most abundant species (those that made up 99% of the euphausiid assemblage). There was a clear separation of these species into three distinct groups based on their vertical distributions: 1) species in which over 50% of the population migrated to a shallower depth range at night, and thus categorized as strong vertical migrators (Figure 10); 2) species in which 19.5-41.3% of the population migrated to a shallower depth range at night, and thus categorized as weak vertical migrators (Figure 11); and 3) species where less than 2% of the population moved to a shallower depth range at night, and thus categorized as non-vertical migrators (Figure 12).

Six of the 16 abundant species were strong vertical migrators, five species were weak vertical migrators, and five species showed no discernable vertical migrations. All six of the species that were considered strong vertical migrators had over 50% of their respective day populations caught at deeper depths (between 200-600 m), while over 50% of their night populations were caught between 0-200 m. Four of the five species that showed a weak vertical migration pattern had over 50% of their respective day populations caught between 200-600 m but only 19.5-41.3% of their night populations caught at shallower (0-200 m) depths. The other weak migrator, *Bentheuphausia amblyops*, was found primarily between 600-1200 m (40.4% between 600-1000 m and 46.1% between 1000-1200 m) during the day, with a small portion (11.8%) migrating up to 200-600 m at night. Of the five species that showed no vertical migration, more than 50% of the *Stylocheiron abbreviatum* and *Stylocheiron carinatum* individuals were caught between 0-200 m during both the day and the night. The remaining three species (*Stylocheiron longicorne*, *Stylocheiron elongatum*, and *Nematobrachion boopis*) were caught primarily between 200-600 m during both the day and night.

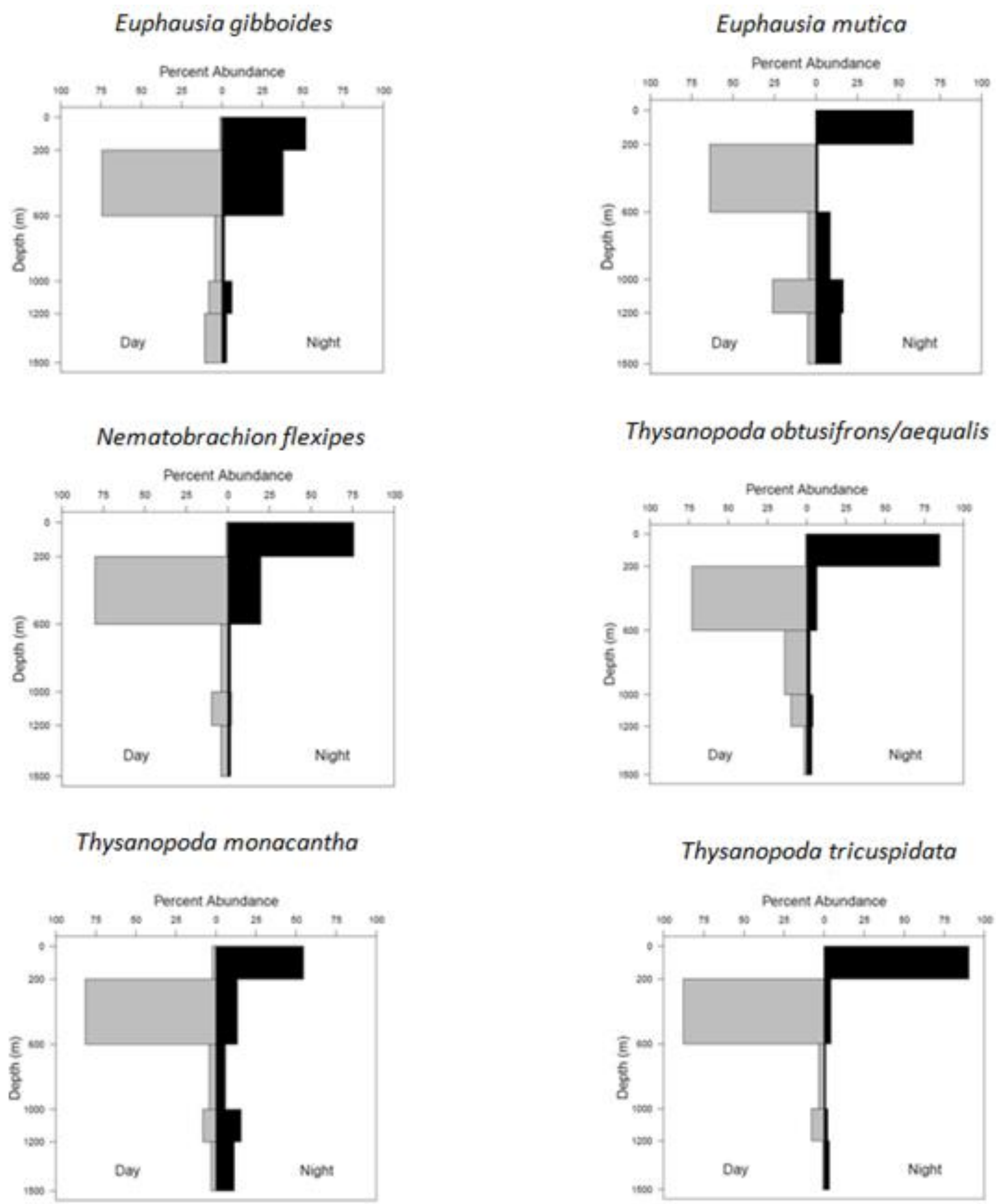

Figure 10. Vertical distribution patterns for abundant species that are strong vertical migrators.

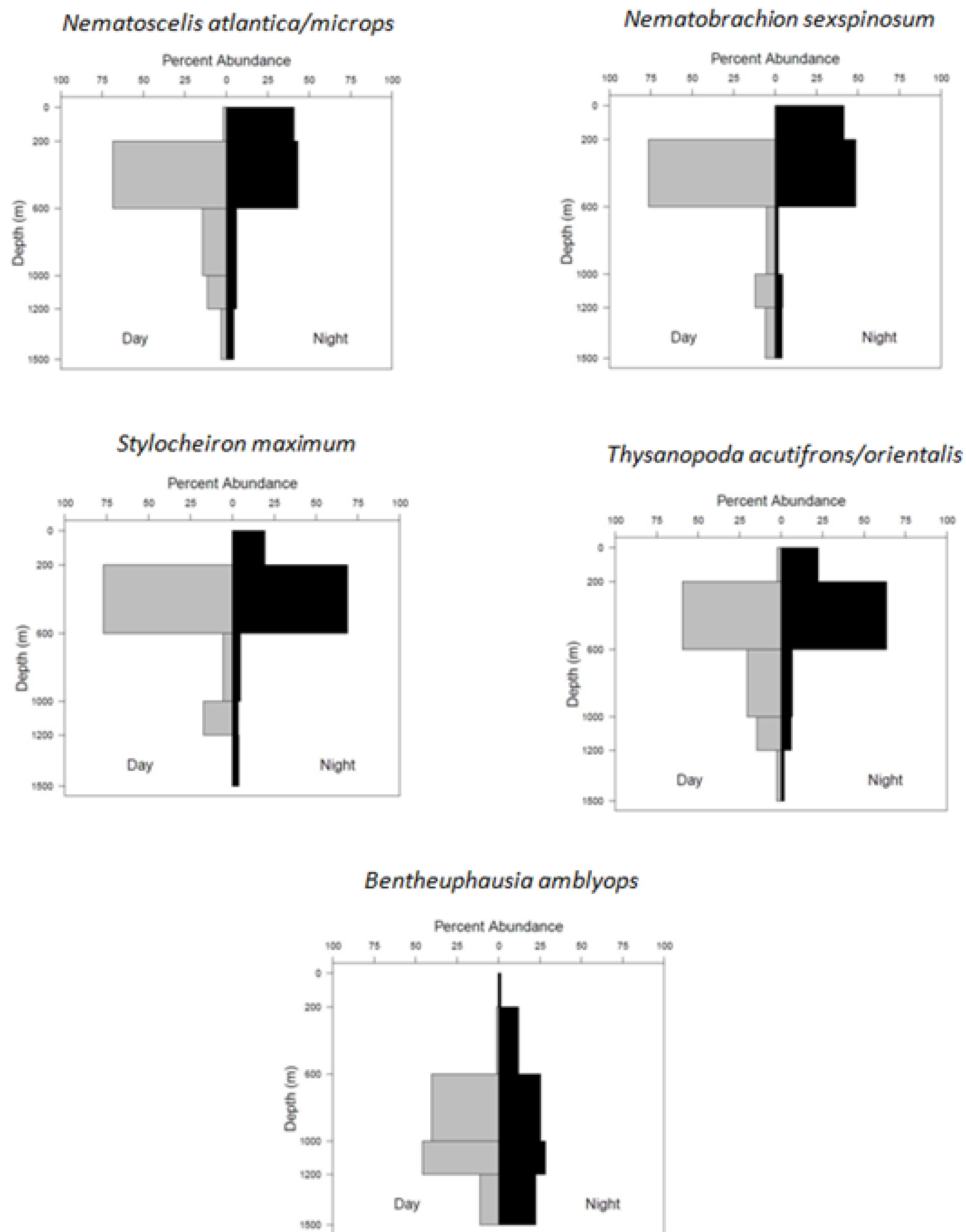

Figure 11. Vertical distribution patterns for abundant species that are weak vertical migrators.

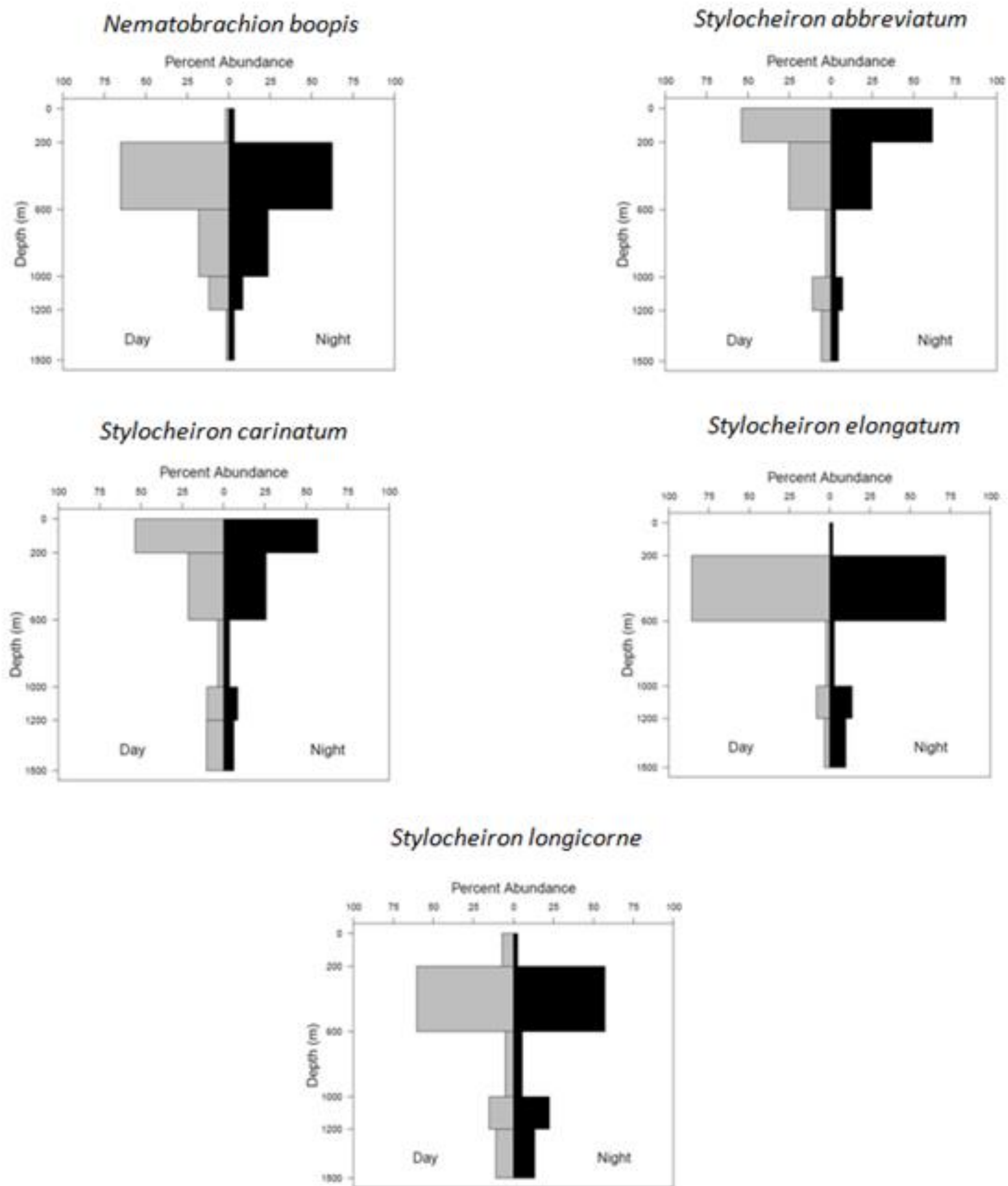

Figure 12. Vertical distribution patterns for abundant species that are non-vertical migrators.

The 15 species that accounted for the remaining 1% of total euphausiid abundance were not caught in sufficient quantities to create meaningful vertical distribution graphs. Table 2 shows the depth distribution of these rare species.

Table 2. Abundance and vertical distribution of rare euphausiids.

Species	**Depth Range (m)**	**Total Number of Individuals Collected**	
		Day	**Night**
Euphausia americana	0-200	0	0
	200-600	0	0
	600-1000	1	0
	1000-1200	0	0
	1200-1500	0	2
Euphausia brevis	0-200	0	0
	200-600	0	0
	600-1000	0	0
	1000-1200	1	0
	1200-1500	0	0
Euphausia frigida/lucens	0-200	0	0
	200-600	0	0
	600-1000	1	0
	1000-1200	0	0
	1200-1500	0	0
Euphausia hemigibba/pseudogibba	0-200	0	0
	200-600	0	14
	600-1000	0	0
	1000-1200	0	3
	1200-1500	0	0

Euphausia krohnii	0-200	0	0
	200-600	21	0
	600-1000	0	0
	1000-1200	5	1
	1200-1500	0	5
Euphausia tenera	0-200	0	0
	200-600	0	1
	600-1000	0	1
	1000-1200	0	4
	1200-1500	0	1
Nematoscelis megalops	0-200	0	0
	200-600	0	0
	600-1000	0	0
	1000-1200	0	2
	1200-1500	0	0
Nematoscelis tenella	0-200	0	9
	200-600	27	26
	600-1000	5	7
	1000-1200	4	3
	1200-1500	1	9
Stylocheiron affine	0-200	0	2
	200-600	0	0
	600-1000	0	0
	1000-1200	0	0
	1200-1500	1	0
Stylocheiron robustum	0-200	0	3
	200-600	12	42
	600-1000	2	2
	1000-1200	1	1
	1200-1500	0	0

Stylocheiron suhmi	0-200	0	1
	200-600	0	0
	600-1000	0	0
	1000-1200	0	0
	1200-1500	0	1
Thysanopoda cornuta	0-200	0	5
	200-600	8	16
	600-1000	25	5
	1000-1200	0	0
	1200-1500	0	1
Thysanopoda cristata	0-200	1	0
	200-600	0	12
	600-1000	1	0
	1000-1200	0	0
	1200-1500	0	0
Thysanopoda egregia	0-200	0	0
	200-600	0	1
	600-1000	1	2
	1000-1200	0	0
	1200-1500	1	0
Thysanopoda pectinata	0-200	0	7
	200-600	44	34
	600-1000	8	2
	1000-1200	0	2
	1200-1500	2	0

Near-slope Vs Offshore Comparison

Abundance

The total number of individuals caught per unit volume was greater in the near-slope samples vs offshore samples (Figures 13 and 14). However, in terms of individual species' contributions to the total abundance, the relative abundance of each species (i.e. the percent contribution to the total abundance) remained fairly consistent (less than a 2% difference in relative abundance) for the species categorized as abundant in both locations (Table 3), with the exception of *Nematoscelis atlantica/microps* and *Euphausia mutica* (Figure 13). *Nematoscelis atlantica/microps* accounted for 56.1% of the total abundance for near-slope samples vs 49.4% of the total abundance for offshore samples. *Euphausia mutica* accounted for 0.1% of the total abundance for near-slope samples vs 2.6% of the total abundance for offshore samples. While *N. atlantica/microps* was the most abundant species in both near-slope and offshore samples, *E. mutica* was the 7th most abundant species in offshore samples and the 16th most abundant in near-slope samples.

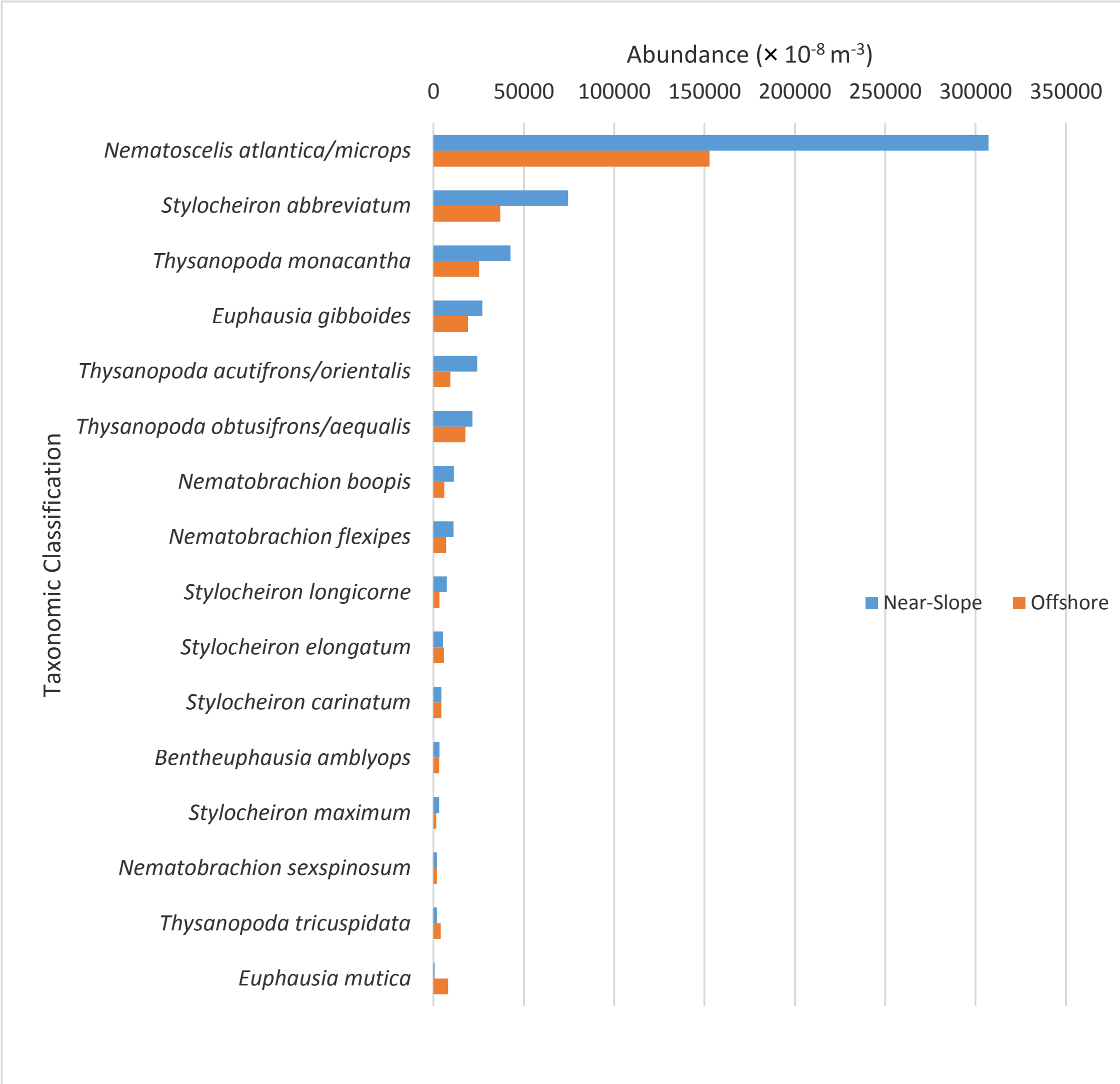

Figure 13. Near-slope and offshore abundances for abundant euphausiids.

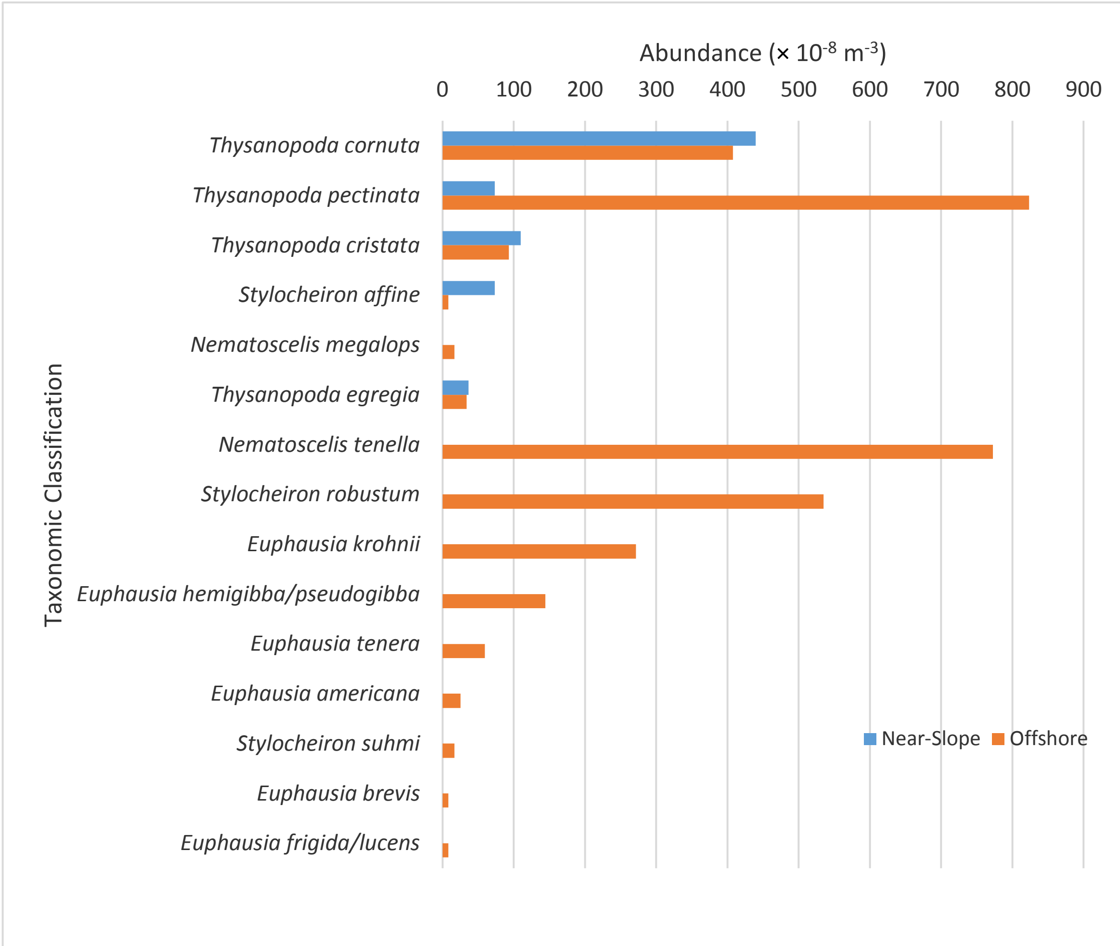

Figure 14. Near-slope and offshore abundances for rare euphausiids. Note: X-axis maximum value is substantially lower than that of figure 13.

Table 3. The percentage of the total catch contributed by abundant euphausiid species for offshore and near-slope assemblages.

Abundant Euphausiids	% of Near-slope Assemblage	% of Offshore Assemblage
Nematoscelis atlantica/microps	56.1	49.4
Stylocheiron abbreviatum	13.6	12.0
Thysanopoda monacantha	7.8	8.2
Euphausia gibboides	4.9	6.2
Thysanopoda obtusifrons/aequalis	3.9	5.7
Thysanopoda acutifrons/orientalis	4.4	3.0
Euphausia mutica	0.1	2.6
Nematobrachion flexipes	2.0	2.3
Nematobrachion boopis	2.0	1.9
Stylocheiron elongatum	0.9	1.9
Stylocheiron carinatum	0.8	1.4
Thysanopoda tricuspidata	0.3	1.3
Stylocheiron longicorne	1.4	1.0
Bentheuphausia amblyops	0.6	1.0
Nematobrachion sexspinosum	0.4	0.6
Stylocheiron maximum	0.6	0.5

A Spearman's Rank correlation revealed euphausiids in this study had a significant ($\rho = 0.90$, DF = 31 $p < 0.001$) monotonic relationship, meaning that as near-slope abundances increased, each species' respective offshore abundance also increased. Mann-Whitney *U* tests were conducted on the abundant euphausiid species, and eight species were significantly more abundant over the near-slope than offshore, while one species (*Euphausia mutica*) was significantly more abundant in offshore samples than in near-slope samples (Table 4).

Table 4. Species with significant differences between near-slope and offshore abundances. * indicates location with significantly greater abundance ($p < 0.01$ Mann-Whitney Wilcoxon test).

Species	Near-slope Abundance ($\times 10^{-8}$ m^{-3})	Offshore Abundance ($\times 10^{-8}$ m^{-3})
Nematoscelis atlantica/microps	307173*	152725
Stylocheiron abbreviatum	74522*	36980
Thysanopoda monacantha	42537*	25228
Thysanopoda acutifrons/orientalis	24181*	9391
Nematobrachion flexipes	10991*	7090
Nematobrachion boopis	11211*	5969
Euphausia mutica	586	8118*
Stylocheiron longicorne	7438*	3235
Stylocheiron maximum	3078*	1435

With respect to the rare euphausiid species, 10 species were found in offshore samples but not in near-slope samples with *Nematoscelis tenella* (n=91), *Stylocheiron robustum* (n=63), *Euphausia krohnii* (n=32), and *Euphausia hemigibba/pseudogibba* (n=17) occurring in abundances of over 10 individuals. The abundance of the remaining six species ranged from one to seven (Table 4). There were no species found in near-slope samples that were not found in offshore samples.

Biomass

The overall biomass for the euphausiid assemblage over the near-slope was substantially higher than it was for the offshore assemblage (Figures 15 and 16). This overall difference results from 11 of the 16 abundant euphausiid species having higher biomass totals in samples collected over the near-slope. *Nematoscelis atlantica/microps* had the highest biomass for both near-slope and offshore locations.

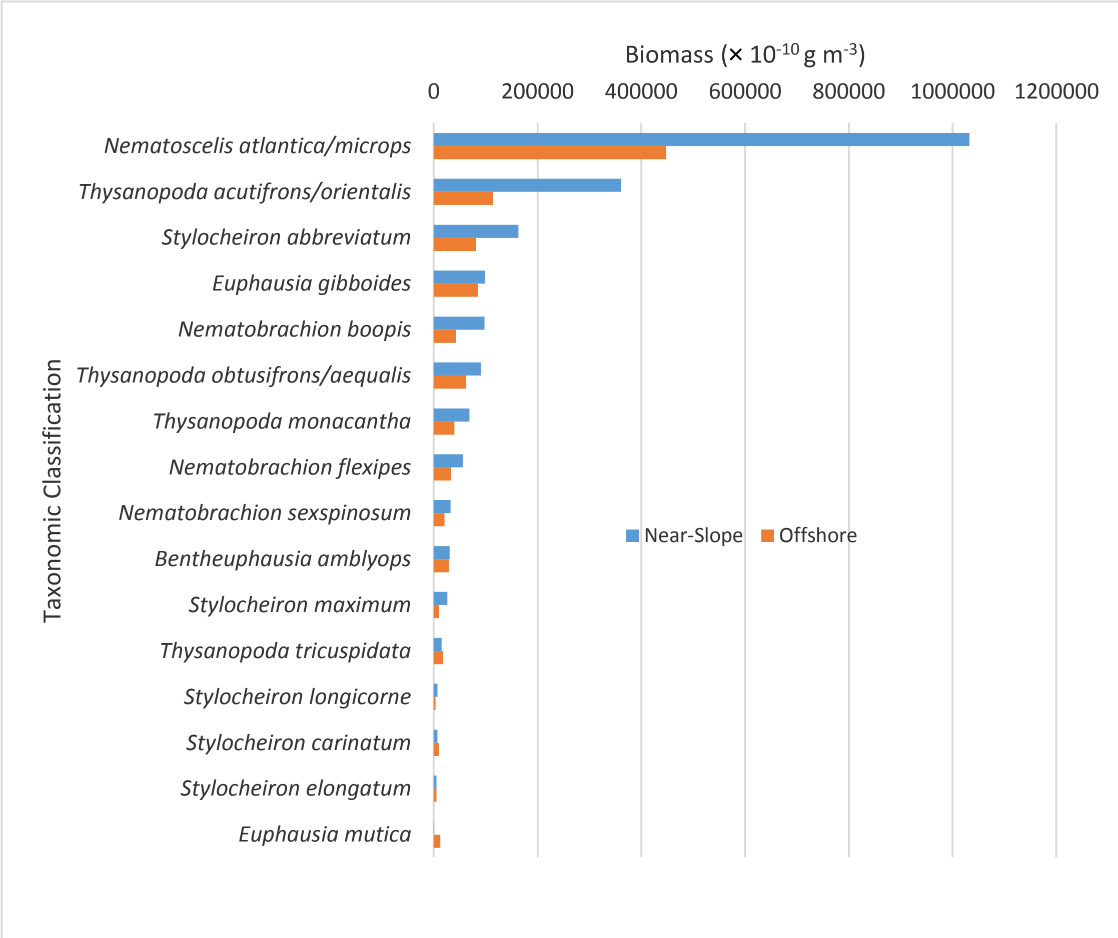

Figure 15. Near-slope and offshore assemblage biomass for abundant euphausiids.

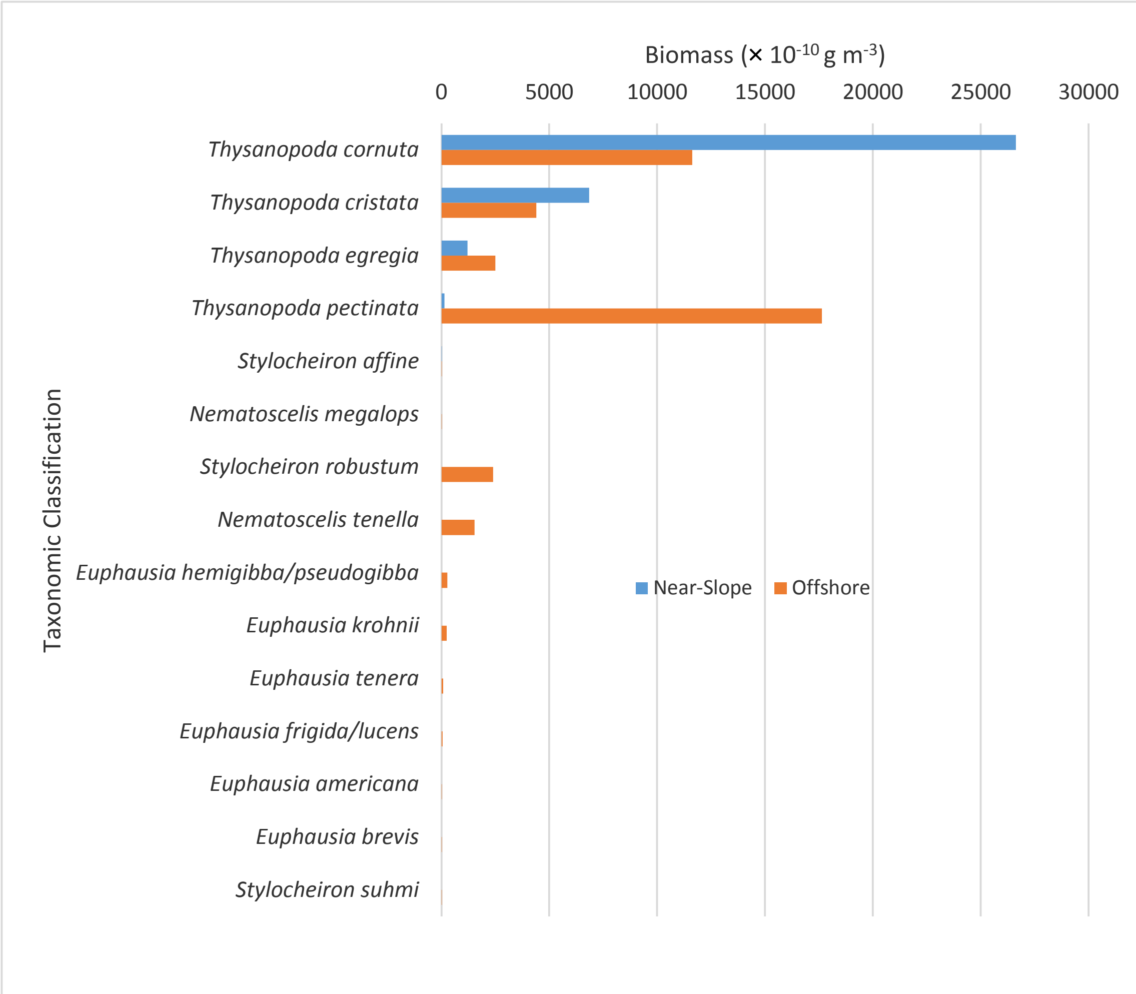

Figure 16. Near-slope and offshore assemblage biomass for rare euphausiids. Note: X-axis maximum value is significantly lower than that of figure 15.

Shannon Diversity (H') and Pielou's Evenness (J') Indices

Only samples from mesopelagic and epipelagic zones were compared because bottom depth varied between stations. Diversity was significantly higher ($p < 0.01$) in the near-slope samples ($H' = 1.54$) than the offshore samples ($H' = 1.19$) between 0-200 m during the day. In all other depth ranges, both day and night, the diversity was significantly higher ($p < 0.05$) in the offshore samples (Tables 5 and 6). The greatest diversity was in the epipelagic zone during the night for both near-slope ($H' = 1.79$) and offshore (*H’* = 1.88) samples, but was significantly higher in the offshore samples. The upper and lower mesopelagic assemblages were more evenly distributed offshore during the day, whereas the epipelagic assemblage was more evenly distributed over the near-slope.

Table 5. Evenness and diversity indices for daytime near-slope and offshore assemblages of euphausiids. *S* = species richness, *N* = total number of individuals × 10^{-4} m^{-3}, *J'* = Pielou's evenness index, *H'* = Shannon diversity index.

Depth Range (m)	*S*	*N*	*J’*	*H’*
Offshore Samples				
0-200	10	5	0.52	1.19
200-600	21	64	0.53	1.62
600-1000	21	9	0.52	1.59
Near-slope Samples				
0-200	10	11	0.67	1.54
200-600	17	89	0.51	1.44
600-1000	20	31	0.35	1.06

Table 6. Evenness and diversity indices for nighttime near-slope and offshore assemblages of euphausiids. *S* = species richness, *N* = total number of individuals × $10^{-4}$$m^{-3}$, *J'* = Pielou's evenness index, *H'* = Shannon diversity index.

Depth Range (m)	*S*	*N*	*J’*	*H’*
Offshore Samples				
0-200	21	88	0.62	1.88
200-600	26	70	0.52	1.69
600-1000	22	9	0.57	1.80
Near-slope Samples				
0-200	16	131	0.65	1.79
200-600	17	66	0.53	1.50
600-1000	12	18	0.67	1.68

Gravid Female Data

Gravid females were found in seven species (Table 7). *Nematoscelis atlantica/microps* had the highest number of gravid females, and *Euphausia tenera* had the highest percentage of gravid females. *N. atlantica/microps* was the only species in which gravid females were caught in all five depth ranges. Tables 8 and 9 show a monthly representation of gravid female abundance and what percent of that species population the gravid abundance represents. Only one species had gravid females in April (*N. atlantica/microps*), while five species had gravid females in May and six species had gravid females in June. *N. atlantica/microps* is the only species in which gravid females were caught in all three months of sampling with the greatest abundance (2925 × $10^{-7}m^{-3}$) and percent (10.0%) of population gravid occurring in May.

Table 7. Abundances (× $10^{-7}m^{-3}$) of gravid euphausiid species for each depth range and the percent of the population that gravid females represent.

Species	Abundance ($10^{-7}m^{-3}$)					% of Total Population
	0-200 m	200 -600 m	600-1000 m	1000-1200 m	1200-1500 m	
Euphausia gibboides	0	6	0	0	0	0.1
Euphausia tenera	0	0	0	12	0	28.6
Nematoscelis atlantica/microps	1165	3936	739	324	194	9.3
Stylocheiron abbreviatum	0	0	5	18	9	0.1
Stylocheiron carinatum	11	6	0	0	4	0.9
Stylocheiron elongatum	0	6	2	0	4	0.6
Stylocheiron maximum	0	6	0	0	0	1.2

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Table 8. Gravid female abundance (× $10^{-7}m^{-3}$) by month for each species of Euphausiacea. *NA indicates no individuals of that species were collected. “0” indicates that individuals of that species were collected but none of them were gravid.

Species	**Abundance (× $10^{-7}m^{-3}$)**		
	April	**May**	**June**
Euphausia gibboides	0	8	0
Euphausia tenera	*NA	0	2
Nematoscelis atlantica/microps	2381	2925	1132
Stylocheiron abbreviatum	*NA	5	5
Stylocheiron carinatum	0	8	3
Stylocheiron elongatum	*NA	0	5
Stylocheiron maximum	0	3	2

Table 9. The percent of a species population that gravid females represent by month for each species of Euphausiacea. *NA indicates no individuals of that species were collected. “0” indicates that individuals of that species were collected but none of them were gravid.

Species	**Percent of Population Gravid**		
	April	**May**	**June**
Euphausia gibboides	0	0.2	0
Euphausia tenera	*NA	0	33.3
Nematoscelis atlantica/microps	8.4	10.0	8.8
Stylocheiron abbreviatum	*NA	0.1	0.1
Stylocheiron carinatum	0	1.0	3.2
Stylocheiron elongatum	*NA	0	0.6
Stylocheiron maximum	0	1.0	1.4

DISCUSSION

Abundance and Biomass

A total of 51,559 euphausiid specimens were collected, with a total biomass of 1.837 kg. Sixteen species (categorized as abundant species) accounted for 99% of euphausiid abundance, while the other fifteen species (categorized as rare species) accounted for the remaining 1% of the total euphausiid assemblage. Kinsey and Hopkins (1994) found 28 species of euphausiids, of which they considered 27 abundant enough to include in their study from the top 1000 m of the water column in the eastern Gulf of Mexico. Their top seven species (comprising 83% of the total euphausiid assemblage) in decreasing order of abundance, were *Euphausia tenera*, *Stylocheiron carinatum*, *Euphausia americana*, *Euphausia hemigibba*, *Nematoscelis microps*, *Stylocheiron elongatum and Stylocheiron longicorne.* *Euphausia tenera*, their most abundant species, was one of the rare species in the current study. The most abundant species in the current study, *N. atlantica/microps* accounted for 51.2% of all euphausiids caught. Even combined values of *N. atlantica* and *N. microps* from the Hopkins and Kinsey study still puts them as the 5th most abundant species in their study. These data indicate that there are substantial differences between euphausiid assemblages in the eastern Gulf (Kinsey and Hopkins Standard Station) and the northern portion of the Gulf in the current study.

Gasca *et al*. (2001) collected Euphausiacea from the southern Gulf of Mexico, although they only trawled in the epipelagic zone (0-200 m). They found 17 species of euphausiids and determined that three species, *Stylocheiron carinatum, Stylocheiron suhmi*, and *Euphausia tenera* (in decreasing order of abundance) contributed to approximately 75% of the total abundance. Although Gasca *et al*. only covered the top 200 m of the water column, which might affect their rankings compared to the current study, *Stylocheiron suhmi* and *Euphausia tenera* were extremely rare in the current study, with totals of two and six collected respectively in 340 samples from all depths. *S. suhmi* was also rare in Kinsey and Hopkins (1994) study, but *E. tenera* and *S. carinatum* were in their top three.

Neither Gasca *et al*.'s (2001) (*Stylocheiron carinatum, Euphausia tenera, Stylocheiron suhmi*) nor Kinsey and Hopkins' (1994) (*S. carinatum, E. tenera*, *Euphausia americana*) three most abundant euphausiids were among the top ten most abundant euphausiids in the current study. The species that were most abundant in the Gasca *et al*. and Kinsey and Hopkins studies (*E. americana* average body length = 11.15 mm; *E. tenera* average body length = 10.86 mm; *S. carinatum* average body length = 12.01 mm; and *S. suhmi* average body length = 5.77 mm) are all relatively small compared to this study's three most abundant species - *N. atlantica/microps* (average body length = 16.36 mm), *Stylocheiron abbreviatum* (average body length = 13.80 mm), and *Thysanopoda monacantha* (average body length = 13.08 mm). Oil droplets in the water could have a great impact on smaller species due to their larger surface area to volume ratios; as animals increase in size, their surface area doubles, but their volume triples. The relatively larger surface area means a larger area for contaminants to diffuse into the body, and the smaller volume means less internal components to dilute the contaminants. This means the oil should have a greater impact on smaller individuals. Therefore, it is possible that the larger species dominated in this study because of the impact of oil on smaller species; however, there are no pre-spill baseline data to determine whether this is simply the normal assemblage for this area.

Looking at data from the two offshore stations (SE-5 and SE-6) in the current study that correspond to Kinsey and Hopkins' (1994) Standard Station, it can be seen that four of the top five species have the same abundance rankings as the rest of the offshore samples and therefore different from Kinsey and Hopkins data. However, Kinsey and Hopkins used two nets in their study; Tucker trawls with a 333-µm mesh cod-end (smaller than the 1-mm mesh codend in the current study) and a MOCNESS system with 4-mm mesh (with a 1-mm codend), which is a larger mesh size than the 3-mm net mesh in the current study. This means that some of their trawls (MOCNESS) would select for larger euphausiids, while others (Tucker trawls) would be able to catch smaller individuals, so the differences between their study and the current study may be due to trawling techniques (avoidance and extrusion). In addition, quantitative trawls at Standard Station have not been carried out since their study over 20 years ago, so it is not known if the assemblage has changed over this time. As stated above, the small species that were so abundant in the Kinsey and Hopkins and Gasca *et al*. studies were very rare in the current study. Whether these differences are simply due to regional differences or a result of the oil spill cannot be assessed from the data presented here; further studies are required at the current study site, to determine if/how the euphausiid assemblage is changing with time.

Near-slope Vs Offshore

Near-slope stations had more euphausiids on average than offshore stations and station to station variance was very low for both near-slope (1.19×10^{-5} m^{-3}) and offshore (6.41×10^{-6} m^{-3}) stations (Table 10). This suggests that there was actually a greater abundance of euphausiids in near-slope waters vs offshore waters rather than skewed data as a result of more trawling offshore. The distributions of nine of the abundant species were significantly different (Mann-Whitney Wilcoxon test $p < 0.05$) between the near-slope and offshore locations (Table 4). Eight of these species were significantly more abundant in the near-slope stations, while one species, *Euphausia mutica*, was significantly more abundant in the offshore stations, being the 16th most abundant over the near-slope but the 7th most abundant species found offshore. The vast majority of the euphausiid assemblage was found between 0-600 m in both locations, which was also reported by Castellanos and Gasca (1996) and Kinsey and Hopkins (1994) at their study sites, indicating that deeper depths offshore cannot account for the distribution differences, and the reason remains to be determined.

Table 10. Euphausiid abundances for offshore and near-slope stations.

Near-slope Stations	Abundance ($\times 10^{-4}$ m^{-3})	Offshore Stations	Abundance ($\times 10^{-4}$ m^{-3})
B001	148.52	B003	33.74
B016	97.56	B061	32.36
B080	104.08	B064	33.01
B162	40.25	B065	5.93
B163	35.78	B078	65.93
B184	43.30	B079	10.67
B185	10.40	B081	65.69
B245	61.58	B082	46.33
B246	77.26	B083	74.78
B247	43.85	B175	19.61
B254	51.76	B248	72.11
SW-1	76.80	B249	32.60
SW-2	54.09	B250	78.92
		B251	27.06
		B252	41.56
		B255	53.37
		B286	10.79
		B287	35.05
		SE-1	15.63
		SE-2	13.21
		SE-3	24.92
		SE-4	16.75
		SE-5	98.23
		SE-6	67.86
		SW-10	17.98
		SW-11	15.64
		SW-3	15.81
		SW-5	15.41
		SW-6	14.08
		SW-7	10.68
		SW-8	10.50
		SW-9	10.63
Mean	65.02	Mean	33.96
Variance	0.01194	Variance	0.00641

The Spearman's rank correlation indicates that there is a strong positive monotonic relationship between offshore and near-slope euphausiid assemblages, meaning that as the abundance of near-slope species increased, so did the abundance of the offshore assemblage. However, in spite of this relationship, euphausiid abundance and diversity are quite different between the two regions.

The offshore assemblage was significantly more diverse than the near-slope assemblage at all depths and times of day, with the exception of the epipelagic assemblage sampled during the day, which was significantly more diverse over the near-slope (Tables 5 and 6). Diversity values incorporate species richness and evenness within a population and since species richness was the same for both locations in the epipelagic zone (10 species), the low number of individuals offshore (5×10^{-4} m^{-3}) compared to those over the near-slope (11×10^{-4} m^{-3}) might explain the observed differences.

Species richness in night assemblages increased in the epipelagic zone for both offshore and near-slope samples compared to their respective day assemblages. The greatest increase occurred in the offshore epipelagic samples (10 species during the day, 20 species at night). This means that 10 species were present during the night trawls that were not present during the day in the epipelagic zone for offshore samples. This was due to the nighttime vertical migrations of these species. These findings are supported by Biggs *et al.* (1977) and Castellanos and Gasca (1999), who also noted species richness increased during the night in the epipelagic zone.

Of the ten species that were present only in the offshore samples, four of them (*N. tenella, S. robustum, E. krohnii* and *E. hemigibba/pseudogibba)* were collected in substantial numbers (91, 63, 32 and 17) and distributed across multiple stations. The remaining six species were collected in much lower numbers (one to seven) and additional near-slope sampling is needed before drawing any conclusions about their geographical restrictions.

Temperature and Salinity

A thermocline was present between 25-600 m and a halocline was present between 125-500 m at both near-slope and offshore locations. Bergstrom and Stromberg (1997), studying the euphausiid assemblage in the Swedish west coast, found that *Meganyctiphanes norvegica* did not vertically migrate through a thermocline present between 50-60 m, although *Thysanoessa raschii* did. This suggests that some euphausiid species may be limited by thermoclines with respect to their vertical distribution, but others are not. Since the thermocline in the present study extended for hundreds of meters and 16 species of euphausiids traversed these depths, it does not appear that the presence of a thermocline inhibited the vertical activity of euphausiids in this study. In addition, the lack of differences in these parameters between offshore and near-slope stations indicates that differences in distribution patterns for these species cannot be attributed to these factors.

Gravid Female Data

Seven species of Euphausiacea in this study had at least one gravid female. Six of these species were categorized as abundant, while one (*Euphausia tenera*) was a rare species. Gravid females were found at all depth ranges with the majority found between 200-600 m. *Nematoscelis atlantica/microps* (total of 1683 gravid females, 9.3% of the sampled population) gravid females were present in all depth ranges, with the vast majority occurring between 0-600 m depth. The total number of gravid *N. atlantica/microps* females (the only species for which large numbers of gravid females were found) varied from April-June, but the total number of individuals varied as well, so there were no substantial differences in the percent of gravid females collected each month. Four of the seven species that had at least one gravid female, had the largest percent of their population gravid in the month of June. In addition, the number of species with gravid females increased from one in April, to five in May, to six in June. Previous studies suggest that euphausiids reproduce seasonally (Cuzin-Roudy, 2000; Gómez-Gutiérrez and Robinson, 2005), and data from the current study point towards a seasonal aspect to their reproduction as well.

Vertical Distribution

There were six species of strong vertical migrators, five species of weak vertical migrators, and five species that showed no vertical migration. The data here support the conclusions of Kinsey and Hopkins (1994) that *Euphausia gibboides, Euphausia mutica*, *Nematobrachion flexipes, Thysanopoda monacantha, Thysanopoda obtusifrons/aequalis*, and *Thysanopoda tricuspidata* are strong vertical migrators. Based on the data reported here, *T. tricuspidata*, whose sample size was too small for Kinsey and Hopkins (1994) to categorize, can now also be added to the list of strong vertical migrators in the Gulf of Mexico.

Nematoscelis atlantica/microps and *Stylocheiron maximum* were considered to be vertical migrators by Kinsey and Hopkins (1994), but their sample size was not large enough for them to distinguish between strong and weak vertical migrators. Based on the large sample sizes in the current study, these species are clearly weak vertical migrators, as are *Nematobrachion sexspinosum, Bentheuphausia amblyops*, and *Thysanopoda acutifrons/orientalis*.

Kinsey and Hopkins (1994) found *Stylocheiron abbreviatum* and *Stylocheiron elongatum* to be non-vertical migrators, conclusions that are supported by the current study. In addition, *Nematobrachion boopis*, *Stylocheiron carinatum*, and *Stylocheiron* *longicorne* all showed no vertical migration behavior in the current study. Kinsey and Hopkins (1994) conducted more discreet depth samples than was possible in this study, and found very small vertical movements for *N. boopis* from 400-450 m during the day to 350-400 m during the night. These are very small vertical movements that did not take these species into the epipelagic zone, so it is difficult to determine if these are true vertical migrations. They also found that *S. carinatum* moved from the mid-epipelagic to the shallow epipelagic (from 100-125 m during the day to 50-75 m during the night) which is also a very small vertical movement, so conclusions about their migratory behavior remain to be verified. Their conclusions that *S. longicorne* was a vertical migrator are not supported by the results of the current study. Their conclusion was based on a small sample size and apparent movements from 200-300 m during the day, to 125-200 m during the night. These depth ranges encompass two of the depth ranges in the current study, so if vertical migrations were occurring, they should have been apparent. Based on the large sample size in the current study and the fact that the percentage of the population at night in the epipelagic zone (2.3%) was actually lower than during the day (7.4%), this species should be considered a non-vertical migrator.

Table 11 shows depth ranges for all euphausiids caught in the Gulf of Mexico from previous studies. Most of this study's findings support the previous studies with respect to depth range. However, this study found 18.7% (39 individuals) of *Nematobrachion flexipes*, 20.4% (170 individuals) of *Stylocheiron abbreviatum*, 24.6% (49 individuals) of *Stylocheiron carinatum*, and 31.9% (31 individuals) of *Stylocheiron longicorne* in waters deeper than 600 m during the day, which has not been previously reported. In addition, individuals of *N. flexipes* (N = 24), *S. abbreviatum* (N = 125), *S.*

carinatum (N = 36), and *S. longicorne* (N = 22) were found deeper than 1000 m, and their respective depth ranges should be expanded as well.

Table 11. Depth distributions of Euphausiacea species found in the Gulf of Mexico. * indicates species for which information is included from the current study.

Species	Depth (m)	Sources
*Bentheuphausia amblyops**	500-2000	Springer and Bullis (1956),
*Euphausia americana**	0-700	Biggs *et al.* (1977), Castellanos and Gasca (1999), Gasca *et al.* (2001), Moore (1950), Kinsey and Hopkins (1994)
- Depth range extended	0-1500	
*Euphausia brevis**	0-600	Biggs *et al.* (1977), Castellanos and Gasca (1999), Gasca *et al.* (2001), Moore (1952), Kinsey and Hopkins (1994)
- Depth range extended	0-1200	
*Euphausia hemigibba**	0-550	Biggs *et al.* (1977), Castellanos and Gasca (1999), Gasca *et al.* (2001), Kinsey and Hopkins (1994)
*Euphausia gibboides**	0-400	Biggs *et al.* (1977), Castellanos and Gasca (1999), Gasca *et al.* (2001), Kinsey and Hopkins (1994)
- Depth range extended	0-1500	
*Euphausia krohni**	0-600	Springer and Bullis (1956)
- Depth range extended	0-1500	
*Euphausia mutica**	0-600	Biggs *et al.* (1977), Castellanos and Gasca (1999), Gasca *et al.* (2001), Kinsey and Hopkins (1994)
- Depth range extended	0-1500	
*Euphausia pseudogibba**	0-400	Biggs *et al.* (1977), Gasca *et al.* (2001)
*Euphausia tenera**	0-1000	Biggs *et al.* (1977), Castellanos and Gasca (1999), Gasca *et al.* (2001), Moore (1950), Kinsey and Hopkins (1994)
- Depth range extended	0-1500	
*Nematobrachion boopis**	100-600	Kinsey and Hopkins (1994)
- Depth range extended	100-1500	
*Nematobrachion flexipes**	50-600	Biggs *et al.* (1977), Castellanos and Gasca (1999), Kinsey and Hopkins (1994)
- Depth range extended	50-1500	
*Nematobrachion sexspinosum**	100-600	Kinsey and Hopkins (1994)
- Depth range extended	50-1500	

*Nematoscelis atlantica**	100-1000	Biggs *et al.* (1977), Castellanos and Gasca (1999), Gasca *et al.* (2001), Kinsey and Hopkins (1994)
- Depth range extended	100-1500	
*Nematoscelis megalops**	100-500	Felder and Camp (2010)
- Depth range extended	100-1200	
*Nematoscelis microps**	100-1000	Castellanos and Gasca (1999), Gasca *et al.* (2001), Kinsey and Hopkins (1994)
- Depth range extended	100-1500	
*Nematoscelis tenella**	100-600	Castellanos and Gasca (1999), Kinsey and Hopkins (1994)
- Depth range extended	100-1500	
*Stylocheiron abbreviatum**	0-500	Biggs *et al.* (1977), Castellanos and Gasca (1999), Gasca *et al.* (2001), Kinsey and Hopkins (1994)
- Depth range extended	0-1500	
*Stylocheiron affine**	0-300	Biggs *et al.* (1977), Castellanos and Gasca (1999), Gasca *et al.* (2001), Kinsey and Hopkins (1994)
- Depth range extended	0-1500	
*Stylocheiron carinatum**	0-300	Biggs *et al.* (1977), Castellanos and Gasca (1999), Gasca *et al.* (2001), Castellanos and Gasca (1996), Kinsey and Hopkins (1994)
- Depth range extended	0-1500	
*Stylocheiron elongatum**	200-500	Castellanos and Gasca (1999), Gasca *et al.* (2001), Kinsey and Hopkins (1994)
- Depth range extended	0-1500	
*Stylocheiron longicorne**	100-400	Castellanos and Gasca (1999), Gasca *et al.* (2001), Kinsey and Hopkins (1994)
- Depth range extended	100-1500	
*Stylocheiron maximum**	140-400	Kinsey and Hopkins (1994)
- Depth range extended	140-1500	
*Stylocheiron robustum**	280-600	Kinsey and Hopkins (1994)
- Depth range extended	0-1500	
*Stylocheiron suhmi**	0-200	Biggs *et al.* (1977), Castellanos and Gasca (1999), Gasca *et al.* (2001), Kinsey and Hopkins (1994)
- Depth range extended	0-1500	
Thysanoessa gregaria	0-150	Castellanos and Gasca (1999)
*Thysanopoda aequalis**	0-600	Biggs *et al.* (1977), Castellanos and Gasca (1999), Gasca *et al.* (2001), Kinsey and Hopkins (1994)
- Depth range extended	0-1500	
*Thysanopoda cornuta**	630-2500	Springer and Bullis (1956)
- Depth range extended	0-2500	

*Thysanopoda cristata**	280-800	Felder and Camp (2010)
- Depth range extended	0-800	
*Thysanopoda egregia**	800-2000	Felder and Camp (2010)
- Depth range extended	200-2000	
*Thysanopoda monacantha**	100-700	Biggs *et al.* (1977), Springer and Bullis (1956), Kinsey and Hopkins (1994)
- Depth range extended	100-1500	
*Thysanopoda obtusifrons**	0-1000	Kinsey and Hopkins (1994)
- Depth range extended	0-1500	
*Thysanopoda orientalis**	0-1000	Springer and Bullis (1956), Kinsey and Hopkins (1994)
- Depth range extended	0-1500	
*Thysanopoda pectinate**	0-200	Springer and Bullis (1956)
- Depth range extended	0-1500	
*Thysanopoda tricuspidata**	0-300	Biggs *et al.* (1977), Castellanos and Gasca (1999), Gasca *et al.* (2001)
- Depth range extended	0-1500	

CONCLUSIONS

The positive monotonic relationship and the statistical analyses of the diversity and evenness indices indicate that there are no significant differences with respect to these parameters between the offshore and near-slope assemblages of Euphausiacea in the northern Gulf of Mexico. However, eight species of euphausiids had significantly higher abundances over the near-slope while one species had a significantly higher abundance offshore. The current study also shows potential seasonality with respect to reproduction as suggested by previous studies. These data are vital for modelling potential effects that anthropomorphic disturbances may inflict on the region and how/if Euphausiacea can recover from them. Lastly, further studies will be needed to determine if the larger species dominating in this region are normal for this region or can be attributed to an assemblage shift resulting from the *Deepwater Horizon* oil spill.

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APPENDIX I. Sample data from the Meg Skansi 7 cruise in the northern Gulf of Mexico

Sample	Date	Latitude (°N)	Longitude (°W)	Min. trawl depth (m)	Max. trawl depth (m)	Vol. filtered (m^3)	Solar cycle	Depth zone
B001N_01	20-Apr	28.97	87.97	1000	1182		N	2
B001N_02	20-Apr	28.96	87.96	600	1000		N	3
B001N_03	20-Apr	28.95	87.95	201	600		N	4
B001D_03	21-Apr	28.91	87.90	200	602	42989.7	D	4
B001D_04	21-Apr	28.89	87.86	0	200	23466.5	D	5
B175N_01	21-Apr	28.99	87.50	1201	1502	28885	N	1
B001N_04	21-Apr	28.91	87.93	6	201		N	5
B175D_01	22-Apr	28.95	87.52	1200	1500	33817.9	D	1
B175D_02	22-Apr	28.92	87.53	1002	1200	19875.2	D	2
B175N_02	22-Apr	28.96	87.50	1002	1201	20866.2	N	2
B175N_03	22-Apr	28.94	87.51	596	1002	54620.7	N	3
B252N_01	22-Apr	28.49	87.51	999	1503		N	1a
B252N_02	23-Apr	28.44	87.50	601	999		N	3
B252N_03	23-Apr	28.41	87.48	202	601		N	4
B252N_04	23-Apr	28.38	87.46	0	202		N	5
B252D_02	23-Apr	28.46	87.44	600	996	32233.4	D	3
B252D_03	23-Apr	28.44	87.42	200	600	33241.9	D	4
B252D_04	23-Apr	28.41	87.41	0	200	24764.3	D	5
B252D_01	23-Apr	28.50	87.47	996	1501		D	1a
B003N_01	24-Apr	28.01	87.03	1001	1499		N	1a
B080D_04	24-Apr	28.45	86.96	0	200	20225.1	D	5
B080N_04	24-Apr	28.41	86.97	0	199	20225.1	N	5
B003D_01	25-Apr	27.99	86.98	1001	1500		D	1a
B003D_02	25-Apr	27.96	86.93	601	1001	45253.5	D	3
B003D_03	25-Apr	27.93	86.88	200	601	35926.4	D	4
B003D_04	25-Apr	27.89	86.83	0	200	21156.9	D	5
B003N_02	25-Apr	27.97	86.98	598	1001	46389.9	N	3
B003N_03	25-Apr	27.93	86.94	200	598	48124.2	N	4
B003N_04	25-Apr	27.90	86.92	10	200	26634.1	N	5
B287N_01	25-Apr	27.95	87.51	1000	1499		N	1a
B287D_02	26-Apr	27.91	87.44	601	998	41895.2	D	3
B287D_03	26-Apr	27.87	87.43	200	601	43186.1	D	4
B287D_04	26-Apr	27.82	87.43	0	200	24060.5	D	5
B287N_02	26-Apr	27.91	87.51	600	1000	41703.2	N	3
B287N_03	26-Apr	27.87	87.48	201	600	45792	N	4
B287N_04	26-Apr	27.83	87.46	0	201	18473.6	N	5
B287D_01	26-Apr	27.97	87.48	998	1501		D	1a

B251N_01	4-May	28.46	88.54	1202	1400		N	1
B081N_01	5-May	28.50	87.99	1201	1501	28806	N	1
B081N_02	5-May	28.50	87.96	999	1201	15255.1	N	2
B251D_01	5-May	28.48	88.54	1203	1403	24534	D	1
B251D_02	5-May	28.50	88.52	1001	1203	25034.8	D	2
B251D_03	5-May	28.51	88.49	600	1001	48694.3	D	3
B251D_04	5-May	28.54	88.43	200	600	46895.6	D	4
B251D_05	5-May	28.55	88.39	0	200	25633.8	D	5
B251N_02	5-May	28.48	88.53	1001	1202	25219.9	N	2
B251N_03	5-May	28.50	88.51	599	1001	66539.5	N	3
B251N_04	5-May	28.55	88.47	199	599	38870.4	N	4
B251N_05	5-May	28.58	88.46	0	199	17178.1	N	5
B081D_01	6-May	28.51	88.02	1200	1501	27647.1	D	1
B081D_02	6-May	28.54	88.01	1000	1200	13997	D	2
B081D_03	6-May	28.55	88.00	601	1000	35786.2	D	3
B081D_04	6-May	28.58	87.99	200	601	41671	D	4
B081D_05	6-May	28.62	87.97	0	200	25131.1	D	5
B081N_03	6-May	28.50	87.94	600	999	48838.2	N	3
B081N_04	6-May	28.49	87.88	199	600	48185.5	N	4
B081N_05	6-May	28.48	87.83	0	199	27840.5	N	5
B082N_01	6-May	27.99	88.03	1200	1501	35902.1	N	1
B082D_02	7-May	28.01	87.98	1000	1200	23006	D	2
B082D_03	7-May	28.01	88.01	600	1000	53615.9	D	3
B082D_04	7-May	28.02	88.07	197	600	51963.5	D	4
B082D_05	7-May	28.02	88.12	0	197	42205.7	D	5
B082N_02	7-May	27.97	88.07	1000	1200	19337.9	N	2
B082N_03	7-May	27.96	88.09	600	1000	35250.1	N	3
B082N_04	7-May	27.95	88.11	201	600	44365.8	N	4
B082N_05	7-May	27.93	88.14	0	201	27647.4	N	5
B250D_01	8-May	27.99	88.51	1200	1500	28991.9	D	1
B250D_02	8-May	27.98	88.54	994	1200	22920.3	D	2
B250D_03	8-May	27.97	88.56	601	994	44005.6	D	3
B250D_04	8-May	27.96	88.62	365	601		D	4a
B250N_01	8-May	27.93	88.61	1201	1501		N	1
B250N_02	9-May	27.90	88.65	1001	1201	39369	N	2
B250N_03	9-May	27.88	88.67	600	1001	24823.6	N	3
B250N_04	9-May	27.85	88.71	164	600	46545.1	N	4
B250N_05	9-May	27.82	88.75	0	164	134.2	N	5
B249D_01	9-May	27.69	88.58	1197	1501	30530.5	D	1
B249D_02	9-May	27.64	88.58	1000	1197	19192.5	D	2
B249D_03	9-May	27.62	88.58	601	1000	51064.3	D	3
B249D_04	9-May	27.58	88.59	200	601	48855.6	D	4
B249D_05	9-May	27.54	88.60	0	200	25731.7	D	5

B249N_01	9-May	27.50	88.49	1200	1500	61864.6	N	1
B064D_01	10-May	27.49	88.98	1200	1500	28628.3	D	1
B064D_02	10-May	27.46	88.98	1000	1200	24418.5	D	2
B064N_01	10-May	27.50	88.99	1201	1501	45796.3	N	1
B249N_02	10-May	27.44	88.51	1001	1200	28706.7	N	2
B249N_03	10-May	27.41	88.52	601	1001	49009	N	3
B249N_04	10-May	27.37	88.54	200	601	40857.6	N	4
B249N_05	10-May	27.33	88.55	0	200	28558.9	N	5
B083D_04	11-May	27.90	88.89	0	199		D	5
B064N_02	11-May	27.47	88.96	998	1201	24242.8	N	2
B064N_03	11-May	27.45	88.94	576	998	50321.5	N	3
B064N_04	11-May	27.42	88.90	201	576	38843.4	N	4
B064N_05	11-May	27.39	88.88	0	201	26178	N	5
B083D_01	11-May	27.99	88.98	1000	1200	17855.1	D	2
B083D_02	11-May	27.98	88.96	601	1000	47858.9	D	3
B083D_03	11-May	27.94	88.93	199	601	63254.2	D	4
B083N_01	11-May	28.05	88.98	1000	1202	28183.6	N	2
B083N_02	11-May	28.02	88.98	601	1000	46424.9	N	3
B083N_04	12-May	27.93	88.93	0	194		N	5
B083N_03	12-May	27.98	88.95	194	601	60248	N	4
B184N_01	14-May	28.47	88.79	601	1005	64562	N	3
B184D_01	15-May	28.43	88.70	999	1201	22321.3	D	2
B184D_02	15-May	28.46	88.71	601	999	48536.7	D	3
B184D_03	15-May	28.50	88.73	201	601	46947.2	D	4
B184D_04	15-May	28.54	88.76	9	201	26528.1	D	5
B184N_02	15-May	28.51	88.83	200	601	67442.2	N	4
B184N_03	15-May	28.56	88.89	5	200	23462	N	5
B016D_01	16-May	27.99	90.01	200	440	30381.4	D	4
B016D_02	16-May	28.02	90.00	10	200	21696.4	D	5
B016N_02	16-May	28.05	89.84	201	595	55882.5	N	4
B016N_03	16-May	28.10	89.88	0	201	30102.8	N	5
B185N_02	16-May	27.94	89.53	400	600	28187	N	4
B185N_01	16-May	27.91	89.49	600	857		N	3b
B185D_03	17-May	27.99	89.51	0	601		D	4c
B185D_01	17-May	27.95	89.51	800	900	14086.9	D	3
B185D_02	17-May	27.97	89.51	601	800	19269.4	D	3
B248N_01	17-May	27.53	89.46	1201	1301	16607.7	N	1
B248N_02	17-May	27.55	89.45	1001	1201	34556.9	N	2
B061N_01	18-May	27.49	89.96	1000	1175	25877.1	N	2
B248D_01	18-May	27.48	89.49	1200	1302	10757.8	D	1
B248N_03	18-May	27.60	89.45	601	1001	46050.6	N	3
B248N_04	18-May	27.64	89.46	200	601	46045.3	N	4
B248N_05	18-May	27.69	89.46	5	200	24455.8	N	5

B061D_01	19-May	27.48	89.94	999	1099		D	2
B061D_02	19-May	27.47	89.92	798	999	22992.1	D	3
B061D_03	19-May	27.45	89.90	601	798	19227.8	D	3
B061D_04	19-May	27.44	89.88	195	601	41216.4	D	4
B061D_05	19-May	27.42	89.84	8.4	195	6478.5	D	5
B061N_02	19-May	27.48	89.93	800	1000	26231.9	N	3
B061N_03	19-May	27.46	89.90	601	800	30199.9	N	3
B061N_04	19-May	27.45	89.86	200	601	64228.7	N	4
B061N_05	19-May	27.41	89.80	5	200	30541.5	N	5
B247N_01	19-May	27.52	90.52	800	957	12732.3	N	3
B247N_02	19-May	27.51	90.51	601	800	32576.4	N	3
B247D_01	20-May	27.47	90.47	1002	1198	29781.7	D	2
B247D_02	20-May	27.45	90.45	800	1002	21460.3	D	3
B247D_03	20-May	27.43	90.43	600	800	22189.7	D	3
B247D_04	20-May	27.41	90.42	201	600	38788.4	D	4
B247D_05	20-May	27.37	90.39	8	201	27717.9	D	5
B247N_03	20-May	27.49	90.48	400	601	19583.5	N	4
B247N_04	20-May	27.48	90.46	200	400	28482.7	N	4
B247N_05	20-May	27.47	90.43	5	200	22803.2	N	5
B245N_01	21-May	27.44	92.46	700	850		N	3b
B245N_02	21-May	27.42	92.44	599	700		N	3b
B245D_02	21-May	27.47	92.54	401	600	18081.7	D	4
B245D_03	21-May	27.46	92.53	200	401	20770.5	D	4
B245D_04	21-May	27.44	92.53	100	200	13137.5	D	5
B245D_05	21-May	27.42	92.52	10	100	8176.3	D	5
B245N_03	21-May	27.41	92.44	400	599	21344.6	N	4
SW-2N_01	22-May	27.53	92.02	600	700		N	3b
B245N_04	22-May	27.39	92.43	201	400	22934.7	N	4
B245N_05	22-May	27.37	92.42	5	201	29858	N	5
SW-2D_01	22-May	27.56	92.02	402	599	27334	D	4
SW-2D_02	22-May	27.54	92.01	201	402	23641.3	D	4
SW-2D_03	22-May	27.52	91.99	100	201	12549	D	5
SW-2D_04	22-May	27.51	91.99	8	100	11928.1	D	5
B246N_01	23-May	27.49	91.47	800	850		N	3c
B246D_01	23-May	27.54	91.52	800	875	8869.8	D	3
B246D_02	23-May	27.53	91.51	601	800	20929.4	D	3
B246D_03	23-May	27.51	91.50	398	601	18140.8	D	4
B246D_04	23-May	27.49	91.49	200	398	20440.2	D	4
B246D_05	23-May	27.47	91.49	0	200	19828.9	D	5
B246N_02	23-May	27.49	91.46	600	800	30431	N	3
SW-2N_02	23-May	27.51	92.01	400	600	26557	N	4
SW-2N_03	23-May	27.49	92.01	201	400	28307.3	N	4
SW-2N_04	23-May	27.46	92.00	100	201	14296.8	N	5

SW-2N_05	23-May	27.44	92.00	5	100	13819.9	N	5
SW-1D_01	24-May	27.52	91.03	801	850		D	3c
SW-1N_01	24-May	27.48	90.98	801	1001		N	3d
B246N_03	24-May	27.50	91.43	400	600	26285.2	N	4
B246N_04	24-May	27.50	91.40	200	400	31777.9	N	4
B246N_05	24-May	27.50	91.36	6	200	27674	N	5
SW-1D_02	24-May	27.52	91.02	601	801	18392.1	D	3
SW-1D_03	24-May	27.50	91.01	399	601	21510.4	D	4
SW-1D_04	24-May	27.48	91.00	201	399	23461.6	D	4
SW-1D_05	24-May	27.46	90.98	9	201	27547.2	D	5
SW-1N_02	25-May	27.51	91.00	600	801	18975.4	N	3
SW-1N_03	25-May	27.53	91.02	400	600	20043.5	N	4
SW-1N_04	25-May	27.55	91.04	200	400	20998.4	N	4
SW-1N_05	25-May	27.58	91.06	6	200	25503.2	N	5
B065D_02	3-Jun	27.48	88.01	1000	1200	16967.7	D	2
B065D_03	3-Jun	27.47	88.02	600	1000	41756.5	D	3
B065D_05	3-Jun	27.44	88.07	5	200	26488.7	D	5
B065N_03	3-Jun	27.53	87.95	600	1000	43911	N	3
B065N_05	3-Jun	27.49	88.01	5	200	26142.6	N	5
B286N_01	3-Jun	27.50	87.46	1200	1502	34571.2	N	1
B079N_01	4-Jun	27.50	87.01	1200	1502	29231.6	N	1
B286D_01	4-Jun	27.52	87.52	1199	1506	32426	D	1
B286D_02	4-Jun	27.55	87.54	1000	1199	19595.1	D	2
B286D_03	4-Jun	27.56	87.56	600	1000	48892.4	D	3
B286D_04	4-Jun	27.57	87.62	200	600	50987.4	D	4
B286N_02	4-Jun	27.51	87.50	1000	1200	17552.3	N	2
B286N_03	4-Jun	27.52	87.51	597	1000	44804.2	N	3
B286N_04	4-Jun	27.54	87.55	200	597	46437.9	N	4
B286N_05	4-Jun	27.56	87.59	5	200	21731.5	N	5
B079D_01	5-Jun	27.48	86.98	1200	1500	35537	D	1
B079D_02	5-Jun	27.51	87.00	1000	1200	25411.8	D	2
B079D_03	5-Jun	27.54	87.02	600	1000	49808.9	D	3
B079D_04	5-Jun	27.58	87.06	200	600	54322.5	D	4
B079D_05	5-Jun	27.63	87.09	5	200	28154.6	D	5
B079N_02	5-Jun	27.52	87.04	1001	1200	16309.3	N	2
B079N_03	5-Jun	27.53	87.06	600	1001	52105.1	N	3
B079N_04	5-Jun	27.56	87.10	200	600	66156.6	N	4
B079N_05	5-Jun	27.60	87.15	5	200	26403.1	N	5
B255N_01	5-Jun	27.52	86.52	1200	1501	34702.8	N	1
B255D_05	6-Jun	27.62	86.50	5	201		D	5
B254N_01	6-Jun	27.91	86.52	1200	1500	31804.4	N	1
B255D_01	6-Jun	27.48	86.49	1201	1499	18461.2	D	1
B255D_02	6-Jun	27.50	86.49	1001	1201	23481.6	D	2

B255D_03	6-Jun	27.53	86.49	600	1001	37726.9	D	3
B255D_04	6-Jun	27.57	86.49	201	600	52107.1	D	4
B255N_02	6-Jun	27.54	86.55	1000	1200	22512	N	2
B255N_03	6-Jun	27.56	86.58	599	1000	44632.7	N	3
B255N_04	6-Jun	27.59	86.62	201	599	58603	N	4
B255N_05	6-Jun	27.63	86.66	5	201	22906.1	N	5
B163N_01	7-Jun	28.01	86.08	800	1002	20280.3	N	3
B163N_02	7-Jun	27.99	86.06	600	800	17576.8	N	3
B254D_01	7-Jun	27.88	86.46	1199	1500	30629.4	D	1
B254D_02	7-Jun	27.91	86.48	1000	1199	19845	D	2
B254D_03	7-Jun	27.94	86.48	600	1000	46240.3	D	3
B254D_04	7-Jun	27.96	86.43	200	600	50179	D	4
B254D_05	7-Jun	27.97	86.37	5	200	24208.5	D	5
B254N_02	7-Jun	27.92	86.55	1000	1200	17732.5	N	2
B254N_03	7-Jun	27.92	86.57	600	1000	42204.4	N	3
B254N_04	7-Jun	27.93	86.62	200	600	45810.4	N	4
B254N_05	7-Jun	27.93	86.67	5	200	20775.1	N	5
B078N_01	8-Jun	27.52	86.04	1200	1501	40052	N	1
B163D_01	8-Jun	27.84	86.12	1201	1503	32845.3	D	1
B163D_02	8-Jun	27.85	86.08	1000	1201	17794.7	D	2
B163D_03	8-Jun	27.85	86.05	599	1000	41389.8	D	3
B163D_04	8-Jun	27.85	86.00	201	599	35389.7	D	4
B163D_05	8-Jun	27.85	85.96	3	201	24293.3	D	5
B163N_03	8-Jun	27.98	86.05	401	600	27295.3	N	4
B163N_04	8-Jun	27.96	86.02	200	401	34127.3	N	4
B163N_05	8-Jun	27.93	86.00	5	200	45826.7	N	5
B078N_02	9-Jun	27.49	86.00	1000	1200	27045.5	N	2
B078N_03	9-Jun	27.47	85.97	599	1000	57867.4	N	3
B078N_04	9-Jun	27.43	85.92	200	599	49834.4	N	4
B078N_05	9-Jun	27.40	85.88	5	200	21919.7	N	5
B162N_01	9-Jun	27.53	85.65	1200	1500	59904.3	N	1
B162D_01	10-Jun	27.48	85.63	1202	1500	58567.1	D	1
B162D_02	10-Jun	27.49	85.60	1001	1202	36684.3	D	2
B162D_03	10-Jun	27.50	85.58	601	1001	70440.8	D	3
B162D_04	10-Jun	27.51	85.54	201	601	80224	D	4
B162D_05	10-Jun	27.53	85.51	13	201	23883.1	D	5
B162N_02	10-Jun	27.49	85.63	1000	1200	46654.1	N	2
B162N_03	10-Jun	27.47	85.61	592	1000	87540.2	N	3
B162N_04	10-Jun	27.43	85.59	201	592	67976.9	N	4
B162N_05	10-Jun	27.39	85.58	6	201	35307.9	N	5
SE-6N_01	10-Jun	27.00	85.49	1200	1501	82923.6	N	1
SE-5N_01	11-Jun	26.99	86.01	1200	1502	62709.7	N	1
SE-6D_01	11-Jun	26.99	85.51	1200	1500	64868.9	D	1

SE-6D_02	11-Jun	27.01	85.48	1000	1200	40996.1	D	2
SE-6D_03	11-Jun	27.02	85.46	600	1000	98830.7	D	3
SE-6D_04	11-Jun	27.06	85.42	200	600	96157.5	D	4
SE-6D_05	11-Jun	27.07	85.37	0	200	36674.9	D	5
SE-6N_02	11-Jun	27.01	85.44	1000	1200	42390.6	N	2
SE-6N_03	11-Jun	27.01	85.42	600	1000	82616	N	3
SE-6N_04	11-Jun	27.02	85.37	200	600	90914.8	N	4
SE-6N_05	11-Jun	27.03	85.32	5	200	31349.3	N	5
SE-5D_01	12-Jun	26.95	85.97	1175	1501		D	1
SE-5D_02	12-Jun	26.98	85.96	1001	1175	35197.1	D	2
SE-5D_03	12-Jun	27.00	85.96	600	1001	100841.2	D	3
SE-5D_04	12-Jun	27.04	85.94	200	600	89737.9	D	4
SE-5D_05	12-Jun	27.07	85.91	5	200	26897.9	D	5
SE-5N_02	12-Jun	27.01	85.99	1000	1200	35397.2	N	2
SE-5N_03	12-Jun	27.03	85.98	600	1000	106644.6	N	3
SE-5N_04	12-Jun	27.07	85.94	201	600	103579.2	N	4
SE-5N_05	12-Jun	27.12	85.90	5	201	26416.4	N	5
SW-11N_01	17-Jun	27.00	92.52	1200	1253	7564	N	1
SW-11N_02	17-Jun	27.00	92.52	1000	1200	37208.8	N	2
SW-11N_03	17-Jun	26.98	92.54	600	1000	90838.5	N	3
SW-10N_01	18-Jun	26.94	91.95	1200	1350	34420.9	N	1
SW-10N_02	18-Jun	26.92	91.95	996	1200	46752.9	N	2
SW-11D_01	18-Jun	27.00	92.49	1200	1257	24839.9	D	1
SW-11D_02	18-Jun	26.99	92.48	990	1200	44991.2	D	2
SW-11N_04	18-Jun	26.97	92.57	199	600	100670.5	N	4
SW-11N_05	18-Jun	26.94	92.60	5	199	31465.7	N	5
SW-10D_01	19-Jun	27.00	92.00	1200	1353	59174.7	D	1
SW-10D_02	19-Jun	26.97	91.99	1000	1200	54916	D	2
SW-10D_03	19-Jun	26.94	91.98	599	1000	119286	D	3
SW-10D_04	19-Jun	26.89	91.96	200	599	77020.8	D	4
SW-10D_05	19-Jun	26.84	91.96	5	200	25026.5	D	5
SW-10N_03	19-Jun	26.90	91.94	600	996	95489.9	N	3
SW-10N_04	19-Jun	26.85	91.92	200	600	111912.5	N	4
SW-10N_05	19-Jun	26.80	91.89	5	200	30596.7	N	5
SW-9N_01	19-Jun	27.02	91.50	1200	1501	57830.1	N	1
SW-9D_05	20-Jun	26.99	91.44	0	202		D	5
SW-9N_05	20-Jun	26.91	91.44	0	199		N	5
SW-8N_01	20-Jun	27.01	91.02	1200	1500	69260.4	N	1
SW-9D_01	20-Jun	27.09	91.51	1198	1502	80898.5	D	1
SW-9D_02	20-Jun	27.06	91.48	999	1198	30620.6	D	2
SW-9D_03	20-Jun	27.05	91.48	600	999	74551.8	D	3
SW-9D_04	20-Jun	27.02	91.46	202	600	69085.7	D	4
SW-9N_02	20-Jun	26.99	91.49	1000	1200	30651.9	N	2

SW-9N_03	20-Jun	26.98	91.48	583	1000	89728.6	N	3
SW-9N_04	20-Jun	26.94	91.46	199	583	97929.6	N	4
SW-7N_01	21-Jun	27.00	90.50	1200	1400	32097.2	N	1
SW-8D_01	21-Jun	27.06	91.00	1200	1502	72483.9	D	1
SW-8D_02	21-Jun	27.03	90.97	999	1200	31236.5	D	2
SW-8D_03	21-Jun	27.02	90.97	598	999	71305.3	D	3
SW-8D_04	21-Jun	26.99	90.95	200	598	85798.4	D	4
SW-8D_05	21-Jun	26.96	90.93	5	200	52050.1	D	5
SW-8N_02	21-Jun	26.98	91.01	1002	1200	48324.4	N	2
SW-8N_03	21-Jun	26.96	90.99	602	1002	85098	N	3
SW-8N_04	21-Jun	26.94	90.96	199	602	106202.5	N	4
SW-6N_01	22-Jun	27.04	90.03	1200	1500	53230.4	N	1
SW-6N_02	22-Jun	27.01	90.04	1000	1200	32108.5	N	2
SW-7D_01	22-Jun	26.98	90.52	1199	1401	36927.4	D	1
SW-7D_02	22-Jun	26.96	90.51	999	1199	30858.5	D	2
SW-7D_03	22-Jun	26.95	90.50	600	999	78984.2	D	3
SW-7D_04	22-Jun	26.91	90.49	199	600	94372.6	D	4
SW-7D_05	22-Jun	26.88	90.48	0	199	37690.8	D	5
SW-5N_01	23-Jun	27.00	89.51	1200	1500	62907.7	N	1
SW-5N_02	23-Jun	26.97	89.51	1001	1200	43827.1	N	2
SW-6D_01	23-Jun	27.01	90.12	1200	1501	66811.7	D	1
SW-6D_02	23-Jun	26.97	90.12	999	1200	28320.6	D	2
SW-6D_03	23-Jun	26.96	90.12	600	999	67635.7	D	3
SW-6D_04	23-Jun	26.93	90.10	201	600	105046.3	D	4
SW-6D_05	23-Jun	26.89	90.08	0	201	35114.8	D	5
SW-6N_03	23-Jun	26.99	90.04	600	1000	84620.9	N	3
SW-6N_04	23-Jun	26.96	90.03	201	600	81385.6	N	4
SW-6N_05	23-Jun	26.93	90.01	5	201	32524.5	N	5
SW-3N_01	24-Jun	26.99	88.49	1200	1505	57554.9	N	1
SW-3N_02	24-Jun	27.00	88.53	1001	1200	36117.1	N	2
SW-5D_01	24-Jun	26.98	89.51	1199	1501	46940.1	D	1
SW-5D_02	24-Jun	26.96	89.52	998	1199	25052.5	D	2
SW-5D_03	24-Jun	26.95	89.52	600	998	74199.4	D	3
SW-5D_04	24-Jun	26.92	89.51	199	600	124325.7	D	4
SW-5D_05	24-Jun	26.87	89.47	0	199	28550.6	D	5
SW-5N_03	24-Jun	26.95	89.52	601	1001	71838.4	N	3
SW-5N_04	24-Jun	26.92	89.53	200	601	104815.4	N	4
SW-5N_05	24-Jun	26.87	89.54	1	200	33192.6	N	5
SW-3D_01	25-Jun	26.99	88.46	1199	1502	37416.1	D	1
SW-3D_02	25-Jun	27.00	88.48	1000	1199	30065	D	2
SW-3D_03	25-Jun	27.00	88.50	600	1000	65990.5	D	3
SW-3D_04	25-Jun	27.02	88.53	200	600	90142.6	D	4
SW-3D_05	25-Jun	27.03	88.57	5	200	29494.9	D	5

SW-3N_03	25-Jun	27.01	88.56	600	1001	87963.4	N	3
SW-3N_04	25-Jun	27.02	88.61	200	600	87043	N	4
SW-3N_05	25-Jun	27.01	88.65	5	200	29179.4	N	5
SE-2D_01	26-Jun	26.97	87.51	1198	1500	71453.4	D	1
SE-2D_02	26-Jun	26.93	87.51	998	1198	15204.7	D	2
SE-2D_03	26-Jun	26.93	87.51	600	998	32512.7	D	3
SE-2D_04	26-Jun	26.92	87.53	200	600	106667.6	D	4
SE-2D_05	26-Jun	26.93	87.57	2	200	17193.2	D	5
SE-4N_01	26-Jun	26.99	86.52	1194	1501	59446.2	N	1
SE-3N_01	27-Jun	27.03	87.01	1200	1499	64228.4	N	1
SE-3N_02	27-Jun	26.99	86.99	1000	1200	42990.1	N	2
SE-4D_01	27-Jun	27.01	86.46	1200	1505	44726.2	D	1
SE-4D_02	27-Jun	26.99	86.47	1000	1200	33396.5	D	2
SE-4D_03	27-Jun	26.97	86.49	600	1000	56451.7	D	3
SE-4D_04	27-Jun	26.95	86.51	201	600	90639.2	D	4
SE-4D_05	27-Jun	26.92	86.54	6	201	37257.3	D	5
SE-4N_02	27-Jun	26.97	86.55	1000	1194	40022.3	N	2
SE-4N_03	27-Jun	26.95	86.57	599	1000	74550.2	N	3
SE-4N_04	27-Jun	26.92	86.60	200	599	98490.9	N	4
SE-4N_05	27-Jun	26.92	86.64	7	200	35915.8	N	5
SE-1N_01	28-Jun	26.99	88.00	1200	1500	59626.5	N	1
SE-1N_02	28-Jun	27.01	88.03	1000	1200	47095.8	N	2
SE-3D_01	28-Jun	27.01	87.00	1200	1500	41336.6	D	1
SE-3D_02	28-Jun	26.99	87.02	1000	1200	26480.1	D	2
SE-3D_03	28-Jun	26.98	87.03	600	1000	72300.6	D	3
SE-3D_04	28-Jun	26.95	87.07	200	600	74990.2	D	4
SE-3D_05	28-Jun	26.93	87.10	6	200	28230.2	D	5
SE-3N_03	28-Jun	26.97	86.99	592	1000	81489.2	N	3
SE-3N_04	28-Jun	26.94	86.97	201	592	77120.3	N	4
SE-3N_05	28-Jun	26.91	86.96	5	201	34525.7	N	5
SE-1D_01	29-Jun	26.95	88.00	1201	1500	69695.2	D	1
SE-1D_05	29-Jun	27.03	88.15	5	199	17150.5	D	5
SE-1N_03	29-Jun	27.02	88.05	601	1000	104143.9	N	3
SE-1N_04	29-Jun	27.05	88.10	200	601	100204.1	N	4
SE-1N_05	29-Jun	27.07	88.14	0	200	23064.8	N	5

N/A indicates samples where flow data could not be calculated