CAMINADA HEADLAND BEACH BENTHIC ORGANISM SURVEY: YEAR 4

by

Jerry A. McLelland, PhD

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c/o

Richard DeMay,
Project manager

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Contact information:
J. McLelland
Gulf Benthic Taxonomy Assessement
111 Cotton Creek Dr, Hattiesburg, MS 39402
Ph: 228-257-9207
email: mudcritters@gmail.com

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Figure 1. Map showing locations of benthic stations at Caminada Headland Beach, Fourchon, Louisiana in Years 2 - 4.

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Background

A pre-construction survey of the gulf shoreline benthic community from wet sand (intertidal) and wrack line habitats at four stations along the Caminada Headland Beach (Fourchon, Louisiana) was conducted April 1-2, 2013, as part of a beach and dune restoration project which requires monitoring of wintering piping plovers (*Charadrius melodus*) in that area (McLelland 2013). The 2013 survey showed that the intertidal macrobenthic population was dominated by the polychaete annelid, *Scolelepis squamata* and the amphipod crustacean, *Lepidactylus triarticulatus*. Although the latter was more numerous, the two populations were nearly equal in total biomass. The beach wrack-line invertebrate community at three of the four stations was dominated by large numbers and a rich variety of small insects, but was lower in total biomass than the corresponding intertidal zone fauna.

Year 2 of the survey was conducted April 16-17, 2014, and focused on three aspects: (1) revisiting the same four gulf-side stations to assess changes in the macroinvertebrate population structure resulting from beach renourishment and dune construction (post-construction); (2) survey an additional six gulf-side sites along the Caminada Headland Beach extending eastward from those surveyed in 2013 in order to provide a baseline for further restoration to commence as part of Phase II; and (3) survey the benthic community at three bayside sites within the Caminada Headland Beach and Dune Restoration project footprint, areas known to provide forage for transient shorebirds. To allow comparison between sampling events, all year 2 samples were collected in the same manner as those of year 1 (McLelland 2014).

Year 3 of the survey, conducted March 30-April 1, 2015, was essentially a repeat of the Year 2 survey with the purpose of continuing observations on the macroinvertebrate assemblages and assessing the impact on the benthic community from further beach renourishment progressing eastward along the headland beach. The same stations from Year 2 were surveyed using the same procedures.

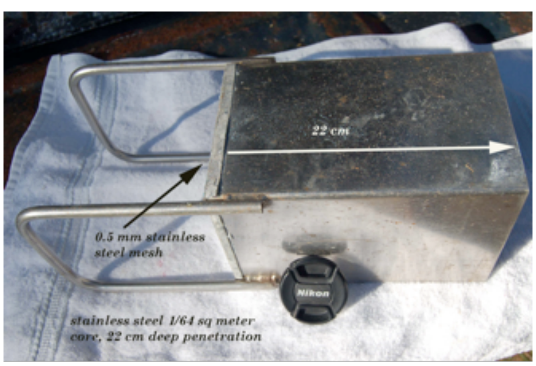

Figure 2. Box Core used in intertidal sampling. Photo by J.M. Foster.

Year 4 of the survey, conducted April 4-5, 2016, repeated the surveys from years 2 and 3 at the same stations using the same methodology, with the purpose of continuing the impact assessment from beach construction and renourishment. The locations of the 10 beach stations and 3 bayside stations sampled in year 4 and in previous years of the survey appear on the map in Figure 1.

Field Procedures.

Intertidal samples were collected at each station near mid-swash zone - that area halfway between the point at which waves break on the beach face and the upper extent of the moving water. A handT held stainless steel box core, described by Saloman and Naughton (1977), was used for intertidal sampling (Fig. 2). The coring device, six inches (12.5cm) on a side and penetrating to a depth of 18T 20cm, was used to collect three replicate quantitative samples at approximately 1 meter apart and representing 0.0156m^2 of substrate. Box Core samples were treated with a weak formalin solution to anesthetize motile organisms, then repeatedly elutriated through a 0.5mm mesh sieve. The elutriation technique served to float off softT bodied infauna (e.g. polychaetes, amphipods) from the samples. The remaining sediment was screened through a 1.0mm sieve to remove possible heavier bodied organisms (e.g., mollusks). Samples were preserved in the field with rose bengalT stained 5% formalin, labeled and returned to the laboratory for analysis. Rose bengal, a protein stain, facilitates the detection of benthic organisms among the sediment and detritus in the samples during the laboratory sorting process.

The wrack line community was sampled following National Water Quality Assessment (NAWQA) Program protocols (Moulton et al, 2002) for the collection of richest-targeted habitat (RTH) samples corresponding to approximately 0.25 square meters of wrack substrate (fine organics, shells, woody debris, drift vegetation, etc.) per sample. Three replicate samples were collected by scooping out about 5 cm of sediment inside a 0.25 square meter quadrant that was placed at about two meter intervals within a 10 meter section of the wrack line (Fig. 3). Large debris particles were removed from the samples by sifting through a coarse screen (4.0 mm) that was dipped in a water bucket to dislodge clinging organisms (spiders, insects, etc.). Samples were then processed and preserved in a similar manner to the box cores using elutriation and screening through a 1.0mm sieve.

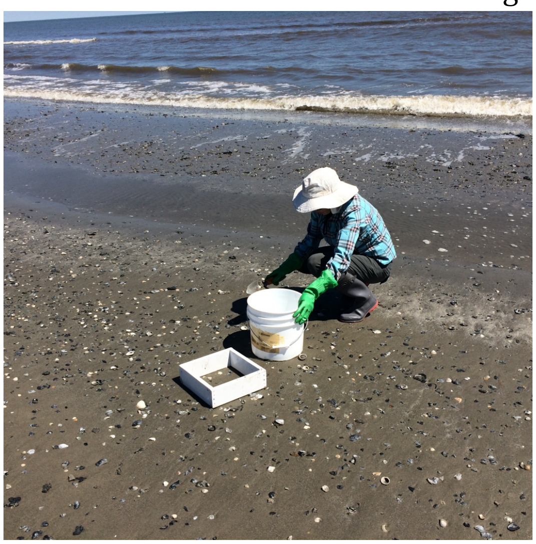

Figure 3. 0.25 m quadrant used for sampling beach wrack fauna. Photo by J. McLelland.

One qualitative multi-habitat (QMH) wrack-line sample per station was collected to account for large and rare specimens (i.e. crabs, snails, etc.) occurring among the flotsam and jetsam within the same homogenous wrack-line section used for the collection of RTH samples. The purpose of this sample was to provide an indication of RTH sampling efficiency. QMH sampling, based on NAWQA protocols, was conducted by pushing a wide-mouth kicknet along the 10-meter wrack-line section with the ensuing sediment and debris (e.g., Sargassum weed) being washed by agitation in a sampling bucket. Organisms resulting from this action were placed in a jar, labeled and preserved.

Additional physical data included GPS coordinates, salinity, water and air temperatures, wind speed and direction, and sea state (Table 1). The three bayside stations were sampled similarly to the beach station wrack-line habitats except that no QMH sample was collected (see Table 2 for station data).

Table 1. Caminada Headland Beach Gulf Side Benthic Field Data – April, 2016

	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9	Station 10
Date sampled	4/5/16	4/5/16	4/5/16	4/4/16	4/5/16	4/5/16	4/4/16	4/4/16	4/4/16	4/4/16
Time on Site	1210 - 1300	1055 - 1140	0900 - 0950	1500 - 1550	1000 - 1050	0800 - 0855	1405 - 1450	1205 - 1310	1020 - 1120	0820 - 1015
Latitude	N 29.09062	N 29.11008	N 29.12433	N 29.13875	N 29.11744	N 29.13131	N 29.15314	N 29.16858	N 29.18178	N 29.18773
Longitude	W -90.21355	W -90.17789	W -90.15517	W -90.13157	W -90.16645	W -90.14365	W -90.10928	W -90.08617	W -90.06346	W -90.05132
Station ID no.	ID 334	ID 417	ID 406	ID 421	ID 411	ID 401	ID 526	ID 426	ID 493	ID 490
Intertidal length	2.4m	1.7m	4.0m	3.6m	1.2m	1.6m	4.4m	4.7m	2.0m	1.7
Wrack to water	2m	2.7m	0.5m	0.5m	0.5m	1.0m	0.5m	1.0m	3.0m	13.0m
Sample types:										
box cores	3	3	3	3	3	3	3	3	3	3
wrack semi-quant	3	3	3	3	3	3	3	3	3	3
wrack qualitative	1	1	1	1	1	1	1	1	1	1
Physical data:										
salinity ppt	25	24	24.5	22.5	23	25	22	24	25	22
air temp °C	22.8	23.7	20.5	21.6	22.1	20	22.6	21.6	20.2	18.5
water temp °C	21.7	21.1	19.7	21.9	20.7	18.8	23.4	21.9	20.6	17
wind speed mph	5	5	5 - 10	5	5	5	5	5	15-Oct	10
wind direction	N	N	N	N	N	N	N	N	N	N
% cloud cover	0	0	0	0	0	0	0	0	0	0
sea state ft	1	1-2	1	1-2	1-2	1	2	1-2	1	1

Table 2. Caminada Headland Beach Bayside Benthic Field Data – for April 2016

	BS 1	BS 2	BS 3
Date sampled	4/4/16	4/4/16	4/5/16
Time on Site	1315 - 1330	1120 - 1200	1315 - 1335
Latitude	N 29.17120	N 29.18457	N 29.11876
Longitude	W -90.08742	W -90.06447	W -90.16828
Station ID no.		ID 493	ID 711
Intertidal length	-	-	-
Wrack to water	-	-	-
Sample types:			
box cores	-	-	-
wrack semi-quant	3	3	3
wrack qualitative	-	-	-
Physical data:			
salinity ppt	12	14.5	17
air temp °C	20	19.4	25.1
water temp °C	29.1	24.4	28.5
wind speed mph	5	5	< 5
wind direction	N	N	N
% cloud cover	0	0	0
sea state ft	-	-	-

Laboratory Procedures.

Sorting was conducted under a stereoscopic dissecting microscope to remove all macrobenthic organisms and recognizable fragments. Specimens were counted and identified to the lowest possible taxonomic category with representative reference material being retained and transferred to 70% ethanol for storage. The remaining material was separated into major groups of prey items (e.g, annelids, arthropods, mollusks), preserved in ethanol and set aside for biomass measurement. A numerical database was constructed using Microsoft Access and data was further condensed and organized in spreadsheet format using Microsoft Excel. Numbers counted were converted to numbers per square meter using 64.103 per individual for box core data and 16 per individual for the 0.25 meter quadrant. Metrics of species diversity (H'), equitability (J') and dominance were calculated using formula incorporated in the Excel spreadsheet. Numerical, biomass, and diversity data for quantitative samples are presented in Tables 3 and 4 for the intertidal and wrack-line communities respectively and in Table 5 for the bayside benthic community. The values in these tables represent totals of the three replicate samples collected at each station. A complete phylogenetic listing of organisms from all samples appears in Appendix II.

Species diversity is the number of different species in a particular area (species richness) weighted by some measure of abundance such as number of individuals or biomass. The Shannons Weiner Diversity Index (H') is the most popular mathematical expression of species richness and evenness in use in ecological investigation, including benthic monitoring studies. According to Pielou (1966), who studied the use of H' in detail, the index is appropriate to use when random samples are drawn from a large community in which the total numbers of species is known. H' is calculated as $-\sum \rho i \log n(\rho i)$, where ρi is the proportion of the total number of specimens *i* expressed as a proportion of the total number of species for all species in the ecosystem. The product of $\rho i \log n(\rho i)$ for each species in the ecosystem is summed and multiplied by −1 to give H'.

The species equitability index (J'), also known as Evenness, is another measure of how well the abundance of individuals is spread among the number of species. It is calculated as H'/H_{max}, where H_{max} is the maximum possible value of H', and equals the log of S, which is the number of species (species richness). The index of dominance, a measure of how a population is dominated by one or a few species, is calculated simply as 1-J'.

Figure 4. Typical Gulf-side beach face.

Total benthic biomass (by weight) of piping plover prey species was measured following methods described by Versar, Inc. (2002). Samples composed of prey specimen groups (see above), pooled from all replicates, were air dried to a constant weight at 60ºC in a drying oven and then baked for 4 hours at 500ºC in a muffle furnace to determine the ash-free dry weight. Samples were weighed before and after baking using an analytical balance accurate to 0.0001 g. Bivalves and barnacles in the samples were crushed prior to drying to eliminate fluid trapped in the shells.

Results.

<u>General field observations</u>. As in previous years, the typical beach face at most of the Gulf-side stations was flat with little contour (Fig. 4). The substrate consisted of very fine, firmly packed sediment overlaying sparse amounts of shell hash composed of fine flakes at some stations and coarse rubble at others, usually the most recently reconstructed. The sediment was light brown in color due likely to large amounts of fine silt originating from nearby rivers and bays. The newly constructed beach at stations 5-7 contained only a minimal amount of

Figure 5. Wrack-line at eastern stations.

sand and much larger shell particles and rubble originating from dredge material taken from offshore. It was noted that at stations 1 and 2 a deeper layer of sand had accumulated at these construction sites from 2014, and to a lesser degree at stations 3 and 4 since 2015, allowing the recruitment and colonization of more normal infaunal populations. As in previous years, many of the larger shell pieces at the non-constructed stations toward the eastern end still showed evidence of oil contamination with encrusted sand and weathered tar residue. The wrack line, indicated by the most recent high-tide mark, was almost non-

Figure 6. Spionid polychaete tubes from easternmost station wrack material. Scale = mm.

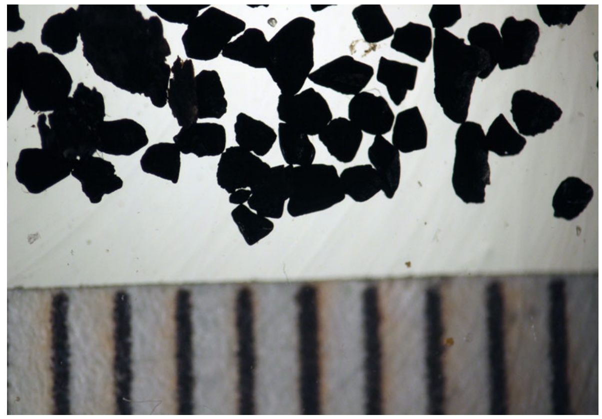

Figure 7. Coal-like sediment particles from easternmost stations. Scale = mm.

discernable at all stations, being devoid of deposited debris such as the hyacinths and *Sargassum* seen in previous years. The easternmost stations, 9 and 10, did have a shallow layer of sand-encrusted tubes at the wrack line, likely the product of spionid polychaetes (Figs. 5, 6). It also worth noting that the sediment at the easternmost stations had a considerable amount of small coal-like particles, probably originating from weathered tar balls (Fig. 7).

The three bayside stations, open to the bay on the north side, appeared unchanged from years 2 and 3. They were similar in that they were typical exposed mud/sand-flat areas with standing water replenished by tidal inundation, and with varying amounts of fringing vegetation (Fig. 8). The sediment was composed of mud and fine-grained sand topped by a thin algal mat. Quadrant sampling at these stations was conducted at the waterline in sediment either exposed or with about a centimeter of water coverage.

Figure 8. Typical bayside station behind Caminada Headland Beach.

Benthic fauna.

During the Year 4 sampling period, a total of 4,072 organisms were examined from Caminada Headland Beach samples (3,445 from the 10 Gulf-side stations and 627 from the three bayside stations) representing 75 nominal taxa from five phyla. These totals include specimens examined from the qualitative wrack-line (QMH) samples collected at the beach stations (see Appendix I).

Gulf-side Stations

Among the ten Gulf-facing stations, as in 2015, station 8 again had by far the largest number of intertidal individuals collected with over 16,000 organisms/m^2, largely due to high numbers of the haustoriid amphipod, *Lepidactylus triarticulatus* and the bivalve *Donax variabilis* (Figs. 9 and 11). These two organisms were also prominent at Stations 9 and 10, and to lesser extents at stations 2, 5, and 7. The highest density of total organisms in the beach wrack-line community occurred at Station 9 (7,216/m^2) with substantial numbers (5,760/m^2) also at station 2 (Fig. 10). High numbers of *Lepidactylus*, embedded in the upper few cm of sediment in the wrack line, accounted for the densities of over 1000/ m^2 at all but two of the beach stations (Fig. 12) but were highest at the aforementioned stations 9 and 2.

Intertidal species diversity (H') values, ranging between 0.778 and 0.347, were higher than corresponding wrack-line values at all stations except station 10 which registered a wrack value of 0.805, the latter owing to a high species richness (23 taxa) at that station. Dominance values (1-J') in the wrack-line zone were higher than corresponding intertidal values at all stations except station 10. Large numbers of embedded amphipods in the wrack community and higher numbers of crustaceans and bivalves in the intertidal core samples undoubtedly influenced these trends (see Figs. 13 and 14, Table 3 data).

In terms of macrofaunal biomass, there was considerably more g /m^2 of available nutrition in the intertidal zone than in the wrack community (see the scales of Figs. 15 and 16) except for Station 4 which had exceptionally low intertidal values. Peaks of intertidal biomass at Stations 1-3 and 5 were influenced by the presence of large-bodied bivalve molluscs (*Donax variabilis*) at Station 1 and sub-adult mole crabs (*Emerita talpoida*) at Stations 2,3 and 5 (Figs. 15 and 17). It is worth noting that although the numbers of *Donax* were higher at Stations 8 and 9 (10,128 and 1,218 /m^2), than at Station 1 (769/m^2) they were mostly juveniles with low biomass (see Table 3 data). In the wrack community, the major players in terms of biomass were annelids, amphipods and molluscs embedded in the moist sand beneath the wrack line, especially at Stations 2, 4 and 9 (Figs. 16 and 18). In comparing the biomass totals of all stations (Figs. 19 and 20), molluscs (54%) and crustaceans (45%) dominated the intertidal zone, with a scant representation by annelids and other taxa (about 1%), while crustaceans (54%), molluscs (38%) and annelids (6%) prevailed in the wrack community.

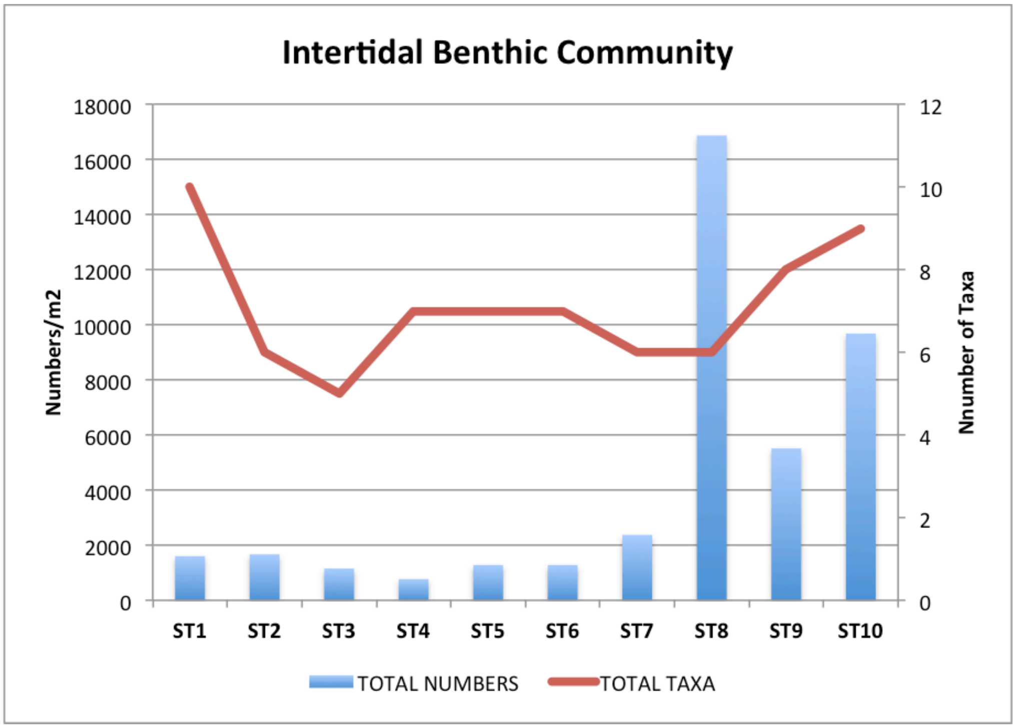

Figure 9. Intertidal total density vs. richness.

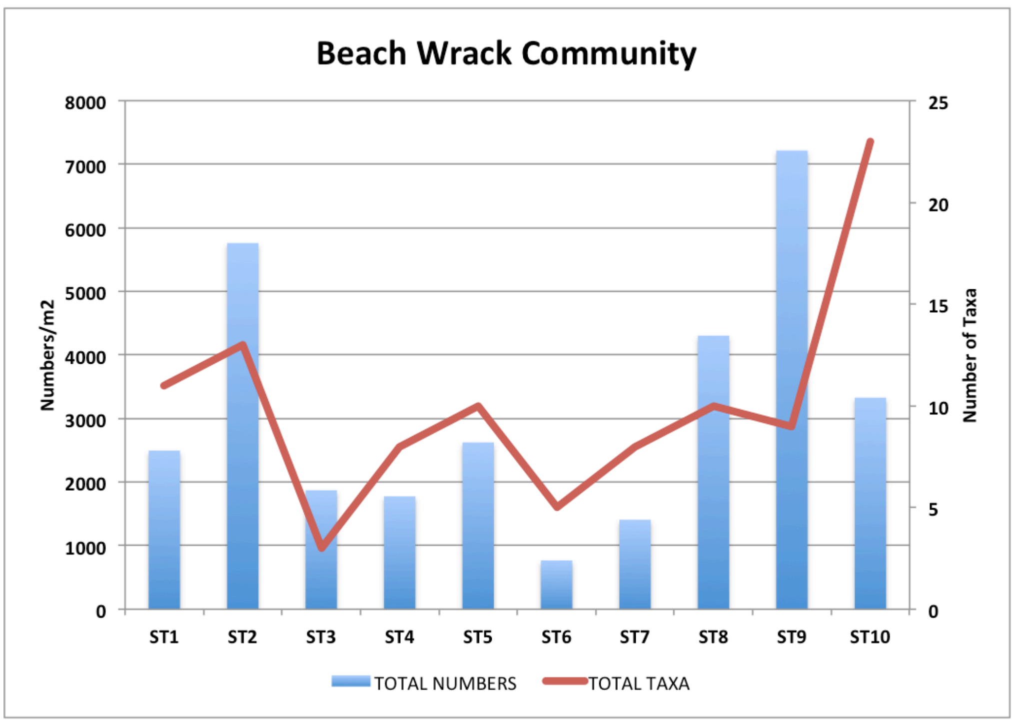

Figure 10. Wrack-line total density vs. richness

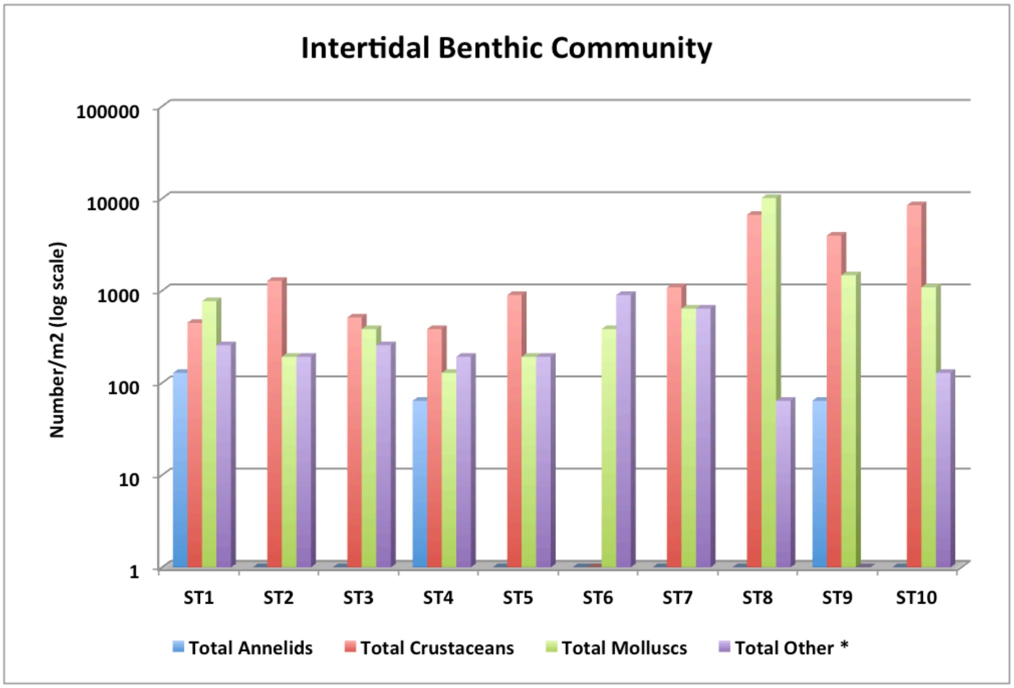

Figure 11. Gulf-side intertidal macrobenthic components.

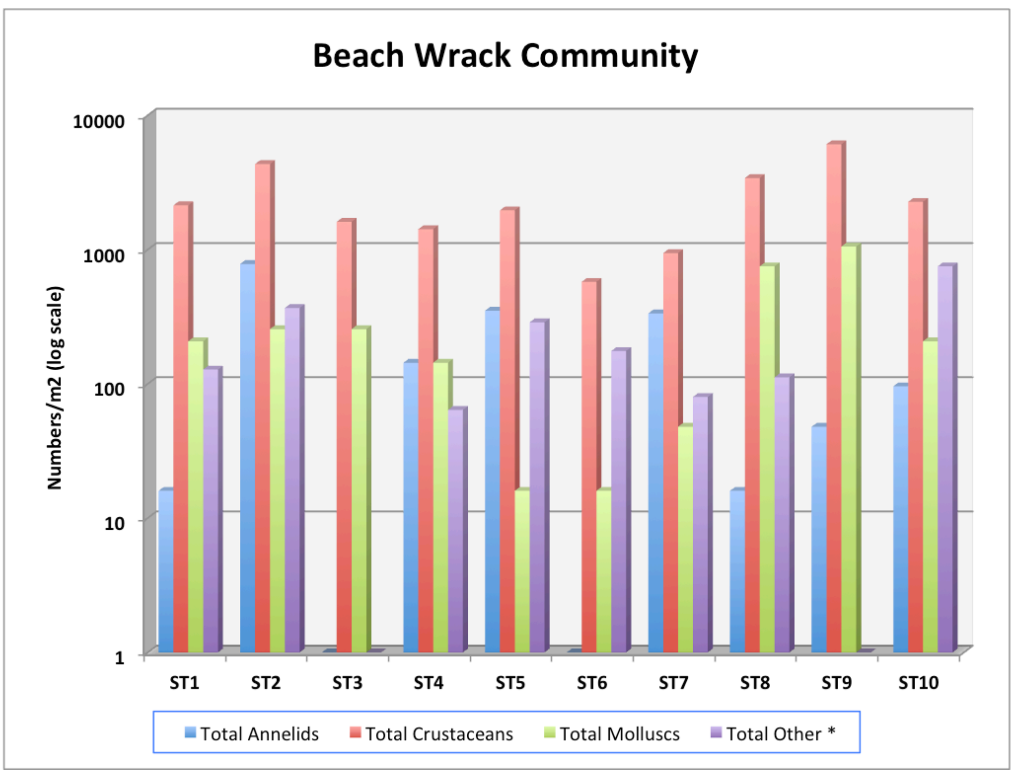

Figure 12 . Gulf-side wrack community macrobenthic components.

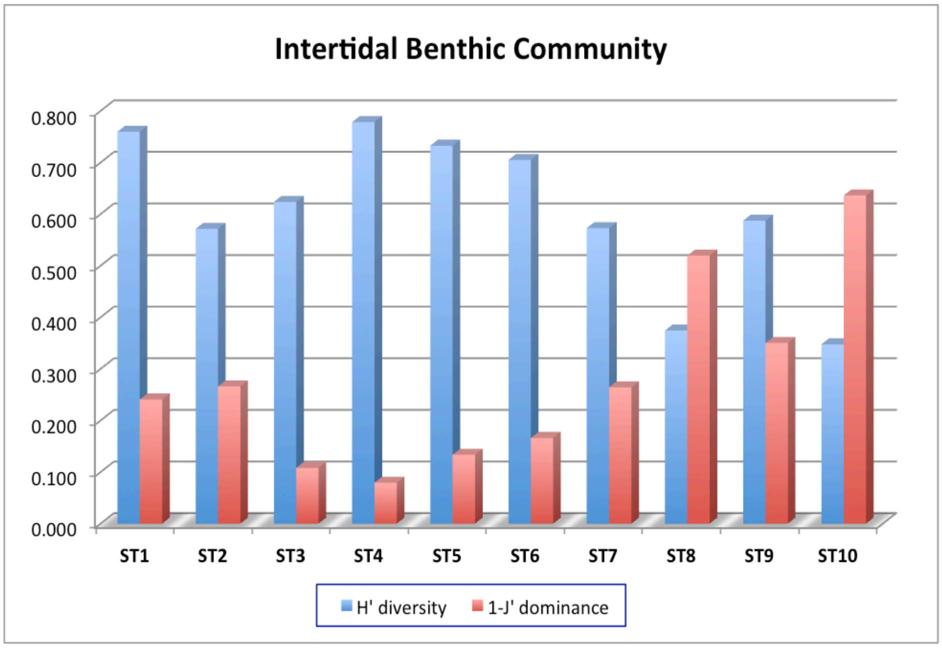

Figure 13. Gulf-side intertidal diversity indices.

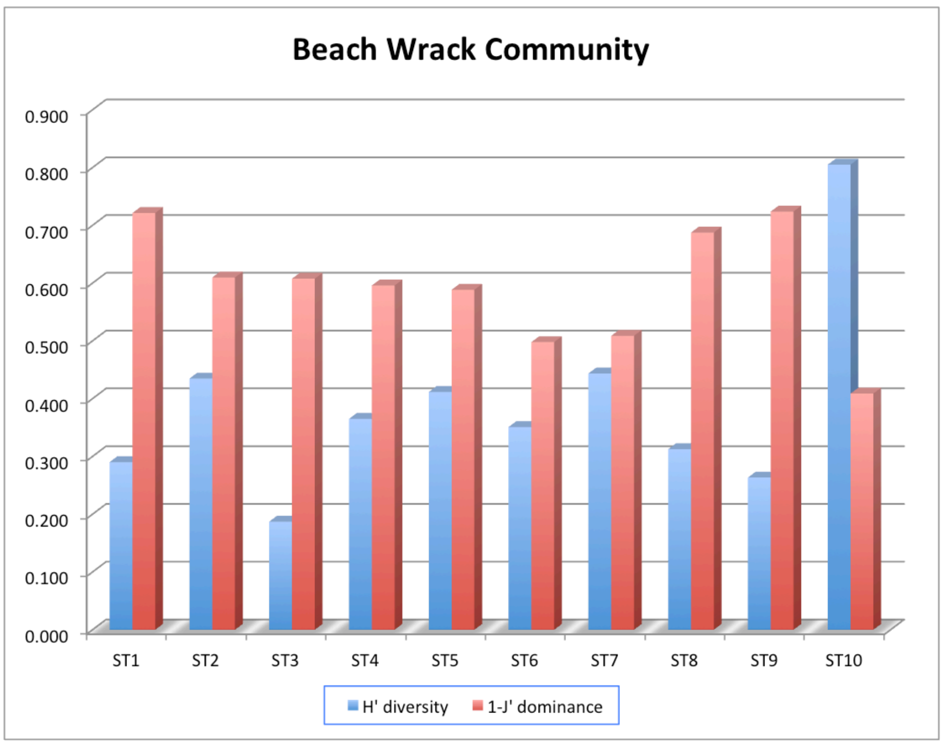

Figure 14. Gulf-side wrack-line diversity indices.

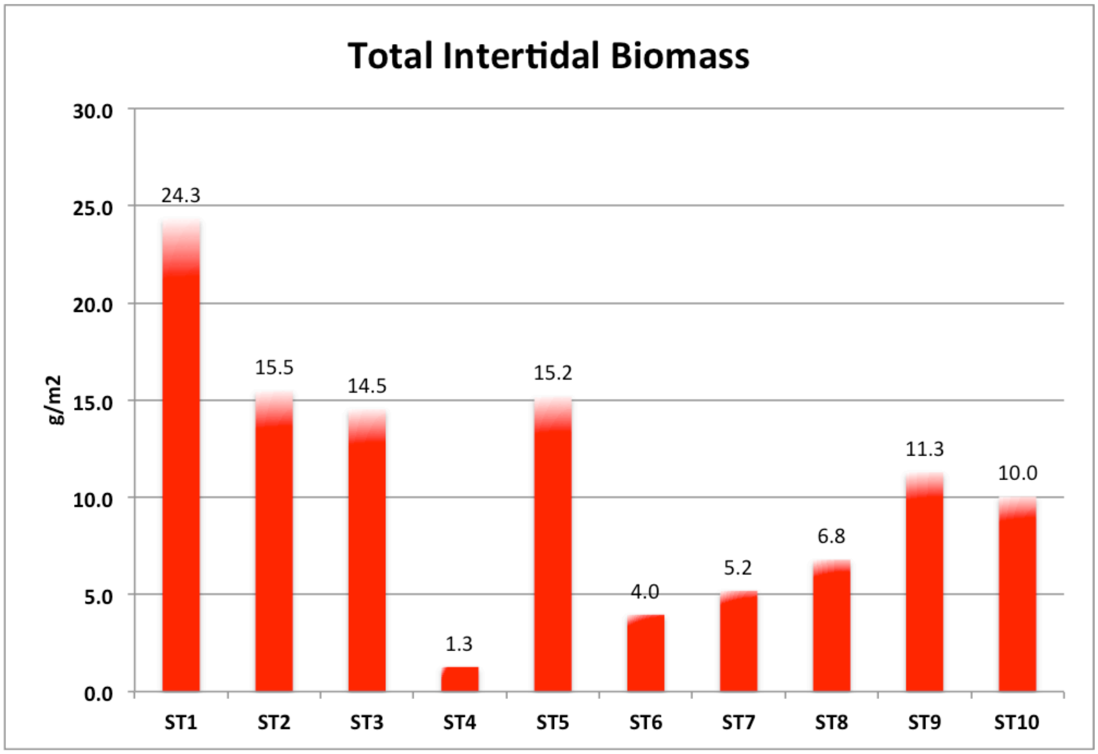

Figure 15. Gulf-side stations total intertidal biomass.

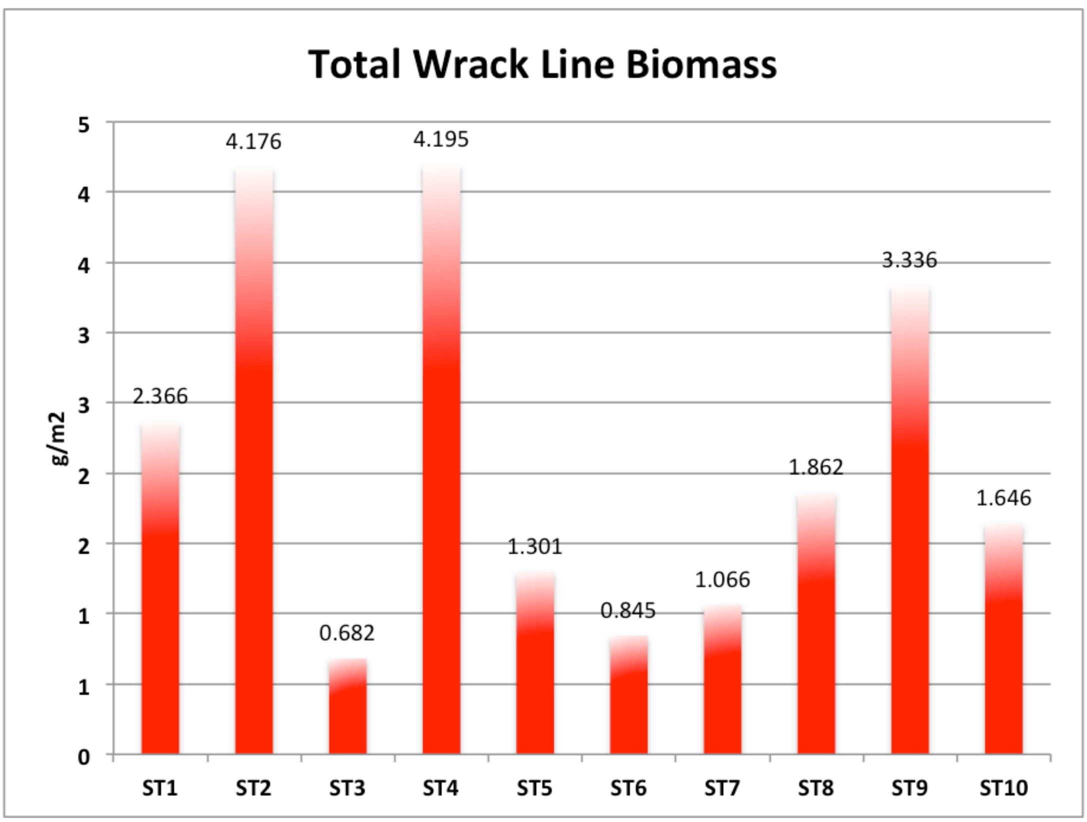

Figure 16. Gulf-side stations total wrack-line biomass.

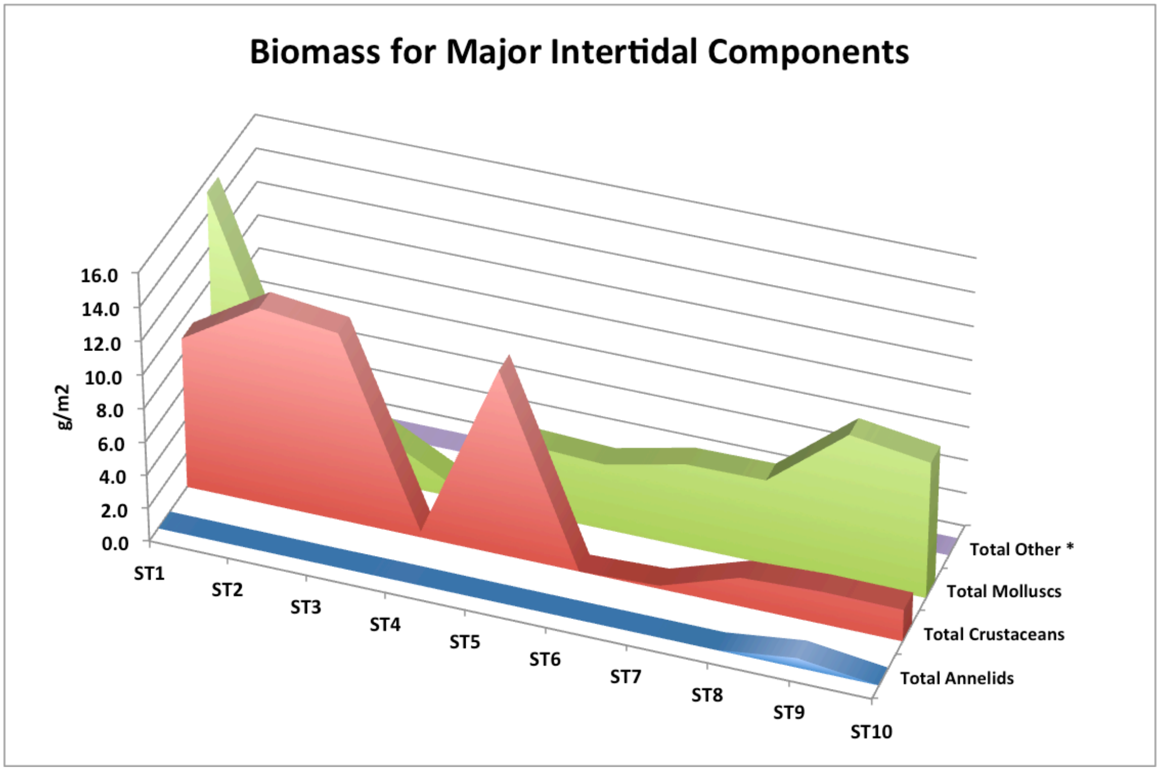

Figure 17. Gulf-side stations intertidal biomass components.

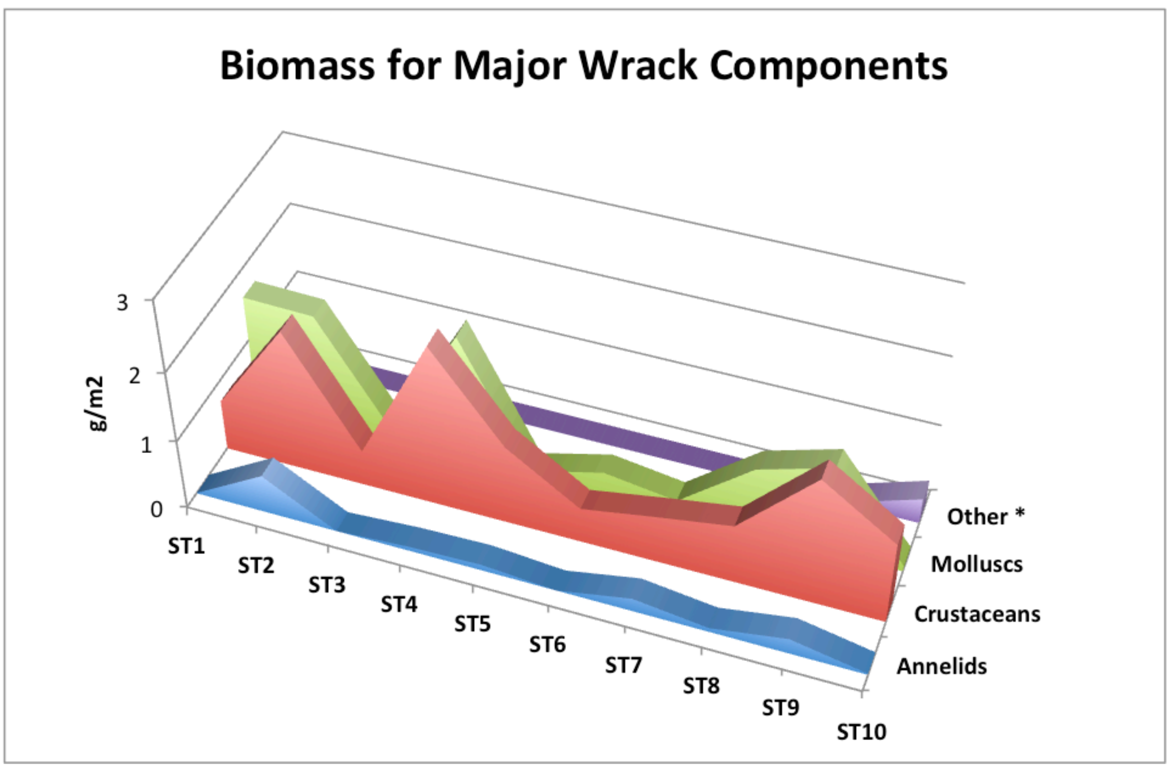

Figure 18 . Gulf-side stations wrack-line biomass components.

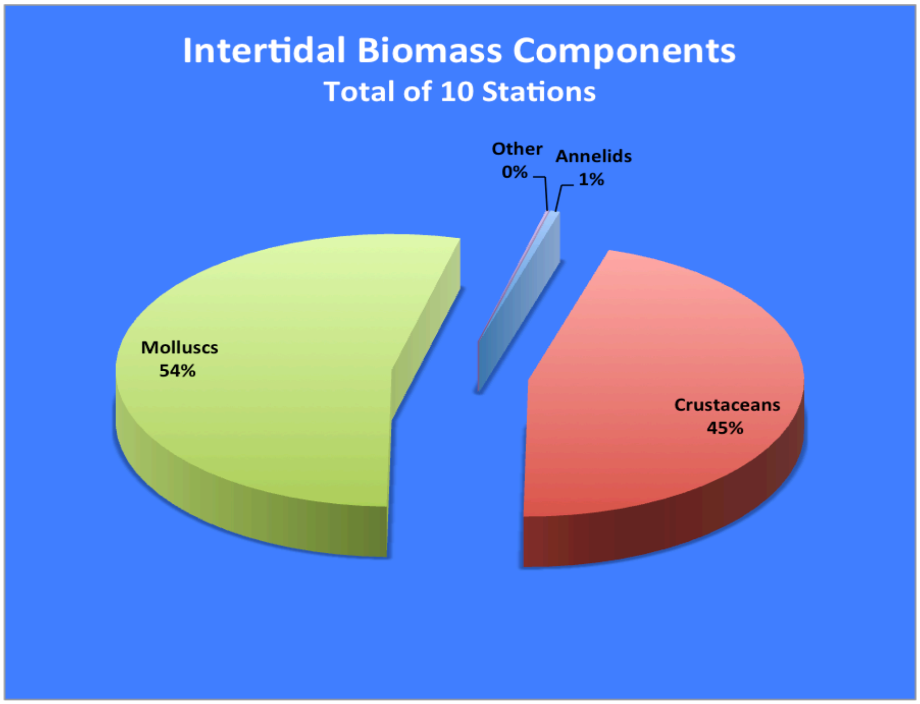

Figure 19. Gulf-side stations combined intertidal biomass components.

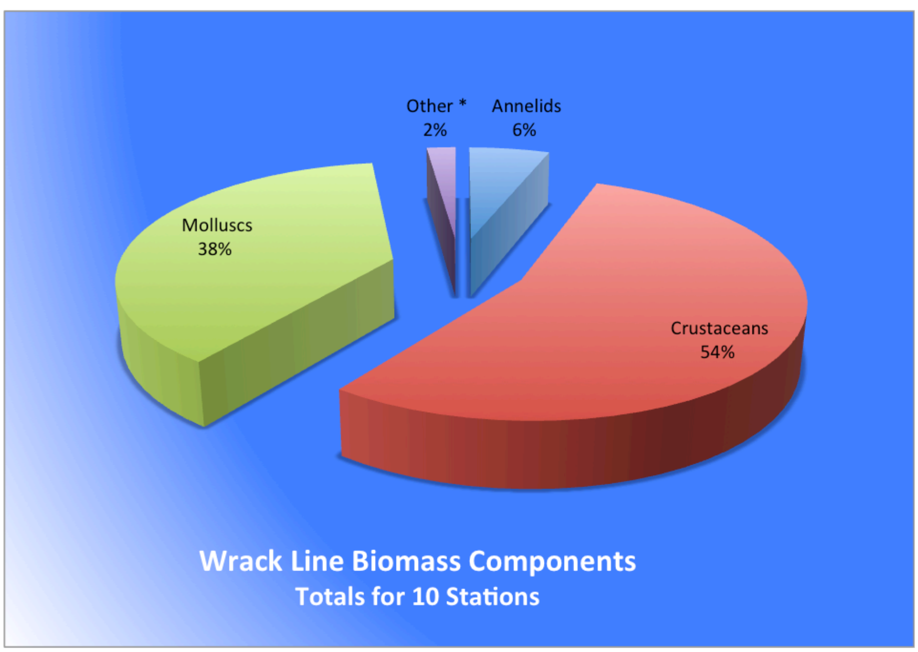

Figure 20. Gulf-side stations combined wrack-line biomass components.

Bayside Stations

Of the three bayside sites, station BS1 had a slightly higher density (4,160 organisms/m2) but was second in number of taxa (Fig. 21). Station BS1 displayed the lowest H' diversity index and highest degree of dominance among the three stations, the latter metric due to a large numbers of small podocopid ostracods (2896/m^2) encountered there (Figs. 22 and 23). Polychaete annelids dominated the bayside fauna in terms of biomass and richness with eleven species spread quite evenly among the three stations. The most abundant polychaetes recorded were the small spionid, *Streblospio gynobranchiata* and the capitellid, *Heteromastus filiformis* with numbers of 1856 and 1280/m^2 respectively at BS2. The fauna at the bayside stations was typical of that found in low energy, mesohaline embayments of northern Gulf of Mexico estuaries characterized by low oxygenated, detritus-rich silt bottoms (Heard 1982).

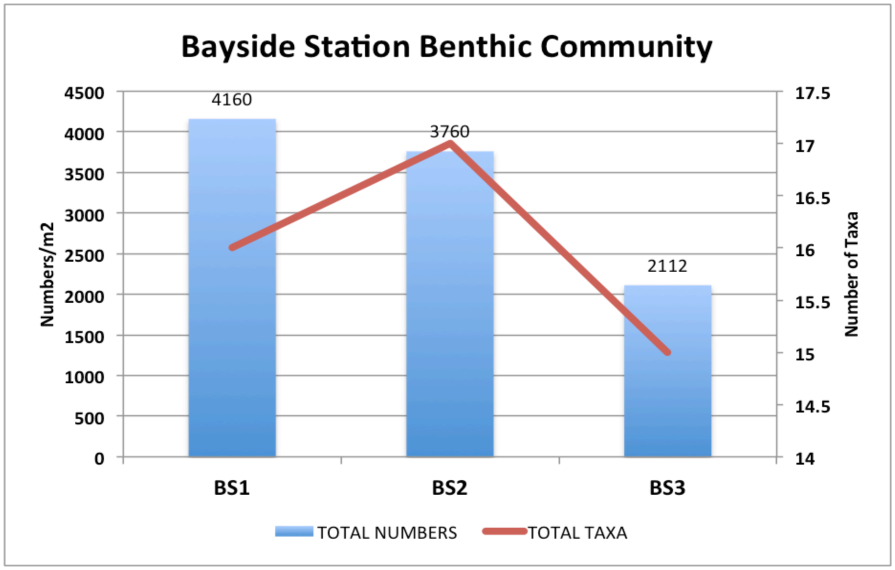

Figure 21. Bayside stations. Total macrobenthic density vs. richness.

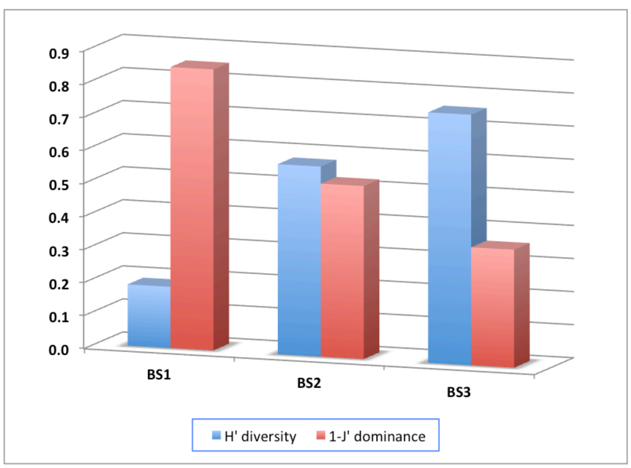

Figure 22. Bayside stations. Diversity indices.

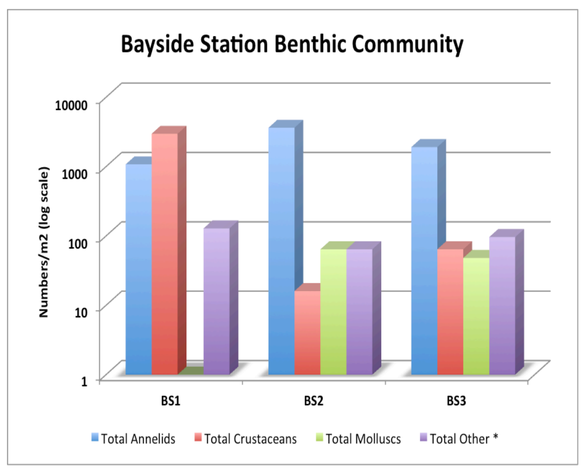

Figure 23. Bayside stations. Macrobenthic components.

Macrobenthic biomass values at the bayside stations mirrored somewhat the species richness trend with correspondingly higher values occurring at BS2. This peak in biomass reflected the predominance of polychaetes present, including the large-bodied nereids, *Alitta succinea* and *Laeonereis culveri*. The total biomass at Station BS2 more than tripled that of BS1, which, in turn, was double that of BS3 (Figs. 24 and 25). Over all three bayside stations, annelids accounted for 91% of the biomass (Fig. 26).

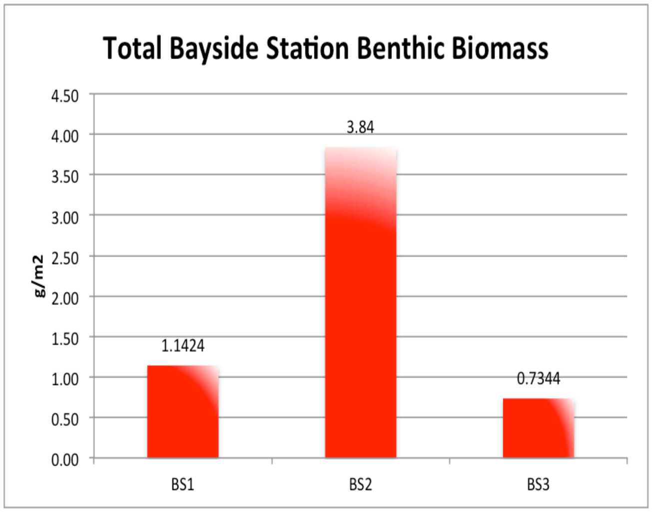

Figure 24. Bayside stations. Macrobenthic biomass.

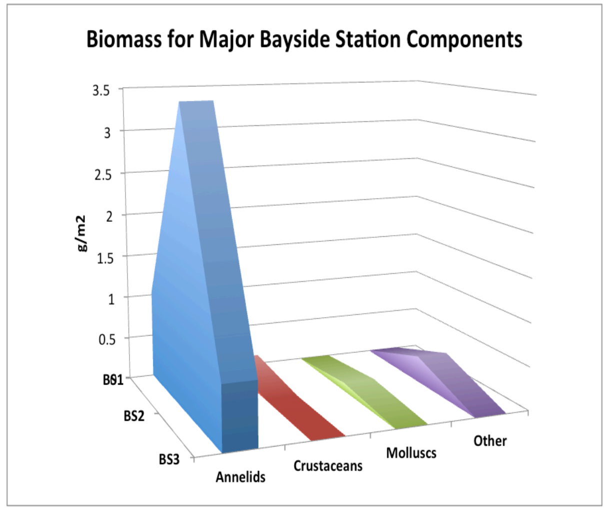

Figure 25. Bayside stations. Macrobenthic components.

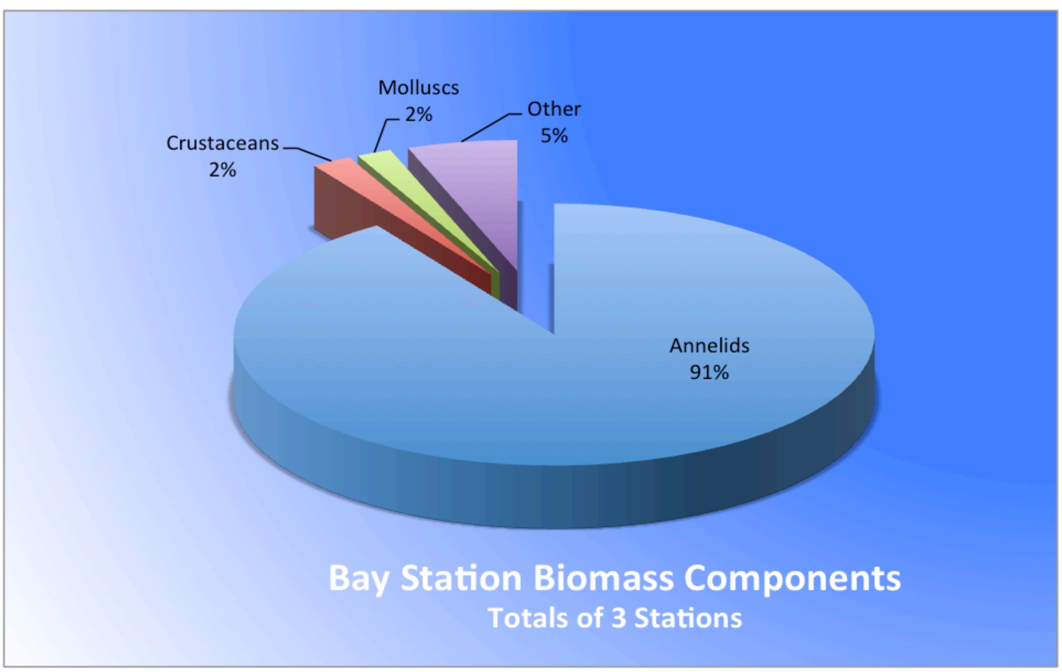

Figure 26. Bayside stations. Combined macrobenthic biomass components.

Beach Stations 1-4: Four-year comparisons.

The faunal and physical data at stations 1 through 4 provide a comparison of four years of benthic investigations since only these stations were sampled in year 1 (2013). However the full compliment of 10 Gulf-side and three bayside stations are available for comparison between 2014 and 2016 and will be dealt with later.

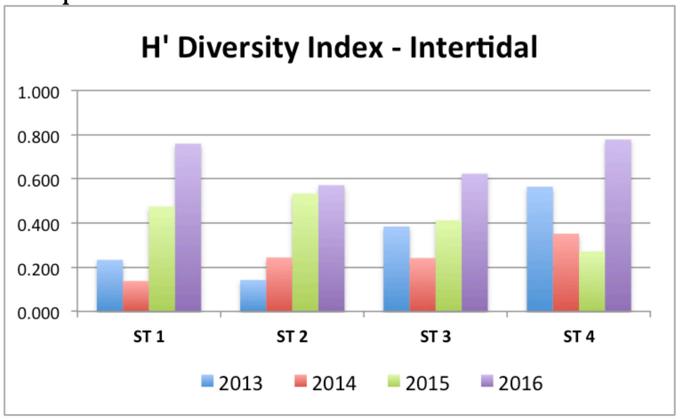

Figure 27. Intertidal diversity - 4 years.

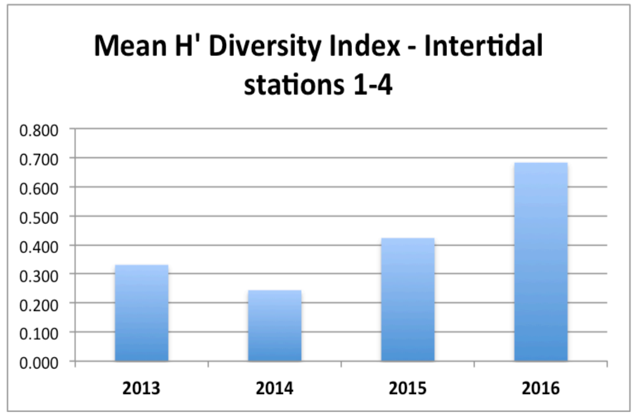

Figure 28. Intertidal mean diversity - 4 years.

Intertidal zone. H' species diversity which was higher at stations 3 and 4 than stations 1 and 2 in the first two years of the study declined below stations 1 and 2 in 2015; in fact, station 4 showed the lowest H' value among the four stations for 2015 (Fig. 27). This all changed in 2016 when H' values were higher at all four stations than in the previous three years. Likewise, the mean H' value of all four stations in 2016 was substantially higher showing an increase over the 2015 value which in itself was higher than the previous two years (Fig. 28). From a numeric standpoint, large peaks in total macrobenthic density at stations 1 and 2 in 2013 (> 12,000 / m^2) were not seen again in following years at those stations due to the decline in intertidal crustaceans. Likewise the peak at station 4 in 2015 (> 18,000 / m^2) plummeted to minimal levels the following year (Fig. 29). The increase in numbers of molluscs at stations 1 and 4 was responsible for peaks of biomass (> 70 g / m^2) at those stations in 2015, since these organisms are larger and heavier than their annelid and crustacean counterparts; however, although these extreme peaks declined in 2016, total biomass was still greater than those shown in 2013 and 2014 at stations 1-3 (Fig. 30). In

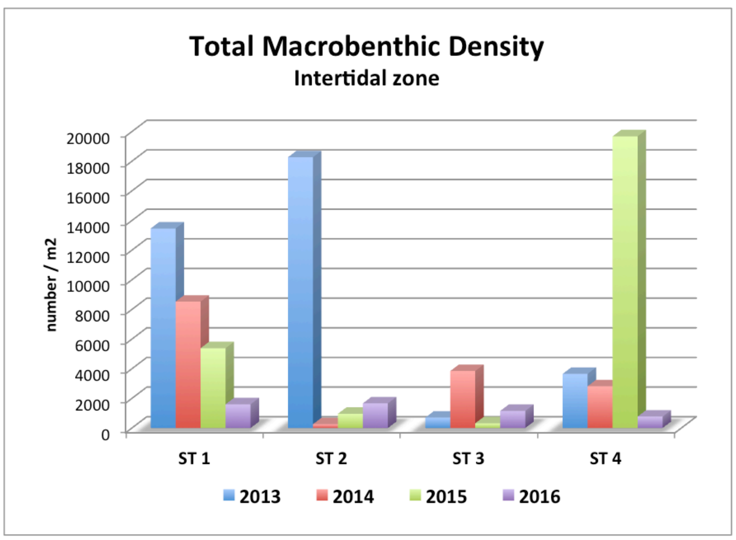

Figure 29 . Total macroinvertebrate density - 4 years.

comparing the total biomass components at the four stations over the four-year period (Figs. 31-34) it can be seen that the molluscs biomass steadily increased from 16 to 91 percent in 2015 and then was supplanted by an increase in crustacean biomass (58%) in 2016. This latter uptick was no doubt due to the presence of not only large numbers of haustoriid amphipods but, more importantly, the presence of sub-adult mole crabs (*Emerita talpoida*) in the samples.

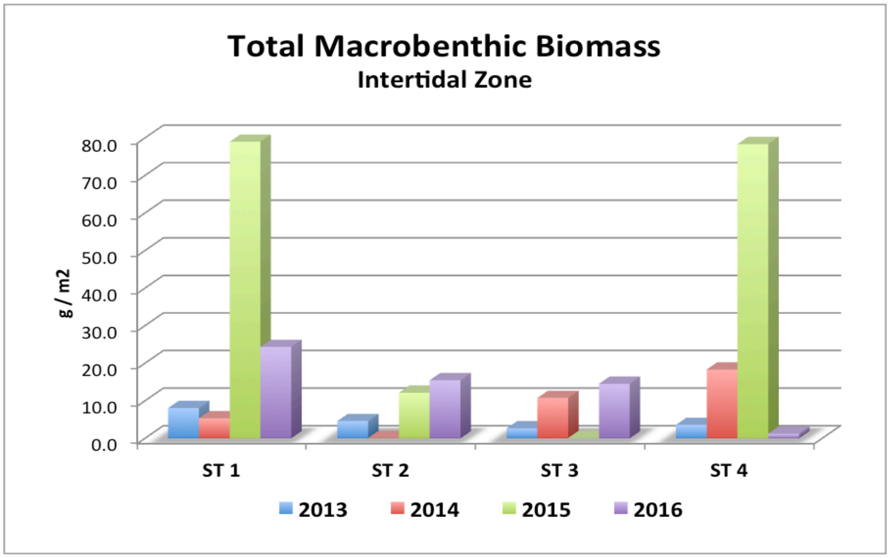

Figure 30. Total macroinvertebrate biomass - 4 years.

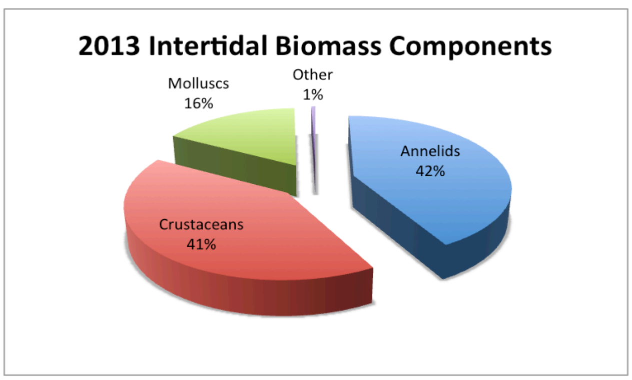

Figure 31. Combined components for four stations – 2013.

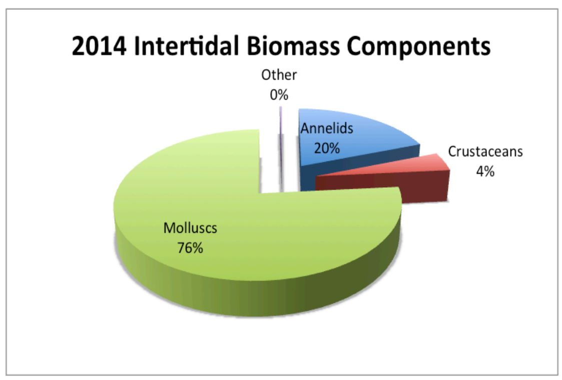

Figure 32. Combined components for four stations - 2014.

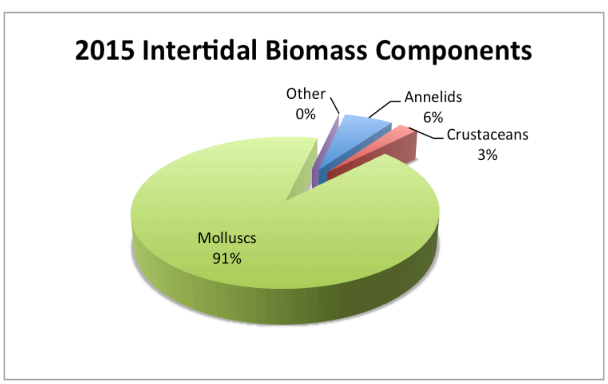

Figure 33. Combined components for four stations - 2015.

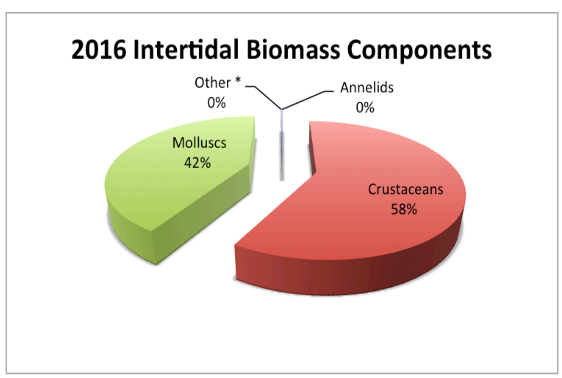

Figure 34 . Combined components for four stations - 2016.

Wrack-line community. During the four years of the study, the total macrobenthic density in the wrack community was quite variable among stations 1-4. Stations 2 and 3 showed increases in total numbers for 2016 but decreases at stations 1 and 4 (Fig. 35).

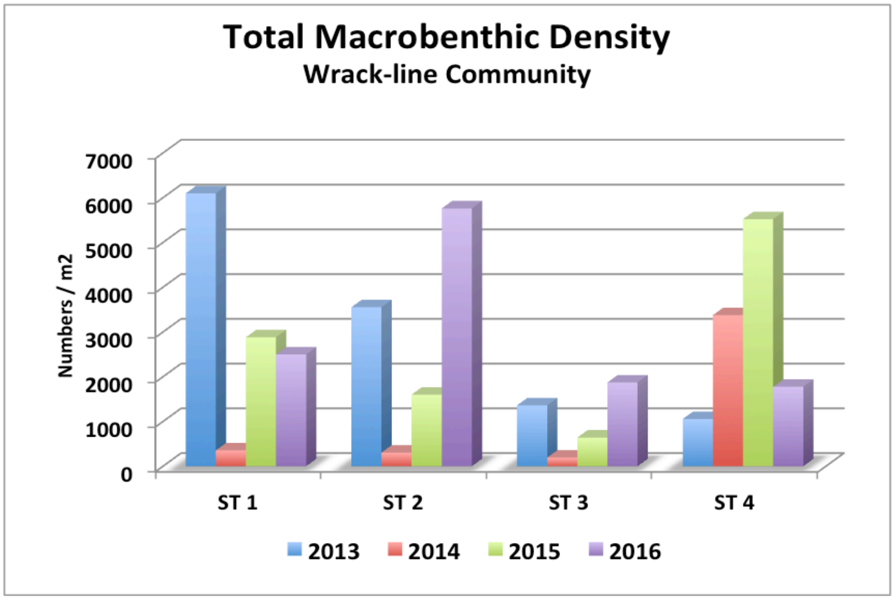

Figure 35. Total wrack macroinvertebrate density - 4 years.

Meanwhile the total biomass increased at all four stations (Fig. 36), especially at stations 2 and 4 that had substantial numbers of embedded haustoriid amphiods (*Lepidactylus triarticulatus*) and large-bodied bivalves and annelids (station 2). Although the H' diversity index for station 4 showed a slight increase in 2016 over the previous year, the overall mean diversity among stations 1-4 was at its lowest level during the current study (Figs. 37 and 38). This decrease in diversity and species richness probably resulted from the lack of wrack debris (*Sargassum*, hyacinths, etc.) that was present in previous years. Such debris serves as structure and microhabitats for the cryptic and attached invertebrate fauna such as caprellid amphipods, calanoid copepods and goose-neck barnacles, all of which were absent or rare in 2016. During the 4-year study, crustaceans were always an important part of the wrack community total biomass, reaching a high of 98% of all faunal group components in 2014 (Figs. 39-42), while insects became less prevalent after 2013.

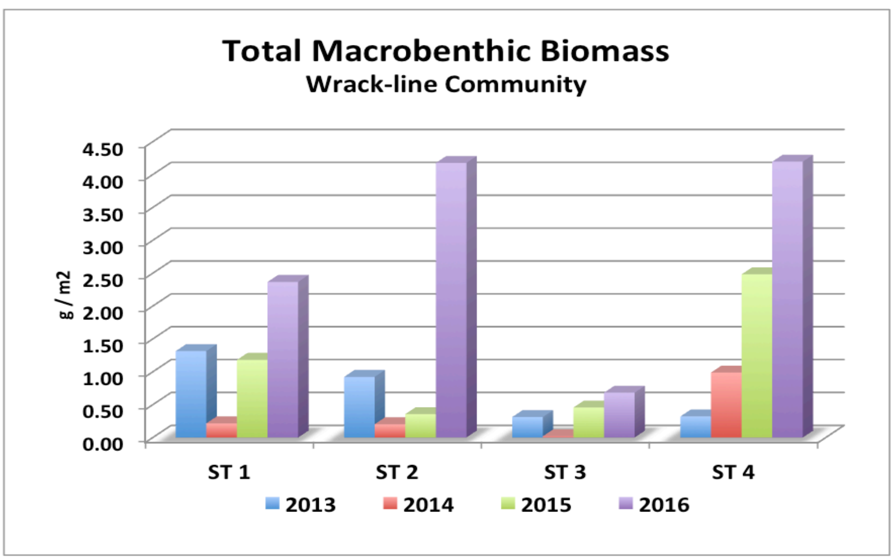

Figure 36. Total wrack macroinvertebrate biomass - 4 years.

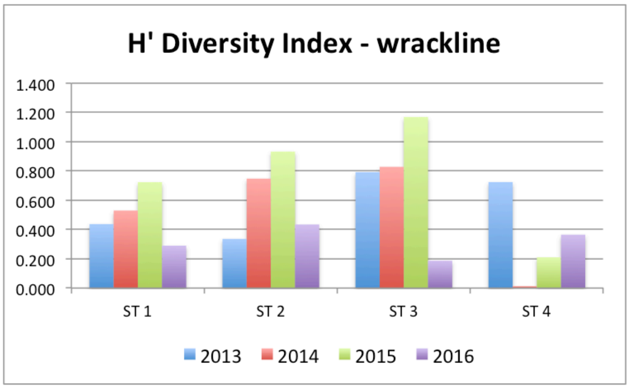

Figure 37. Wrack-line station species diversity - 4 years.

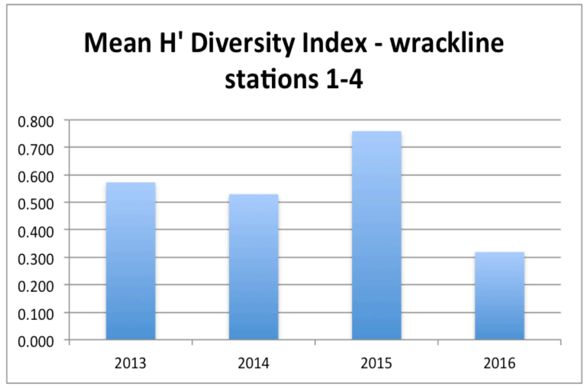

Figure 38. Wrack-line mean diversity - 4 years.

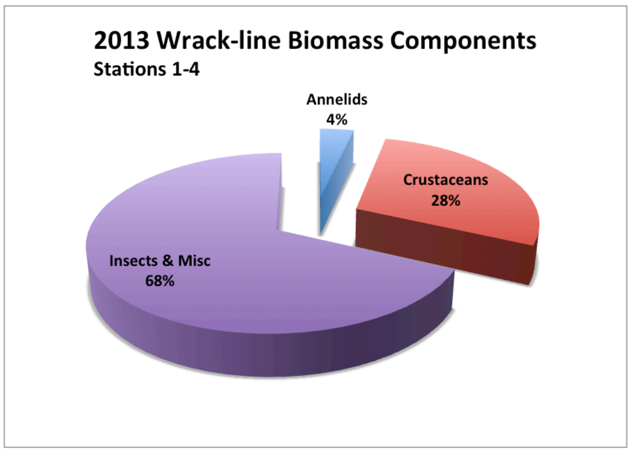

Figure 39. Combined components for four stations - 2013.

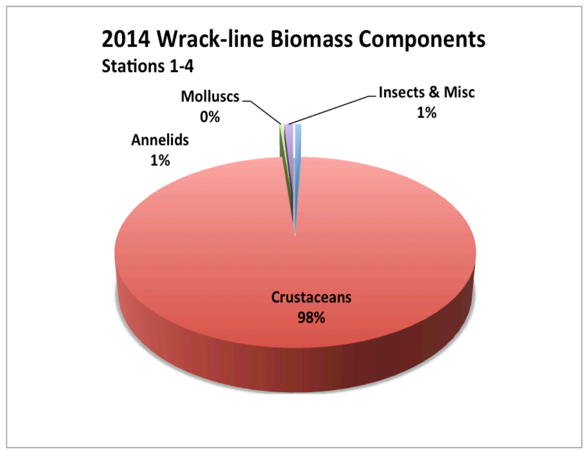

Figure 40. Combined components for four stations - 2014.

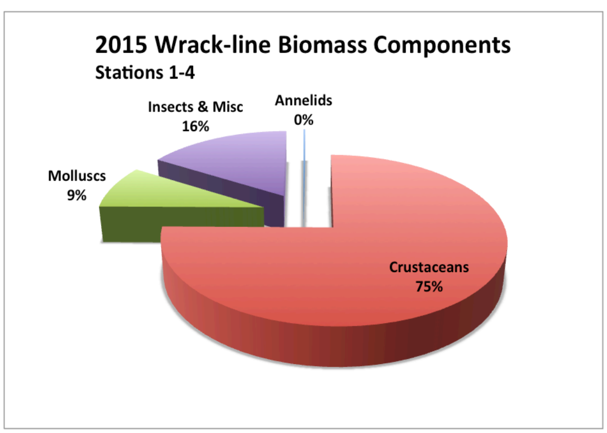

Figure 41. Combined components for four stations - 2015.

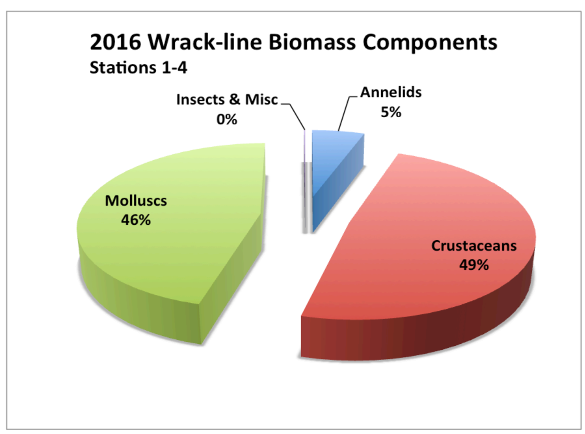

Figure 42. Combined components for four stations - 2016.

Beach Stations 1-10: Three-year Comparisons.

Intertidal zone. In comparing mean intertidal values over all ten stations, the macroinvertebrate community continued the trend set in 2015 with declining density and increasing H' diversity but with a return of mean biomass values to a level near that of 2014. The 2016 density values were less than half the 2015 figures while the H' index for 2016 increased to nearly double that of the previous year (Figs. 43 - 45). The high values of molluscan biomass seen in 2015, reaching a peak of 204.5 g/m^2 at station 8, were absent in 2016 (Fig. 46). Even though there was a large number of molluscs at station 8 in 2016 (Fig. 47), the biomass values were depressed given the smaller size of individual clams. The annelid contribution to overall intertidal biomass plummeted to 1% in 2016, while crustaceans showed a corresponding large increase from 7% in 2015 to 45% in 2016 (Figs. 48 - 50), due largely to the presence of afore-mentioned sub-adult mole crabs (*Emerita talpoida*) at stations 2, 3 and 5.

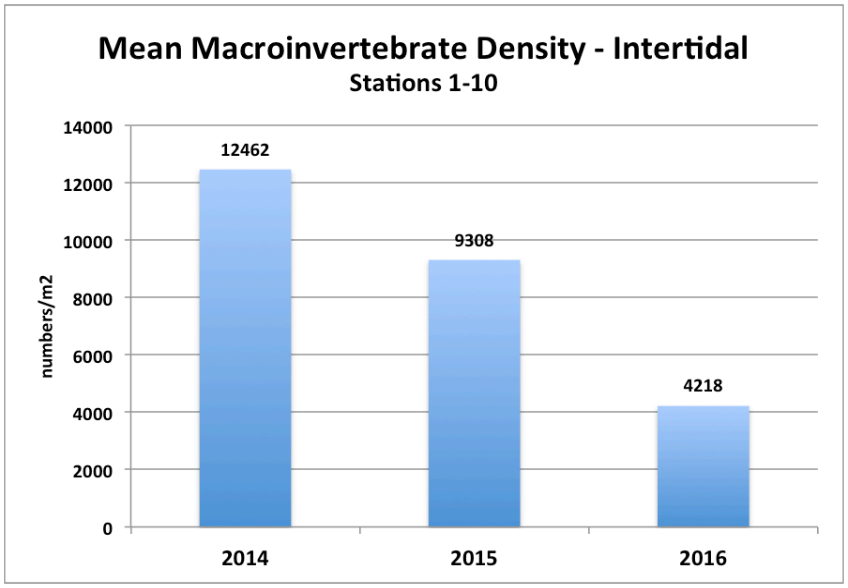

Figure 43. Mean intertidal density over 10 stations - 3 years.

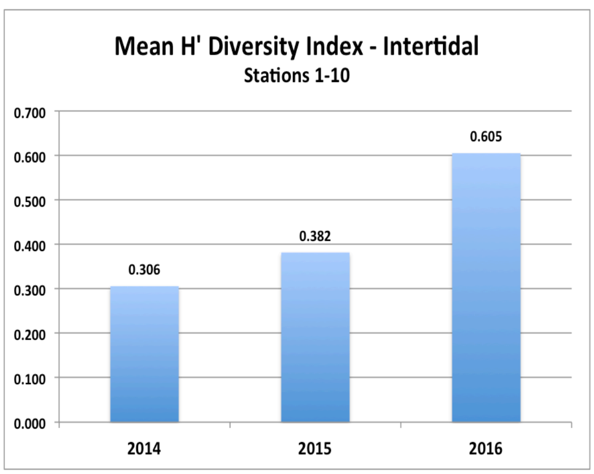

Figure 44. Mean intertidal diversity over 10 stations - 3 years.

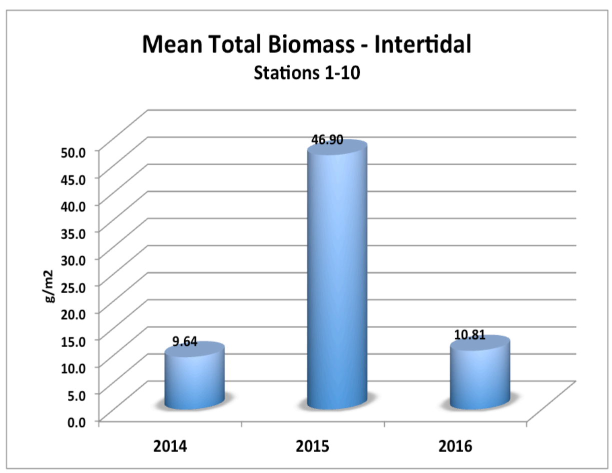

Figure 45. Mean intertidal biomass over 10 stations - 3 years

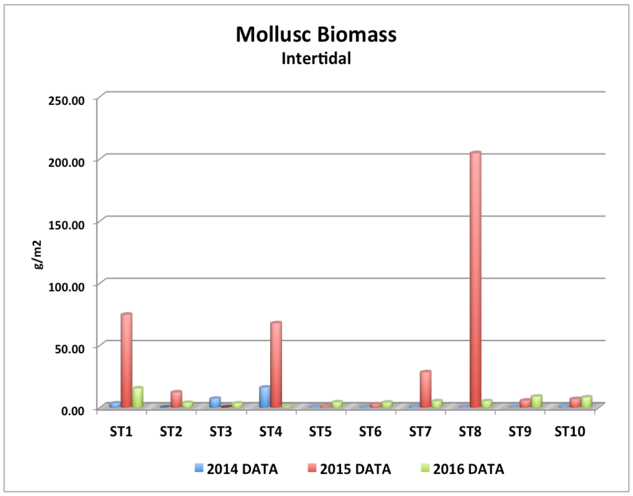

Figure 46. Mollusc intertidal biomass over 10 stations - 3 years

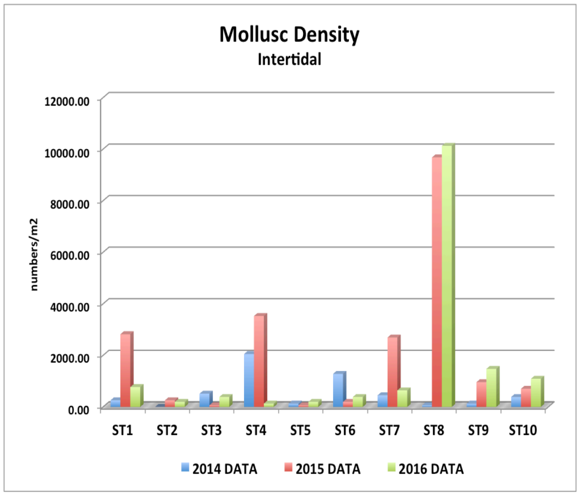

Figure 47. Mollusc intertidal density over 10 stations - 3 years

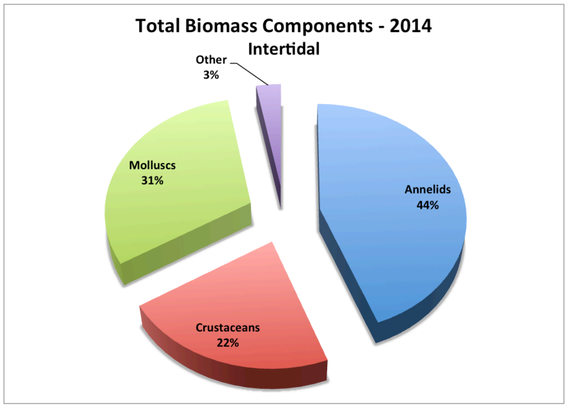

Figure 48. Combined intertidal components for 10 stations - 2014

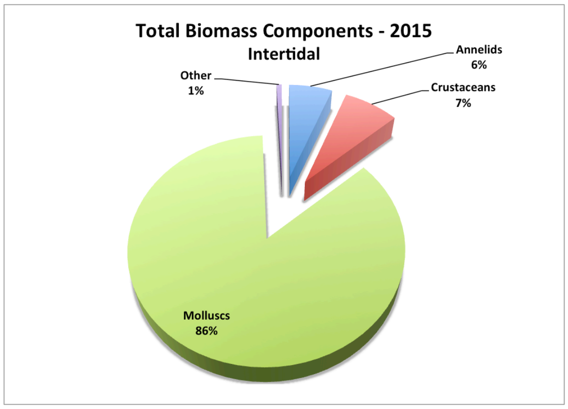

Figure 49 . Combined intertidal components for 10 stations - 2015

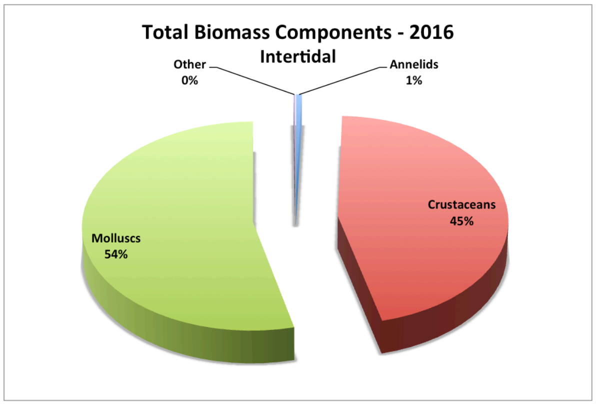

Figure 50. Combined intertidal components for 10 stations - 2016

Wrack-line community. The 2016 wrack-line macroinvertebrate community, averaged over the 10 beach stations, decreased in mean density and diversity from the previous year but did show a slight increase in total biomass (Figs. 51-53). The main reason for the 2016 drop in overall density and diversity values can be attributed to the near absence of washed-up debris (e.g., *Sargassum* and riverine water hyacinths) that was present in previous years. The characteristic cryptic structure of beach debris provides micro-habitats for cryptic and attached fauna and also attract insects to the rotting vegetation; factors that likely have a positive effect on the available prey items for nesting and foraging shore birds in the area. Because of the decrease in wrack debris in 2016, a major component of the beach wrack community that was notably down in abundance from the previous year was the volume of insects and spiders. Crustaceans, mostly haustoriid amphipods, embedded in the damp sand above the high tide water line once again proved substantial in density and biomass (Figs. 54 and 55) and accounted for the largest percentage of the total wrack community biomass in all three years of the study (Figs. 56-58).

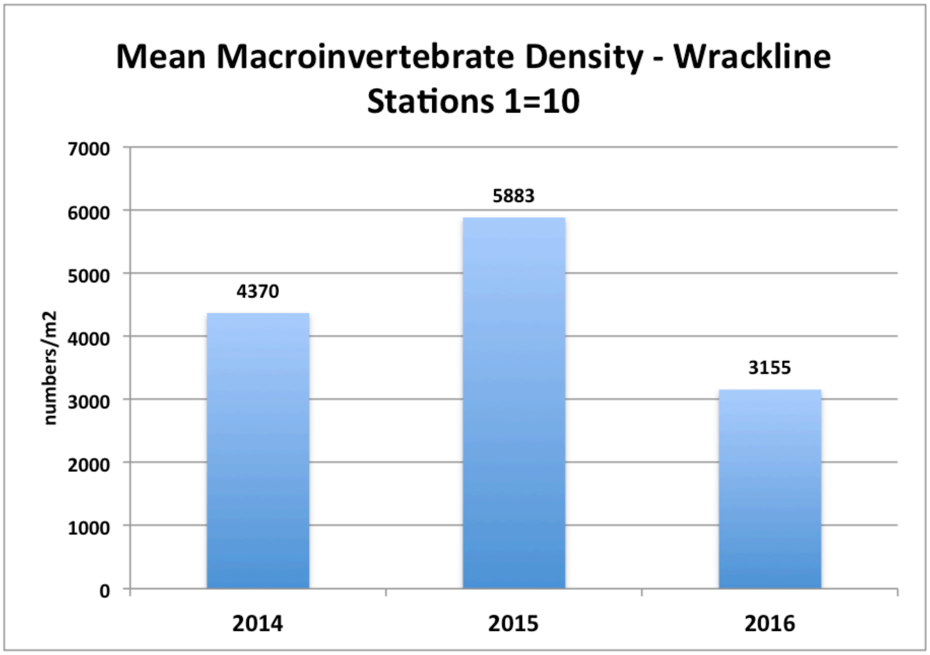

Figure 51. Mean wrackline density over 10 stations - 3 years.

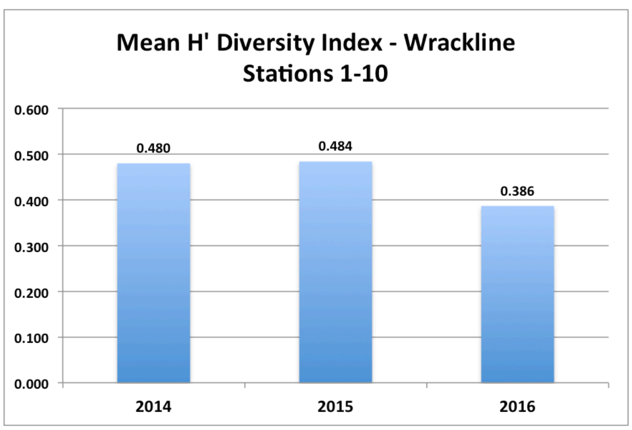

Figure 52. Mean wrackline diversity over 10 stations - 3 years.

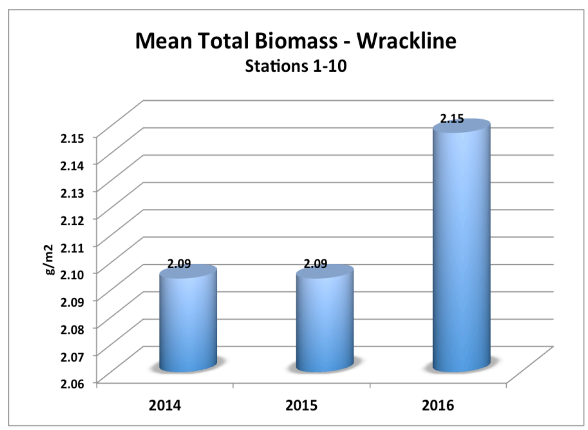

Figure 53. Mean wrackline biomass over 10 stations - 3 years.

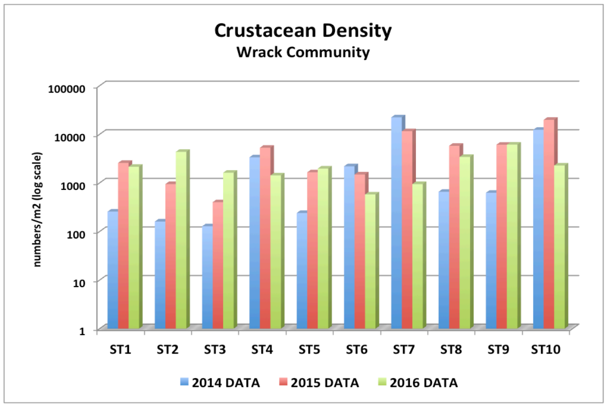

Figure 54. Crustacean wrackline density over 10 stations - 3 years.

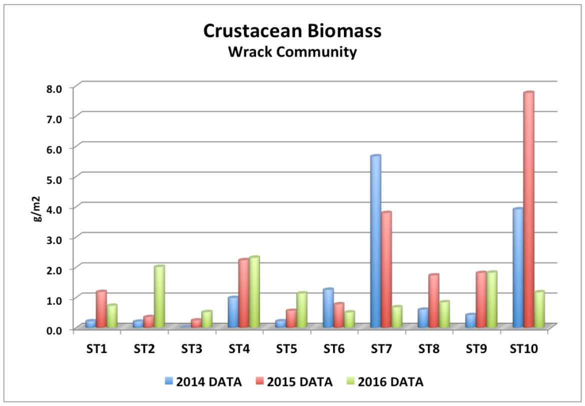

Figure 55. Crustacean wrackline biomass over 10 stations - 3 years.

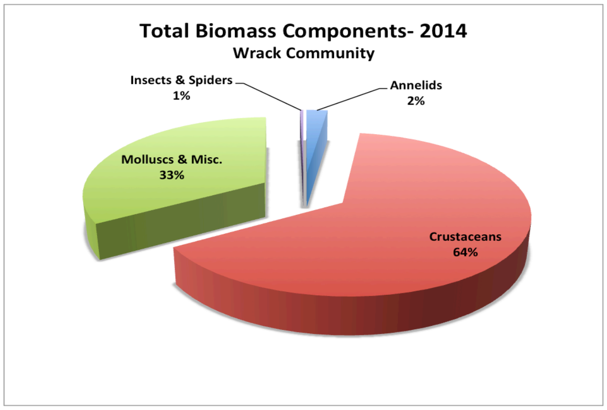

Figure 56. Combined wrackline components over 10 stations - 2014.

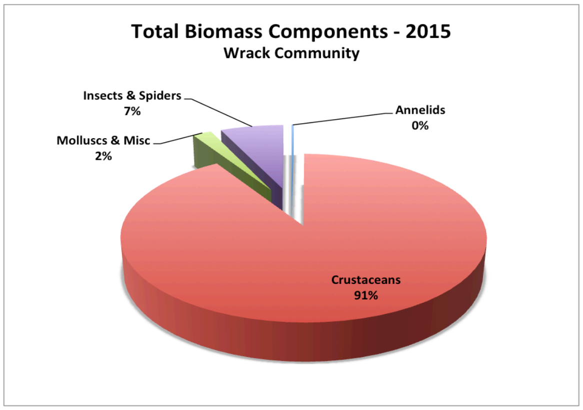

Figure 57. Combined wrackline components over 10 stations - 2015.

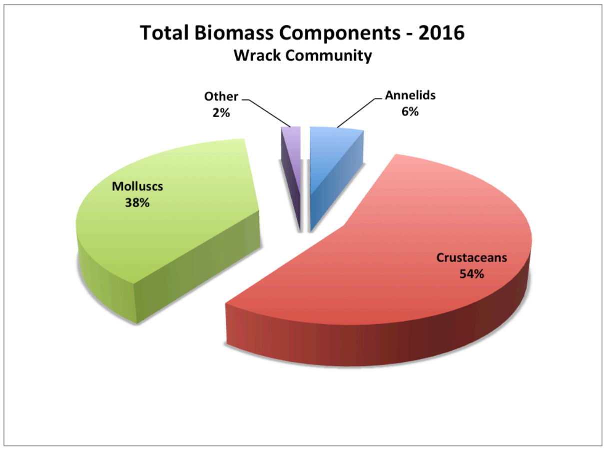

Figure 58. Combined wrackline components over 10 stations - 2016.

Bayside Stations: Three-year comparisons.

Mean values for density, diversity and biomass all showed decreases in 2016 from the previous year with diversity being even lower than the mean 2014 index (Figs. 59 - 61). Total macrobenthic biomass increased in 2016 at stations BS2 and BS3 but was substantially less than the level shown at BS1 in 2015 (Fig. 62). Annelid densities were at their highest levels at stations BS2 and BS3 during 2016 while being at their lowest level at BS1 for the same year (Fig. 63). In comparing the combined bayside biomass components over the three years, annelids once again prevailed with 91% in 2016, increasing from 61 and 71 percent over the previous two years respectively, while molluscs and crustaceans fell to their lowest percentages (Figs. 64 - 66). Insects, a major component in the 2014 bayside biomass, were minimally present in 2016, being lumped into the 5% "other" category along with miscellaneous taxa such as spiders and nemerteans.

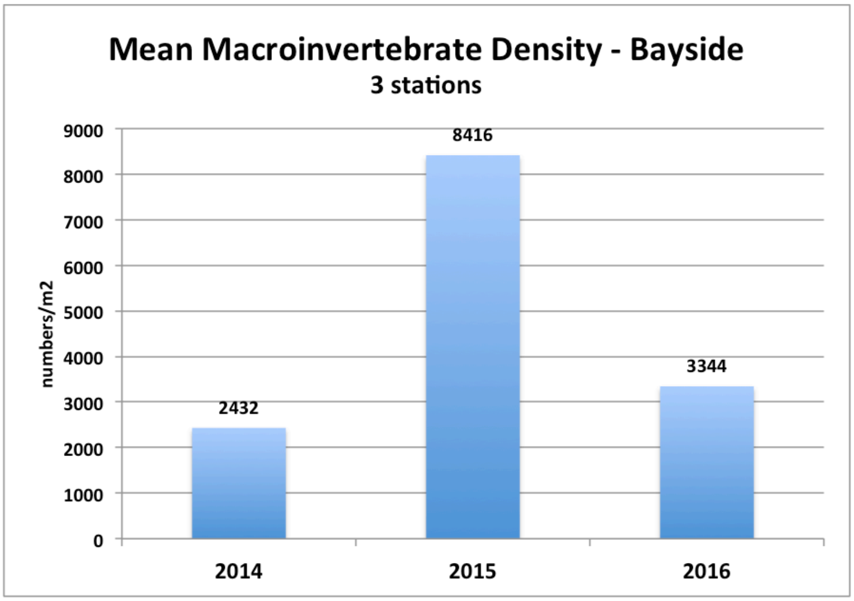

Figure 59. Mean bayside density over three stations - 3 years.

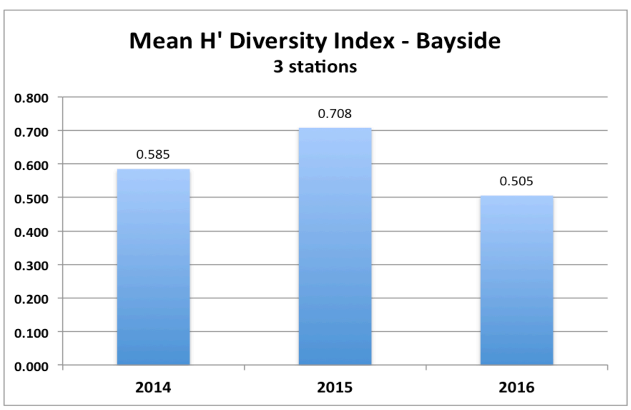

Figure 60. Mean bayside H' diversity over three stations - 3 years.

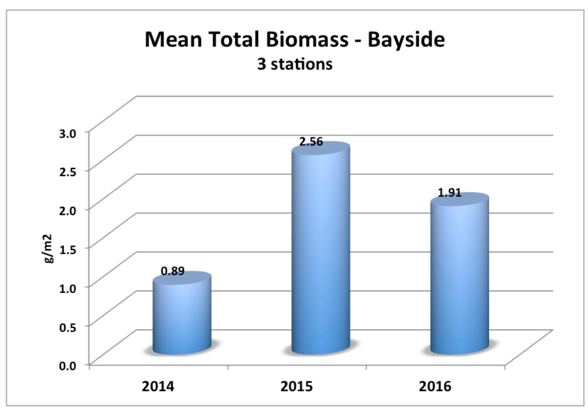

Figure 61. Mean bayside biomass over three stations - 3 years.

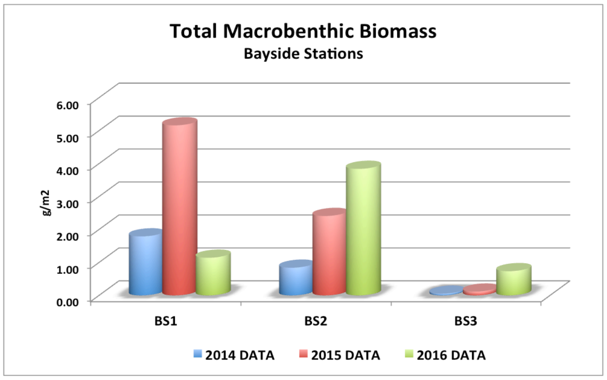

Figure 62. Total bayside biomass over three stations - 3 years.

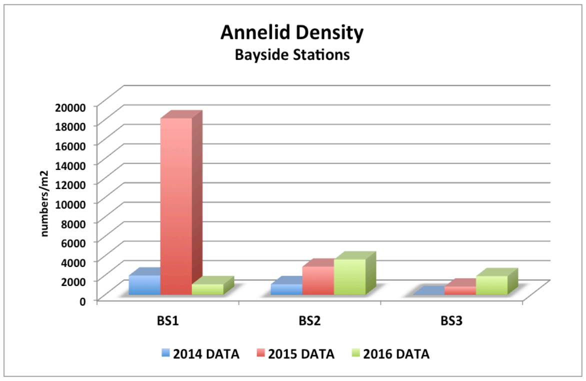

Figure 63. Bayside annelid density over three stations - 3 years.

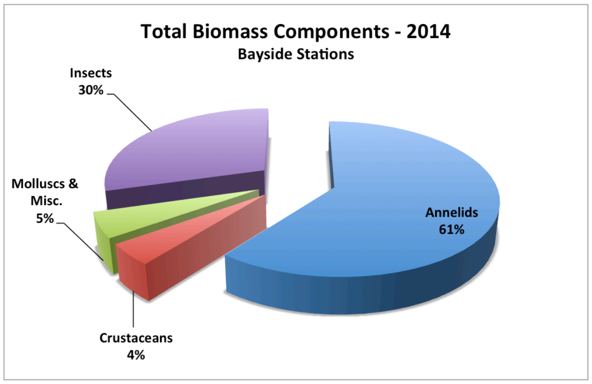

Figure 64. Combined bayside biomass components over three stations - 2014.

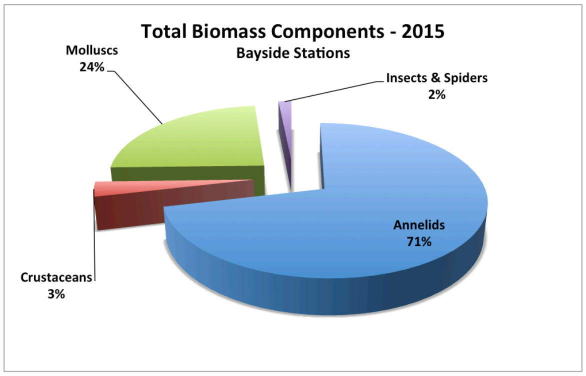

Figure 65. Combined bayside biomass components over three stations - 2015.

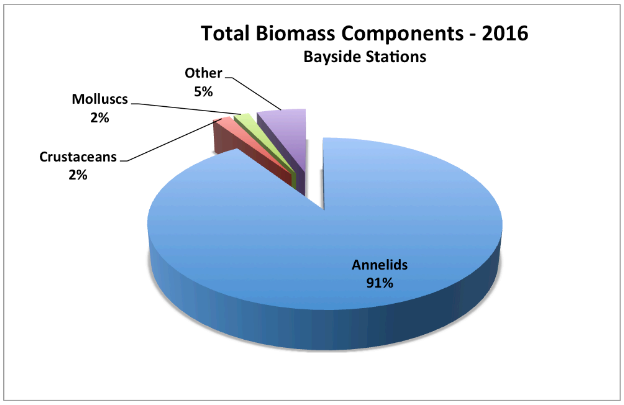

Figure 66. Combined bayside biomass components over three stations - 2016.

Post-construction Prey Biomass Analysis.

One purpose of this benthic community monitoring effort was to assess the return of the project area to pre-project conditions, regarding the impact on piping plover benthic prey from beach construction activities. USFWS defines this return to normalcy as having been attained when at least 70 percent of the pre-project average biomass level is re-established. Since wrack-line structure varied greatly from year to year, with different amounts and types of deposited debris, comparisons of sampling periods were limited to the intertidal community, specifically to the composite biomass of the annelid, crustacean and mollusc populations inhabiting the mid-swash zones. These organisms commonly occurred at all stations and are known to be important in the diet of piping plovers (DoW 2016, NW 2016). The pre-project target value of 3.29 g/m^2 ash-free dry weight biomass was calculated as 70 percent of the mean total of the four beach stations sampled in 2013 (see following table) and was used to represent the comparative biomass value for the project area.

2013 DATA	ST1	ST2	ST3	ST4		
Annelids	5.58	1.04	0.02	1.29		
Crustaceans	2.46	2.17	2.62	0.50		
Molluscs	0.02	1.33	0.00	1.77	average	**70%**
total	8.06	4.54	2.63	3.56	**4.70**	3.29

Figures 67 to 69 below show comparisons of the 70% target value to intertidal biomass totals from each of ten beach stations from collections made after commencement of construction activities in 2014, 2015, and 2016. Note that stations in the figures were ordered from west to east corresponding to their actual positions along the beach as seen in Figure 1.

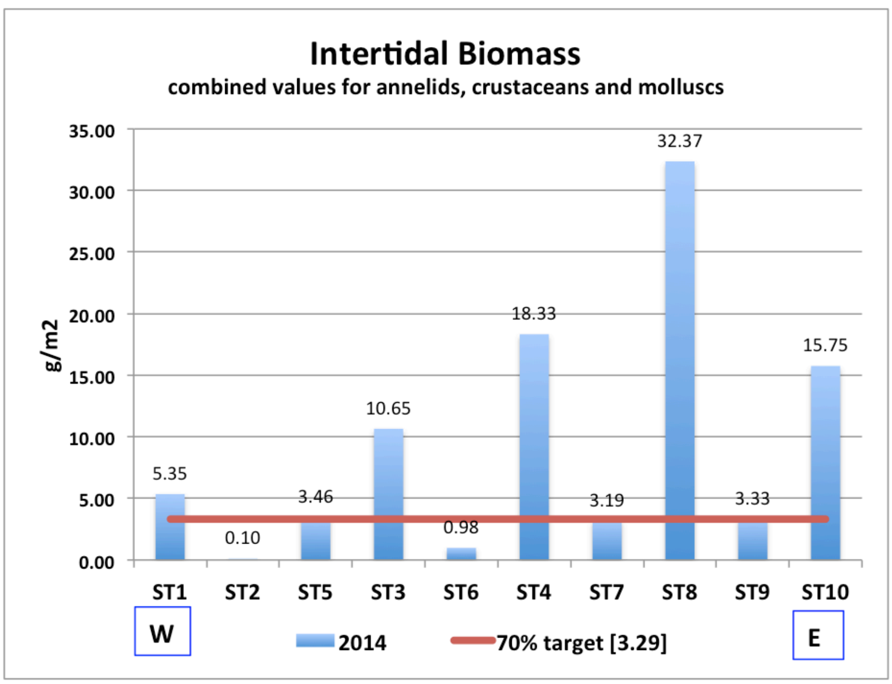

Figure 67. Composite intertidal biomass values compared to the 70% recovery target value - 2014.

Results of this analysis show that the number of stations with total biomass values exceeding the 3.29 g/m2 target steadily increased from seven in 2014, to eight in 2015 and nine in 2016. In 2014, stations 1 and 2 were sampled shortly after construction and showed depressed biomass levels at these stations compared to later years (Fig. 67). In

2015, stations 3 and 6 were listed as "recently constructed" and had corresponding biomass values below the 70% target. By 2016, all the west-end stations from 1 to 6 had re-established biomass levels well above the 70% target of 3.29 g/m2 (Fig. 68); likewise, stations 8 to 10 at the east end, sampled before construction had commenced, also had biomass levels well above the target (Fig. 69).

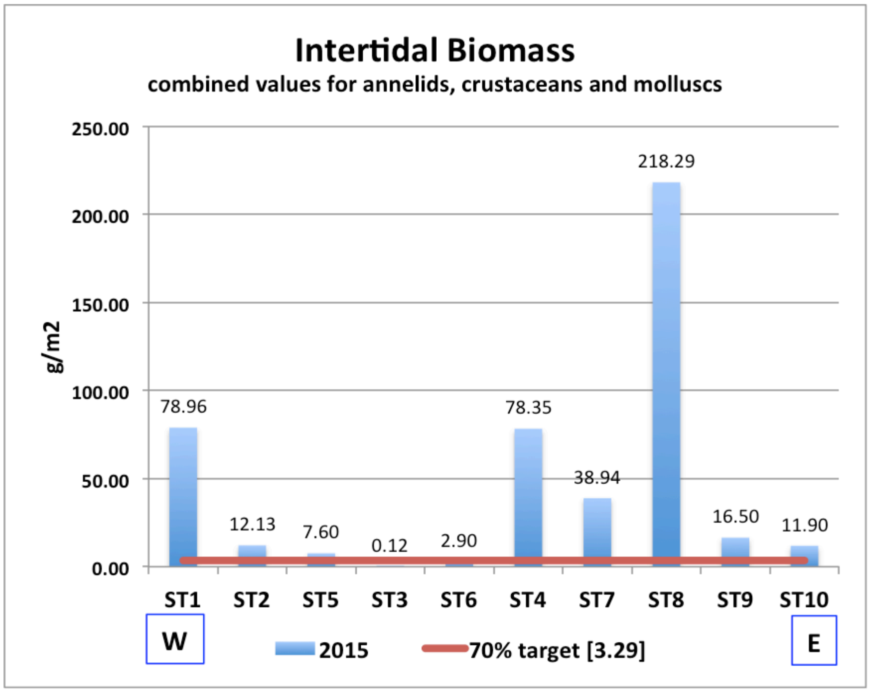

Figure 68. Composite intertidal biomass values compared to the 70% recovery target value - 2015.

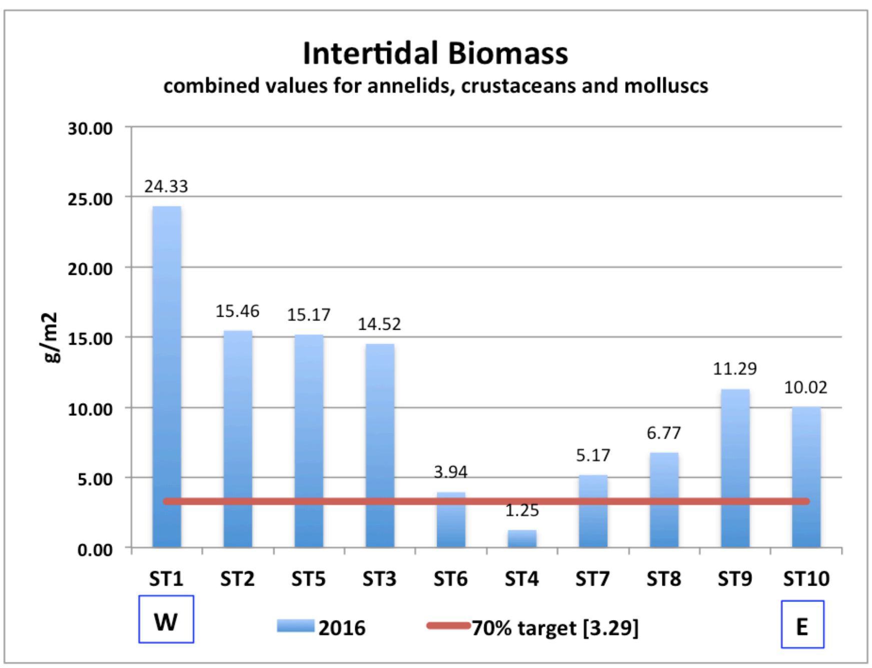

Figure 69. Composite intertidal biomass values compared to the 70% recovery target value - 2016.

Summary and Conclusions

The key components in the Macrobenthic community from the previous three surveys were again present along the Caminada Headland Beach in 2016. The polychaete, *Scolelepis squamata*, the amphipod, *Lepidactylus triarticulatus* and the bivalve mollusc, *Donax variablilis* accounted for most of the Macrobenthic density and biomass in both, the intertidal zone and wrack community at the ten beach stations. These intertidal species are commonly-occurring inhabitants of intertidal and near-shore benthic habitats from the barrier island and mainland beaches from the Florida panhandle area to Texas (Rakocinski et al. 1991, 1993; McLelland and Heard 1991; Mikkelsen and Bieler 2008; Tunnel et al. 2010). The Caminada beach wrack community, because of the near absence of deposited debris and its associated fauna in 2016, was notably different from previous years by its decreased mean density and diversity. Mean biomass in the wrack-line community, however showed an increase because of the large numbers of embedded amphipods found at most stations.

The three bayside stations on the backside of Caminada Headland Beach had typical faunal components seen in the previous two years; however, the 2016 mean biometrics showed slight decreases in all three categories – density, diversity and biomass. The polychaete biomass, especially at BS2 was the most notable feature of the bayside benthic community, typified by the usual brackish water species, *Streblospio gynobranchiata, Laenonereis culveri*, and three species of Capitellidae. Also numerically important were large numbers of small podocopid ostracods found at BS1. These mesohaline organisms are common along bays and estuaries of the northern Gulf of Mexico (Heard 1982; LaSalle and Bishop 1987).

Results of an assessment analysis on the re-establishment of benthic biomass after beach construction showed that the number of stations with total biomass values exceeding a 70% target value based on 2013 pre-construction values, steadily increased from seven in 2014, to eight in 2015 and nine in 2016. By 2016, all the west-end beach stations from 1 to 6 that had undergone construction during the previous two years had re-established biomass levels well above the 70% target value.

The findings of Year 4 of the Caminada Headland Beach benthic survey are summarized thus:

1. 75 nominal taxa from five different phyla were represented from the total of 4,072 organism examined. The intertidal organisms *Scolelepis squamata, Lepidactylus triarticulatus*, *Ancinus depressus* and *Donax variabilis* accounted for most of the numeric density and biomass (g/m2) at the 10 beach stations while 11 species of polychaetes led by the spionid, *Streblospio gynobranchiata*, the capitellid, *Heteromastus filiformis*, and the phyllodocid, *Eteone heteropoda* were important food resources at the three calm-water bayside stations.

2. Among the beach stations, Station 8 had the highest numerical density of organisms and biomass in the intertidal zone owing to the large numbers of annelids and bivalve molluscs while station 9 featured the highest density of wrack-line organisms (over 7,000 / m2), due to a healthy population of embedded *L. triarticulatus*, while station 10 had the larger number of taxa (23) among wrack environments sampled.

3. H' diversity values in the intertidal zone ranged between 0.778 and 0.347 and were higher than corresponding wrack-line values at all stations except station 10 because of its high species richness. Dominance values (1-J') in the wrack-line zone were higher than corresponding intertidal values at all stations except station 10. Large numbers of embedded amphipods in the wrack community and higher numbers of crustaceans and bivalves in the intertidal core samples undoubtedly influenced these trends.

4. Intertidal macrobenthic biomass at the Gulf-side stations was overall greater than at corresponding wrack-line communities except for station 4. Peaks of intertidal biomass at Stations 1-3 and 5 were influenced by the presence of large-bodied bivalve molluscs (*Donax variabilis*) at Station 1 and sub-adult mole crabs (*Emerita talpoida*) at Stations 2,3 and 5. In the wrack community, the major players in terms of biomass were annelids, amphipods and molluscs embedded in the moist sand beneath the wrack line, especially at Stations 2, 4 and 9.

5. Of the three bayside sites, station BS1 had a slightly higher density (4,160 organisms/m2) but was second in number of taxa (Fig. 21). Station BS1 displayed the lowest H' diversity index and highest degree of dominance among the three stations. The total biomass at Station BS2 more than tripled that of BS1, which, in turn, was double that of BS3. Polychaete annelids dominated the bayside fauna in terms of biomass and richness with eleven species spread evenly among the three stations.

6. Data from Gulf-side stations 1-4 collected from 2013 to 2016 were compared. In the intertidal zone, H' values were higher in 2016 at all four stations than in the previous three years. Likewise, the mean H' value of all four stations in 2016 was substantially higher showing an increase over the 2015 value which in itself was higher than the previous two years. Large peaks in total macrobenthic density at stations 1 and 2 in 2013 (> 12,000 / m^2) were not seen again in following years at those stations due to the decline in intertidal crustaceans. Likewise the peak at station 4 in 2015 (> 18,000 / m^2) plummeted to minimal levels in 2016. The increase in numbers of molluscs at stations 1 and 4 was responsible for peaks of biomass (> 70 g / m^2) at those stations in 2015; however, although these extreme peaks declined in 2016, total biomass was still greater than those shown in 2013 and 2014 at stations 1-3. In comparing the total intertidal biomass components at the four stations over the four-year period, molluscs biomass steadily increased from 16 to 91 percent in 2015 and then was supplanted by an increase in crustacean biomass (58%) in 2016. In the wrack community, stations 2 and 3 showed increases in total numbers for 2016 but decreases at stations 1 and 4 while the total biomass increased at all four stations, especially at stations 2 and 4 that had substantial numbers of embedded amphiods and large-bodied bivalves and annelids. Although the H' diversity index for station 4 showed a slight increase in 2016 over the previous year, the overall mean diversity among stations 1-4 was at its lowest level during the current study. During the 4-year study, crustaceans were always an important part of the wrack community total biomass, reaching a high of 98% of all faunal group components in 2014 (Figs. 39-42), while insects became less prevalent after 2013.

7. Three years of data from 10 Gulf-side and 3 bayside stations were compared. The mean intertidal value over all ten stations for macroinvertebrate density was lower in 2016 than in the previous two years while the corresponding value for H' diversity showed an increase and that for biomass was similar to 2014 levels. The high values of molluscan biomass seen in 2015, reaching a peak at station 8, were absent in 2016 even though there

were a large number of mostly juvenile molluscs at that station. The annelid contribution to overall intertidal biomass plummeted to 1% in 2016, while crustaceans showed a corresponding large increase from 7% in 2015 to 45% in 2016. The 2016 wrack-line macroinvertebrate community decreased in mean density and diversity from the previous year, owing to a near absence of washed-up debris, but did show a slight increase in mean total biomass. Crustaceans, mostly amphipods embedded in the damp sand above the high tide waterline, accounted for the largest percentage of the total wrack community biomass in all three years of the study. At the bayside stations, mean values for density, diversity and biomass all showed decreases in 2016 from the previous year with diversity being even lower than the mean 2014 index. Values for total macrobenthic biomass and annelid density increased in 2016 at stations BS2 and BS3 but were substantially less than the levels shown at BS1 in 2015. In comparing the combined bayside biomass components over the three years, annelids once again prevailed with 91% in 2016, increasing from 61 and 71 percent over the previous two years respectively, while molluscs and crustaceans fell to their lowest percentages.

Table 3. Summary of Intertidal Box Core Data – condensed by station.
Values in numbers/ m^2

TAXA	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10
ANNELIDA										
Polychaeta										
Order Eunicida										
Family Lumbrineridae										
Unid. Lumbrineridae									64	
Order Spionida										
Family Spionidae										
Scolelepis squamata	128			64						
ARTHROPODA										
Arachnida										
Unid. Arachnida						64				
Order Araneae										
Family Linyphiidae										
Unid. Linyphiidae				64						
Family Lycosidae										
Unid. Lycosidae				64						
Entognatha										
Order Poduromorpha										
Unid. Collembola	64		192	64		128	64	64		
Family Hypogastruridae										
Unid. Hypogastruridae			64			513	449			
Insecta										
Order Coleoptera										
Family Staphylinidae										
Unid. Staphylinidae	64				64					
Order Diptera										
Unid. Diptera	64						64			64
Family Culicidae										
Unid. Culicidae					64					
Family Sciaridae										
Unid. Sciaridae		192			64	64				
Order Hemiptera										
Family Miridae										
Unid. Miridae	64									
Order Lepidoptera										
Unid. Lepidoptera										64

TAXA	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10
Malacostraca										
Order Amphipoda										
Family Haustoriidae										
Lepidactylus triarticulatus	256	962	385	256	385			5897	2308	7949
Family Isaeidae										
Microprotopus raneyi									64	
Family Oedicerotidae										
Ameroculodes miltoni								64		321
Family Talitridae										
Platorchestia sp.	64	64								
Order Cumacea										
Family Bodotriidae										
Cyclaspis varians								64		
Order Decapoda										
Family Hippidae										
Emerita talpoida	64	192	128		128					
Order Isopoda										
Family Sphaeromatidae										
Ancinus depressus	64	64		128	385		1090	641	1603	192
MOLLUSCA										
Bivalvia										
Order Arcoida										
Family Arcidae										
Anadara transversa									64	
Order Veneroida										
Family Donacidae										
Donax variabilis	769	192	385	128	192	321	641	10128	1218	577
Family Mactridae										
Mulinia lateralis									128	192
Family Semelidae										
Abra aequalis						64				192
Family Veneridae										
Petricolaria pholadiformis										128
Gastropoda										
Order Neotaenioglossa										
Family Caecidae										
Caecum johnsoni									64	
MISC TAXA										

TAXA	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10
Chordata										
Demersal fish eggs						128	64			
TOTAL NUMBERS	1603	1667	1154	769	1282	1282	2372	16859	5513	9680
TOTAL TAXA	10	6	5	7	7	7	6	6	8	9

diversity indices

Hmax'	1.000	0.778	0.699	0.845	0.845	0.845	0.778	0.778	0.903	0.954
H' diversity	0.760	0.571	0.624	0.778	0.732	0.705	0.573	0.374	0.587	0.347
J' evenness (equitability)	0.760	0.734	0.892	0.921	0.867	0.834	0.736	0.481	0.650	0.364
1-J' dominance	0.240	0.266	0.108	0.079	0.133	0.166	0.264	0.519	0.350	0.636

numbers/m2

Total Annelids	128	0	0	64	0	0	0	0	64	0
Total Crustaceans	449	1282	513	385	897	0	1090	6667	3974	8462
Total Molluscs	769	192	385	128	192	385	641	10128	1474	1090
Total Other *	256	192	256	192	192	897	641	64	0	128

AFD biomass - g

Total Annelids	0.0001	0	0	0.0001	0	0	0	0	0.003	0
Total Crustaceans	0.0468	0.0613	0.0586	0.0019	0.0574	0	0.001	0.009	0.0101	0.0099
Total Molluscs	0.0796	0.0191	0.0169	0.0045	0.0215	0.0205	0.0259	0.0262	0.0456	0.0422
Total Other *	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0	0.0001

AFD biomass - g/m2

Total Annelids	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.58	0.00
Total Crustaceans	9.00	11.79	11.27	0.37	11.04	0.00	0.19	1.73	1.94	1.90
Total Molluscs	15.31	3.67	3.25	0.87	4.13	3.94	4.98	5.04	8.77	8.12
Total Other *	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.02

* includes insects, spiders, and misc. taxa

Table 4. Summary of Wrack-line Quantitative Data – condensed by station.
Values in numbers/m^2

TAXA	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10
ANNELIDA										
Polychaeta										
Order Eunicida										
Family Lumbrineridae										
Unid. Lumbrineridae								16	16	
Order Sabellida										
Family Oweniidae										
Owenia fusiformis									16	
Order Spionida										
Family Spionidae										
Polydora sp.									16	
Scolelepis squamata	16	784		144	352		336			96
ARTHROPODA										
Arachnida										
Order Araneae										
Family Linyphiidae										
Unid. Linyphiidae								16		32
Family Lycosidae										
Unid. Lycosidae										16
Entognatha										
Order Poduromorpha										
Unid. Collembola	16	16		32	112		32	32		
Family Hypogastruridae										
Unid. Hypogastruridae		176		16	32	128	16			
Insecta										
Order Coleoptera										
Family Staphylinidae										
Unid. Staphylinidae	16	32			16					
Order Diptera										
Unid. Diptera		32			32		16	48		96
Family Chironomidae										
Unid. Chironomidae							16			
Family Culicidae										
Unid. Culicidae					48	32				
Family Mycetophilidae										
Unid. Mycetophilidae										32

TAXA	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10
Family Sciaridae										
Unid. Sciaridae	48	80			32	16		16		32
Family Sciomyzidae										
Unid. Sciomyzidae	16									
Order Hemiptera										
Family Aphididae										
Unid. Aphididae				16						32
Family Cicadellidae										
Unid. Cicadellidae	16									16
Order Hymenoptera										
Family Eulophidae										
Unid. Eulophidae	16	16								
Malacostraca										
Order Amphipoda										
Family Ampithoidae										
Ampithoe valida										80
Family Caprellidae										
Caprella equilibra										48
Family Corophiidae										
Unid. Corophiidae										16
Family Haustoriidae										
Lepidactylus triarticulatus	2128	4272	1616	1392	1968	576	928	3376	6080	1744
Family Isaeidae										
Microprotopus raneyi									32	16
Family Oedicerotidae										
Ameroculodes miltoni								32		16
Family Talitridae										
Platorchestia sp.		64					16			32
Order Decapoda										
Unid. Megalops larva										16
Family Hippidae										
Emerita talpoida				16						
Order Isopoda										
Family Sphaeromatidae										
Ancinus depressus		16		16						
Maxillopoda										
Order Cyclopoida										
Unid. Cyclopoid copepod	16									16
Order Sessilia										
Family Balanidae										

TAXA	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10
Amphibalanus amphitrite								16		256
Pycnogonida										
Unid. Pycnogonida										32
MOLLUSCA										
Bivalvia										
Unid. Bivalvia										128
Order Veneroida										
Family Donacidae										
Donax variabilis	192	144	240	144	16	16	48	736	784	
Family Mactridae										
Mulinia lateralis									176	
Family Montacutidae										
Mysella planulata	16									
Family Semelidae										
Abra aequalis		112	16					16	64	32
Family Veneridae										
Petricolaria pholadiformis									32	48
MISC TAXA										
Chordata										
Demersal fish eggs					16					496
Unid. Ascidiacea		16								
TOTAL NUMBERS	2496	5760	1872	1776	2624	768	1408	4304	7216	3328
TOTAL TAXA	11	13	3	8	10	5	8	10	9	23

diversity indices

Hmax'	1.041	1.114	0.477	0.903	1.000	0.699	0.903	1.000	0.954	1.362
H' diversity	0.290	0.435	0.187	0.365	0.412	0.351	0.444	0.312	0.263	0.805
J' evenness (equitability)	0.279	0.390	0.392	0.404	0.412	0.502	0.491	0.312	0.276	0.591
1-J' dominance	0.721	0.610	0.608	0.596	0.588	0.498	0.509	0.688	0.724	0.409

numbers/m2

Total Annelids	16	784	0	144	352	0	336	16	48	96
Total Crustaceans	2144	4352	1616	1424	1968	576	944	3424	6112	2272
Total Molluscs	208	256	256	144	16	16	48	752	1056	208
Total Other *	128	368	0	64	288	176	80	112	0	752

TAXA	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10
					AFD biomass - g					
Total Annelids	0.0001	0.0116	0	0.0013	0.0018	0	0.004	0.0012	0.0046	0.0004
Total Crustaceans	0.0151	0.0419	0.0107	0.0482	0.0236	0.0105	0.0141	0.0175	0.0379	0.0244
Total Molluscs	0.034	0.0334	0.0035	0.0378	0.0016	0.007	0.004	0.02	0.0264	0.0018
Total Other *	0.0001	0.0001	0	0.0001	0.0001	0.0001	0.0001	0.0001	0.0006	0.0077
					AFD biomass - g/m2					
Total Annelids	0.005	0.557	0.000	0.062	0.086	0.000	0.192	0.058	0.221	0.019
Total Crustaceans	0.725	2.011	0.514	2.314	1.133	0.504	0.677	0.840	1.819	1.171
Total Molluscs	1.632	1.603	0.168	1.814	0.077	0.336	0.192	0.960	1.267	0.086
Total Other *	0.005	0.005	0.000	0.005	0.005	0.005	0.005	0.005	0.029	0.370

* includes insects, spiders, and misc. taxa

Table 5. Summary of Bayside Quantitative Data – condensed by station.
Values in numbers/m²

TAXA	BS1	BS2	BS3
ANNELIDA			
Polychaeta			
Order Phyllodocida			
Family Nereididae			
Alitta succinea		16	
Laeonereis culveri	144	32	64
Family Phyllodocidae			
Eteone heteropoda	224	288	112
Order Spionida			
Family Spionidae			
Dipolydora socialis			16
Polydora cornuta		32	
Streblospio gynobranchiata	320	1856	800
Order Terebellida			
Family Ampharetidae			
Hobsonia florida	96	32	
Family Cirratulidae			
Aphelochaeta sp.		48	
Subclass Scolecida			
Family Capitellidae			
Capitella capitata	96	32	672
Heteromastus filiformis	192	1280	208
Mediomastus ambiseta			32
ARTHROPODA			
Arachnida			
Order Araneae			
Family Lycosidae			
Unid. Lycosidae		16	
Entognatha			
Order Poduromorpha			
Unid. Collembola		16	
Insecta			
Order Diptera			
Unid. Diptera			48
Family Chironomidae			
Unid. Chironomidae			16
Tanypus clavatus	16		

TAXA	BS1	BS2	BS3
Family Sciaridae			
Unid. Sciaridae	16	16	32
Order Hemiptera			
Family Aphididae			
Unid. Aphididae	16		
Order Hymenoptera			
Family Formicidae			
Unid. Formicidae	32		
Malacostraca			
Order Amphipoda			
Family Ampeliscidae			
Ampelisca sp.	16		
Family Corophiidae			
Unid. Corophiidae	16		
Family Haustoriidae			
Lepidactylus triarticulatus	16		48
Family Isaeidae			
Microprotopus raneyi		16	
Order Isopoda			
Family Idoteidae			
Edotea triloba	16		
Ostracoda			
Order Podocopida			
Unid. Podocopida	2896		16
MOLLUSCA			
Bivalvia			
Unid. Bivalvia		16	16
Order Pholadomyoida			
Family Lyonsiidae			
Lyonsia floridana			16
Order Veneroida			
Family Solecurtidae			
Tagelus plebeius		16	
Gastropoda			
Order Cephalaspidea			
Family Cylichnidae			
Acteocina canaliculata		32	16

TAXA	BS1	BS2	BS3
MISC TAXA			
Chordata			
Demersal fish eggs	48		
Nemertea			
Unid. Nemertea		16	
TOTAL NUMBERS	4160	3760	2112
TOTAL TAXA	16	17	15

diversity indices			
Hmax'	1.230	1.204	1.176
H' diversity	0.185	0.574	0.757
J' evenness (equitability)	0.150	0.477	0.644
1-J' dominance	0.850	0.523	0.356

		numbers/m2	
Total Annelids	1072	3616	1904
Total Crustaceans	2960	16	64
Total Molluscs	0	64	48
Total Other *	128	64	96

		AFD biomass - g	
Total Annelids	0.0215	0.0715	0.015
Total Crustaceans	0.0022	0.0001	0.0001
Total Molluscs	0	0.002	0.0001
Total Other *	0.0001	0.0064	0.0001

		AFD biomass - g/m2	
Total Annelids	1.032	3.432	0.720
Total Crustaceans	0.106	0.005	0.005
Total Molluscs	0.000	0.096	0.005
Total Other *	0.005	0.307	0.005

* includes insects, spiders, and misc. taxa

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Appendices.

Appendix I. Qualitative beach wrack-line data (QMH). Numbers represent specimens observed in samples.

TAXA	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10
ANNELIDA										
Clitellata: Oligochaeta										
Order Haplotaxida										
Family Enchytraeidae										
Unid. Enchytraeidae										1
Polychaeta										
Order Eunicida										
Family Onuphidae										
Diopatra cuprea									1	
Order Spionida										
Family Spionidae										
Scolelepis squamata		1								
ARTHROPODA										
Arachnida										
Order Araneae										
Family Linyphiidae										
Unid. Linyphiidae				1				1	1	
Entognatha										
Order Poduromorpha										
Unid. Collembola	4									
Family Hypogastruridae										
Unid. Hypogastruridae		3		3	30	4	2			
Insecta										
Order Coleoptera										
Family Carabidae										
Unid. Carabidae		1								
Family Staphylinidae										
Unid. Staphylinidae		2	1						1	
Order Diptera										
Unid. Diptera	2	1		1				1		1
Family Chironomidae										
Unid. Chironomidae								1		
Family Culicidae										
Unid. Culicidae				1					1	
Family Phoridae										

TAXA	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10
Unid. Phoridae										1
Family Sciaridae										
Unid. Sciaridae	1	2			1					
Order Hemiptera										
Family Aphididae										
Unid. Aphididae										1
Family Cercopidae										
Unid. Cercopidae										1
Family Cicadellidae										
Unid. Cicadellidae							1	1		
Malacostraca										
Order Amphipoda										
Family Caprellidae										
Caprella equilibra										2
Family Corophiidae										
Unid. Corophiidae										2
Apocorophium louisianum									1	
Family Haustoriidae										
Lepidactylus triarticulatus	34	7	9	19	2	3	24	33	16	2
Family Isaeidae										
Microprotopus raneyi	3						2	6	324	1
Family Oedicerotidae										
Ameroculodes miltoni								4		
Family Talitridae										
Platorchestia sp.	18	9			4					
Order Decapoda										
Family Callianassidae										
Unid. Callianassidae zoea								2		
Order Isopoda										
Family Sphaeromatidae										
Ancinus depressus				1				2	7	
Maxilllopoda										
Order Calanoida										
Unid. Calanoid copepod				1						1
Order Sessilia										
Family Balanidae										
Amphibalanus amphitrite	1			1	1				8	17
MOLLUSCA										
Bivalvia										

TAXA	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10
Unid. Bivalvia										7
Order Arcoida										
Family Arcidae										
Lunarca ovalis									1	
Order Veneroida										
Family Donacidae										
Donax variabilis	1		17	2				21	9	
Family Mactridae										
Mulinia lateralis									18	
Family Montacutidae										
Mysella planulata							1			
Family Semelidae										
Abra aequalis	5	1	2		22			2	16	9
Veneridae										
Petricolaria pholadiformis									10	
Gastropoda										
Order Neotaenioglossa										
Family Naticidae										
Tectonatica pusilla									1	
MISC TAXA										
Chordata										
Demersal fish eggs					1			4		20
Unid. Ascidiacea								1		

Appendix II. Phylogenetic listing of taxa.

Phylum	Class	Subclass	Order	Suborder	Family	Taxon	Authority
Annelida	Clitellata	Oligochaeta	Haplotaxida	Tubificina	Enchytraeidae	Unid. Enchytraeidae	
	Polychaeta	Errantia	Eunicida		Lumbrineridae	Unid. Lumbrineridae	
					Onuphidae	Diopatra cuprea	(Bosc, 1802)
			Phyllodocida	Nereidiformia	Nereididae	Alitta succinea	(Leukart, 1847)
						Laeonereis culveri	(Webster, 1880)
				Phyllodociformia	Phyllodocidae	Eteone heteropoda	Hartman, 1951
		Sedentaria	Sabellida		Oweniidae	Owenia fusiformis	Delle Chiaje, 1841
			Spionida	Spioniformia	Spionidae	Dipolydora socialis	(Schmarda, 1861)
						Polydora cornuta	Bosc, 1802
						Polydora sp.	
						Scolelepis squamata	(Muller, 1806)
						Streblospio gynobranchiata	Rice & Levin, 1998
			Terebellida	Cirratuliformia	Cirratulidae	Aphelochaeta sp.	
				Terebellomorpha	Ampharetidae	Hobsonia florida	Hartman, 1951
			[Scolecida]		Capitellidae	Capitella capitata complex	(Fabricius, 1780)
						Heteromastus filiformis	(Claparede, 1864)
						Mediomastus ambiseta	(Hartman, 1947)
Arthropoda	Arachnida					unid. Arachnida	
			Araneae		Linyphiidae	Unid. Linyphiidae	
					Lycosidae	Unid. Lycosidae	
	Entognatha	Collembola				Unid. Collembola	
			Poduromorpha		Hypogastruridae	Unid. Hypogastruridae	
	Insecta	Pterygota	Coleoptera	Adephaga	Carabidae	Unid. Carabidae	
				Polyphaga	Staphylinidae	Unid. Staphylinidae	
			Diptera			Unid. Diptera	
				Brachycera	Sciomyzidae	Unid. Sciomyzidae	
				Nematocera	Chironomidae	Tanypus clavatus	Beck, 1962
						Unid. Chironomidae	
					Mycetophilidae	Unid. Mycetophilidae	
					Culicidae	Unid. Culicidae	
					Phoridae	Unid. Phoridae	
					Sciaridae	Unid. Sciaridae	
			Hemiptera	Auchenorrhyncha	Cercopidae	Unid. Cercopidae	
				Heteroptera	Miridae	Unid. Miridae	
				Sternorrhyncha	Aphididae	Unid. Aphididae	
					Cicadellidae	Unid. Cicadellidae	
			Hymenoptera	Apocrita	Eulophidae	Unid. Eulophidae	
					Formicidae	Unid. Formicidae	

Phylum	Class	Subclass	Order	Suborder	Family	Taxon	Authority
			Lepidoptera			Unid. Lepidoptera	
	Malacostraca	Eumalacostraca	Amphipoda	Caprellidea	Caprellidae	Caprella equilibra	Say, 1818
				Gammaridea	Ampeliscidae	Ampelisca sp.	
					Ampithoidae	Ampithoe valida	Smith, 1873
					Corophiidae	Apocorophium louisianum	Shoemaker, 1934
						Unid. Corophiidae	
					Haustoriidae	Lepidactylus triarticulatus	Robertson & Shelton, 1980
					Isaeidae	Microprotopus raneyi	Wigley, 1966
					Oedicerotidae	Ameroculodes miltoni	Foster & Heard, 2002
					Talitridae	Platorchestia sp.	
			Cumacea		Bodotriidae	Cyclaspis varians	Calman, 1912
			Decapoda			Unid. Megalops larva	
				Pleocyemata	Callianassidae	Unid. Callianassidae zoea	
					Hippidae	Emerita talpoida	(Say, 1817)
			Isopoda	Flabellifera	Sphaeromatidae	Ancinus depressus	(Say, 1818)
			Isopoda	Valvifera	Idoteidae	Edotea triloba	(Say, 1818)
	Maxilllopoda	Theocostraca	Sessilia	Balanomorpha	Balanidae	Amphibalanus amphitrite	(Darwin, 1854)
		Copepoda	Calanoida			Unid. Calanoid copepod	
			Cyclopoida			Unid. Cyclopoid copepod	
	Ostracoda	Podocopa	Podocopida			Unid. Podocopida	
	Pycnogonida					Unid. Pycnogonida	
Chordata	Actinopterygii					Demersal fish eggs	
	Ascidiacea					Unid. Ascidiacea	
Mollusca	Bivalvia					Unid. Bivalvia	
		Heterodonta	Pholadomyoida		Lyonsiidae	Lyonsia floridana	Conrad, 1849
			Veneroida		Donacidae	Donax variabilis	Say, 1822
					Mactridae	Mulinia lateralis	(Say, 1822)
					Montacutidae	Mysella planulata	(Stimpson, 1857)
					Semelidae	Abra aequalis	(Say, 1822)
					Solecurtidae	Tagelus plebeius	(Lightfoot, 1786)
					Veneridae	Petricolaria pholadiformis	(Lamarck, 1818)
		Pteriomorphia	Arcoida		Arcidae	Anadara transversa	(Say, 1822)
						Lunarca ovalis	(Bruguiere, 1789)
	Gastropoda	Opisthobranchia	Cephalaspidea		Cylichnidae	Acteocina canaliculata	(Say, 1822)
		Prosobranchia	Neotaenioglossa		Caecidae	Caecum johnsoni	Winkley, 1908
					Naticidae	Tectonatica pusilla	(Say, 1822)
Nemertea						Unid. Nemertea	