Sargassum Community Studies near Bermuda, 2015

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Abstract

The Sargasum community was sampled around Bermuda in June 2013 on two cruises. The longer Sea Dragon cruise allowed for sample collection up to ~75 nm SW of Bermuda while the Twin Vee cruise was restricted with 10 nm to the SE of Bermuda. The *Sargassum* community again demonstrated very high patterns of abundance for two shrimp species (*Latreutes fucorum, Hippolyte coerulescens*) compared to the historic samples of Butler et al (1983). Other species, such as the amphipod *Sunampithoe pelagica*, appear reduced compared to the historic data. Plastic marine debris was observed in nearly all *Sargassum* samples with an average of 135 pieces per kg of *Sargassum*. Plastic marine debris was also found at very high levels (~78,600 pieces per sq km) in surface manta trawls, similar to other reported data. 43 sea birds were observed on the two cruises, primarily great shearwaters (*Ardenna gravis)* and the longtail (*Phaethon lepturus catesbyi*) and three other unidentified species.

Introduction:

The Sargasso Sea is defined as the area formed by four different currents, the Gulf Stream, the North Atlantic Current, the Canaries Current, and the Equatorial Current (Butler et al., 1983). This area is inhabited by the floating ecosystem of *Sargassum* seaweed that many hundreds of species rely on, especially juvenile sea turtles. It is a significant area for many migratory species such as whales, fishes, sharks, and seabirds (Hallet, 2011; Lafolley et al 2012).

The *Sargassum* community is made up of two types of brown algae species, *Sargassum natans* and *Sargassum fluitans.* These species have developed air bladders that keep them afloat on the ocean surface and they can occur as scattered clumps or in extensive windrows (Witczak and Smith, 2014). These communities support hundreds of marine species that can spend up to their whole lives living within the *Sargassum* for protection (Smith et al., 2013). The Sargasso Sea as a whole has a significant impact on the total biodiversity of the Atlantic Ocean and is therefore an important component to study (Coston-Clements et al 1991; Block et al. 2005; Hallett 2011b; Lafolley et al. 2011).

However, the *Sargassum* community is threatened by many human activities including pollution, over-fishing, ship traffic, and harvesting of *Sargassum* (Laffoley et al., 2012). Plastic marine debris accumulates to very high levels in the *Sargasso Sea* (Lavender-Law et al., 2010).

As well, the impacts of global climate change and ocean acidification could pose a threat to this community. There are efforts to help protect this community and spread awareness through projects like www.sargassoalliance.org. Only Bermuda has jurisdiction over a small portion of the Sargasso Sea to help with conservation efforts within its Exclusive Economic Zone (Trott et al., 2010; Laffoley et al., 2012). In order to effectively conserve the *Sargassum* community we must first understand the biology and ecology of this ecosystem to determine what factors may be changing the composition of the community. The recent study by Huffard et al. (2014) shows that there may actually be some changes in the associated species composition that have occurred within the *Sargassum* community since the 1970s. These results accord with other recent observations made around Bermuda (Grenfell and Smith, 2012; Wight and Smith, 2013; Harrigan, 2013; Witczak and Smith 2014) which also found similar trends and patterns, with significantly larger shrimp populations, while some crabs have diminished.

This study is aimed to examine the diversity and abundance of attached and mobile invertebrates associated with the *Sargassum* found around Bermuda. An assessment of plastic debris associate with Sargassum and also floating on the ocean surface were made. Observations of sea birds were also recorded. This study is part of an ongoing project, conducted in the same month each year, extending back to 2013, and this allows for detailed comparisons between years, to determine changes or differences compared to recent and historical samples.

Methods:

Sampling for this study was conducted on two different occasions. First, sampling occurred on the S/V *Sea Dragon* in offshore waters from June 5th to June 6th and samples were collected from ~10 to 70 nm SW of Bermuda. The second sampling was done from the small boat *Twin Vee,* on June 9th about 10 nm SE of Bermuda in the southeastern waters of Bermuda (Fig. 1). Discrete clumps (1-5) of *Sargassum* were collected by dip net and aggregated to form a sample and put into a 70% ethanol solution. The aggregation was a method to capture a representative sample of *Sargassum* at a particular time and place before moving the vessel varying distances and collecting another sample. This approach attempted to provide a wide spatial sampling of *Sargassum* (>10 nm for the Sea Dragon, < 5 nm for the SE samples) but constrained in time (<48 hours, for the Sea Dragon, <3 hours for the SE samples).

The large mobile animals were extracted from the *Sargassum* and placed in separate dishes for identification. Each sample was thoroughly examined for any small mobile creatures still lodged in the *Sargassum*. The animals were then identified using a key provided by Morris and Mogelberg (1973). Sub-samples of 10 branches, 8 to 10 cm in length, were then taken from each *Sargassum* clump to estimate the abundance of epifaunal species present. The rank abundance of each taxa was estimated as: Absent = 0 individuals, Rare = 1-10, Less common = 11-50, Common = 51-100, Abundant=101-500, Very abundant =>500. The rankings for each epifaunal species were then converted into a numerical value (Absent=0, Rare=1, Less common=2, Common=3, Abundant=4, and Very abundant=5) and averaged for each species per 10 sub-samples. However, some *Sargassum* samples were small enough that 10 branches could not be obtained.

After period of preservation time in 70% ethanol (3-4 weeks), the samples were then wet-weighed (+/- 0.1g). The total number of individuals per species was determined for each sample and then divided by that sample's wet weight to normalize the abundance of each species per kilogram of *Sargassum*.

Surface plastic marine debris

Two surface manta trawls were collected on the *Sea Dragon* cruise on June 6th from 31^{o} 21.4256; 65^{o} 22.5407 to 31^{o} 22.4225, 65^{o} 19.5827 from 9:22 AM to 10:25 AM and again from 31^{o} 46.5172; 65^{o} 07.0348 to 31^{o} 47.6196, 65^{o} 03.6654 from 16:33 PM to 17:37 PM on June 6th. Each manta trawl was conducted for 1 hour at a speed of ~2 knots. The samples were examined for plastic debris and the numbers of plastic particles counted. Plastic particles were also counted in the *Sargassum* dip net samples. The number of floating plastic pieces were also recorded on the both the *Sea Dragon* and *Twin Vee* cruises

Seabird observations

A watch was maintained for sea birds at all times and each seabird observed was observed to the lowest possible taxonomic level based on the quality of the observation (distance of bird form the vessel, duration of observation, flight character, plumage characteristics).

Results:

<u>*Sea Dragon* Dip net samples</u>

The dip net samples from the S/V *Sea Dragon* had a total of 1819 individuals identified and an average of 4076.2 individuals per kg of *Sargassum* wet weight. The most abundant organism present in the sample was the snail *Litiopia melanostoma* at 1736 individuals per kg of *Sargassum* wet weight. Another highly abundant organism in these samples was the anemone *Pseudoactinia melanaster* at 267.6 individuals per kg of *Sargassum* wet weight. The amphipod *Sunampithoe pelagica* also had a high abundance at 545.5 individuals per kg *Sargassum* wet weight, and the amphipod *Biancolina sp.* was at 260 individuals per kg *Sargassum* wet weight. There were two other species of shrimps that were abundant in these samples as well, *Hippolyte coerulescens* was averaged at 133 individuals per kg *Sargassum* wet weight and *Latruetes fucorum* was averaged at 124.5 individuals per kg of *Sargassum* wet weight (Table 1).

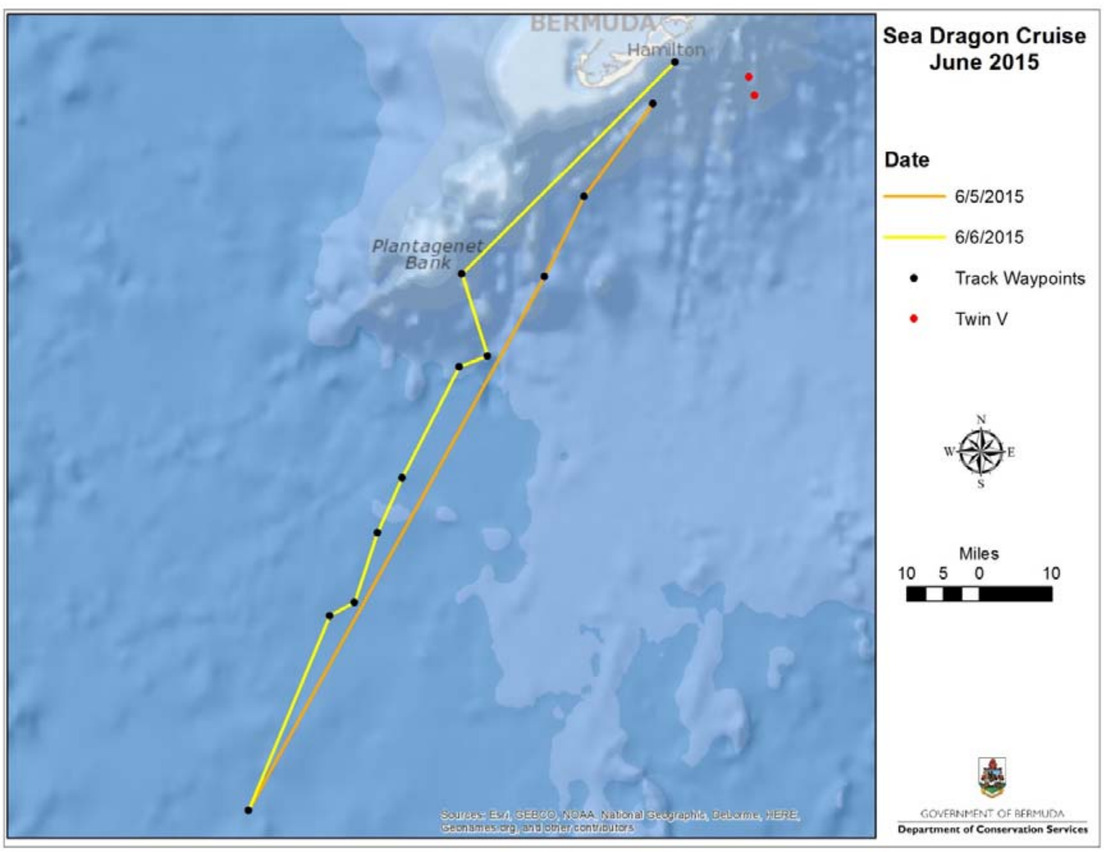

Figure 1. Sampling track of the S/V *Sea Dragon* and the location of the Twin Vee collection sites to the SE of Bermuda

SE Dip net samples

The samples taken on the South East (SE) cruise had a total of 5856 individuals identified and averaged at 6374 individuals per kg of *Sargassum* wet weight. The most abundant species in these samples was the snail *Litiopia melanostoma* at 4964.9 individual per kg of *Sargassum* wet weight. Two amphipods also had significant abundance levels with *Sunampithoe pelagica* having 1201.9 individuals per *Sargassum* wet weight and *Biancolina sp.* having 863.0 individuals per *Sargassum* wet weight. As well there were two shrimp species that were abundant as well, where the *Latruetes fucorum* averaged at 370.2 individuals per kg wet weight *Sargassum* and *Hippolyte coerulescens* averaged at 134.6 individuals per kg *Sargassum* wet weight (Table 1).

All of the different species identified were plotted with regard to density of individuals per kg *Sargassum* wet weight. There seemed to be a positive correlation, with an R^2 value of 0.8495, were more mass of *Sargassum* contained more individuals (Fig 2).

A comparison of epifaunal species found on the S/V *Sea Dragon* and in the South East (Table 2) there was only one species of hydroid, *Campanularia volubilis*, that was classified as Common in both of the data sets. There were quite a few species of hydroids, mostly *Clytia*, that were classified as rare in both of the data sets.

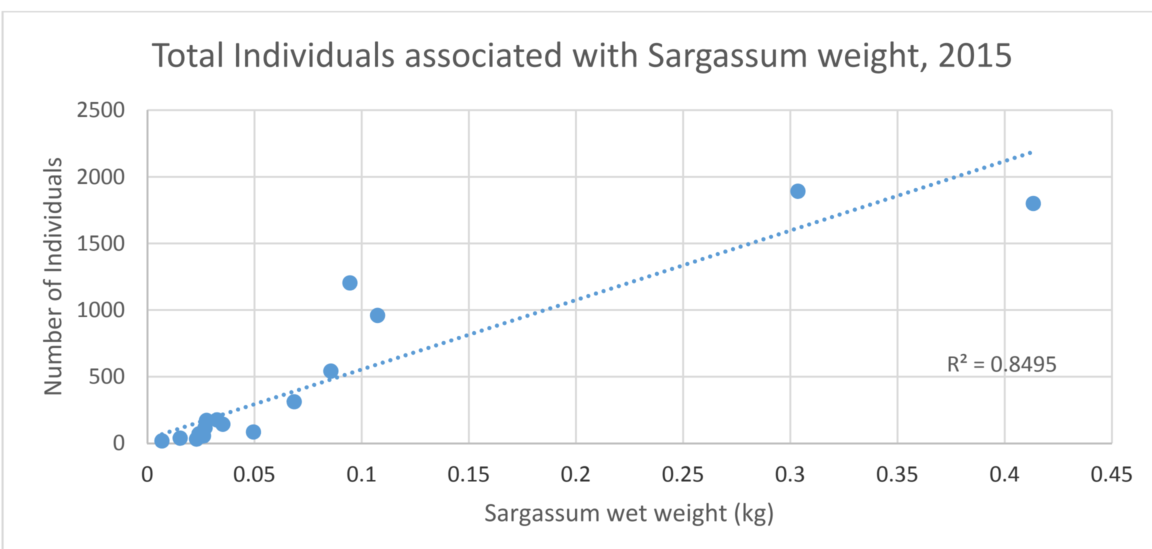

Fig. 2 Relationship of density of individuals with *Sargassum* wet weight.

Fig 2. Robbie Smith (L) and Pearce Cooper (R) dip-netting *Sargassum* samples

Fig 3. Joshua Stevens and Leslie Acton sort through a *Sargassum* sample

Table 1. Average mobile species densities, normalized to wet weight *Sargassum* (#/kg) for each sampling period on the Sea Dragon cruise and the South East (SE) samples in June 2015. n= number of clumps per sample. Mean and Standard Error (SE) are calculated from all samples.

		Sea Dragon				S E		
		June 5	June 6-1	June 6-2	June 6-3	June 9	Mean	SE
Type	**Species**	n=3	n=2	n=4	n=4	n=4	n=17	
Anemone	*Pseudoactinia melanaster*	0.0	319.7	82.8	82.8	626.8	218.7	78.6
Flatworm	*Acerotisa notulata*	13.8	0.0	0.0	0.0	0.0	2.4	2.4
Flatworm	*Amphiscolops sargassi*	266.9	0.0	0.0	0.0	0.0	47.1	38.9
Flatworm	*Hoploplana grubei*	27.7	0.0	0.0	0.0	0.0	4.9	4.9
Flatworm	unidentified	0.0	5.8	7.3	0.0	0.0	2.4	1.8
Polychaete	*Platynereis dumerillii*	0.0	74.3	7.1	5.1	24.6	17.4	9.0
Polychaete	*Platynereis coccinea*	0.0	0.0	0.0	0.0	2.3	0.5	0.5
Shrimp	*Hippolyte coerulescens*	104.3	157.2	165.1	110.4	134.6	133.4	16.9
Shrimp	*Latruetes fucorum*	161.7	167.8	138.4	61.0	370.2	182.3	29.2
Shrimp	*Leander tenuicornis*	21.8	36.1	31.3	5.1	4.7	17.8	5.3
Shrimp	Unidentified	27.7	5.8	25.4	20.4	22.1	21.6	6.6
Crab	*Planes minutus*	140.0	103.6	124.6	40.5	92.0	97.4	11.8
Crab	*Portunus sayii*	0.0	0.0	7.7	0.0	0.0	1.8	1.8
Crab	*Unidentified*	0.0	0.0	0.0	0.0	1.4	0.3	0.2
Snail	*Litiopia melanostoma*	369.6	3428.3	3235.1	401.4	4964.9	2492.4	561.2
Amphipod	*Hemaegina minuta*	13.8	55.8	37.5	251.8	6.2	19.3	9.1
Amphipod	*Sunampithoe pelagica*	1156.0	465.7	497.6	277.5	1201.9	690.6	126.9
Amphipod	*Biancolina sp.*	76.7	284.1	335.4	45.5	863.0	394.2	79.5
Amphipod	*Luconacia incerta*	57.4	18.6	282.6	0.0	66.4	105.1	43.9
Amphipod	Unidentified	21.8	17.5	10.8	0.0	130.5	39.2	16.3
Isopod	*Bagatus minutus*	0.0	0.0	7.7	0.0	25.4	7.8	3.2
Pycnogonid	*Anoplodactylus petiolatus*	0.0	11.7	7.7	5.1	23.2	9.8	3.6
Pycnogonid	*Endeis spinosa*	0.0	0.0	0.0	0.0	13.9	3.3	1.8
Copepod	unidentified	0.0	5.8	7.7	7.7	0.0	2.5	1.9
Crustacean	unidentified	0.0	0.0	0.0	0.0	0.6	0.1	0.1
Nudibranch	*Doto pygmaea*	0.0	11.7	3.6	0.0	6.9	3.9	1.7
Nudibranch	*Scyllaea pelagica*	49.0	48.9	17.9	9.5	38.7	29.9	9.3
Nudibranch	*Spurilla neopolitana*	43.6	0.0	0.0	0.0	5.6	9.0	7.6
Nudibranch	Unidentified	13.8	5.8	14.6	0.0	0.6	6.7	4.1
Nudibranch	gray, unidentified	98.0	74.3	0.0	0.0	0.0	26.0	18.9
Nudibranch	Egg sac	0.0	11.7	7.3	10.0	7.1	7.1	3.1
Sargassum Fish	*Histrio histrio*	0.0	5.8	0.0	0.0	13.1	3.8	2.0

Table 2. Rank abundance of epifaunal species in *Sea Dragon* and SE *Sargassum* samples, 2015

		South East		Sea Dragon		
Taxa	**Epifaunal Species**	**Average**	**Rank**	**Average**	**Rank**	**Notes**
Polychaete	*Spirorbis formosus*	1.15	Rare?	1.46	Rare?	Both Rare
Bryozoan	*Membranipora tuberculata*	1.10	Rare	1.25	Rare?	Both Rare
Bryozoan	*Thalamoporella falciaferia*	0.00	Absent	0.02	Rare?	Different
Barnacle	*Lepas pectinata*	0.65	Rare?	0.14	Rare?	Both Rare
Barnacle	*Lepas hilli*	0.03	Rare?	0.03	Rare?	Both Rare
Barnacle	*Lepas anserifera*	0.13	Rare?	0.02	Rare?	Both Rare
Barnacle	*Lepas fascicularis*	0.03	Rare?	0.03	Rare?	Both Rare
Hydroid	*Aglaeophenia latercarinata*	0.08	Rare?	0.46	Rare?	Both Rare
Hydroid	*Aglaeophenia perpusilla*	0.00	Absent	0.11	Rare?	Different
Hydroid	*Aglaeophenia rigida*	0.03	Rare?	0.00	Absent	Different
Hydroid	*Plumularia setaceoides*	0.00	Absent	0.06	Rare?	Different
Hydroid	*Obelia dichotoma*	0.08	Rare?	0.07	Rare?	Both Rare
Hydroid	*Obelia geniculata*	0.00	Absent	0.07	Rare?	Different
Hydroid	*Obelia bicuspidata*	0.00	Absent	0.35	Rare?	Different
Hydroid	*Clytia noliformes*	0.48	Rare?	1.13	Rare?	Both Rare
Hydroid	*Clytia cylindrica*	0.18	Rare?	0.16	Rare?	Both Rare
Hydroid	*Clytia longicyatha*	0.10	Rare?	0.23	Rare?	Both Rare
Hydroid	*Clytia johnstoni*	0.03	Rare?	0.00	Absent	Different
Hydroid	*Clytia raridentata*	0.00	Absent	0.09	Rare?	Different
Hydroid	*Campanularia volubilis*	2.65	Common?	2.47	Common?	Both Common
Hydroid	*Plumularia floridana*	0.05	Rare?	0.34	Rare?	Both Rare
Hydroid	*Plumularia margaretta*	0.05	Rare?	0.18	Rare?	Both Rare
Hydroid	*Gonothyarea integra*	0.00	Absent	0.53	Rare?	Different
Hydroid	*Eucopella sargassicola*	0.08	Rare?	0.28	Rare?	Both rare
Hydroid	*Antenella secundaria*	0.00	Absent	0.02	Rare?	Different
Algae	Blue Green Algae	0.00	Absent	0.04	Rare?	Different
Algae	*Ceramium* sp.	0.00	Absent	0.02	Rare?	Different
Fish	Flying Fish eggs	0.00	Absent	0.23	Rare?	Different
Total taxa		17		26		

Table 3. Comparison of mobile species densities, normalized to *Sargassum* wet weight, from recent studies with historic data from Butler et al, June 1973. SD refers to *Sea Dragon* cruises.

		2015				2014				2013		1973	
Type	**Species**	SD Mean	SD SE	S East Mean	S East SE	S D Mean	SD SE	S East Mean	S East SE	Mean	SE	Mean	SE
Anemone	Pseudoactinia melanaster	267.5	95.9	60.2	21.4	63.2	105.2	0.0	0.0	14.6	8.8	9.6	41.5
Flatworm	Acerotisa notulata	3.2	3.1	0.0	0.0	1.3	2.9	0.0	0.0			0.6	2.4
Flatworm	Gnesioceros sargassicola	0.0	0.0	0.0	0.0	45.1	69.7	18.7	15.8	7	2.4	10.5	19
Flatworm	Amphiscolops sargassi	61.6	50.6	0.0	0.0								
Flatworm	Platynereis dumerillii	15.2	11.0	24.6	10.6	7.9	15.6	4.5	9.1			25.5	34.6
Flatworm	Platynereis coccinea	0.0	63.9	2.3	2.3								
Flatworm	Hoploplana grubei	6.4	6.4	0.0	0.0								
Flatworm	unidentified	3.1	2.3	0.0	0.0	6.1	13.6						
Shrimp	Hippolyte coerulescens	133.0	20.5	134.6	32.7	34.1	6.7	9.0	12.9	38.4	11.7		
Shrimp	Latruetes fucorum	124.5	16.0	370.2	23.4	581.7	236.0	224.9	143.9	142.9	24.2	11.4	21.6
Shrimp	Leander tenuicornis	21.8	6.6	4.7	2.2	14.8	9.3	30.1	14.3	6	1.3	0.2	1.1
Shrimp	Unidentified	21.4	8.2	22.1	10.2	108.1	67.5	4.0	4.7				
juv. Shrimp		0.0	0.0	0.0	0.0					20	5.8		
Crab	Planes minutus	99.0	15.2	92.0	11.8	22.3	18.2	3.3	4.3	4.6	1	18.1	30
Crab	Portunus sayii	2.4	2.4	0.0	0.0	0.0	0.0	10.5	8.1	0.9	0.6	0	0
Crab	Unidentified	0.0	0.0	1.4	0.8								
Snail	Litiopia melanostoma (est.)	1731.6	450.6	4964.9	1355.0	25.3	20.6	35.0	25.1	0.1	0.1	23.75	66.46
Sea slug	Doto pygmaea	2.9	2.0	6.9	2.4	3.0	6.8	0.0	0.0				
Nudibranch	Egg sac	7.1	3.9	7.1	4.5								
Nudibranch	Scyllaea pelagica	37.3	14.2	38.7	3.7	4.3	6.7	0.0	0.0	0.5	0.4	1.7	7.73
Nudibranch	Spurilla neopolitana	10.1	10.1	5.6	2.6								
Pipefish	Syngnathus pelagicus	0.0	0.0	0.0	0.0								
Sargassum Fish	Histrio histrio	0.9	0.9	13.1	6.5	3.4	5.6	1.9	3.8	2.1	1.5	0.2	1.1
Isopod	Carpias bermudensis	0.0	0.0	0.0	0.0					34.8	28.5		
Amphipod	Sunampithoe pelagica	545.5	115.6	1201.9	246.1	576.7	253.9	19.2	19.9			57.2	126.8
Amphipod	Biancolina Sp.	260.0	39.6	863.0	151.4	2.1	3.0	42.5	30.6			0.2	1.4
Amphipod	Luconacia Incerta	117.1	57.4	66.4	12.8								
Amphipod	Unidentified	6.0	3.4	130.5	44.5								
Amphipod	Biancola? Large head, no eye	0.0	0.0	0.0	0.0					0.9	0.4		
Amphipod	Sunampithoe; no pigment eye	0.0	0.0	0.0	0.0					2.8	1.9		
Amphipod	Bagatus minutus	2.4	2.4	25.4	4.4							303.1	557.4
Amphipod	Hemiaegina minuta	23.3	11.7	6.2	4.7	70.5	47.5	18.0	19.8	10.4	5.2		
Nudibranch	Unidentified	7.5	3.0	0.6	0.6								
Nudibranch	gray, unidentified	18.6	30.3	0.0	0.0								
Sea Spider	Anoplodactylus petiolatus	10.7	5.5	23.2	10.0	15.8	16.7	3.3	4.3			3.6	9.6
Sea Spider	Endeis spinosa	0.0	0.0	13.9	4.7								
Isopod	Bagatus sp?	0.0	0.0	0.0	0.0								
Unidentified	gray squishy things	4.6	0.0	0.0	0.0								
Unidentified	Brown, rubbery lumps	1.5	1.4	0.0	0.0								
Unidentified	fleshy body?	0.0	0.0	0.0	0.0								
copepod	Paracalanus sp?	3.3	2.5	0.0	0.0					0.5			
Polychaeta?	White 2 eyes	0.0	0.0	0.0	0.0								
Crustecean	unidentified	0.0	0.0	0.6	0.6								

Plastic marine debris particles

Plastic particle were in observed in 12 of 13 *Sea Dragon* (SD) dip net samples and in 4 of 4 SE (Twin Vee) samples (Table 4). An average density of 135 (+/- 24.0) pieces of plastic were found per kg wet weight of *Sargassum*. 4 pieces of large plastic marine debris (>25 cm^2) were observed on June 5th and 1 piece on June 6th. A large aggregation of ropes was observed on the Twin Vee cruise on June 9th.

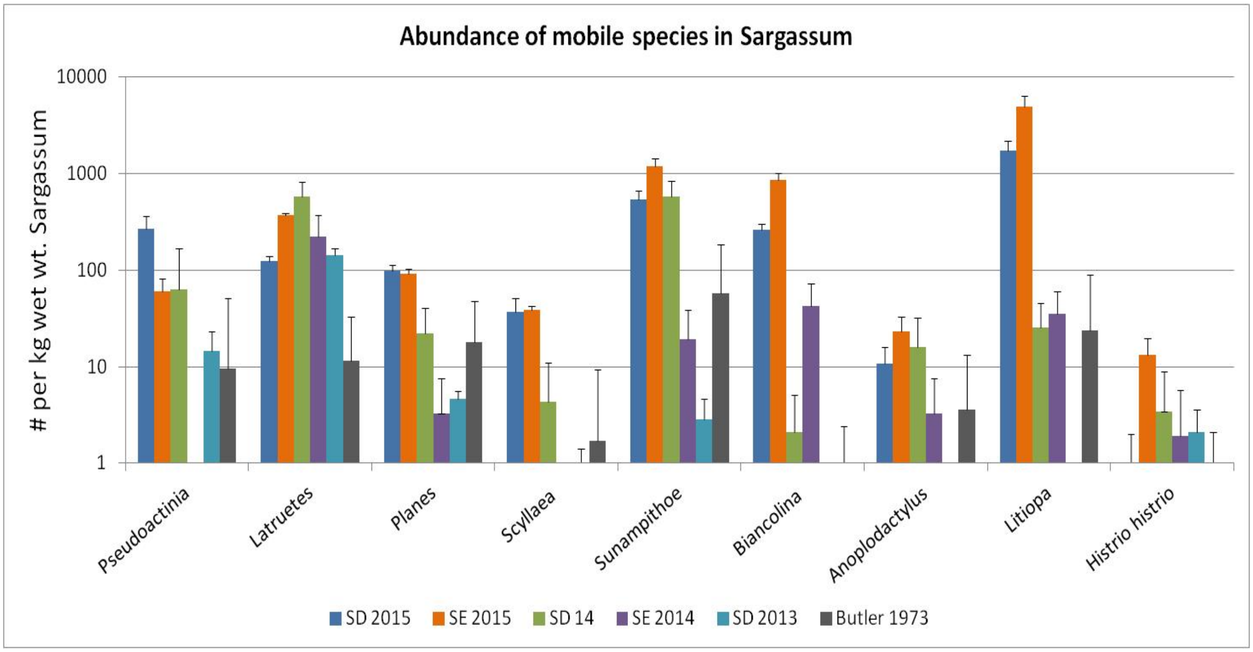

Fig. 5. Changes in patterns of abundance of the dominant invertebrate species observed in the *Sargassum* community, in comparison to data from June, 1973. These data are highlighted in Table 3.

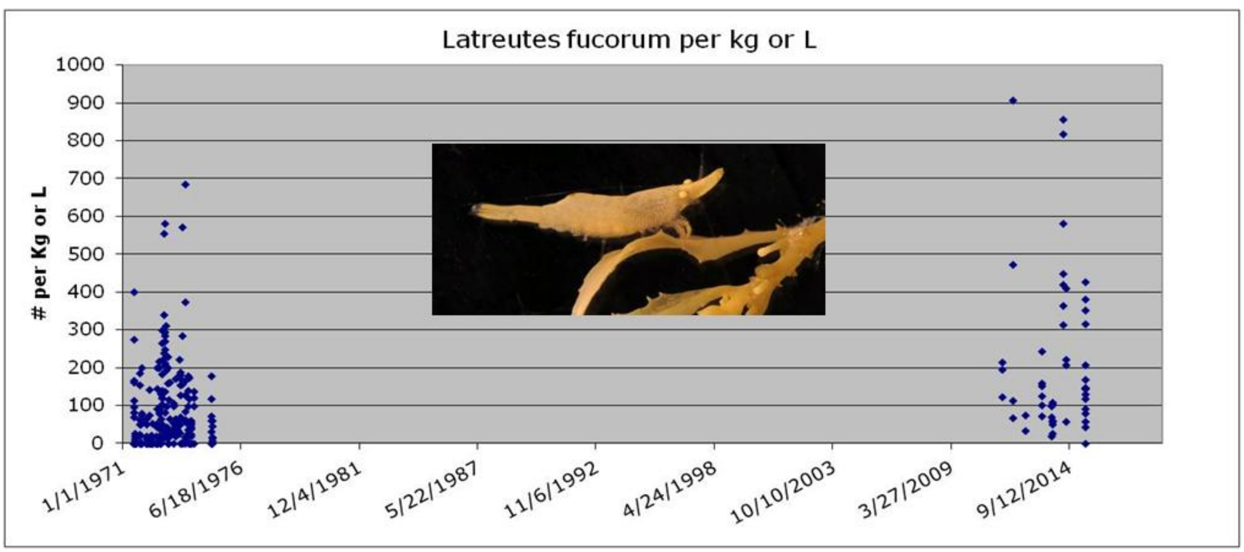

Fig. 6. Scatterplot of abundance of the shrimp *Latreutes fucorum* comparing all the Butler et al 1983 samples to all recent samples.

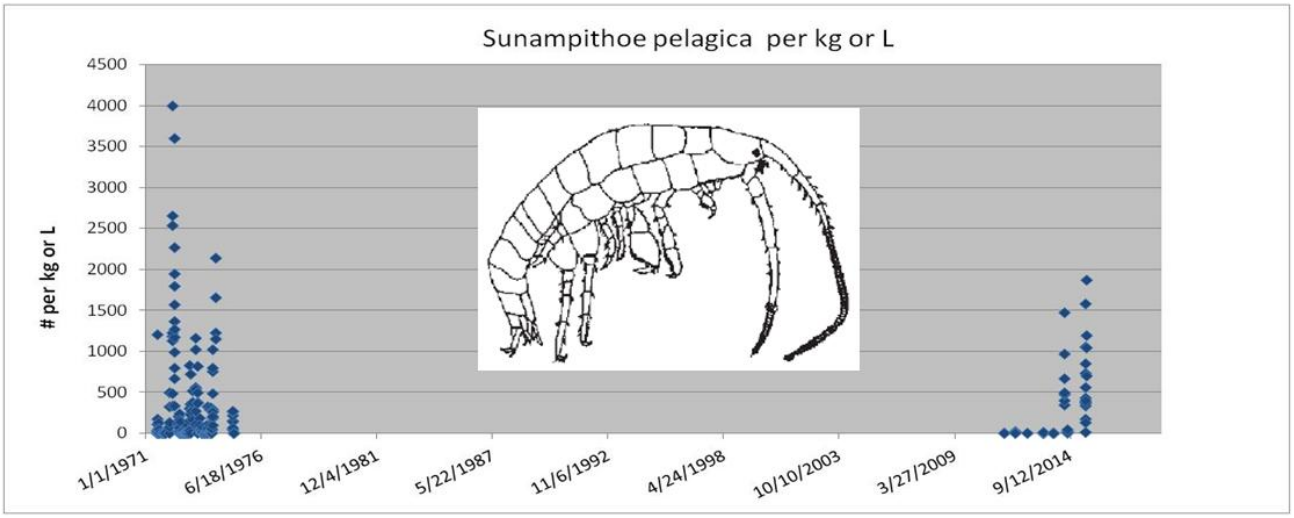

Fig. 7. Scatterplot of abundance of the amphipod *Sunampithoe pelagica* comparing all the Butler et al 1983 samples to all recent samples.

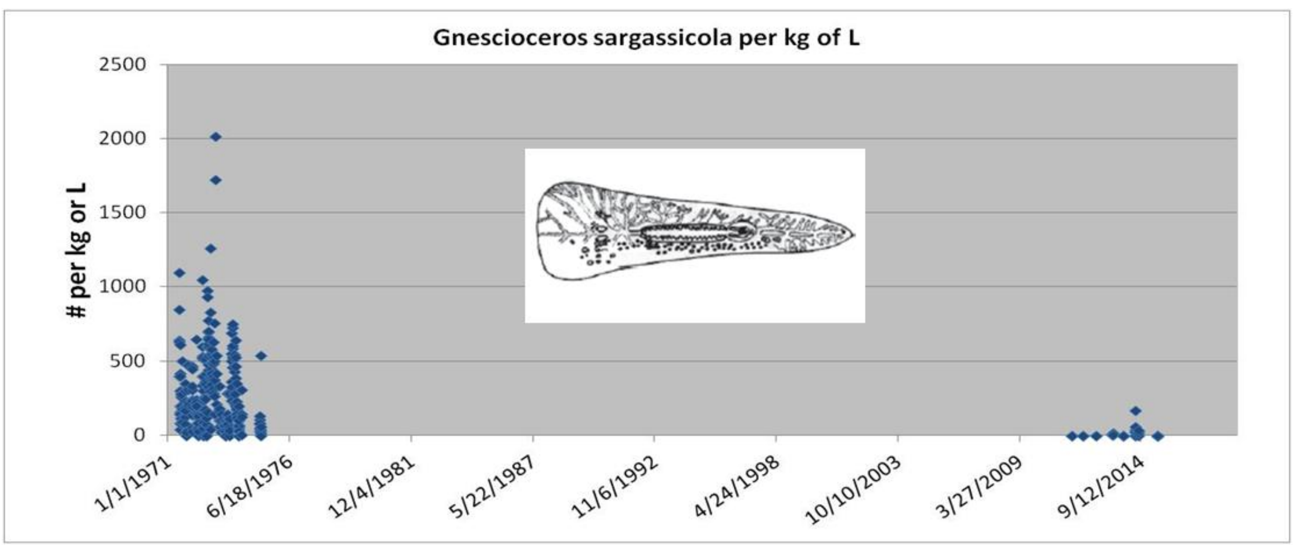

Fig. 8. Scatterplot of abundance of the flatworm *Gnescioceros sargassicola* comparing all the Butler et al 1983 samples to all recent samples.

Table 4 Plastic particles observed in dip net samples

Date	Sample #	Sargassum wet wt (g).	# pieces	pieces/ kg wet wt. Sargassum
5-Jun-15	SD 1-1	15.3	0	0.0
5-Jun-15	SD 1-2	6.8	1	147.1
5-Jun-15	SD 1-3	24.1	4	166.0
6-Jun-15	SD 2-1	85.6	31	362.1
6-Jun-15	SD 2-2	26.9	4	148.7
6-Jun-15	SD 3-1	35.3	11	311.6
6-Jun-15	SD 3-2	32.5	4	123.1
6-Jun-15	SD 3-3	68.5	10	146.0
6-Jun-15	SD 3-4	27.6	4	144.9
6-Jun-15	SD 4-1	23	6	260.9
6-Jun-15	SD 4-2	26.2	1	38.2
6-Jun-15	SD 4-3	49.5	6	121.2
6-Jun-15	SD 4-4	25.1	2	79.7
9-Jun-15	SE 1	400.2	16	40.0
9-Jun-15	SE 2	107.4	13	121.0
9-Jun-15	SE 3	94.5	3	31.7
9-Jun-15	SE 4	303.5	17	56.0
			Mean	135.2
			SE	24.0

<u>Manta trawl samples</u>

The manta trawl in the morning of June 6th captured 29 pieces of plastic marine debris after a 1 hour trawl, covering an area of about 0.0024 sq. km. This equates to ~12,000 pieces of plastic per sq. km. The afternoon trawl on June 6th captured 190 pieces of plastic marine debris after a 1 hour trawl, covering an area of about 0.0024 sq. km. This equates to ~78,600 pieces of plastic per sq. km.

Seabird observation

43 sea birds were observed on June 5th, June 6th and June 9th (Table 5). 26 were shearwater, predominantly great shearwaters (*Ardenna gravis)*, followed by 13 longtails (*Phaethon lepturus catesbyi*), a storm petrel, probably a Leach's (*Oceanodroma leucorhoa*) , a unidentified tern and two unidentified birds. An unusual aggregation of great shearwaters (*Ardenna gravis)* was observed on the *Twin Vee* cruise on June 9th. We were attempting to catch

fishes below a floating rope tangle and one great shearwater came to rest on the water to observe our activity. Within 10 minutes, 3 more joined and then a total of 7 great shearwaters had aggregated around us and followed us for about 20 minutes, stopping when we stopped to dip net *Sargassum*. This behavior is well known to offshore fishermen in Bermuda.

Table 5 Sea bird observations on the Sea Dragon and SE (Twin Vee) cruise June 2015

Date	Location		Time	Species	Note
5-Jun-06	~3 nm s of Spit buoy		13:45	great shearwater	
5-Jun-06	32 13.29111	64 43.8440	14:45	longtail	hdng S
			14:45	great? shearwater	
5-Jun-06	31 55.7270	64 56.7990	18:30	great shearwater	
			20:00	4 great shearwater	
			20:00	1 longtail	
6-Jun-16	31 07.8500	65 27.9082	6:50	great shearwater	
			7:15	longtail	hdng S
			7:18	2 longtails	hdng W
			7:30	1 longtail	plunge dive
			7:40	sooty? shearwater	hdng E
			7:45	longtail	hdng S
			7:50	longtail	
			7:50	shearwater, white chest	
6-Jun-15	31 29.5524	65 16.8701	12:00	3 longtails	plunge dive
6-Jun-15	31 35.1016	65 13.8808	12:50	2 greater shearwaters	
				2 other birds	
				1 tern forked tail, black cap	
6-Jun-15	31 47.6196	65 03.6654	18:05	3 great shearwaters	
				longtail	
6-Jun-15	~2 nm SE of Plantagent Bank		19:00	2 great shearwater	
			20:00	1 great shearwater	
7-Jun-15	~2 nm S of John Smith's Bay		7:00	1 great shearwater	
9-Jun-15	32 14 06.5	64 31 36.0	14:00	7 great shearwaters	resting
			14:30	longtail	hdng S
			15:00	Leach's storm petrel	hdng SE

Fig 5 Great shearwater (*Ardenna gravis)* resting near the Twin Vee on June 9th

Discussion:

The comparison of mobile species data from 2015, 2014, 2013, and 1973 (Table. 3, Fig. 5) showed some significant patterns of changes to the community living within *Sargassum* near Bermuda. In this first assessment current data collected in early summer are compared to a data set from June 1973 in Butler et al (1983). The most significant change observed was with the snail *Litiopa melanostoma* where the number of individuals per kg *Sargassum* wet weight increased significantly in 2015 compared to the other years (Table 3, Fig 5). As well it seems that the abundance of the anemone *Pseudoactinia melanaster* has increased, but not as significantly. The amphipod *Sunampithoe pelagica* seems to be significantly abundant in the *Sargassum* recently, except for the year 2013, and the amphipod *Biancolina sp.* has increased in abundance since the1973 data. The isopod *Bagatus minutus (*now *Carpias minutus)* was very abundant in 1973, but in recent years has become rare. *Latruetes fucorum* has been the most abundant of the species of shrimp recently and has had an increase in abundance compared to 1973. The shrimp *Hippolyte coerulescens* has been consistently abundant since 2013 but was not recorded in June 1973.

The apparent changes in patterns of abundance of many mobile invertebrates over time are better evaluated by comparing the recent data sets against the entire Butler et al (1978) data set. Some seasonal variation in patterns of abundance in many taxa are evident in Butler et al (1978) and were noted through statistical analyses by Huffard et al (2014). Thus, there is merit in direct comparisons within seasons. But there is more to be learned by considering the patterns observed in recent data against the patters of variability in the various taxa over the span of the Butler et al study (1971-1975), as this will reveal if the recent apparent high patterns of species abundance had ever been observed previously.

The recent patterns of abundance in the shrimp *Latreutes fucorum,* do show exceptionally high levels against all the historic data (Fig. 6). Also notable is that this shrimp has been consistently present in the recent samples whereas it was very frequently absent in the historical samples. The recent data are evidence that this shrimp has either been released from some predator pressure and/or has had sustained reproductive success that allows the species to remain persistent at high levels over several years. In contrast to this, the amphipod *Sunampithoe pelagica* appears to have increased over time against data from June 1973. But a comparison to the entire data set shows a different picture, where the amphipod's abundance appears to be quite depressed today (Fig 7). Likewise the flatworm *Gnesiceros sargassicola*, is also significantly reduced compared to the historic samples (Fig 8).

Two other assessments of the apparent changes in the mobile species data are worth noting. The apparent high densities of the snail *Litiopa melanostoma* in recent samples were also observed in the Butler et al data but at only one time point (data not shown). If the current high levels observed continue then this pattern would be indicative of a change in the factors that may have limited the snail's population in the past but it is too early to make that conclusion. More strikingly, the persistent abundance of the shrimp *Hippolyte coerulescens,* is unprecedented (Table 3). Butler et al (1983) recorded this shrimp in only 6 of their 246 samples and only at very low levels. Thus we can conclude that several factors must be promoting the survival and successful reproduction of this shrimp over the past 3 years.

The epifaunal species (hydroids, bryozoans, barnacle and spirorbid worms were not common in the 2015 samples, many of them being classified as rare. The only species that was classified higher, as Common, was *Campanularia volubilis* which was not classified as Common in the previous studies (Witczak and Smith, 2014). The recent data are not compared to the Butler et al (1983) due to different assessment techniques. Huffard et al (2104) did note some declines in some epifaunal species, compared to the Butler et al (1983) data.

These recent data from 2105 do show some changes in abundance and diversity of the *Sargassum* fauna that correspond with the study by Huffard et al. (2014). The strong persistent increase in diverse crustaceans (shrimps and amphipods) may be accounted for if their predators (crabs and fishes, based on the food web outlined in Butler et al (1983) have been reduced. The Sargassum crab, *Planes minutes,* appears to have a persistent population, and higher than the June 1973 data (Table 3) but in comparison to the entire Butler et al (1983) the levels may be reduced slightly. So this would not support a predator-release hypothesis for the current high levels of abundance of diverse shrimps and amphipods.

Very little is known about fishes associated with *Sargassum* around Bermuda. Lapointe et al (2014) estimated fish density from ~50-120 fishes per kg of *Sargassum* around Bermuda and other Caribbean locations in cruises done in 1989 and1990. No other data exist for Bermuda. The species listed by Lapointe et al (2014) are similar to other data sets in the Atlantic (Casazza and Ross, 2008) and the great majority of predators (e.g. filefishes). The sampling methodology used by Butler et al (1973) and also in this study (dip nets) is entirely unable to assess fishes associated with *Sargassum* except for the tightly integrated *Histrio* and *Sygnathus* that cling to the seaweed. Thus, the Butler et al food web model is likely very deficient is describing the true feeding relationships and the effects of top predatory fishes. It is difficult to assess if there have been substantive changes in associated fish population in *Sargassum* today, compared to the early 1970s, but concerns about the status of pelagic fishes (jacks, flyingfishes, scad, tuna etc) may be reflected in the *Sargassum* community if their populations have been declining.

The persistent presence of plastic marine debris in our samples indicate a serious threat to many species associated with *Sargassum*, both the resident fishes and invertebrates. Pelagic fishes, seabirds and juvenile turtle also forage in *Sargassum* and in open waters and are likely to ingest plastic in error (Boerger et al, 2008; Wilcox et al 2016). The high density of floating plastic pieces (78,600 per sq km) found in our manta trawl accord with those reported by Lavender-Law et al (2010) for the Sargasso Sea.

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Fig 6. Sea Dragon crew on return from the cruise.

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