Effect of wrack accumulation on salt marsh vegetation, Jamaica Bay Wildlife Refuge, New York City, New York

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Abstract

In April 2004, five arrays in different types of salt marsh vegetation were covered with 15-20cm of wrack secured in place, in an attempt to duplicate the natural deposition of wrack on the marsh by tides and storms, and to quantify and extend anecdotal observations and the results of previous studies. A control plot in each array was left uncovered; another plot was covered with only 2-3cm. The wrack was removed from one plot in each array at one, two, four, and six month intervals. Up to two months of wrack coverage appeared to have little effect on either density or standing crop (recorded six months after initial coverage) of the principal marsh species, *Spartina alterniflora, S. patens, Distichlis spicata, Juncus gerardii,* and marsh margin *Phragmites australis*. Except for *Phragmites,* however, these species appeared to be strongly inhibited after four months of continual coverage, and killed or extremely inhibited after six months. Wrack 2-3cm thick (never removed) appeared to inhibit the aforementioned species after six months, but not as much as the 15-20cm wrack mat. These results are fairly consistent with those of an earlier study that focused on *Spartina alterniflora* only, except that two months' coverage seemed sufficient to kill back most of the *S. alterniflora* in that study. *Phragmites'* apparent resistance to wrack cover can be explained by the considerable energy reserves of its large rhizomes and the ability of its awl-like shoots to penetrate a thick wrack mat. Future studies should focus on recovery of the vegetation once the wrack has been removed, and on chemical changes in the soil caused by the decaying wrack, which may in turn affect the future course of vegetation development.
Keywords: salt marsh, wrack, Jamaica Bay, wildlife refuge, New York.

1 Introduction

Wrack, composed mostly of dead marsh plant stems and leaves, primarily *Spartina alterniflora* (salt marsh cordgrass) with lesser amounts of *Phragmites australis* (tall reed), is naturally deposited upon salt marsh vegetation by tidal action. If wrack is thick enough and covers the marsh grasses and forbs for a sufficient period of time, it will smother and kill the salt marsh plants, with the exception of the woodier, more robust *Iva frutescens* ssp. *oraria* (high tide bush). In an earlier study [3], *Spartina alterniflora,* at least its above-ground parts, at Jamaica Bay Wildlife Refuge was killed in plots covered with wrack for 60 consecutive days or longer.

Spartina alterniflora is the dominant plant over approximately 70 percent of the total area of salt marsh at Jamaica Bay Wildlife Refuge [1, 3]. Monocultures of this coarse rhizomatous perennial grass occupy two of the arbitrarily determined vegetation zones within the salt marsh described by Stalter and Lamont [6], the high low marsh and low low marsh or creek bank marsh. Other important salt marsh species are *Spartina patens* (salt meadow grass), *Distichlis spicata* (spike grass), and *Salicornia spp.* (salt wort/glass wort). *S. alterniflora* occasionally may be found in a third sub community, the lower upper marsh, dominated by *Distichlis spicata* and *Spartina patens*. A fourth community, the high upper marsh, is dominated by *Iva frutescens* ssp. *oraria*. A fifth sub community, dominated by *Juncus gerardii* (black rush) occupies a small portion of the Jamaica Bay salt marsh.

1.1 The problem

In the aforementioned study, Byer et al. [3] examined the effect of the accumulation of wrack only in plots where *Spartina alterniflora* was dominant. The objective of this present study was to investigate the effect of extended wrack coverage in five vegetation zones including the *Spartina alterniflora* monoculture. Monitoring of the experimental manipulation of wrack mats may provide quantitative information useful in interpreting the following: (1) the time needed to smother and kill major salt marsh species within several undisturbed salt marsh vegetation types, (2) successional relationships as various salt marsh species invade plots uncovered following extended wrack coverage, (3) the time needed for each of the original species in each sub community to reach parity with that species' importance before the artificial disturbance, (4) how long it takes wrack mats to decompose on site in each vegetation type.

1.2 Site description

The following vegetation types can be identified in Jamaica Bay salt marshes:

1) The *Phragmites australis* community that colonizes fresh to brackish marshes, a near-monoculture of the named species. This is not a salt marsh community, but is included in this study because it often borders salt marshes at Jamaica Bay.

2) The *Spartina patens/Distichlis spicata* community occupies higher elevations within the marsh. This community may be dominated by either species, and may also contain *Limonium carolinianum* (sea lavender) and *Salicornia europaea* (glass wort).
3) The *Juncus gerardii* (black rush) community, essentially a monoculture, generally occupies ground over an abandoned road bed at Jamaica Bay Wildlife Refuge.
4) The *Spartina alterniflora* community, also a near monoculture, is found at relatively low elevations. A tall form up to 2m occupies creek banks while a shorter form, generally less than 1m, occupies "higher" ground. Environmental factors may be responsible for the different growth forms [3]. Our study site was confined to the zone occupied by the tall form.

2 Methods

Five arrays of permanent experimental plots were established in the above communities, with two arrays in the *Spartina patens/Distichlis* community. The dominant taxa in these arrays were the most abundant salt marsh species at Jamaica Bay Wildlife Refuge (Table 1). Vegetation in each of the above consisted of nearly pure stands of each species with the exception of the *S. patens/Distichlis* community. Within the latter, one array was placed at a site where *S. patens* was dominant and *Distichlis* a less abundant associate; the second, where *Distichlis* was dominant and *S. patens* an unimportant associate. Each array was 1.5m wide and consisted of eight 1m x 1.5m plots in a row roughly parallel to the water's edge. In each of these plots, a central 0.5m x 1m sample plot was marked off, surrounded by a 0.25m wide buffer zone (0.5m between adjacent sample plots). Each array was GPS-located and permanently marked at the corners, as were the 1m x 1.5m and the 0.5m x 1m plots.

Table 1: Relative abundance of salt marsh species, Jamaica Bay, New York. Abundance data from Stalter and Lamont [6]. Vascular plant species classified according to Gleason and Cronquist [4].

Species	**Abundance**
Aster tenuifolius	infrequent
Atriplex hastate	infrequent
Distichlis spicata	frequent
Iva frutescens ssp. *oraria*	infrequent
Juncus gerardii	frequent
Limonium carolinianum	infrequent
Salicornia europaea	frequent
Spartina alterniflora	frequent
Spartina patens	frequent
Suaeda calceoliformis	infrequent
Suaeda maritima	infrequent

At the start of the experiment, October 2003, all plots were sampled to provide baseline data. The parameters sampled, in the initial and all subsequent observations, were: number of shoots by species, plant height as a mean of three measurements taken in each of four quarters of the sample plot and in the center, and visual cover estimates.

In early April 2004, wrack was collected and placed upon each array, except for one control plot and one plot designated to duplicate the conditions used by Bertness and Ellison [2] in their experiments, at a thickness of 15-20cm. The latter plot, hereinafter called the "Bertness Plot", was covered with only 2-3cm of wrack. Wrack was oriented parallel to the long axis of the arrays insofar as possible. To secure the wrack for the duration of the study, fish netting with 6.5cm mesh was laid over the wrack-covered arrays and held in place with a peripheral rope tied to stakes at the corners of the array and attached to the netting with special snap clips purchased from Forestry Suppliers of Jackson MS. Fifteen cm wire staples were used to fasten the rope to the ground. An additional rope was attached at each end of the array at the center and stretched taut down the length of the array.

Table 2: Denisty (stems/m^2) of salt marsh species in five sub communities at a Jamaica Bay salt marsh. The plant communities (arrays) are (1) *Spartina alterniflora* community, (2) *Spartina patens/Distichlis spicata* community dominated by *S. patens*, (3) *Spartina patens/Distichlis spicata* community dominated by *Distichlis*, (4) *Juncus gerardii* community, (5) *Phragmites australis* salt marsh border community. All plots were sampled between 1 and 15 October, 2004 in plots covered with wrack in early April 2004, wrack removed after the number of months indicated.

Array	Species	Control	1 month	2 months	4 months	6 months	Bertness
1	*Spartina alterniflora*	1,400	1,600	1,400	100	-	100
2	*Spartina patens*	5,735	4,276	2,500	700	-	100
	Distichlis spicata	-	-	900	2,300	500	100
	Phragmites australis	100	-	-	-	-	-
3	*Distichlis spicata*	3,958	2,700	1,900	1,100	-	1,100
	Spartina patens	1,200	-	-	-	-	-
	Phragmites australis	-	100	100	-	-	-
4	*Juncus gerardii*	4,433	1,556	2,179	2,288	400*	200*
5	*Phragmites australis*	64	144	64	32	32	32

In May 2004, one plot in each array was uncovered and sampled. Subsequently, one plot in each array was uncovered and sampled in June, August and October 2004. During all marking, manipulation, and sampling of the arrays and plots, attention was given to minimize trampling and disturbance of the study plots.

During 1-15 October 2004, vegetation within each experimental plot and the control were sampled with three randomly located 10x10cm quadrats. Stems were first counted, by species. Then, the vegetation was cut at ground level. Standing crop (gms. of vegetation/m^2) was determined. Data is presented in Tables 2 and 3.

Table 3: Standing crop (gms/m^2) of salt marsh species in five sub communities at a Jamaica Bay salt marsh. Plant communities (arrays) and wrack covering and removal schedule as in Table 2. Sampling was done between 1 and 15 October 2004.

Array	Species	Control	1 month	2 months	4 months	6 months	Bertness
1	*Spartina alterniflora*	579.8	886.5	813.4	122.7	-	3.5
2	*Spartina patens*	546.1	641.5	346.2	26.7	-	171.4
	Distichlis spicata	-	-	163.7	0155.7	182.9	31.6
	Phragmites australis	173.9	-	-	-	-	-
3	*Distichlis spicata*	476.6	290.4	267.1	61.6	-	252.3
	Spartina patens	98.2	-	-	-	-	-
	Phragmites australis	-	44.8	117.1	-	-	-
4	*Juncus gerardii*	240.1	152.4	229.7	296.8	26.1	104.3
5	*Phragmites australis*	1,591.0	703.0	93.9	353.0	786.0	678.0

3 Results and discussion

Taking into account the small sample size, most of the species, in most of the arrays, show no tendency to decline in either density or standing crop after one or two months of wrack coverage. After four months of coverage, some species, e.g. *S. alterniflora* in Array 1, *S. patens* in Array 2 and *Distichlis* in Array 3, appear to show a marked tendency to decline in both density and standing crop. After six months of coverage, most of the species in most arrays have been completely killed back, or at least drastically reduced in both numbers and standing crop.

Compared to results from an earlier study [3], in which two months of wrack coverage was found to kill most of the above-ground parts of *S. alterniflora,* here a notable reduction was not evident, including in the latter species, until wrack had remained on the plots for four months. At this time we can suggest no reason for this difference.

Distichlis was present in the two, four and six month plots in Array 2. It appeared to tolerate wrack cover at this site better than the dominant *S. patens. Distichlis* produces thicker culms than those of *S. patens,* which may have enabled spike grass to penetrate wrack cover. Also, most *Distichlis* biomass was rhizomes, which, unlike photosynthetic tissue, may be little impacted by exclusion of light so long as their energy reserves are not exhausted. Why, then. *Distichlis* in Array 3, where it is the dominant species, appears to be more vulnerable is hard to explain. Perhaps differences in one or more environmental factors between the two arrays are responsible.

Phragmites is the lone species that showed no declining trend with long-term wrack coverage. The large size of this grass, the large energy reserves of its rhizomes, and an ability of its awl-like shoots to penetrate 15-20cm of wrack may provide it relative immunity to wrack impact.

In the Bertness plots, from which wrack was not removed before observations were made in October 2004, both density and standing crop of all species were somewhat to considerably less than in the controls of the same arrays. It thus appears that even the relatively thin wrack layer placed on these plots was somewhat effective in killing the plants underneath and/or in suppressing their growth, although not as effective after six months as the thicker, 15-20cm layer that had been placed on the other experimental plots.

In general, the results of this experiment are consistent with those of the earlier study cited [3] involving *Spartina alterniflora* alone, and with the anecdotal observations of many ecologists [2, 5]. Long-term residence of wrack on salt marsh vegetation tends to kill it back, as one would expect of any substance or object that excludes sunlight from the vegetation. After the wrack is removed, either by human hands or by natural forces such as tides and storms, a bare patch may be exposed. This, however, does not appear to lead to permanent change in the marsh vegetation. The patch is soon recolonized. If the wrack has not remained on the area long enough to kill the rhizomes beneath it, these may produce new shoots of the same species that were killed back, or rhizomes may grow into the area from the un-impacted surrounding vegetation. Sometimes the bare patch is invaded by the annual *Salicornia europaea*; numerous dense patches of this species can be seen within the marsh. Although further studies will be necessary to clarify the role of *Salicornia* in salt marsh dynamics, it seems probable that it is a stage in a micro-succession, and that these patches will soon be re-invaded by the original dominant species.

Another question deserving of further study is how the presence of wrack on an area may change the soil chemistry, and how this may affect the subsequent dynamics of the vegetation.

A comparison of Bertness and Ellison's [2] results with our own shows that, when continuously covered with only 2-3cm of wrack in a Rhode Island salt marsh, the same species involved in our study were completely killed much more quickly (within 35 to 70 days depending upon the species) than when covered with 15-20cm in our own plots (4 to 6 months, or ~120-180 days). An examination of the methods used by these authors may provide the key to these differences. They uncovered their plots briefly each week for monitoring purposes, then replaced the wrack and netting. This regimen likely resulted in much disturbance and mechanical damage to the plants as wrack and netting were repeatedly removed and replaced. This could have been a major factor in the relatively rapid demise of Bertness and Ellison's plants. We think that our protocol of using plots covered for differing periods of time, covering and uncovering each plot only once, caused less disturbance and gave a truer indication of the impact of the wrack itself on the plants.

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