Identification of Fouling Organisms Covering Mussel Lines and Impact of a Common Defouling Method on the Abundance of Foulers in Tracadie Bay, Prince Edward Island.

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ABSTRACT

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Mussel growers are constantly searching for the most effective and profitable ways to reduce fouling on their mussel lines. In Prince Edward Island, they allow the socks to touch the bottom so that rock crabs (*Cancer irroratus*) may climb on them and dislodge or consume some of the fouling. After a few weeks, the socks are resuspended in the water column. A study was undertaken in summer and fall 2001 to verify the effectiveness of this method in reducing the abundance of foulers. This study also identified the species of foulers present in Tracadie Bay (P.E.I.) in relation to the season. Our results showed that the main foulers were the ascidian *Molgula* sp., red algae, mussel spat, the gastropod *Crepidula fornicata*, crustaceans (e.g. caprellids, gammarids) and the bryozoan *Bugula turrita*. Fouling community composition varied over time. Foulers first appeared in July; by August, the most common fouler was *Molgula* sp. Its biomass declined as the season progressed while mussel spat increased in biomass until it became the dominant species in December. Our results also showed that the method was not effective for reducing fouling. However, it had a significant effect on mussel growth. Mussels that underwent this treatment were longer and heavier than mussels that were not in contact with the bottom; however their condition indices were lower. The results of this study suggest that the method of defouling does not effectively reduce fouling. A study on the competition between mussels and foulers, however, shows that the impact of foulers on mussels is not as great as perceived by growers (LeBlanc 2003).

RÉSUMÉ

LeBlanc, A.R., T. Landry and G. Miron. 2003. Identification of Fouling Organisms Covering Mussel Lines and Impact of a Common Defouling Method on the Abundance of Foulers in Tracadie Bay, Prince Edward Island. Can. Tech. Rep. Fish. Aquat. Sci. 2477 :vii + 18 p.

Les mytiliculteurs sont toujours à la recherche de méthodes efficaces et peu onéreuses afin de réduire les épibiontes qui se retrouvent sur leurs lignes de moules ainsi que sur les moules. À l'Î.P.É., les aquiculteurs laissent les boudins toucher le fond afin de permettre aux crabes communs (*Cancer irroratus*) de grimper et de nettoyer en partie, cette épifaune. Les boudins sont remontés après quelques semaines. Une étude a été entreprise durant l'été et l'automne 2001 afin de vérifier l'efficacité de cette méthode, à savoir la réduction de la biomasse des organismes présents sur les moules. Cette étude a également permis d'identifier les espèces composant la communauté épifaunique dans la baie de Tracadie (Î.P.É.) selon la saison. Les salissures les plus communes étaient l'ascidie *Molgula* sp., des algues rouges, des naissains de moules, le gastéropode *Crepidula fornicata*, plusieurs crustacés (p.ex. caprellidés, gammaridés) et le bryozoaire *Bugula turrita*. La biomasse des espèces composant l'épifaune a varié au cours de la saison. L'épifaune est apparue seulement en juillet. En août, l'espèce la plus commune était *Molgula* sp. Par la suite, la biomasse de *Molgula* sp. diminue et celle des naissains de moules augmente et domine en décembre. Nos résultats montrent également que la méthode n'est pas efficace pour contrôler le recrutement de l'épifaune. Elle a cependant montré un effet significatif sur la croissance des moules. Les moules ayant subi ce traitement étaient plus longues et plus lourdes que les moules qui n'ont pas touché le fond mais leurs indices de condition étaient plus faibles. Les résultats de cette étude suggèrent qu'une autre méthode de gestion devrait être développée puisque celle-ci ne réussit pas à réduire l'abondance de l'épifaune. Des études sur la compétition entre les moules et l'épifaune sont nécessaires afin de mieux comprendre les impacts de cette dernière sur la croissance et la productivité des moules.

INTRODUCTION

Many marine invertebrates have pelagic larvae that require a substrate on which to attach and grow (Barnes 1987, Bertness 1999). Biotic (e.g., oyster reefs) and abiotic (e.g., wharves) structures can serve as substrates. Structures for culturing bivalves are often used as settling grounds by various types of larvae. These foulers can be harmful to aquaculture operations (Arakawa 1990, Cayer et al. 1999, MacNair and Smith 1999, Uribe and Etchpare 1999). Some of them can smother the cultivated bivalves (e.g., algae settling on oyster cages, ascidians accumulating on mussel lines) and reduce water flow (Hunter 1992, Lodeiros and Himmelman 1996). This in turn can lead to a reduction in food availability and reduced growth (Claereboudt et al. 1994, Lodeiros and Himmelman 1996, Taylor et al. 1997). Furthermore, massive fouling increases the weight of the floating structures, rendering them less buoyant, and with time, more likely to sink. This translates into a requirement for additional equipment and more labor to maintain the mussels in the water column.

Some epifaunal organisms are filter feeders, and may compete with bivalves for food (Ellis et al. 2002). Others, such as starfish, may be predators. In contrast, certain species may have beneficial effects. For instance, detritivores such as polychaetes could clean sediments and faeces from clusters of bivalves. Furthermore, certain foulers may prey on species that compete with bivalves for food, such as gastropods that feed on ascidians (Ellis et al. 2002, Osman et al. 1992, Osman and Whitlatch 1995, 1996, 1998, 1999).

Amongst mussel growers, epifauna is perceived as being detrimental to their operations. In Prince Edward Island, Canada, mussels are grown on socks hung on long lines. As previously explained, mussel socks present a suitable place for larvae to settle. The growth of mussels and foulers increases the weight of the socks. As a result, the socks are dragged to the bottom. The most common defouling method practiced by growers is to allow socks to remain on the bottom for a period of time (a few days to a few weeks). The grower then adds buoys to raise the socks to eliminate contact with the bottom. This activity is repeated two to three times during the growing season. When socks touch the bottom, rock crabs (*Cancer irroratus*) gain access to them. Growers

believe that crabs dislodge the epifauna and/or consume part of it. The lines are eventually raised in order to dislodge the crabs, only when they are believed to begin preying on mussels. Lowering and raising the lines may also have an impact on the epifauna.

The objectives of this study were to identify and quantify the species of foulers found in Tracadie Bay (PEI) and to evaluate the effect of the current defouling method on fouling biomass and on mussel growth. It is hoped results from this study will benefit growers by finding effective methods for managing mussel socks.

MATERIALS AND METHODS

Mussel socks were collected from Tracadie Bay, P.E.I., on an approximately monthly basis, on May 31st, July 6th, July 23rd, August 28th, September 26th, October 23rd and November 27th, 2001. The socks were about 2.5 m long and placed at depths of 3 to 4 m depending on tidal cycle. A section of line was prevented from touching the bottom with buoys, and represented our control treatment. The producer managed another section of the same line the same way as his market mussels. These socks eventually touched the bottom as the weight of the growing mussels and foulers increased. The grower allowed them to touch the bottom for a few weeks, and then raised them by adding buoys. This activity was undertaken 2 to 3 times during the sampling period and, for the purpose of this study, they were considered as the treated socks.

Divers placed onion bags (1mm mesh size) over the socks to limit the loss of organisms immediately before collection. Four socks were collected from each section of line at each sampling period. The socks were individually weighed and placed in containers for transport. At the lab, mussels and foulers were manually separated from each other. In July and August, the foulers were fixed in formaldehyde and then preserved in 70% ethanol. For the September to November samples, the foulers and mussels were mixed after separation so that they would be equally distributed in the container. Because of the large quantity of foulers, a subsample form each sock was removed and weighed. Foulers and mussels in each subsample were subsequently

separated and weighed. Foulers were frozen for later identification. For all samples, 30 mussels were frozen for later condition index analysis. After identification, foulers were separated by species (lowest taxa level possible) then dried at 70°C for 48 hours, weighed, ashed at 500°C overnight and weighed again.

The May 31st data were not included in the analyses because control socks were not collected, therefore, no comparison was possible. The total wet weight of socks, the wet weight of mussels and the wet weight per mussel were compared using randomized blocks analysis of variances (ANOVA). The date of sampling was blocked and the factor was the treatment (control and defouling method). The wet weight per mussel was calculated by dividing the total weight of mussels in the subsample by the number of mussels in that subsample. The ash-free weights (AFW) of all foulers on socks were compared using two-factor Kruskal-Wallis tests because equal variances were not obtained despite transformations. The factors were date and treatment. The same was done for each species of foulers except isopods, barnacles and jingle shells (*Anomia* sp.) because they were not frequent enough. Shell length and condition indices ([ash-free flesh weight/dry shell weight] * 100) of mussels were also compared with two-factor Kruskal-Wallis tests with the same factors. Probability levels were fixed at 0.05. Analyses were carried out using SPSS 10.0® for Windows.

RESULTS

The weight of the socks varied from 3.75 (±0.10) kg in late May to 13.35 (± 0.60) kg in November. Foulers began appearing in July, but biomass was very low. Biomass increased until it peaked in September for the control socks and in October for the defouled socks (Fig. 1). However, treatment did not significantly reduce foulers ($H=0.14$, $P>0.5$). The species composing the fouling community also varied with time (Table 1). In late August, the sea squirt *Molgula* sp. dominated, constituting about 70% of the biomass of foulers, while in December, mussel spat was the dominant fouler at about 70%. Other common groups were red algae, polychaetes, *Gammarus* sp., *Bugula turrita*, the slipper shell *Crepidula fornicata*, and caprellids. The gastropods *Astryris lunata* and *Bittium alternatum* were also found on the socks. The jingle shells *Anomia*

sp., isopods and barnacles (*Balanus crenatus*) were found on a few socks and in very small numbers. The analysis of the ash-free dry weights of the different species of foulers showed a significant interaction between date and treatment for all species tested (Table 2) meaning that the factors could not be analysed separately. An interaction implies that the differences between the treatments, whether significant or not, were not of the same magnitude for each date.

The total wet weight of socks (Fig. 2), the wet weight of mussels on socks (Fig. 3) and the weight per mussel (Fig. 4) increased when the treatment was applied (Table 3). The block effect (dates) was also significant (Table 3). For condition indices (Fig. 5) and shell length (Fig. 6), there was a significant interaction between date and treatment (Table 4).

DISCUSSION

Our results showed that the defouling method currently used by growers is not effective in reducing fouling organisms. They also demonstrated that foulers constituted only 10 to 15% of sock weight. This method, however, could have an effect on mussel growth. The method contributed to an increase in sock weight due to larger mussels. The wet weight per mussel for the defouled socks was greater. In addition mussels displayed longer shells and weighed (AFW) more than the control mussels. However, the condition indices of control mussels were higher.

The findings could not be explained by the presence or absence of foulers, since they were equally distributed on mussel socks regardless of treatment. It is, however, understandable why the growers believe the method to be effective. There is a correlation between the reduction in meat yield and the method of defouling used by growers. A possible explanation could be related to spawning. Treated mussels were bigger but had lower condition indices. This might be an indication that they spawned earlier, for a longer period and even perhaps for a second time. Condition indices decreased between August and September (Fig. 4) followed by an increase in the following months. The condition indices of control mussels diminished gradually which could be attributed to

environmental changes related to seasonal fluctuations (e.g. temperature, food availability). These results support the "spawning theory". More studies, however, need to be done in order to better understand the reproduction of cultured mussels and the factors involved.

Foulers started appearing in July and reached their maximum biomass in August. Polychaetes were the first to colonise the socks in July. The ascidian *Molgula* sp. became the most prominent species in late August. It subsequently declined, while mussel spat increased and finally became the dominant species in December. Red algae were also common. They were mostly observed on buoys and lines and at the very top of socks. The community of foulers was very diversified. It included filter feeders, herbivores, detritivores, predators and deposit feeders.

The presence of certain organisms can attract other species. For example, gastropods such as *Mitrella lunata* could be attracted by the presence of ascidians (Osman et al. 1992, Osman and Whitlatch 1995, 1996, 1998, 1999). Ascidians could settle on mussel socks simply because they provide a suitable substrate on which larvae can fix themselves. The presence of detritivores such as polychaetes, caprellids and amphipods could be attributed to sediments and organic matter dispersed amongst the mussels (Arakawa 1990, Mazouni *et al.* 1998a, 1998b). Such organisms can clean the mussels of faeces and silt. Amphipods, like *Gammarus* sp., may also convert unavailable nutrients to nutrients that mussels can then utilise as a food source (Mallet and Mayrand 1995). The ascidian *Molgula* sp., mussel spat, bryozoans and barnacles are all filter feeders (Barnes 1987, Lesser et al. 1992, Bertness 1999, Ellis et al. 2002). They are considered competitors with mussels, though Lesser et al. (1992) demonstrated that most of these groups need to be present in high numbers to significantly compete with mussels. Only one other ascidian, *Ciona intestinalis* has been identified as an important competitor to mussels. This species, however, has not been found in P.E.I. even though another ascidian, *Styela clava*, has recently invaded certain areas of the province, inflicting heavy losses at certain sites. High diversity in a system can prevent or minimise such invasions (McGrady-Steed et al. 1997, Osman and Whitlatch 1999, Stachowicz et al. 1999). The fouling community is a diverse population and by not disturbing it, invasions or even population explosions could be prevented and major economic losses avoided.

More studies on the interactions between foulers, especially between ascidians and mussels are needed. A better understanding of the interactions between the two groups could help sock management. We also need to understand the effects of certain predators on potential prey. An example is the gastropod *Mitrella lunata* and its application as a possible control against ascidian species.

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Table 1. Mean ash-free weights in mg (SE are in parentheses; n = 4) of foulers from socks collected in Tracadie Bay, P.E.I. during the 2001 growing season. C = control; DF = defouled; n/a = data not available; ab = absent.

Species	06/07		23/07		28/08		26/09		23/10		27/11	
	C	**DF**	**C**	**DF**	**C**	**DF**	**C**	**DF**	**C**	**DF**	**C**	**DF**
***Molgula* sp.**	n/a	1 (0)	13 (5)	n/a	3923 (191)	4047 (131)	10 521 (3210)	2275 (850)	1961 (366)	3065 (708)	213 (95)	72 (38)
***M. edulis* spat**	n/a	0 (0)	0 (0)	n/a	1 (1)	737 (414)	2358 (780)	803 (293)	2587 (381)	3031 (685)	5836 (1902)	3209 (736)
Red algae	n/a	2 (0)	254 (38)	n/a	761 (92)	762 (235)	5418 (2260)	510 (332)	1608 (621)	3124 (2323)	507 (320)	2019 (862)
Polychaeta	n/a	63 (6)	89 (11)	n/a	167 (15)	148 (22)	297 (105)	695 (633)	719 (165)	444 (187)	560 (228)	29 (29)
Crepidula fornicata	n/a	ab	ab	n/a	55 (2)	64 (7)	268 (268)	173 (101)	464 (160)	ab	654 (237)	90 (61)
***Gammarus* sp.**	n/a	15 (8)	44 (42)	n/a	168 (65)	84 (59)	157 (70)	ab	ab	ab	ab	ab
Caprellidea	n/a	ab	6 (1)	n/a	206 (34)	174 (5)	783 (256)	9 (4)	416 (108)	211 (124)	66 (32)	9 (4)
Gastropoda	n/a	30 (4)	1 (0)	n/a	4 (1)	24 (5)	10 (9)	2 (2)	32 (32)	6 (6)	6 (6)	ab
Bugula turrita	n/a	ab	0 (0)	n/a	56 (3)	140 (22)	419 (180)	700 (286)	453 (90)	2468 (374)	206 (161)	906 (649)
Isopoda	n/a	0 (0)	0 (0)	n/a	3 (1)	ab	ab	ab	ab	ab	ab	ab
***Anomia* sp.**	n/a	ab	ab	n/a	ab	ab	ab	ab	ab	1 (1)	47 (2)	28 (12)
Balanus crenatus	n/a	ab	0 (0)	n/a	1 (0)	ab	ab	ab	ab	ab	51 (29)	ab

Table 2. Results of two-factor Kruskal-Wallis analyses on the ash-free weight for the species of foulers tested. The factors were date of sampling and treatment (control and defouling).

	DF	H	P		DF	H	P
***Molgula* sp.**				***Gammarus* sp.**			
Treatment	1	0.5	> 0.25	Treatment	1	1.0	< 0.005
Date	4	29.9	< 0.001	Date	4	16.2	> 0.25
Treatment x date	4	383.4	< 0.001	Treatment x date	4	355.8	< 0.001
***Mytilus edulis* spat**				***Bugula turrita***			
Treatment	1	0.1	>0.75	Treatment	1	1.4	> 0.1
Date	4	29.7	< 0.001	Date	4	23.4	< 0.001
Treatment x date	4	441.3	< 0.001	Treatment x date	4	420.1	< 0.001
Polychaetes				***Crepidula fornicata***			
Treatment	1	5.6	< 0.05	Treatment	1	2.2	< 0.05
Date	4	9.8	< 0.05	Date	4	10.0	> 0.1
Treatment x date	4	393.7	< 0.01	Treatment x date	4	373.4	< 0.001
Red algae				**Gastropods**			
Treatment	1	0.4	> 0.5	Treatment	1	0.2	< 0.05
Date	4	13.1	< 0.025	Date	4	9.5	> 0.5
Treatment x date	4	1396.1	< 0.001	Treatment x date	4	321.6	< 0.001
Caprellids							
Treatment	1	7.5	< 0.01				
Date	4	18.4	< 0.005				
Treatment x date	4	395.3	< 0.001				

Table 3. Results of the randomized block ANOVA analysis carried out on total wet weight of socks, total wet weight of mussels and wet weight per mussel. Date of sampling was blocked and the fixed factor was the treatment (control and defouling).

	SS	DF	MS	F	P
Total wet weight of socks					
Treatment	12.107	1	12.107	7.932	0.008
Block (date)	225.261	4	56.315	36.893	< 0.001
Remainder	51.9	34	1.526		
Total wet weight of mussels					
Treatment	11.404	1	11.404	11.404	0.017
Block (date)	232.947	4	58.237	32.151	< 0.001
Remainder	61.585	34	1.811		
Wet weight per mussel					
Treatment	8.813	1	8.813	12.783	0.002
Block (date)	33.591	2	16.795	24.361	< 0.001
Remainder	13.789	20	0.689		

Table 4. Results of two-factor Kruskal-Wallis analyses carried out on shell length and condition indices (CI). The factors were date of sampling and treatment (control and defouling).

	H	P
CI		
Treatment	42.2	< 0.001
Date	25.8	< 0.001
Treatment x date	82 025.4	< 0.001
Shell length		
Treatment	40.7	< 0.001
Date	293.9	< 0.001
Treatment x date	92 286.3	< 0.001

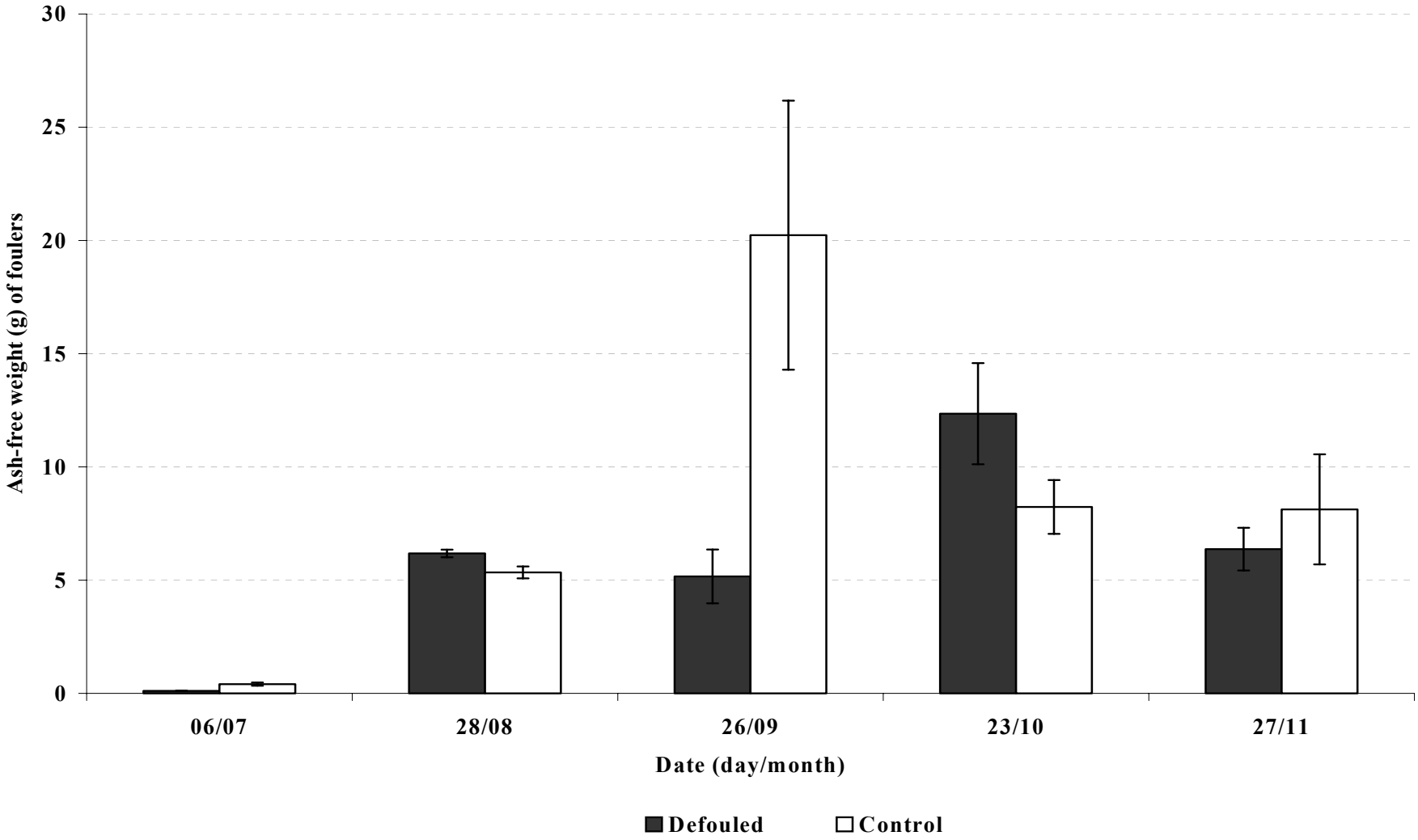

Figure 1. Ash-free weight (g) of foulers, all species included, on mussel socks collected in Tracadie Bay, P.E.I., during the ice-free period of 2001. Means are presented with ± 1SE as error bars, n = 4 for each mean.

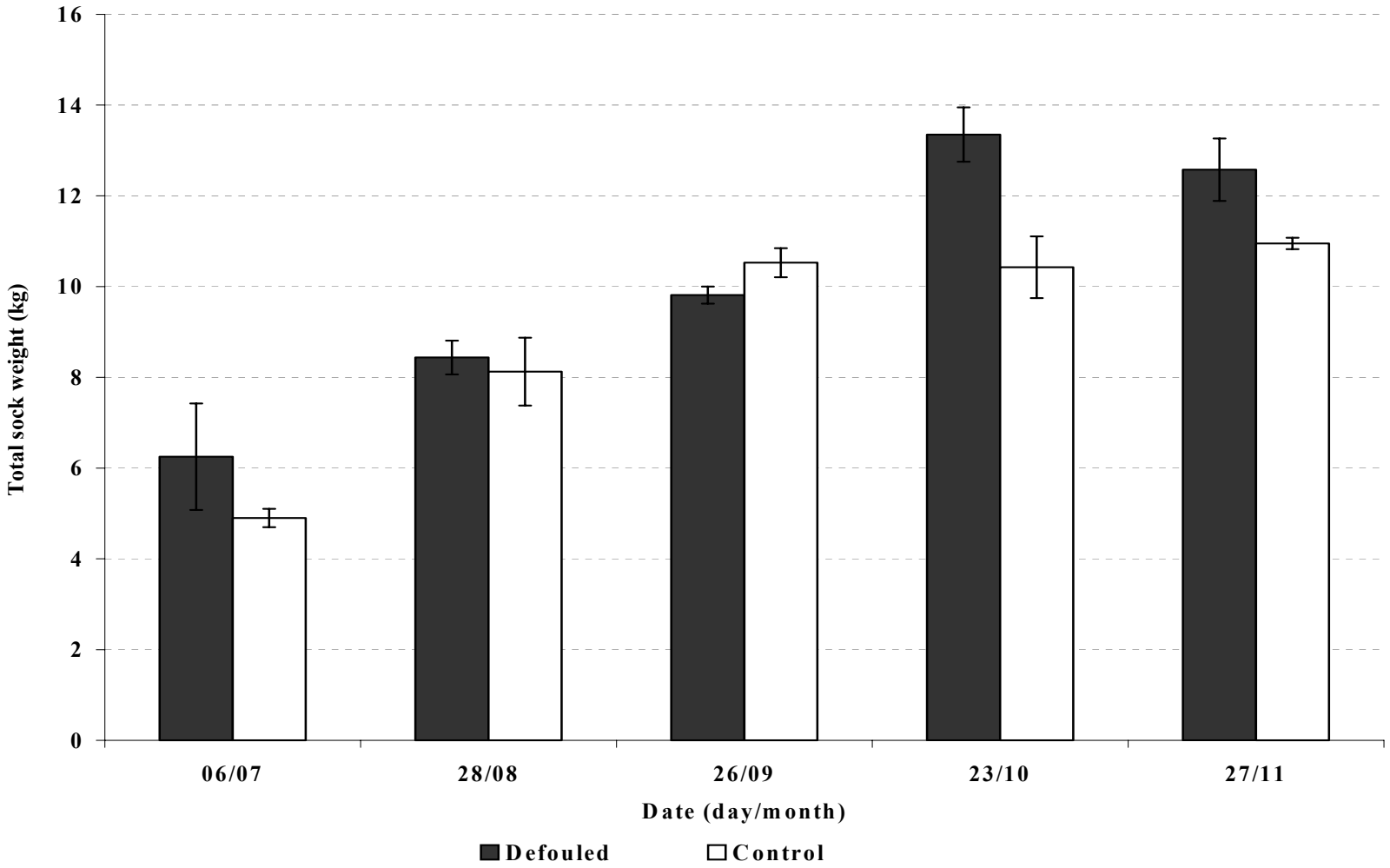

Figure 2. Total weight of mussel socks (kg) collected in Tracadie Bay, P.E.I., during the ice-free period of 2001. Means are presented with ± 1SE as error bars, n = 4 for each mean.

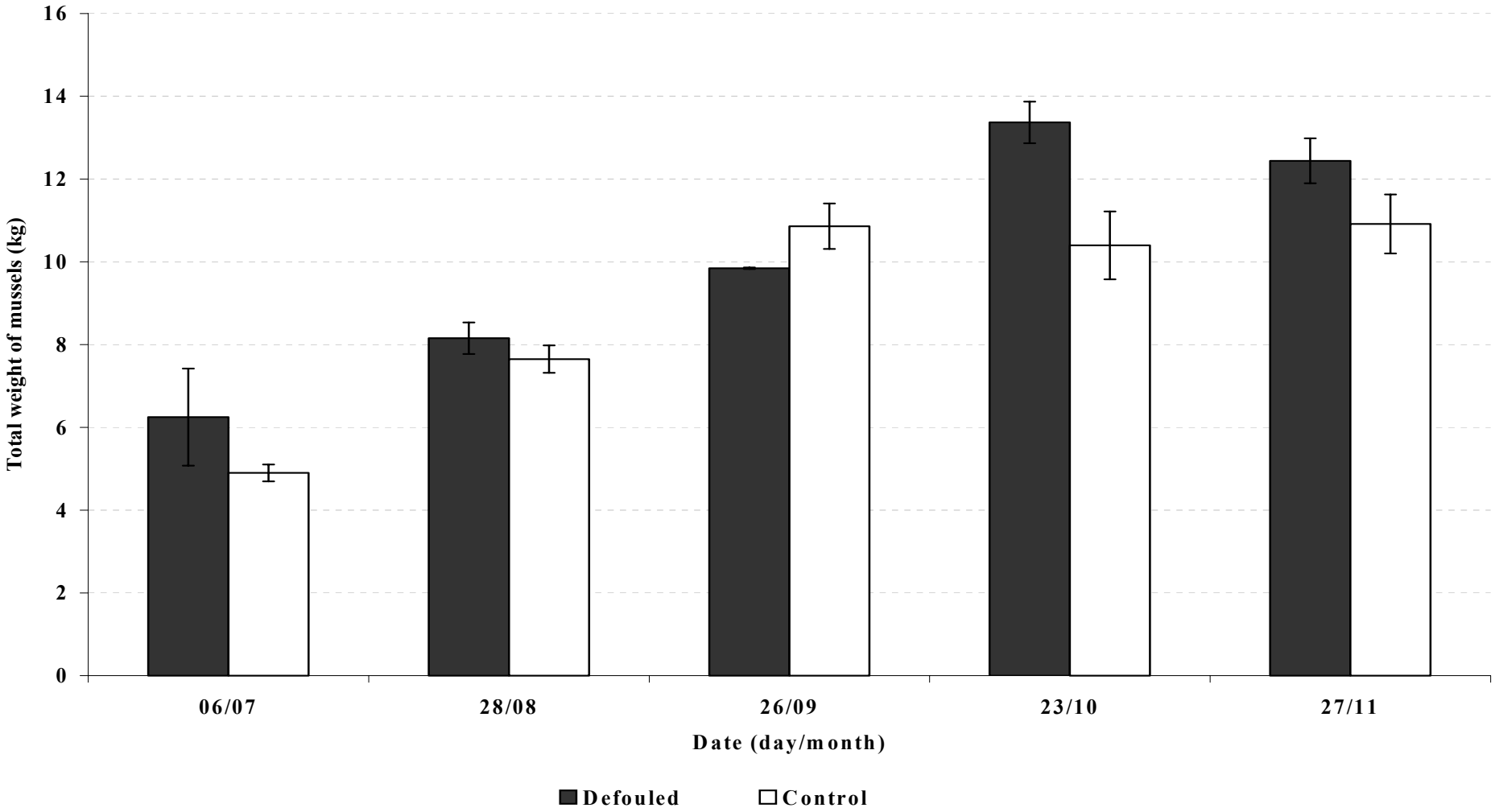

Figure 3. Weight of mussels only (kg) from socks collected in Tracadie Bay, P.E.I., during the ice-free period of 2001. Means are presented with ± 1SE as error bars, n = 4 for each mean.

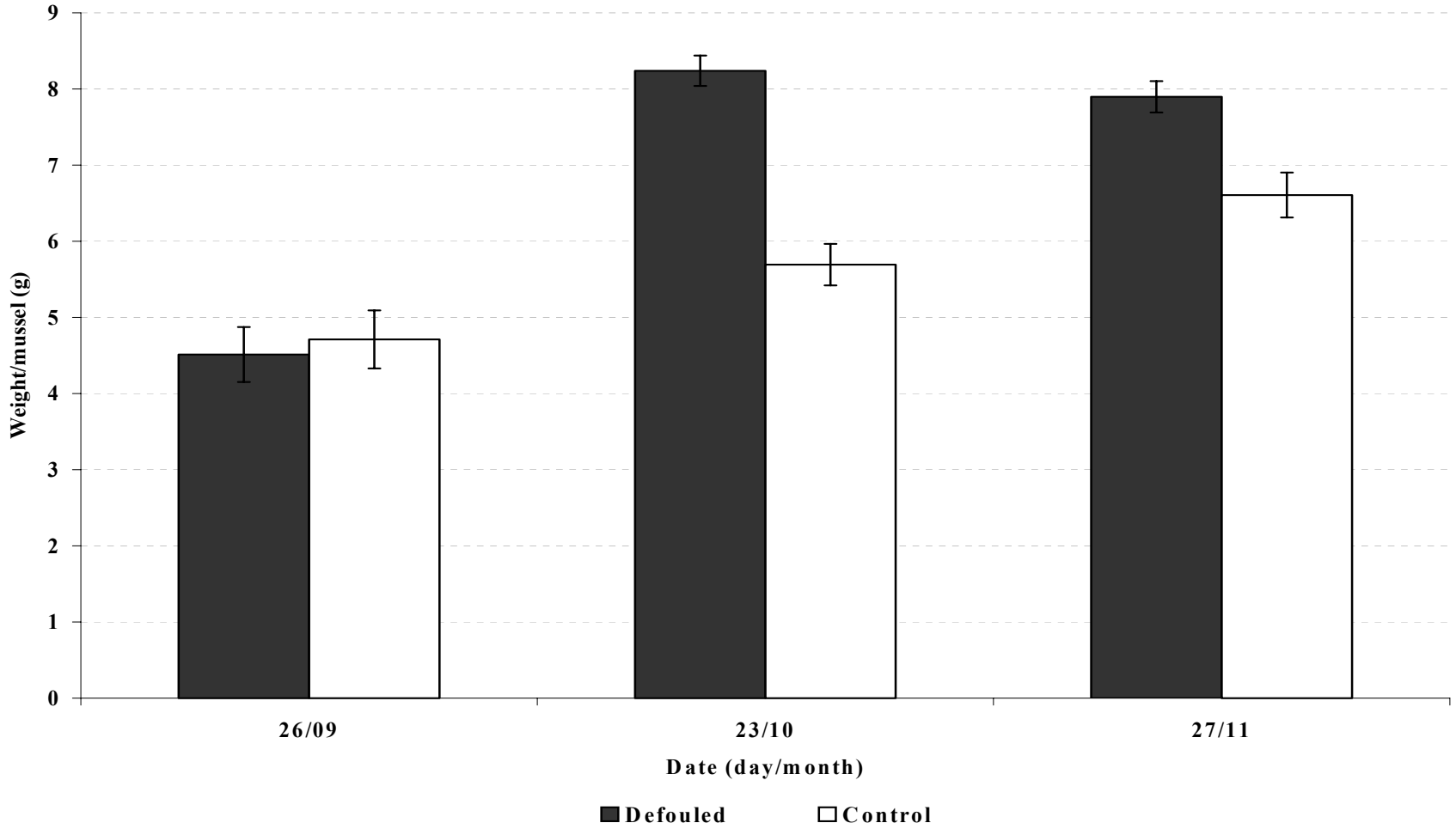

Figure 4. Weight/mussel (g) from socks collected in Tracadie Bay, P.E.I., during the ice-free period of 2001. Means are presented with ± 1SE as error bars, n = 4 for each mean.

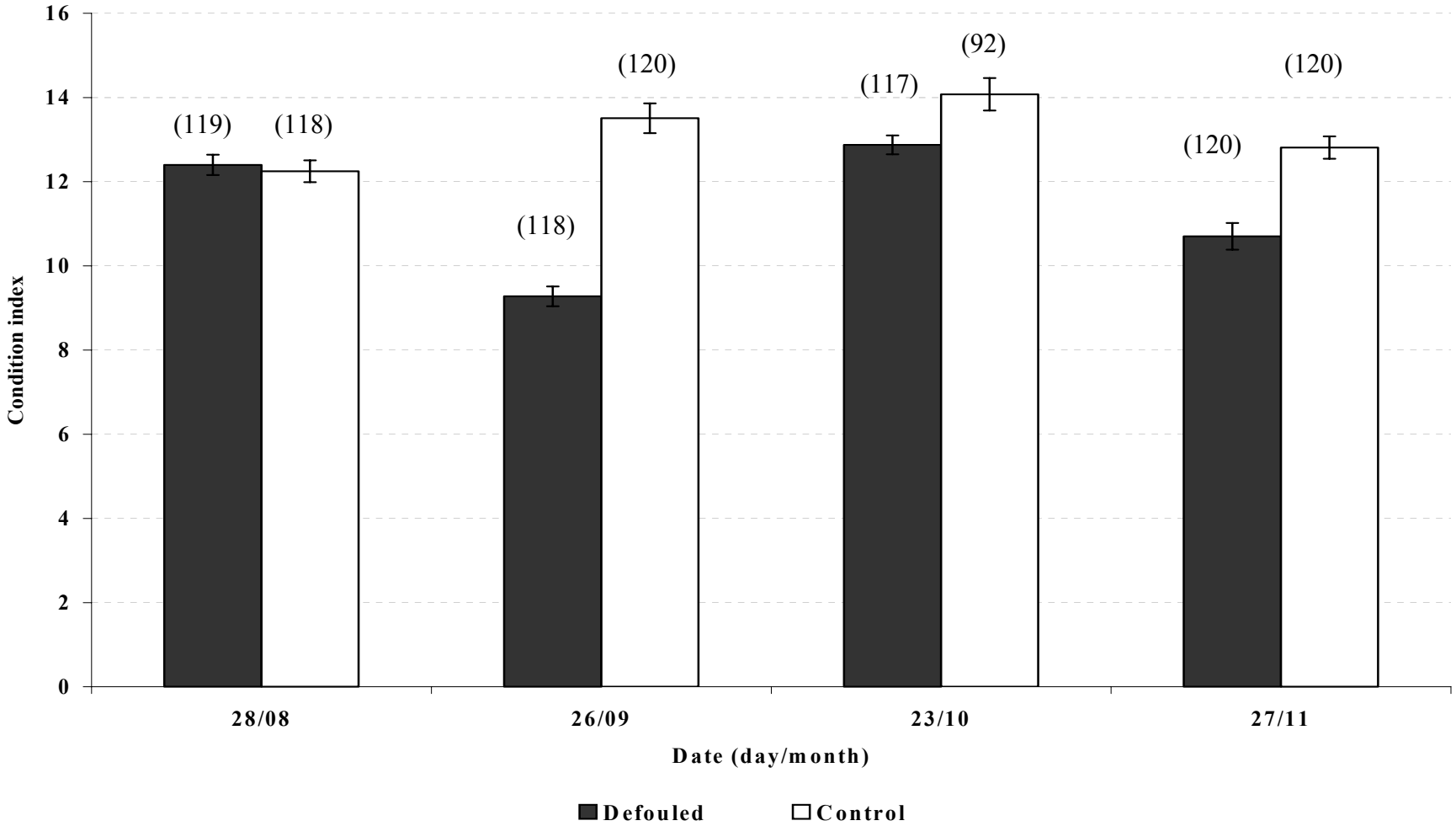

Figure 5. Condition indices of mussels taken from socks collected in Tracadie Bay, P.E.I., during the ice-free period of 2001. Means are presented with ± 1SE as error bars, n in parentheses.

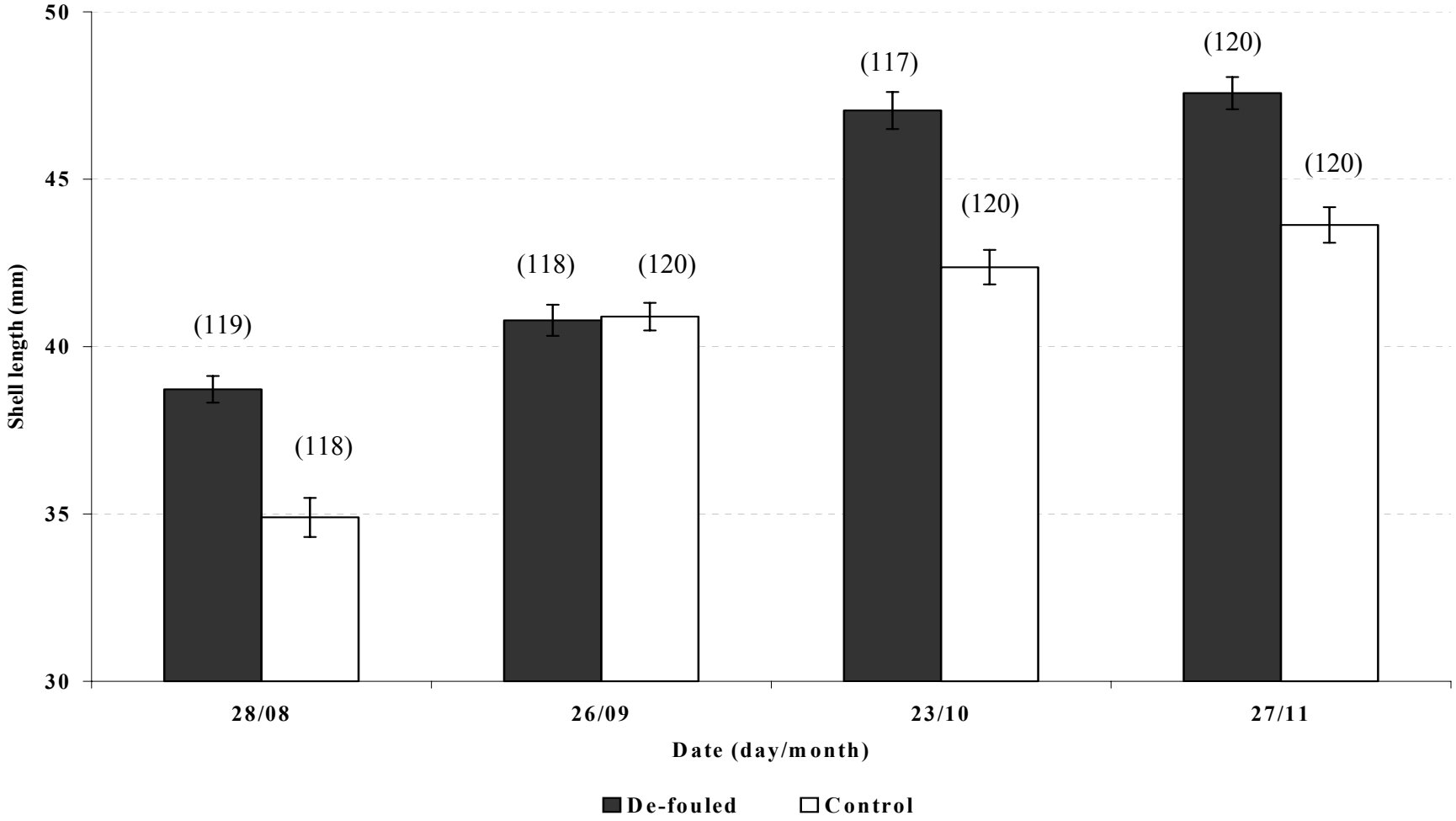

Figure 6. Shell length of mussels from socks collected in Tracadie Bay, P.E.I., during the ice-free period of 2001. Means are presented with ± 1SE as error bars, n in parentheses.