Growing oysters (*Crassostrea virginica*) using the French string technique at an exposed and a sheltered site in Chaleur Bay, New Brunswick

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Growing oysters (*Crassostrea virginica)* using the French string technique at an exposed and a sheltered site in Chaleur Bay, New Brunswick

by

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ABSTRACT

Niles, M., Davidson, L.-A., Nowlan, R., Doiron, S., Sonier R. and Comeau L.A. 2014. Growing oysters (*Crassostrea virginica)* using the French string technique at an exposed and a sheltered site in Chaleur Bay, New Brunswick. Can. Tech. Rep. Fish. Aquat. Sci. 3079: iv + 11 p.

The performance of oysters (*Crassostrea virginica*) grown at an exposed site at depths of 5 and 10 meters was compared to those grown at a sheltered site at a depth of 1.5 meter. The exposed site was located near Stonehaven and the sheltered site was in Caraquet Bay, both in Chaleur Bay, New Brunswick (NB). Oysters were cultivated using a modified French string technique from July 2009 to September 2010. The parameters studied consisted of oyster growth, survival and condition index as well as water temperature and current speed and direction at the culture sites. After 14 months, average shell length of oysters grown at the sheltered site (57.5 mm) was significantly greater than that of oysters grown at the exposed site (49.1 and 48.8 mm at 5 m and 10 m depth, respectively). At the sheltered site nearly 45% of the oysters attained market cocktail size (65-75 mm) while less than 10% achieved this size at the exposed site. Nonetheless, based on shape, all oysters could be classified as Fancy. In the fall (September 2010), the condition index of oysters grown at both depths of the exposed site was greater than those grown at the sheltered site. Water temperatures were below 4°C during the winter months but were colder at the exposed site compared to the sheltered site for the remainder of the year. Current velocities were 25 X greater at the exposed site than at the sheltered site with averages of 15.3 cm/s and 0.6 cm/s, respectively. Currents were predominantly north-east and south-west. Even at these currents, oysters remained attached to the strings and survival rates of 70% or more were achieved at both sites. Fouling was present at both sites.

RÉSUMÉ

Niles, M., Davidson, L.-A., Nowlan, R., Doiron, S., Sonier R. and Comeau L.A. 2014. Growing oysters (*Crassostrea virginica)* using the French string technique at an exposed and a sheltered site in Chaleur Bay, New Brunswick. Can. Tech. Rep. Fish. Aquat. Sci. 3079: iv + 11 p.

La croissance des huîtres (*Crassostrea virginica*) élevées à 5 et 10 mètres de profondeur dans un environnement exposé fut comparée à celle élevées à 1,5 mètre dans un environnement protégé. Le site exposé se trouve près de Stonehaven, tandis que le site protégé est dans la baie de Caraquet, tous deux situés dans la baie des Chaleurs, au Nouveau-Brunswick (N.-B.). Les huîtres ont été cultivées en utilisant une technique sur corde française adaptée (huîtres collées) de juillet 2009 à septembre 2010. L'étude fut réalisée en termes de suivi de la croissance, la survie et l'indice de condition des huîtres ainsi que la température de l’eau et la direction et la vitesse du courant aux sites de culture. Après 14 mois d’élevage, les huîtres cultivées au site protégé avaient une taille nettement supérieure (57,5 mm) à celles cultivées au site exposé (49,1 et 48,8 mm à 5 et 10 m de profondeur, respectivement). Environ 45% des huîtres au site protégé mais moins que 10% de ceux au site exposé ont atteint la taille marchande de l’huître cocktail (65–75mm). Toutefois, tous correspondent à la catégorie de Luxe selon le système de classification des huitres du N.-B. À l'automne (septembre 2010), l'indice de condition des huîtres cultivées aux deux profondeurs au site exposé, était supérieure à celle des huîtres cultivées au site protégé. Les températures d’eau ont demeurées en dessous de 4°C en hiver et étaient plus basses au site exposé comparé au site protégé pour les autres mois de l’année. La vitesse du courant était de 25X plus élevé au site exposé qu’au site protégé avec des moyennes de 15,3 cm / s et 0,6 cm / s, respectivement. Les courants nord-est et sud-ouest dominaient. Tout de même, les huîtres ont restées collées aux cordes et la survie dépassait 70% aux deux sites. Les salissures ont été observées aux deux sites.

1. INTRODUCTION

The eastern oyster (*Crassostrea virginica, Gmelin 1791*) is found in estuaries from the Gulf of St. Lawrence, Canada to the coast of Argentina (Carriker and Gaffney 1996). In New Brunswick, novel suspension aquaculture gear types have been employed since the late 1990's such as floating Vexar® bags and OysterGro® system. Suspension culture reduces the time needed for oysters to reach market size (shell length >76 mm or 65-75 mm for the cocktail category) compared to bottom culture (Doiron 2008). The gear is typically suspended from longlines which can easily be submerged below thick ice cover in the winter months. Another oyster growing technique from Mediterranean France (Étang de Thau) has recently been tested in northern New Brunswick with results that rival those of techniques presently used in the area (Mallet and Doiron 2009). The French string technique consists of gluing oysters in clusters of three on strings using a cement mixture and hanging them vertically from a raft anchored to the bottom. In New Brunswick however, most oyster leases are too shallow for this technique.. Therefore, a modified design of horizontally hung strings within a steel frame was developed and tested in Caraquet, New Brunswick (Mallet and Doiron 2009). Each string can hold 60 oysters.

A previous study by Mallet and Doiron (2009) indicated that the modified French string technique obtained a better performance in oysters in terms of growth and quality when compared to the floating bag technique which is currently popular in New Brunswick. In fact, oysters at the Caraquet site had a growth advantage of approximately 10 mm in one season when compared to those grown in floating bags. The weight and the shape of oysters grown on strings were also superior. Results also pointed to similar growth of oysters independent of location within the gear unit and independent of site. These trials were limited to sheltered shallow bays (Mallet and Doiron 2009). Exposed sites in New Brunswick, on the other hand, may offer deeper waters, a potential for expanding the oyster industry and possibly avoiding fouling problems.

In this study, the performance of oysters cultivated using the modified French string technique in an exposed environment and in a sheltered environment. was compared. More specifically, we compared growth, reproductive condition, fouling and survival of oysters and monitored environmental parameters between the two sites.

2. STUDY SITES

The study was conducted at an exposed site and a sheltered site, both located in Chaleur Bay, northern New Brunswick (NB) (Figure 1). The aquatic habitat classification of ''*Exposed-Intertidal''* can be attributed to Stonehaven and that of ''*Sheltered - 4-6 m''* to Caraquet according to the atlas presented in Cairns *et al*. (2012). The exposed site is a mussel farm operated by Kenny Aquaculture Ltd and located 1.8 km off the coast of Stonehaven NB (47°45.400 / 65°23.250). This site is the only active open-ocean (exposed) mussel lease in the DFO Gulf Region and covers an area of 39 hectares. Its average depth is 23 m. The site is exposed to predominantly northeasternly winds. The sheltered site, farmed by MP Aquaculture, is a 30 hectare oyster lease with an average depth of 6 m located in Caraquet Harbour and sheltered by Caraquet Island (47°49.026 / 64°52.435). MP Aquaculture Inc. launches its boat however is 1.8 km away, at the Caraquet wharf therefore, the time and energy costs for travel would be similar for both sites. These sites are covered by ice during the winter months (from late December to early April, approximately) when their longlines are submerged to avoid ice damage.

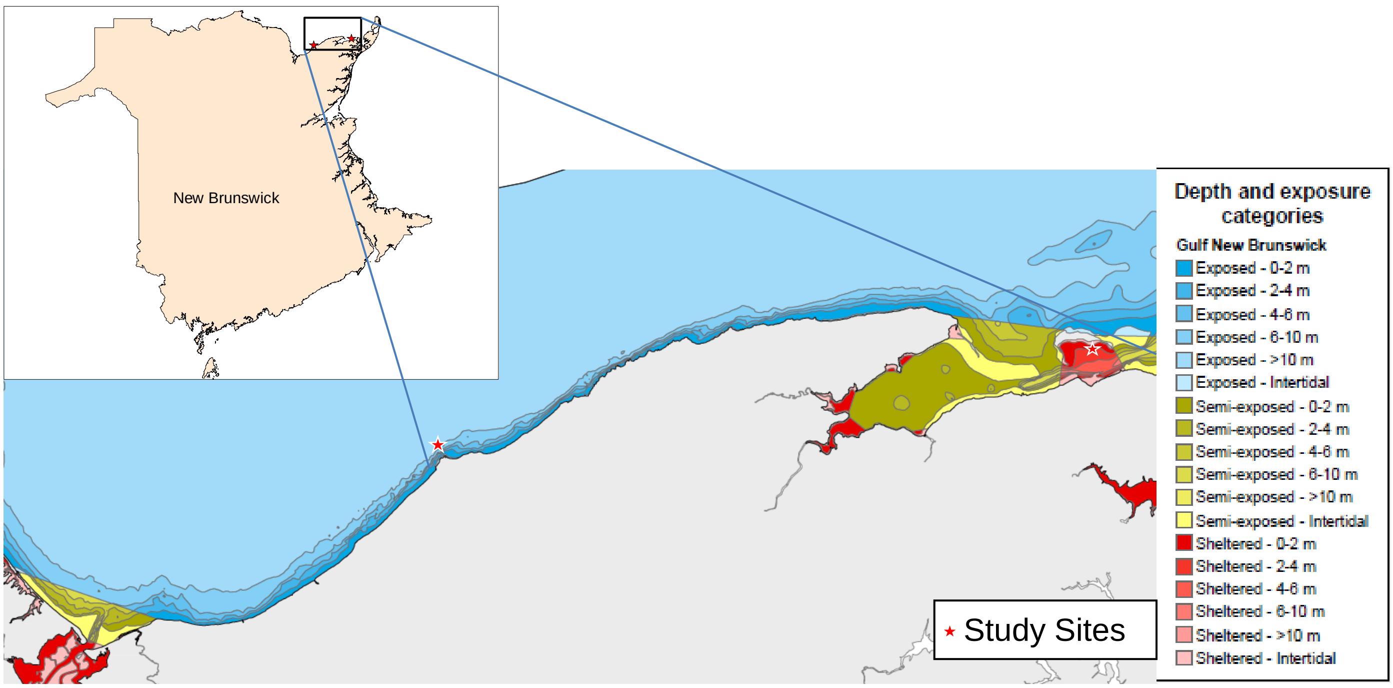
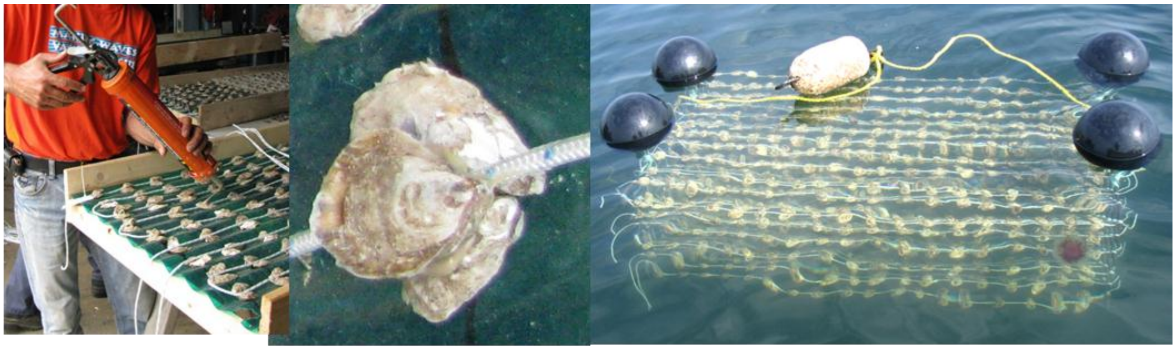


Figure 1. Study sites in Caraquet (Sheltered) and Stonehaven (Exposed), Chaleur Bay, New Brunswick with aquatic habitat classification map adapted from Cairns *et al.* (2012).

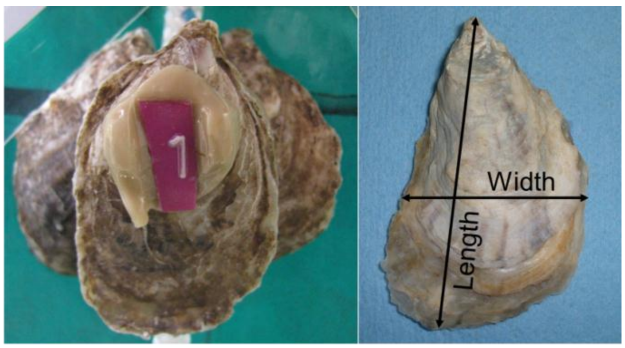
3. MATERIAL AND METHODS

In July, 2009, six French string units were constructed with 30-40 mm (33.8 ± 2.8 mm) oysters originating from the same seed source (Étang Ruisseau Bar, NB, Canada). The oysters were glued on strings in clusters of three. The oyster string units, though smaller, were constructed similarly to those used at the MP Aquaculture inshore site in a previous study (Mallet and Doiron 2009). Each unit was 6 strings deep and 10 strings wide with 54 oysters per string and held 3,240 oysters (Figure 2). Oysters at predetermined positions on selected strings were tagged and measured for shell length as in Mallet and Doiron (2009) (Figure 3).



a) b) c)

Figure 2. Modified French string grow-out method a) Oysters being glued on a string, b) Oysters glued in clusters of three, c) Unit used for the study.



a) b)

Figure 3. Oyster a) tag example b) length and width measurements.

Two units were deployed on longlines at each site and each depth for a period of two growing seasons (2009 and 2010). Units were placed at a depth of 5 and 10 meters from the surface at the exposed site and 1.5 meter from the surface at the sheltered site. Photographic records of fouling were taken in 2010.

The sampling regime was similar to that of Mallet and Doiron (2009). Repeated shell length measurements of the 30 tagged oysters from each unit were taken in July, August and October, 2009 and in June, July, August and September, 2010. Survival was calculated by dividing the number of live oysters by the initial number of oysters at the start of the study and expressing it as a percentage.

In September 2010, a sample of 30 oysters from each unit was taken to the laboratory. The sampled oysters were dissected and measured to obtain the required data to calculate the condition index (CI) following Hawkins *et al.* (1987) methodology:

$$CI = \frac{\text{dry soft tissue weight (g)} \times 1000}{\text{total whole live weight (g)} - \text{dry shell weight (g)}}$$

The dry weights were obtained by drying the soft tissue and shells at 70^{o}C for at least 24 hours.

Oysters were graded in September 2010 according to the New Brunswick oyster grades reported in the Reference Manual for Oyster Aquaculturists (Doiron 2008) (Figure 4).

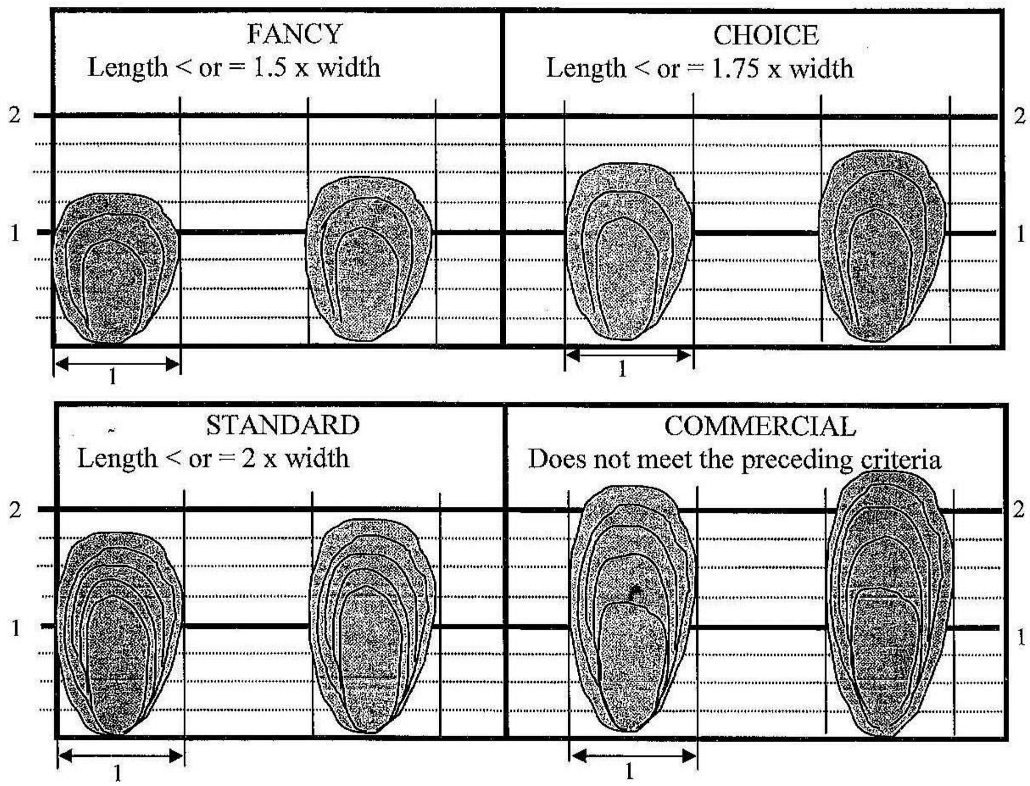


Figure 4. New Brunswick grades reported in the Reference Manual for Oyster Aquaculturists (Doiron 2008).

Acoustic Current Profilers were used to obtain current data (speed and direction). A Sentinel Workhorse 1200 kHz (Teledyne RD Instruments, CA, US) and an Argonaut XR 1500 kHz (Sontek, CA, US) were deployed at the Stonehaven and the Caraquet sites, respectively. Each unit was oriented in an upward pointing position (bottom mounted). Data was collected continuously at 15 minute intervals over from July 11 to August 11, 2009. Water temperature was monitored using Minilog recorders (Vemco, NS, Canada) (Figure 5).

Figure 5. Instruments to record environmental data: a) Acoustic current profilers b) Vemco Minilog recorders.

The shell lengths of the oysters cultured at the exposed site at depths of 5 and 10 meters and those cultured at the sheltered site at a 1.5 meter depth were compared using a repeated measure ANOVA. Normal distribution of the length data was verified with the Kolmogorov-Smirnov test and the data were log-transformed to reduce differences in variances. Comparisons of the effects of depth over time on shell length were made using contrasts (pre-planned comparisons). The multivariate Wilk's Lambda statistic was used throughout and will be expressed here as its F-equivalent. An ANOVA was used to determine if there was a difference in the condition index between oysters from the exposed and those of the sheltered sites sampled in September 2010. All analyses were conducted using Statistical Analysis Software (SAS) version 9.1.

4. RESULTS

The average oyster shell length recorded in 2009 and 2010 at the sheltered and exposed sites are presented in Figure 6 and in APPENDIX 1.

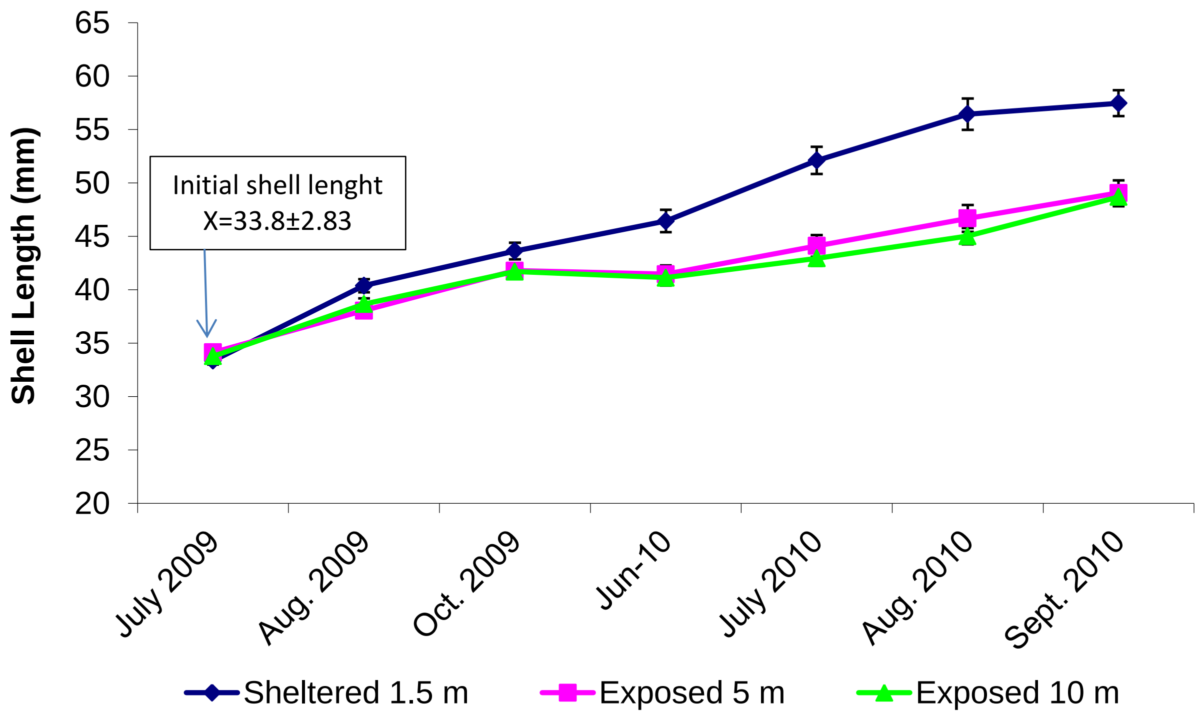


Figure 6. The mean oyster shell length (standard error) at each sampling site and date in 2009 and 2010.

There was no significant difference in oyster shell lengths at the exposed site between oysters grown at a depth 5 m and those grown at a depth of 10 m ($F=6.11$, $p=0.0144$). However, there was a significant difference in shell length between sites (Table 1). Oysters grown at the sheltered site, had a significantly greater shell length than those grown at the exposed site (F=104.83, p<0.01). Over a fifteen month period, that translates into a difference of more than 8.4 mm in shell length. Therefore, the oyster growth rate at the sheltered site was significantly greater than at the exposed site. The average growth rate of oysters from July 2009 to September 2010 was 0.05 mm/day for oysters cultured at the inshore site while it was 0.03 mm/day at both depths at the exposed site (Appendix 1). At the end of the study, in September 2010, 45% of the oysters cultured at the sheltered site reached market size (> 65 mm). At the exposed site only 10% of the oysters cultured at the 5 m depth and none of those at the 10 m depth reached market size.

Over the course of the study, oyster survival was 82% at the 10 m depth and 71% at 5 m depth at the exposed site and 78% at the shallow sheltered site.

Table 1. Anova results comparing the shell lengths of oysters grown at an exposed and a sheltered site at three different depths.

Source	Df	Sum of Squares	Mean Square	F-Value	P
Depth	2	0.0667	0.0334	17.7	<0.0001
Error	65	0.1225	0.0019		

In September 2010, oysters at the sheltered site had a significantly lower condition index than those at the exposed site (F=65.10, p<0.01)(Table 2, Figure 7).

According to the shell length - shell width ratio described in Oyster Growers Reference Manual (Doiron 2008), the oysters cultured at the sheltered site had a mean coefficient of 1.45 and those cultured at the exposed site at depths of 5 m and 10 m, had mean coefficients of 1.39 and 1.35 respectively. These values fall within the ‘’Fancy’’ category.

Table 2. Anova results comparing Condition Index (CI) of oysters grown at an exposed and a sheltered site at three different depths. Sampling was conducted in September 2010.

Source	Df	Sum of Squares	Mean Square	F-Value	P
Depth	2	1756.288	878.144	65.10	<0.0001
Error	174	2347.134	13.489		

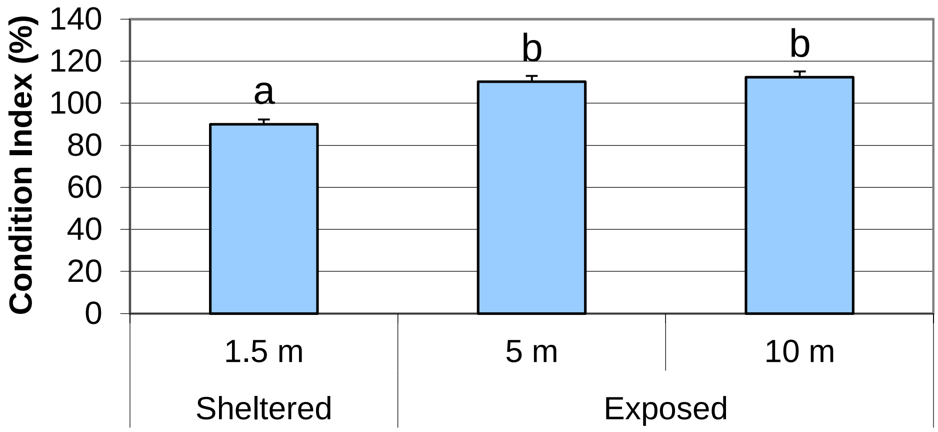


Figure 7. Mean condition index (Hawkins et al. 1987) and standard error of oysters at each site and depth in September 2010. Different letters show significant differences between means according to Contrasts comparison.

Data from acoustic current profilers indicated that both sites experienced north-east and south-west dominant currents (Figure 8). Average current velocities at the exposed site and sheltered sites were 15.3 cm/s and 0.6 cm/s, respectively.

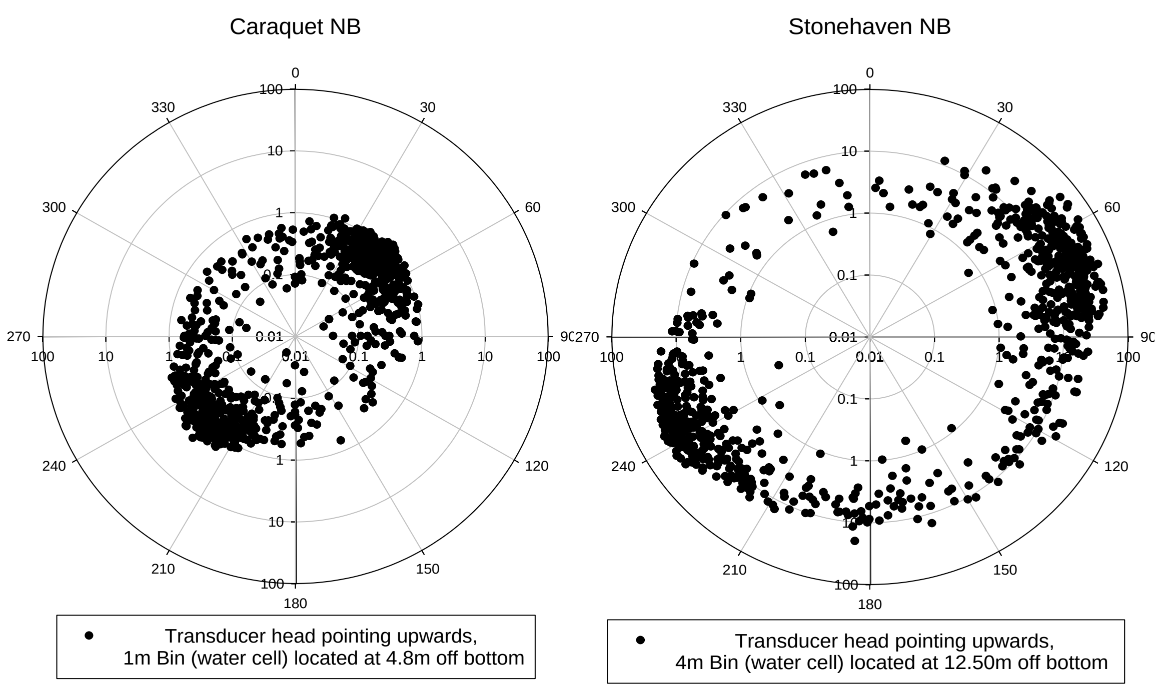


Figure 8. Polar plots showing current velocity (cm/s) near the surface layer at the exposed and sheltered site.

Between December and April, the temperatures at the exposed and sheltered sites stayed below 4°C. In general, the temperatures at the exposed site were lower than at the sheltered site during all other months. Temperatures reached and remained above 20°C for several weeks at the sheltered site but not at the exposed site. The average monthly temperatures at both sites did not reach 25°C (Figure 9).

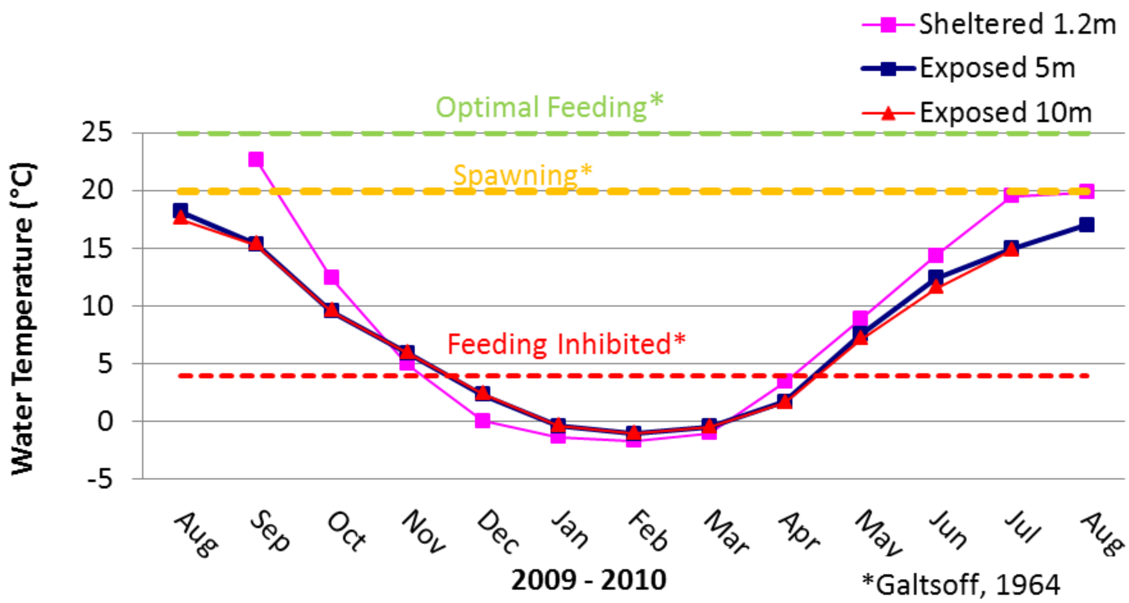


Figure 9. The 2009 to 2010 monthly average water temperatures at the sheltered (1.2 m depth) and exposed (5 and 10 m depth) study sites and Galtsoff (1964) biological thresholds.

During the summer and fall of 2009, heavy fouling was not observed. Both sites are ice covered in winter. The first visit in June 2010 revealed very heavy mussel (*Mytilus edulis*) fouling on the units at the exposed sites and hydroids, *Caprella mutica* and mussel fouling at the sheltered site (Figure 10). By August 2010, hydroids were the major fouling organism at both sites.

a) b)

Figure 10. Fouling on oyster culture strings: a) mussel fouling at the exposed sites b) Hydroid fouling at the sheltered site.

The Caraquet grower at the sheltered site had previous experience with the French strings technique. He developed a husbandry practice to control the fouling problem by exposing the units to air for 2 or 3 days. Mussels or algae on the units dry out and die while the oysters remain unharmed. Subsequently, in 2010, the Stonehaven grower also adopted this practice and was able to better control fouling.

5. DISCUSSION

The current velocities at the exposed site were 25 times faster than that at the sheltered site, yet the oysters remained glued to the strings at both sites. Current velocity is suspected to have an impact on growth rate and it may have contributed to the lower growth rates of the oysters at the exposed site. Since the oysters at the exposed site had a lower growth rate, they would require a longer culture period before they reach market size. Consequently, by the time they do reach market size their overall survival rate would most likely be lower.

The eastern oyster (*Crassostrea virginica*) can live at temperatures between -2^{o}C and 36^{o}C. The temperature for optimum feeding rate for this species is 25^{o}C. Feeding will be inhibited at temperatures below 4^{o}C and spawning will occur at 20^{o}C (Galtsoff 1964). In this study, higher temperatures were observed at the sheltered site compared to the exposed site from April to December which may explain why oyster growth at the sheltered site was significantly greater than at the exposed site. The temperature rose above the spawning temperature threshold at the sheltered site for a few weeks while at the exposed site the temperature did not reach 20 ^{o}C. Hence, the oysters at the exposed site most likely did not spawn. This may explain why, in September 2010, the condition index of oysters was greater at the exposed site than at the sheltered site. Higher condition indices often indicate higher quality and meat yield. Taste was not evaluated in this study, however, it should be included in future studies of oysters cultured at exposed sites.

According to the Reference Manual for Oyster Aquaculturists (Doiron 2008), the oysters cultured using the French string technique at both sites fell into the fancy category, the highest quality in the grading system.

Fouling was observed at both sites even though the current was 25 times faster at the exposed site. After one year, mussels were the dominant fouling organisms at the exposed site while hydroids were dominant at the sheltered site. The opposite fouling dominance occurred in a five month study when comparing an exposed site to a sheltered site in the Magdalen Islands (Cyr *et al.* 2012). In this study, fouling was controlled by periodically exposing the units to air for 2 or 3 days. However, this technique to control fouling incurs extra time and labor costs because units must be brought back to shore for drying. Yet, after 15 months, fouling was lessened and the hydroids were the dominant organisms at both sites. Cyr *et al*. (2012) reported that their attempts to control fouling by using a high pressure water spray were not effective.

If the spray was too powerful, it would break the oyster's new growth and often dislodged the oysters from the rope and weak sprays did not remove the fouling.

6. ACKNOWLEDGEMENT

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APPENDIX 1

The average shell length (mm) and standard error of oysters and growth rate at sampling sites.

Site		Date							Over-all Growth Rate mm/day
	Water Depth (m)	July 21 2009	Aug 26 2009	Oct 7 2009	June 29 2010	July 28 2010	Aug 23 2010	Sept 28 2010	
		Average shell length, mm (SE)							
Caraquet Sheltered	1.5	33.35 (0.374)	40.37 (0.601)	43.63 (0.779	46.42 (1.044)	52.10 (1.265)	56.43 (1.481)	57.45 (1.212)	0.05
Stonehaven Exposed	5	34.14 (0.321)	38.04 (0.580)	41.79 (0.668)	41.45 (0.814)	44.85 (1.019)	46.67 (1.258)	49.05 (1.188)	0.03
	10	33.77 (0.393)	38.66 (0.514)	41.69 (0.678)	41.13 (0.742)	43.25 (0.692)	45.01 (0.757)	48.68 (0.871)	0.03