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WINTER STORAGE OF THE AMERICAN OYSTER (*CRASSOSTREA VIRGINICA*) IN CAPE BRETON, NOVA SCOTIA

by

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ABSTRACT

Freeman, K.R. and R.E. Lavoie. 2003. Winter storage of the American oyster (*Crassostrea virginica*) in Cape Breton, Nova Scotia. Can. Manuscr. Rep. Fish. Aquat. Sci. 2652: iv + 9 p.

As winter sea ice effectively halts commercial harvesting of mature American oysters (*Crassostrea virginica*) from many leases in the Maritimes, aquaculturists have traditionally held late fall product cup valve down under seaweed in cold rooms above 0° but less than 5°C. This holding method, long in use in Cape Breton, was compared with submerging oysters in seawater below the ice as a means of avoiding late winter product deterioration, the inevitable consequence of lengthy dry storage. Roughly equal groups of adult oysters were held by each method and assessed by condition index and organoleptic (sensory) analyses during the winter of 1995. A Student's t-test showed that condition index was ineffective in discriminating between the two lots of oysters. Blind organoleptic testing of the two lots was performed at intervals throughout the winter by a trained assessor who provided a numerical rating of the products for odour, liquor appearance, taste, meat colour and water retention. These data were examined by one-way analyses of variance. Results clearly demonstrated the superiority of "wet" over "dry" storage as a means of avoiding product deterioration.

RÉSUMÉ

Freeman, K.R. and R.E. Lavoie. 2003. Winter storage of the American oyster (*Crassostrea virginica*) in Cape Breton, Nova Scotia. Can. Manuscr. Rep. Fish. Aquat. Sci. 2652: iv + 9 p.

Étant donné que la glace de mer empêche la récolte commerciale d'huîtres américaines matures (*Crassostrea virginica*) dans de nombreuses concessions des Maritimes, les aquaculteurs conservent traditionnellement le produit de fin d'automne sous des algues marines la coquille creuse en-dessous dans des chambres froides entre 0 °C et 5 °C. Nous avons comparé cette méthode d'entreposage, utilisée depuis longtemps à l'île du Cap-Breton, à l'immersion des huîtres dans l'eau de mer sous la glace afin d'éviter la détérioration du produit à la fin de l'hiver, une conséquence inévitable de l'entreposage de longue durée en milieu sec. Au cours de l'hiver 1995, nous avons soumis des groupes semblables d'huîtres adultes à chaque méthode et nous les avons évalués à l'aide d'un indice de condition et d'analyses organoleptiques (sensorielles). Un test t de Student a montré que l'indice de condition ne différait pas entre les deux groupes d'huîtres. Un évaluateur qualifié a effectué des essais organoleptiques aveugles sur les deux groupes d'huîtres à intervalles réguliers au cours de l'hiver et il a fourni une cote numérique de l'odeur, de l'apparence des fluides, du goût, de la couleur de la chair et de la rétention en eau des produits. Nous avons ensuite soumis ces données à une analyse de variance univariée. Les résultats montrent clairement la supériorité du parcage dans l'eau pour éviter la détérioration du produit. Des cinq critères sensoriels, l'odeur était le plus efficace pour différencier les deux groupes.

INTRODUCTION

Following late fall harvests of mature oysters and prior to formation of ice, oyster culturists have traditionally stored their product cup valve down under seaweed in cold rooms whose temperature is maintained just above freezing. This time-honoured method, although yielding generally favourable results for several weeks, has been known to fail to maintain the degree of freshness desired by the consumer. When such dry-stored animals are not packed carefully (with their cup valves down) they will, when they occasionally open, lose intervalvular fluid and desiccate. The same will happen to animals with chipped shells, even though they are carefully packed. As winter ice forms in late December and often remains at some Cape Breton oyster leases until late March, there is a considerable demand placed on this storage method with a reported increasing degree of product deterioration in the later weeks of the ice season and before submerged product can be accessed. While it is self-evident that submerged oysters will keep longer than those stored dry, the construction of a pumped seawater facility specifically for oyster winter storage has already been considered economically unfeasible by the New Brunswick Provincial Government which had the problem researched in the early 1970s (Canplan Consultants, 1974).

Oyster growers on Cape Breton Island, and doubtless elsewhere in the Maritimes, have an interest in maintaining sales into mid spring and could derive benefit from improvements in winter holding. Unfortunately, rates of oyster condition and quality decline during long-term storage, but have had little study, yet it would be advantageous to growers to minimize product deterioration during winter and early spring. If held in seawater below 5°C, metabolic processes of *Crassostrea* slow markedly, and it was surmised that animals so held might exceed storage performance of equally cool but dry-stored oysters. The availability near Isle Madame of a dry cold storage facility at Louisdale and of a shore-anchored, sub-surface longline in Lennox Passage to enable retrieval of oysters held beneath ice, offered the possibility of comparing a "wet" (submerged) method with the traditional dry storage technique. A decision was made to compare the effectiveness of these two holding methods and to employ condition index analyses in addition to organoleptic (sensory) techniques as means of discrimination.

MATERIALS AND PROCEDURE

FIELD AND LABORATORY PROCEDURE

As there are few naturally-occurring American oysters in Lennox Passage, on January 16, 1995, approximately 300 animals were moved from the Bras d'Or Lake at Lynche River to the Richmond Aquaculture Development Corporation (RADCO) aquaculture site holding facility near Louisdale (Figure 1) and held there dry overnight.

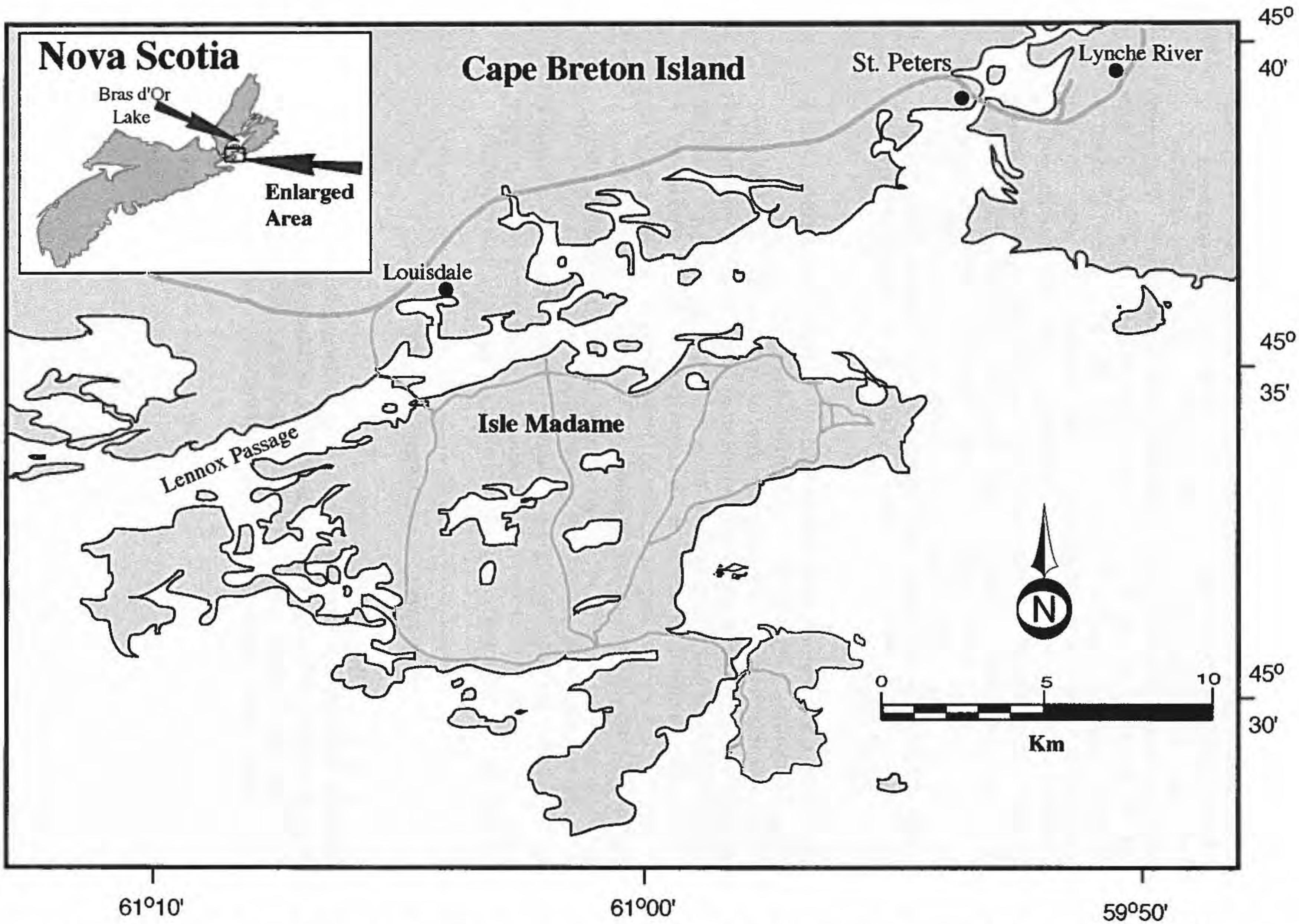

Figure 1. Cape Breton Island and Isle Madame oyster study area. Lynche River estuary, the source of the oyster stocks used, is in a Bras d'Or Lake inlet separated from the North Atlantic at St. Peters by a canal and lock system.

On January 17 a randomly selected pre-treatment sample of 28 animals was obtained from this lot for condition index analysis and 13 more for organoleptic assessment. The remainder of the shipment of roughly 260 animals was then separated into two equal sets, one set of which was moved to a root cellar under a house where the individual animals were placed level, cup valve down, under seaweed. The second half was placed into a series of mesh bags and deployed below the ice on a shore-anchored line at the RADCO aquaculture site nearby in Lennox Passage.

Sampling of the submerged and dry-stored lots for condition-index and sensory tests was performed at two-week intervals beginning January 30 and continued until mid March. A further single (dry stored) sample was taken at the end of March, the long line with attached bags of oysters having been torn away by an ice flow resulting in the loss of the remainder of the submerged lot. During this sampling period, the air temperature taken on top of the seaweed in the root cellar varied from 7.8 to 5.6°C while relative humidity ranged from 74 to 93% with a mean of 85.5 %. Surface seawater temperature on the lease in the same time interval varied between 4.0 and - 2.0°C.

At each sampling occasion, between 12 and 14 animals from each storage lot were taken, assigned a lot designation of either "A" or "B", carefully packaged for thermal protection and shipped to the Halifax Fisheries Research Laboratory for organoleptic (sensory) assessment by one of us (R.L.) the next day. The evaluation protocols employed were those once used by the Fish Inspection Branch (see Table 1).

Table 1. Organoleptic analysis scoring guide for *Crassostrea virginica*, Fish Inspection Branch protocols, 1995.

Sensory Criteria	Scoring Guide					
	5	4	3	2	1	0
Water Retention	Very Full	....	....	....	....	Very Dry
Liquor Appearance	Transparent, Clear	....	....	....	....	Thick, Cloudy
Meat Colour	Creamy, White	....	....	....	....	Very Yellow
Odour	Very Fresh	....	....	....	....	Very Stale
Taste	Very Fresh	....	....	....	....	Very Stale

This was a blind test; for each shipment of two lots the organoleptic assessor did not know whether "A" or "B" represented the wet or dry sources. Unfortunately, some of the original raw data, which normally would appear in an appendix, was lost following its analysis.

Samples of 10 animals were also extracted from each storage source for condition-index analyses. Choice of condition-index analysis protocols was based on a review of comparative tests reported by Crosby and Gale (1990). After examining six methods, these authors recommended, for various reasons, the following equation that was used in this study:

CI = dry soft tissue weight (g) x 1000 / internal shell cavity capacity (g)
where shell cavity capacity (g) is the weight of water that could occupy the empty cavity and which is obtained by subtracting the dry shell weight from the total whole live weight.

DATA TREATMENT

Condition Factor

Following calculation of basic statistics (condition-index means, standard deviations, standard errors), a graph was constructed (Figure 2) comparing dry and submerged condition-index sample means. Larger numeric values of CI indicate higher quality. A Student's t-test was performed on values combined by source over all samplings.

Sensory Analysis

Organoleptic criteria used were those that had been used by the now disbanded Fish Inspection Branch and involved numerical ratings from 0 to 5 of Taste, Odour, Colour, Liquor Appearance and Water Retention (from Table 1) with the larger numeric values being indicative of highest quality. While Fish Inspection originally used more than one person on a taste panel, current organoleptic assessments employed by the Canadian Food Inspection Agency use one person specifically trained for particular analyses. Thus, our use of one expert familiar with oysters is in keeping with current, standard practice.

Each rated variate, across sampling occasions and storage type, was analyzed using one-way analyses of variance (ANOVA). Data from January 17 were regarded as "pre-treatment" and were not included in the series of statistical analyses. The dates the samples were drawn are shown in Table 2 (e.g., 30/1 for 30 January 1995), as are Codes, Groups (Group = nd for dry, nw for wet), the sample sizes (Number), and the means for each of the five variates (Odour, Liquor Appearance, Taste, Meat Colour and Water Retention) for each of the nine samples.

When the group means for each variate are ordered by size, usually the dry treatments have lower means than the wet. The most noticeable exception is group 3d, the mean of which is higher than all other dry means on every variate, and often of the same order as wet means. Group 3d was therefore isolated and given code = 1 in Table 2. More details on Table 2 are given in the Results and Discussion section below.

RESULTS AND DISCUSSION

CONDITION INDEX

While three of the four means in the submerged lot following January 17 are lower than means from their dry stored counterparts, this difference is not large enough to indicate a "true" effect. In fact, condition index data separately compiled from submerged and dry storage sources over all sampling occasions and then analyzed by Student's t-test provided a value of $t = -0.97$. This clearly indicates no true difference between

Table 2. Design, means and analyses of sensory variates.

				Means				
Date	Codes	Group	Number	Odour	Liquor Appearance	Taste	Meat Colour	Water Retention
13/2	1	3d	13	4.231	5.000	4.385	4.231	5.000
30/1	2	2d	13	3.385	3.846	3.692	3.154	3.846
27/2	3	6d	12	4.000	4.333	3.667	3.833	4.917
13/3	4	8d	14	3.214	3.643	2.357	3.500	4.000
27/3	5	9d	13	3.385	3.615	3.154	3.231	4.231
30/1	6	1w	13	4.923	4.923	5.000	4.462	4.923
13/2	7	4w	13	4.769	5.000	5.000	4.462	5.000
27/2	8	5w	12	4.583	4.667	4.167	4.250	5.000
13/3	9	7w	13	4.385	4.462	4.308	3.769	4.462

mse	0.486	0.518	1.176	0.472	0.496
F1-9	11.084	8.166	8.390	7.036	5.813
F2-9	11.005	6.805	8.105	6.533	5.182
F2-5	1.150	0.994	1.672	0.934	2.095
F6-9	0.542	0.569	0.796	1.101	0.653
Fwvd	9.034	5.060	5.361	4.421	2.314

Note: mse = mean square for error; all F values based on 8 and 107 d.f.; Fwvd = variance ratio for the wet versus dry contrast, i.e., sum of means for codes 6 to 9 minus sum of means for codes 2 to 5.

storage methods and confirms the graphical representation in Figure 2 that as a means of comparing storage efficacy, condition-index alone was clearly insufficient, at least for the duration of this experiment and for the sample sizes used.

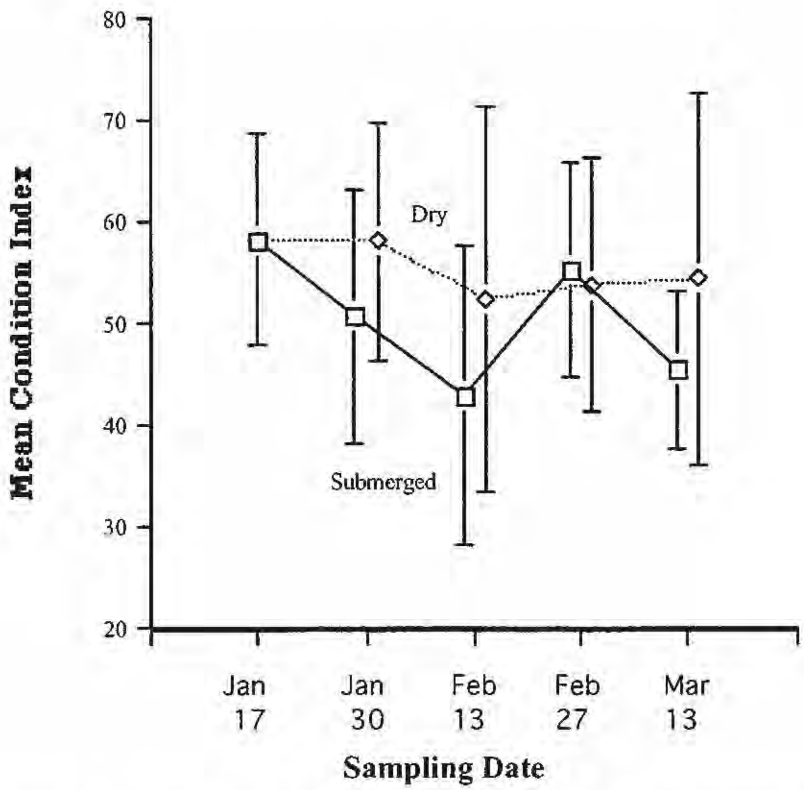

Figure 2. Mean condition index by sampling date, submerged and dry-stored oysters. (confidence intervals = SE x Student's t)

SENSORY ANALYSIS

Analysis of variance was carried out on each of the five variates: the relevant mean squares for error (each having 107 degrees of freedom) are shown on row mse in Table 2. The variance-ratios for the nine means (Between Groups/Within Groups) are given on row F1-9 in Table 2. Since the group 3d seemed so inconsistent with its dry peers, further analyses were carried out over the eight means without 3d, but using 8 d.f. for the ratios' numerators. Those variance-ratios (Between Groups/Within Groups) are given on row F2-9 in Table 2.

The special critical value F[.05]; 8, 107 = 1.106 that will be used, was found by interpolation in Rodger's (1975) tables. By that standard, the sample means differ much more than can be accounted for by random error.

Following the procedures for the post-hoc evaluation of means given by Rodger (1974), 8 d.f. will always be used in this experiment for the post-hoc evaluation of variation in the means. On the question of where the large variation observed in these means arises, the answer seems to be clearly between the wet (high quality) and dry (having lower quality) samples. This is demonstrated by the large variance-ratios for the wet-dry contrast on row Fwvd in Table 2. Each of these (using 8 d.f. for their numerators) is notably larger than the critical 1.106.

It should be noted at this point that, even if group 3d were included among the "drys" for the wet-dry contrast, the variance-ratios would still be quite high (i.e., 7.667; 3.139; 4.135; 3.151; 1.439).

To complete the analysis one should examine the variation in the means that remains after the wet-dry effect is removed. For the wets, that variation is no more than may be accounted for by random selection. The relevant variance-ratios (again all using 8 d.f.) are shown on row F6-9 in Table 2.

Residual variation among the dry means appears to conform rather less with random error, according to their variance-ratios on row F2-5 in Table 2. Three of those (Odour, Taste, Water Retention) are larger than the decision-based criterion 1.106. One of these large variance-ratios (for Taste) is probably due to deterioration over time because the contrast 2d+6d-8d-9d (i.e., early versus late) yields $F(8, 107) = 1.176$. That effect is not found for Odour ($F = 0.515$) nor for Water Retention ($F = 0.231$). Of course, if group 3d is included, the contrast of the three early groups with the two later groups of drys yields "significant" results for three of the five variates (Odour $F = 1.328$; Liquor Appearance $F = 2.200$; and Taste $F = 2.251$).

One can only speculate about the origins of what remains among the large residual variation. For example, it is almost as if the person sampling the dry-stored oysters on 13 February 1995 chose only the "better looking" shells. But there is no independent evidence to support that opinion.

As for the dry variation without 3d, one might attribute it to random decision error. Since the decision-space for this experiment has 8 times 5 = 40 dimensions, with a type-1 error-rate of $E\alpha = 0.05$, we might expect about two decision errors. After the time-trend for Taste is removed from the dry residuals, two "rejectable" null contrasts are what remain.

SUMMARY AND CONCLUSIONS

These one-way ANOVAs have shown that from the point of view of product quality maintenance, and irrespective of the sensory criterion used, wet (submerged) storage of the American oyster is more effective in retaining quality than traditional cold, dry storage under seaweed. While initial expectations were that a choice grade lot of oysters was being used (well-formed, lower valve cupped) it turned out that these were lower grade "commercial" animals with misshapen lower valves, some having shell damage.

In dry storage, a choice oyster stored with the cupped valve down will retain its liquor if it gapes, whereas a commercial oyster cannot. Dry-stored oysters that gape are subject to liquor loss leading to partial or total dehydration and death. In wet storage, oysters that gape, regardless of quality, cannot dehydrate. This would explain why the dry-stored oysters did not retain their quality as well as the wet-stored animals.

In this experiment the dry storage temperatures were always above the ideal 5°C threshold, ranging from 5.6 to 7.8°C, perhaps as a result of radiation from the heated structure above. It can be postulated that above 5°C, temperature triggers some physiological action producing metabolites that thicken the liquor and change the odour of oysters stored in this manner.

The efficacy of wet versus dry storage in retaining meat quality is unquestionable from the foregoing. It is also not very surprising. What is remarkable is that American oysters store dry as well and for as long as they do, a useful attribute in a Maritime climate that during winter is definitely user-unfriendly for aquaculturists. However, given the superiority of wet storage as a way of retaining product freshness, it is clear that the use of running salt-water holding facilities, if available, would greatly enhance the aquaculturist's ability to sell quality product late in the winter season when dry-stored oysters would have to be discarded and potential profits lost. Although the earlier feasibility study for the New Brunswick Government by Canplan Limited indicated marketing circumstances that did not then justify construction of a holding facility, it is uncertain if this holds true today. Maritime oyster growers living near enough to any existing live marine mollusc or crustacean holding facilities would be well advised to investigate possibilities of gaining access to these holding systems. Oysters so held could be marketed as such and in theory could secure a better market price than stocks held dry in cold rooms. Failing that, winter retrieval methodology should be developed, perhaps patterned after winter mussel harvesting in Prince Edward Island, to permit access to caged oysters held beneath the ice.

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