Testing different sleeving materials as a means of reducing losses of mussel seed from diving duck predation at Indian Point Marine Farms: A preliminary assessment

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1 Introduction

The predation of sea birds on various shellfish species is well-documented throughout the world. Large flocks of birds are known to consume vast quantities of shellfish over a short duration and can cause noticeable declines in natural population abundance (Werner et al. 2005). It is estimated, for example, that one adult eider duck can consume between 2.5 kg (Galbraith 1986) and 5 kg of mussels in one day (Furness 1996). Birds are also highly adaptable and will easily migrate to new food sources. For example, the zebra mussel, a non-indigenous species in the Great Lakes, has become an important food source for various species of migratory birds (Mitchell et al. 2000). Another example of adaptation is the substantial negative impact of the lesser scaup on baitfish aquaculture facilities in the US (Wooten and Werner 2004).

It is not surprising that mussel farms are very attractive to species which typically feed on wild shellfish. Cultured mussels are abundant, easily accessible, thin-shelled with a high meat yield and a high rate of energy return per unit effort. Natural predation on cultured mussels is not limited to sea stars and sea ducks – in France for example, substantial losses are also attributed to sea bass. However, in Atlantic Canada, diving sea ducks are the main vertebrate predators of concern. Throughout this region it is estimated that 2-3% of the annual revenue from the mussel industry is lost to duck predation, or between 1 to 2 million dollars. Ice coverage and the ducks' seasonal migration patterns limit their predation activity in most areas, but with the prospect of milder winters due to global warming, losses are expected to increase in the future.

In general, it has been found that shellfish farming activities have few impacts on sea duck populations and, in some instances population abundance has been shown to increase with aquaculture activity (PEI Department of Fisheries 2000). However, it is difficult to ascribe a positive effect to shellfish farming since this may simply be a reallocation of the bird population to an area with a readily-available food source. In British Columbia, Zydelis et al. (2006) concluded that shellfish aquaculture represented at best a positive, or at least a neutral habitat change for scoter populations. In the case of the clam aquaculture industry, they noted that even though scoters are excluded from feeding on cultivated clams by predator netting, their local food supply may be enhanced by the movement and reproduction of the clams under the nets. Roycroft et al. (2006) also concluded that suspended mussel culture appears to have positive or neutral impacts on marine bird species in Ireland.

It is clear that sea ducks have the ability to cause significant impacts on natural or cultured bivalve populations. In PEI where industry production expanded rapidly over two decades to reach 19,000 metric tons in 2006, interactions with diving ducks such as the Great Scaup, Long-tailed Ducks, Common Eiders and Scoters became problematic in some areas, threatening the viability of certain farms. Predation activity is typically seasonal, reaching the highest intensity in the fall during the migration period. However, areas such as Marie Joseph in Nova Scotia located in the immediate vicinity of nesting grounds are under constant threat of predation. In most areas the fall and winter period also coincides with the collection and socking of mussel seed, and flocks of ducks have been known to completely consume whole lines of mussel seed in a matter of days. Winter ice offers an excellent protection against duck predation, but with the recent series of mild winters, the window for duck feeding activity has increased substantially.

Protective predator netting has been a favoured means of excluding predators from the cultured stocks. The raft culture of mussels lends itself to the deployment of predator-exclusion netting, and this material has been used successfully in many areas around the world. However, it would be difficult to deploy protective netting around a mussel farm using the long-line system because of the extensive surface area. Raft culture is also difficult in Nova Scotia given the presence of winter ice.

Numerous scare tactics have been tested in an attempt to reduce the predation rates of sea ducks on cultured mussels. In most instances, rapid habituation by the birds has led to the discontinued usage of these devices. For example, in several regions of Atlantic Canada scarecrows and propane canons have been tested and found to be ineffective over the long-term. Presently, the most effective scare tactic is frequent boat chasing reinforced with blank shots, but this is costly and not necessarily a long-term satisfactory solution. Furthermore, certain duck species feed at night thereby rendering daytime boat chasing ineffective (Dionne et al. 2006).

Of all the options tested, at least two scenarios seem to offer some promise. Ross et al. (2001) concluded that underwater playback was effective but only over a 100-m radius (approximately 1 ha). It is likely that this technology could be substantially improved in terms of augmenting the effective range, given the important advances in technology over the past few years. Dionne et al. (2006) tested protective socking material for cultivated mussels as a deterrence method against diving ducks. Their overall conclusion was that this method held some promise, but the fibres in the material were too slow to degrade thereby trapping mussels inside the sleeve permanently and causing high mortality. However, at Indian Point Marine

Farms (IPMF) mussel seed is typically deployed at high densities in the fall and then harvested and re-sleeved in the spring; in this case protective socking material may provide a viable option.

2 Project description

2.1 Rationale

The New Zealand technology for growing mussels is based on the use of a continuous fuzzy rope, biodegradable cotton mesh, and a mechanized sleeving system which allows for the rapid deployment of large volumes of seed with minimum labour. At Indian Point Marine Farms (IPMF) mussel seed is typically deployed at high densities in the fall, recovered in the spring and redeployed at the final commercial density. However, after the cotton mesh has disintegrated, approximately three weeks after deployment, the seed becomes highly vulnerable to predation by sea ducks. The rationale for this project was to enclose the mussel seed in a protective sleeving material which should biodegrade over two to three months rather than three weeks; this material would thus provide a more effective deterrent against sea ducks.

2.2 Description of the various sleeving materials

Regular Cotton (RC-RN):

This is the cotton mesh typically used at IPMF to deploy mussel seed in the fall. The main supplier is Rainbow Netting (RN), although similar sleeving material can be obtained from other suppliers. It typically degrades within two to three weeks following deployment.

Heavy Cotton (HC-ES):

This experimental mesh was made with a heavier gauge cotton thread and was supplied by Entreprise Shippagan (NB). It was expected that this material would take longer to disintegrate.

Tight-Weave Cotton (TC-RN):

This experimental mesh was supplied by Rainbow Netting. This was made with the same gauge of cotton thread as the Regular Cotton except that the mesh openings were smaller.

Polyester-Cotton – probably mixed weave (PC-RN):

This experimental mesh was obtained from Rainbow Netting - it was not possible to determine the manner in which this mesh was constructed, except that it contained 22% polyester and 78% cotton. It is likely that this sleeving material was a mixed weave of cotton and polyester threads.

Polyester-Cotton – single mixed thread (PC-ES):

This experimental mesh was produced and supplied by Entreprise Shippagan. It was constructed using a single mixed thread of 50% polyester and 50% cotton. The sleeve was woven with all needles, yielding the smallest possible openings or type #20.

Standard blue and black non-degradable mesh:

These are the standard mesh types used by the NS mussel industry. Both types have wide openings which allow the mussels to migrate immediately to the outside of the sleeves. It was hoped that the ducks would eat the mussels on the outside but not touch the mussels on the inside of the sleeves.

2.3 Experimental set-up

On October 31 2007, starting from the south end of a long-line at IPMF, "small" mussel seed (mean 15 mm) were deployed in three types of degradable material: Heavy Cotton (HC-ES), Polyester-Cotton (PC-ES) and Regular Cotton (RC-RN) (Figure 1). This same series was repeated with medium size seed (mean 20 mm). The various treatments were separated on the long-line by black buoys.

On November 14 2007, continuing northwards along the long-line, two more types of sleeving material obtained from Rainbow Netting were deployed: Polyester-Cotton (PC-RN) and Tight-weave Cotton (TC-RN) using similar size seed (mean 15-20 mm). Blue and black non-degradable mesh sleeves were also deployed as a growth comparison.

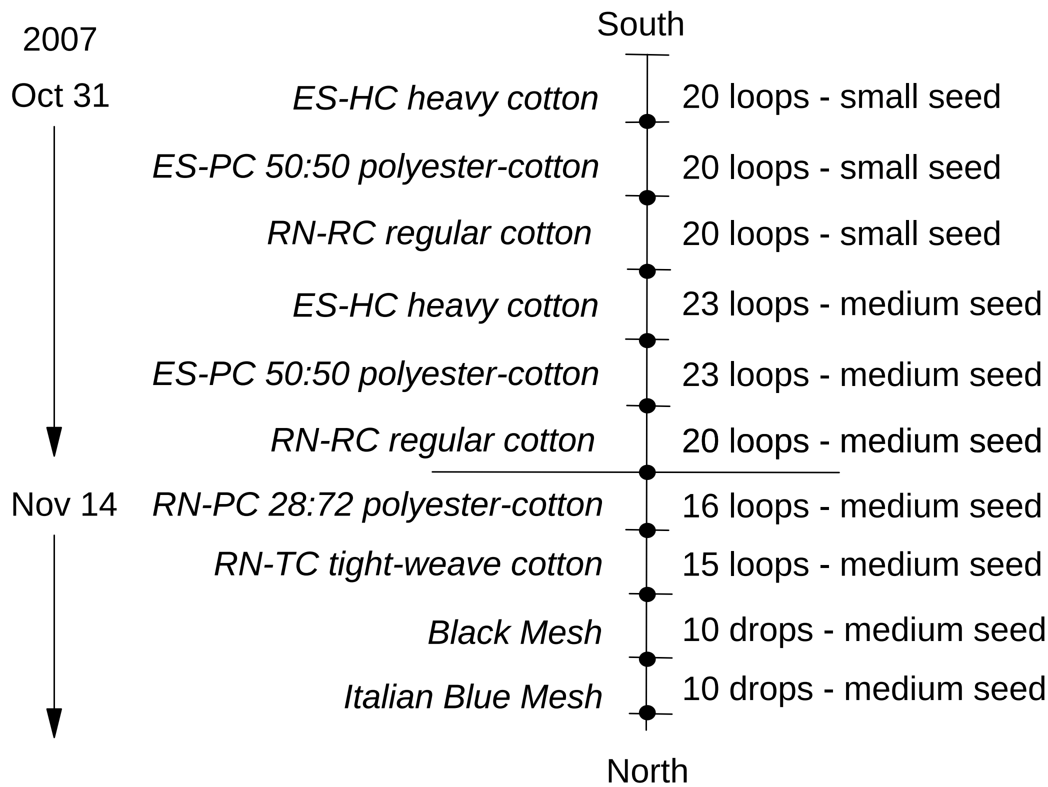

Figure 1: A description of the deployment of small and medium-size mussel seed in the various experimental sleeves on Oct 31 2007 and November 14 2007. The various treatments were separated by black buoys.

2.4 Evaluation

Samples (20-cm lengths) from each sleeve type were removed on Nov 14, Nov 30 and Dec 21 2007, and on March 6 and April 17 2008. Mean shell height was determined and the seed was assessed for mortality. Samples were frozen for subsequent assessment of seed density.

3 Results

3.1 October to December 2007

As of December 21 2007, there was no evidence of growth, mortality, or signs of duck predation in any of the treatments. Differences in the rate of biodegradation were however evident: the polyester-cotton sleeve from Entreprise Shippagan showed no signs of degradation whereas the Regular Cotton from Rainbow Netting was completely degraded (Figures 2-7). Apparently, 7 to 8 scoters were noted in the vicinity of the experimental line.

Figure 2: Dec 21 2007 - Two photos of the medium-grade seed in Polyester-Cotton sleeves from Entreprise Shippagan (PC-ES) after 7 wk. A knife was used to slice open the mesh (bottom photo) - note the absence of mortality in the mussel sample.

Figure 3: Dec 21 2007 - Two photos of the mussel seed in Polyester-Cotton sleeves from Rainbow Netting (PC-RN) after 5 wk – smaller mussels have started to escape but no evidence of mortality was noted upon opening the sleeve.

Figure 4: Dec 21 2007 - Medium-grade seed in Heavy Cotton sleeves from Entreprise Shippagan (HC-ES) after 7 wk – note that mesh is partially degraded.

Figure 5: Dec 21 2007 - Tight-weave cotton sleeves from Rainbow Netting (TC-RN) after 5 wk – mesh barely visible.

Figure 6: Dec 21 2007 - Medium-grade seed in regular cotton sleeves from Rainbow Netting (RC-RN) after 7 wk. The biodegradable mesh has completely disappeared.

Figure 7: Dec 21 2007 - Mussels in blue mesh (above) and black mesh (below) sleeves after 5 wk.

3.2 January-May 2008

The experimental mussel seed longline was sunk in early January and consistent duck activity was reported at the beginning of February 2008. Sampling carried out on March 6 2008 revealed little change in the appearance of the polyester – cotton sleeves (Figure 8-9) but substantial duck predation was noted on the other sleeve types (Figures 10-12).

Figure 8: March 6 2008 – Intact polyester-cotton (50:50) sleeving (PC-ES) - note the tendency for the seed to move upwards to form balls at the top of the sleeve.

Figure 9: March 6 2008 - Polyester-cotton sleeving (28:72) (PC-RN) starting to break down – the mussels were creating holes in the mesh.

Figure 10: March 6 2008 - Rope with mussel shells remaining from heavy cotton sleeve (HC-ES) after duck predation.

Figure 11: March 6 2008 - Deeper section of regular cotton sleeve (RC-RN) which the ducks had not yet touched – this was sampled for growth estimates.

Figure 12: Mar 6 2008 – Blue mesh sleeves following duck predation activity.

By April 17 mussel seed in all the cotton sleeves (RC-RN, TC-RN, HC-ES) and the blue and black mesh had been completed decimated by ducks and most lines were floating on the surface (Figure 13). The only mussel seed remaining were found in the polyester-cotton sleeving materials (PC-ES and PC-RN). Mussels in the PC-RN sleeves which had started to break down had clearly grown; from 18.9 mm in November 2007 to 27.3 mm in April 2008 (Table 1). However, the high incidence of broken shells suggested that the ducks had been recently stripping these sleeves.

Table 1: Summary statistics showing the mean shell length and estimated count per ft in November 2007 and the statistics on the remaining two groups of sleeves in April 2008.

	November 2007					April 2008			
Type	CNT/Ft	Len(Se)	Min	Max		CNT/Ft	Len(Se)	Min	Max
ES-HC	543	18.3 (0.8)	6.5	32.1		0			
ES_PC_Small	648	15.0 (1.0)	7.0	28.6		417	17.7 (1.2)	5.8	35.9
ES_PC_Medium	436	23.5 (1.2)	8.8	36.6		231	20.7 (1.2)	8.0	32.6
RN_RC	501	21.6 (0.8)	9.9	32.4		0			
RN_PC	309	18.6 (1.4)	5.9	31.6		50	27.3 (0.9)	13.3	37.3
RN_TW	430	21.3 (1.1)	8.2	29.3		0			

Two loops of each polyester-cotton material were harvested to estimate the recovery rate of seed. Based on the volume of seed obtained (Liters) and estimates of the number of seed per Liter, the PC-RN sleeves contained approximately 1785 mussels per loop or a recovery rate of 16% (Table 1). These mussels had grown from 18.6 mm in November to 27.3 mm in April. By comparison the PC-ES sleeves which showed no signs of degrading contained approximately 15,000 (small) mussels per 12-m loop for a recovery rate of 64%. In the case of the medium-size seed there were 8,300 (med) mussels per 12-m loop remaining for a recovery rate of 53%. No change in mean shell length was observed in the small (15.1 mm in November vs 17.7 mm in April) or medium-size (20.7 mm in November vs 20.7 mm in April) groups. However, no losses due to mortality or duck predation could be detected. Based on the number of remaining PC-ES loops, we estimated that 585 L of seed remained to be harvested. IPMF staff recovered approximately 600 L of seed in early May and no subsequent mortality was observed in this seed following re-deployment. The estimated recovery rate needs to be interpreted with caution since insufficient sampling was carried out to properly assess the density of mussels per ft of rope. The number (estimated by volume) of seed deployed and the number (estimated by volume) of seed recovered would be a better measurement of productivity.

Figure 13: Apr 17 2008: Floating ropes from biodegradable sleeves stripped by ducks in the spring 2008.

Figure 14: Apr17 2008 - Bare rope from the center of the Regular Cotton (RC:RN) sleeves - the mussel seed was completed removed by ducks.

Figure 15: Apr 17 2008 - undegraded polyester-cotton (PC-ES) sleeving material full of mussel seed.

Figure 16: Harvested mussel seed from polyester-cotton (PC-ES) protective mesh.

4 Discussion

Mussel seed deployed in the fall in biodegradable cotton sleeves becomes vulnerable to sea duck predation after 2-3 weeks. For IPMF which buys seed from outside sources, this translates into a loss of $15,000 and the potential loss of a crop with revenue representing $250,000. Fall purchase of seed is preferable since they are readily available, the option to secure the necessary seed supply to support the mussel farm, and their small size makes the purchase more profitable since seed are purchased on a volume basis and more seed per tub at a standard price will be obtained in the fall.

There are several options that have been proposed to protect mussels from sea duck predation, but very few options have proven so far to be dependable. This project was designed to explore the use of protective mesh as a means of protecting the seed from duck predation. Dionne et al. (2006) tested protective socking material for cultivated mussels as a deterrence method against diving ducks. Their overall conclusion was that although this method held some promise, the fibres in the material were too slow to degrade thereby trapping mussels inside the sleeve permanently and causing high mortality. In Prince Edward Island where this approach was first tested, the strategy of resleeving seed is not practiced using the single 6-ft sock system. In contrast, IPMF typically follows the procedure of deploying mussel seed in the fall at high density using the highly mechanized NZ technology, harvesting and redeploying the seed at a commercial density the following April. This project has shown that the mussel seed deployed in the typical biodegradable mussel sleeve are at high risk of being totally decimated by duck predation. In contrast, mussel seed deployed in a non-biodegradable synthetic mesh can be effectively protected until the following spring when the threat from sea ducks has passed. This mussel seed deployed in this non-degradable mesh had a high survival, but no shell growth was observed. The process of recovering the seed from inside the synthetic mesh is laborious and needs to be mechanized. Manually, 150L of seed per person hour can be harvested, a commercially-unacceptable rate. A technology could however be designed and constructed to recover mussel seed deployed inside protective synthetic mesh and harvested at a rate of 1500 L of seed per hour or one full long-line.

In conclusion, trapping the seed inside a non-degradable synthetic mesh over the winter does not appear to cause mortality and effectively protects against sea duck predation. Slightly larger sleeve diameters and openings of the polyester mesh should be investigated since benefits in growth while maintaining the protection against docks could be achieved. Effort should also be directed towards finding a way to recycle the polyester sleeving material and to mechanize the seed harvesting operation.

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