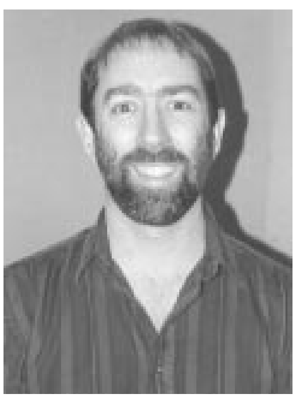
Clam Enhancement Trials in the Bay of Fundy

S.M.C. Robinson



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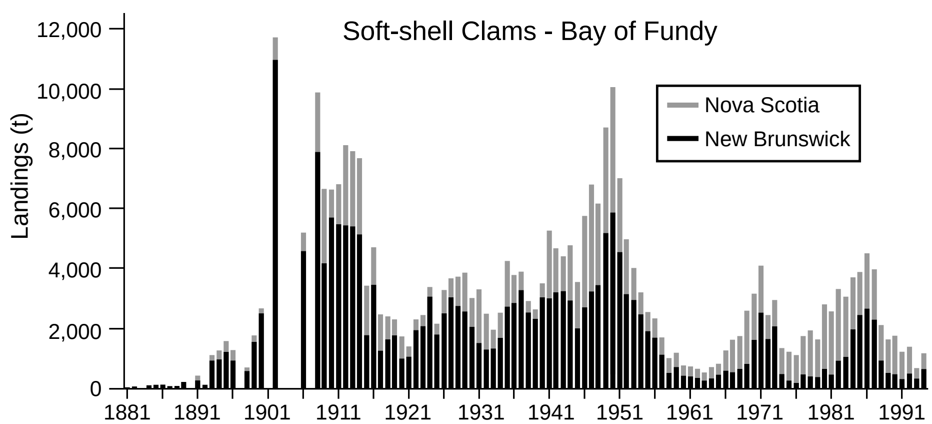

Figure 1: Long-term landing records for the soft-shell clam in the Bay of Fundy.

Introduction

History

The clam fishery for the soft-shell clam, *Mya arenaria*, in the Canadian Maritimes has had a long history with formal catch records dating back to the late 1800s. This species was probably one of the first marine species to be exploited due to its relatively easy access during low tides. The soft-shell clam was an important food source for the native tribes in the area who harvested them extensively for food and the remains of this early exploitation can be seen from the many shell mounds or "middens" in the area. After colonisation by the Europeans, clams continued as a basis for the food industry, first as a direct food source and later as a bait source for the lucrative long-line fishery off the Grand Banks and other groundfishing areas. At the turn of the century, fishing schooners would often stop off in the Annapolis Basin or the Quoddy region in south-western New Brunswick to gather barrels of salted clams for bait. Much of this harvest was very likely unrecorded. In the early to mid 1900s, a canning industry for clams was well established and many clams were exported in this form from the Bay of Fundy.

Recent Past

Harvesting methods have changed very little over the last century with respect to harvesting technology. With the exception of a brief period in the 1960s when automated harvesting techniques were exam-

Method	Concept	Pros	Cons
Rotational Digging	Harvest the clam flats on a rational basis in order to allow certain flats to lie fallow and become more productive.	• allows clams to get a few years of relief from digging pressure • results in better growth and lower mortality • relatively easy management method	• problems arise if there are not enough digging areas to set aside • assumes that the areas closed for conservation will not be lost to pollution
Brushing	Place artificial barriers on the beach in order to increase the rate of natural spat settlement and survival.	• natural method of increasing natural settlement • low-tech and relatively inexpensive	• dependent on natural sources of larvae • very dependent on growth and survival rates • labour intensive for large areas • requires a shift in management towards an ownership-based management style
Relaying	Move juvenile clams for further growout from a high density beach to one that has been depleted through harvesting pressure.	• allows over-harvested areas to be restocked • high-density populations can be thinned for better growth • may allow closed areas to be put back into production • can be linked into a seed/hatchery system	• very dependent on growth and survival rates • labour intensive • requires a shift in management towards an ownership-based management style

Table 1: Summary of the pros and cons of the three enhancement methods tested in south-western New Brunswick.

ined, hand harvesting using a clam fork (hack or digger) is still the only method used in the Bay of Fundy. However, while the harvesting methods have not changed, the landings have generally decreased (Fig. 1). While some of the drops in landings may be due to social conditions at the time (i.e. World War II) and biological events and cycles, the trend of decrease is correct. This drop in landings has had a dramatic effect on the local economies. Although the loss to the communities can not be directly estimated, we can derive an indirect estimate. If we assume that the beaches still have the capacity to support the production levels of the past, then the 10 year average landings of the Bay of Fundy was approximately 5,700 tons from 1945 to 1955. If this biomass of clams was landed today and sold for the current price of $1.90/ kg ($0.85/lb), this would net the diggers and local economies about $10.86 million. In 1994, the total recorded landings amounted to 1191 tons which was worth $2.27 million at $1.90/ kg, a drop of 80 %. This loss in potential annual income is significant to the clam industry. Many of its participants work in several primary industry sectors (agriculture, forestry, fishing) over the course of the year and while their annual income may not be great, each portion is important. In addition, the overhead expenses related to harvesting is small so the bulk of the earnings go directly back into the economy rather than servicing fishing-related debt.

The reasons for the drop are many, but the primary one is the loss of many harvesting areas due to health-related closures from coliform bacteria. These closures have a two-fold effect on the fishery. First, it removes the clams from the wild harvesting base (although depuration plants can use moderately contaminated areas) and it concentrates the diggers on the other open flats. At some point, depending on the size and productivity of the open beaches, this concentration of fishing effort can over-harvest the clam populations. Other factors which affect the productivity of beaches for harvesting are: the occurrence of phytotoxins (such as paralytic shellfish poison (PSP), diarretic shellfish poison (DSP) and domoic acid or amnesiac shellfish poison (ASP)) or normal changes in biological cycles in response to environmental changes (i.e. cooling or warming trends). However, these latter conditions are temporary and only affect the clam production for fixed time periods. In comparison, the loss of clam flats to the wild harvesters due to faecal colifom contamination will likely be permanent unless remediation measures are taken.

Objective

The objective of our enhancement work was to investigate techniques to increase the productivity of the open beaches in order to sustain the wild harvest during the interim period while remediation techniques are being developed to clean up the coastal zone. Remediation is the ultimate goal as it will not matter about the production capacity of a beach if the product is unable to be harvested. The projects were all designed in conjunction with industry partners in order to achieve direct technology transfer and easier acceptance of the results.

Three basic methods were investigated: rotational digging, brushing and relaying (Table 1). These techniques are not new and are basically modifications of projects attempted by industry in the New England areas in the 1950s.

Rotational Digging

A project to investigate the potential for rotational digging was initiated in Lepreau Harbour in the spring of 1991. Two 3 x 9 m plots on a commercially harvested clam beach were established and subdivided into three equal sections; one scheduled to be harvested on an annual basis (1992, 1993, 1994, 1995)), one on a biennial basis (1993, 1995) and the third on a triennial basis (1994). All plots were completely harvested on initiation of the project (1991) by commercial diggers using clam forks. The same diggers harvested the plots in 1992 and 1993. Unfortunately, other com-

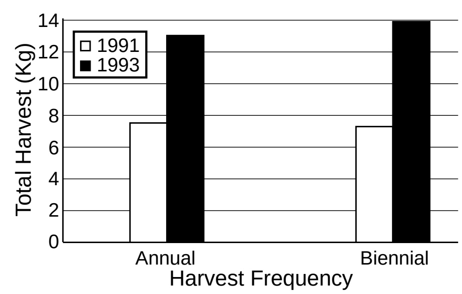

Figure 2: Total weight of clams harvested from the annual (2 harvests) and the biennial plots (1 harvest) between 1991 and 1993. The initial harvests in 1991 from each of the plots are shown so the dark bars represent the new production from the plots from 1991 to 1993.

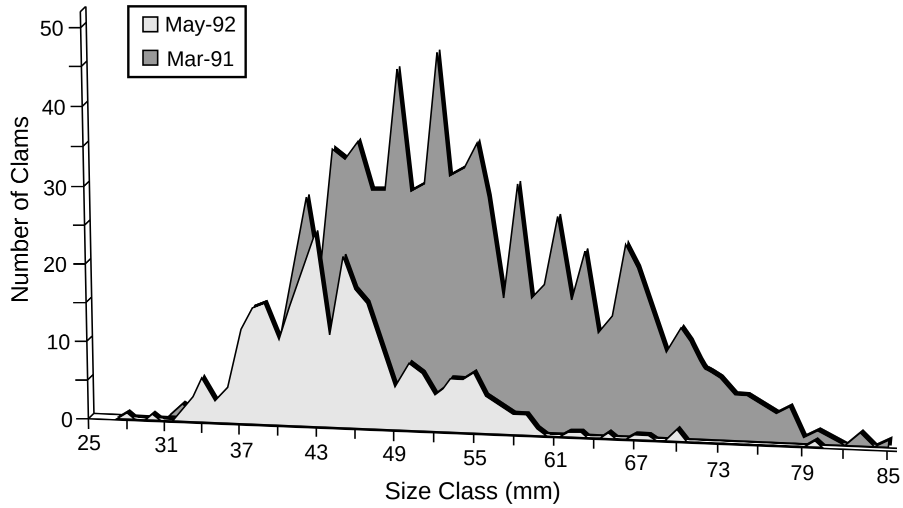

Figure 3: Comparison of the size-frequency distribution between the original harvest of the rotational plots in 1991 vs. the first annual harvest in 1992.

mercial diggers dug through the plots in early 1994 invalidating the remainder of the study (i.e. testing the benefits of triennial harvesting). The clams from each harvesting were taken back to the laboratory at the St. Andrews Biological Station and all were measured using calipers and weighed to the nearest gram.

The results from the first two years of study indicated there were advantages to allowing the plots to lie fallow for a year (Fig. 2). Initially, both the annual and biennial plots had similar harvested biomass of clams, 7.5 vs. 7.3 kg respectively, while at the end of the 2 year trials the biennial plots had approximately 6.5 % more harvested biomass. These results indicate that while the total amount harvested was slightly more in the biennial plots, the catch-per-unit-effort (CPUE) was over double that of the annual plots (13.9 kg/digging vs. 6.5 kg/digging). A comparison of the size frequency distribution between the initial harvest and the first harvest of the annual plots show that the larger sizes are quickly removed from the plots and the harvesters concentrate on the smaller individuals (Fig. 3).

It can be concluded from this study that there are benefits to the concept of rotational digging by increasing the overall catch and increasing the catch rate. Previous work by Robinson and Rowell (1990) indicated there is a definite incidental mortality rate (the mortality rate to those animals left in the beach after the harvesting operation) imparted to the clam population during harvesting. Depending on the time of year of harvesting and the sediment type, the incidental mortality rate may be as high as 50%. While the mortality rate was relatively low in this study based on the relative equality of the total harvested amounts, this study was also conducted in sediment and at a time of year when mortality would have been predicted to be lower. Therefore, if harvesting had occurred at a different time of year, the results may have been more dramatic.

As indicated in Table 1, one of the problems with this technique is that there has to be at least twice as much harvesting area available than is required to maintain the desired landings. Although we were not able to test the triennial harvest, this technique would require three times as much harvesting area. At the present time, with the existing shellfish bed closures, this type of management may have to used in conjunction with other methods for it to be effective.

Brushing

The concept of brushing evolved from early observations of clam diggers on the beaches. They observed that clams were often found around obstructions on the beach, such as logs or rocks. In the late 1950s, according to anecdotal information, clam diggers in Maine tried placing old Christmas trees on the beach to increase the set of soft-shell clams, thus the derivation of the term “brushing”. The theory behind this technique is that the obstacles on the beach surface cause turbulence in the water column as the tide flows over it. This turbulence allows the larvae in the water column, which are competent to settle, more frequent encounters with the bottom. If the bottom is suitable, then the larvae will settle. This concept was revived in the summer of 1990 by industry members in the Lepreau Harbour and Deer Island areas and an experimental site was set up in each area. Each site consisted of two replicate series of four 5 x 5 m plots. One of the four plots had a small fence (1 m wide x 0.5 m high) built of laths on posts spaced 5 cm apart (Fig. 4). The second plot had an identical fence, but also had some crushed clam shell placed on the surface. The third plot had a fence plus a layer of gravel on the surface. The fourth plot was left natural as a control. The plots were established in May of 1990 (before the spawning season) and the plots were sampled in February, June and August of 1991. The experiment was repeated in 1992 at the request of industry, although not at the same locations, and the test of the fences in conjunction with crushed clam shell was eliminated. Plots were sampled for settlement and subsequent survival by taking sediment cores in the experimental plot and sorting the samples in the laboratory. For recovery of small bivalves from the sediment, a floatation technique was developed (Robinson and Chandler 1992) which ensured almost 100% recovery.

Results from the 1990 trials were mixed. The experimental plots at the Clam Cove site on Deer Island were covered with a layer of clam shell approximately 10 cm deep. The same was done for the experimental plots for gravel. The sediment be-

Figure 4: Shot of the clam settlement fences used in the settlement experiments in Lepreau Harbour with Mr. Steven Lomax.

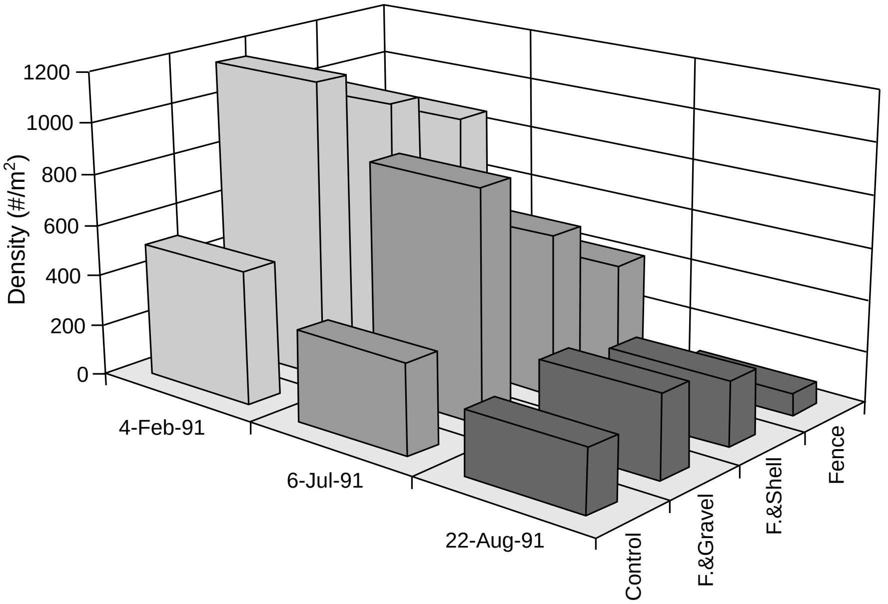

Figure 5: Mean density of soft-shell clam juveniles from core samples taken in the experimental and control plots in February, June and August 1991.

came anoxic underneath and it was impossible for any larvae to settle in these plots. The industry partner from Deer Island lost interest in the project and so this site was abandoned. However, at the Lepreau Harbour site, settlement samples taken in February 1991 indicated there were significant differences in settlement. There were over double the number of spat in the experimental plots compared to the controls (Fig. 5). This difference persisted in the June 1991 samples. However, the pattern of clam density among plots changed after the summer season, based on the August samples.

In 1992, two different sites were chosen by the industry members, one in Northern Harbour on Deer Island and the other in Lepreau Harbour approximately 1000 m east of the 1990 site. Core samples were taken using the same methods used in 1990. The results indicated there was no settlement in Lepreau Harbour at the 1992 site, but there was still significant differences found at the remains of the 1990 control site and the experimental site with the fence and gravel (the other 1990 experimental plots with fences were presumed to have been destroyed by ice) (Fig. 6). The Northern Harbour site on Deer Island showed low levels of settlement in comparison with the other sites and there was no significant differences between the experimental and control plots.

These results from the two years indicate that it is possible to increase the settlement rate of natural larvae and that this increased settlement can result in more spat. However, in determining the number of spat later on in the year, there appear to be more biological processes occurring than simply the number of larvae contacting the bottom. The addition of shell and gravel to the bottom further increased the settlement rates over the simple fences or controls, but only up to a certain point. Too much material can cut off the settlement entirely. Sediment characteristics also play a role. The 1990 Lepreau site was good for settlement based on the densities observed and these patterns persisted. However, the 1992 site at Lepreau was much sandier than the previous site and the Deer Island site had a gravel base with a gelatinous mud layer on top. Both of these types of sediment were unfavourable for either the initial settlement or subsequent survival. Therefore, in conclusion, it appears the brushing technique has some application in certain habitats, but it can not be used to re-stock a beach which has unfavourable characteristics for early juvenile settlement.

Relaying

At present, the only way for beaches, which have been closed due to coliform contamination, to be returned to production, is through depuration. This process involves harvesting the clams with registered diggers and transferring the clams to a shore-based plant where clean water is pumped through the tank, thereby allowing the clams to cleanse themselves. However, another possible solution is moving animals from a contaminated area to a clean, open beach where they can cleanse themselves. This would allow more diggers to participate in harvesting the clams and would also have the potential to put closed areas back into production. In order to test this idea, a project was initiated to relay clams from a closed area on Grand

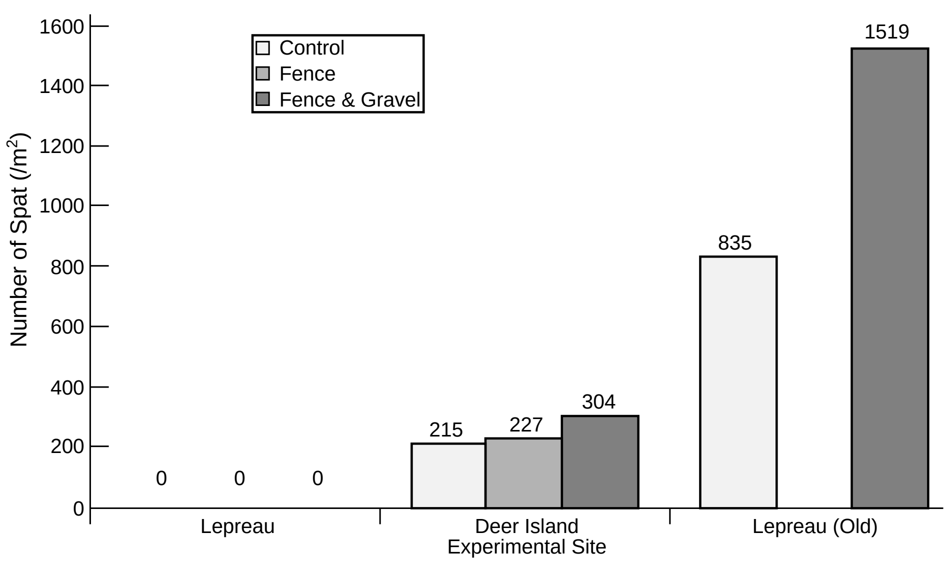

Figure 6: Mean density of soft-shell clam juveniles from core samples taken in the experimental and control plots in Lepreau Harbour and Deer Island in 1992. Samples taken in 1992 from the old Lepreau Harbour site (originally sampled in 1990-91) are shown for reference.

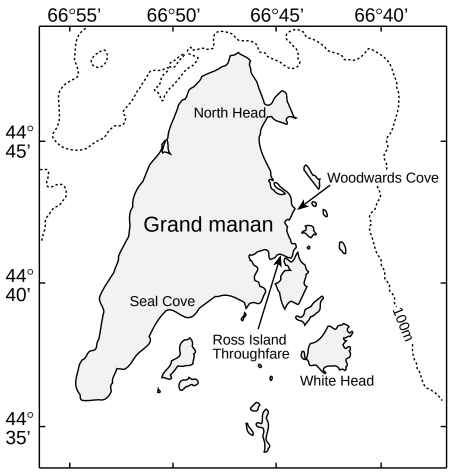

Figure 7: Location of the study sites for the relaying project on Grand Manan where the clams were harvested (Woodwards Cove) and where they were planted (Ross Island Thoroughfare).

Manan (Woodwards Cove) to an open area (Ross Island Thoroughfare) (Fig. 7).

Soft-shell clams were harvested during the first week of September 1993 at Woodwards Cove using a hydraulic rake attached via a 2 inch (50 mm) fire hose to a 5 HP Briggs and Stratton powered impeller water pump (Fig. 8). Over 92,000 clams were harvested, sized and sorted as to small (<15 mm), medium (15 - 30 mm) and large (> 30 mm). The clams were then taken to the Ross Island Thoroughfare and replanted by broadcasting them into defined 10 x 10 m pre-surveyed plots at a density of 75 per m^2. The background density of clams (from the pre-survey) was estimated to be 25 per m^2 and therefore the final density of clams per plot was 100 per m^2. The plots were then sampled approximately 6 weeks later and 7 months later to examine survival of the transplanted clams. Survival was calculated by assuming no mortality for the original clams in the beach and therefore calculating the survival of those introduced (i.e. at $75/m^2$). This method was employed as it we felt the majority of the loss of the clams from the plots would happen to the new clams during their burial process.

Figure 8: Photo of the hydraulic clam harvester used to collect clams from the beach for the relaying project.

Clam samples were taken from both sampling locations during the September and October periods in order to test for the release of faecal coliform bacteria. These samples were analyzed at the microbiological laboratory at the Inspection Branch of the Department of Fisheries and Oceans in Blacks Harbour. The effect on the faecal coliform levels of relaying the clams to a clean, open site from a closed area was quite dramatic (Fig. 9). The levels dropped from 2,400 faecal coliforms per 100 g of clam meat in September to 45 faecal coliforms per 100 g of clam meat 6 weeks later near in October at the open site. This is well below the legal limit for harvesting. At the control site (Woodwards Cove), the counts also dropped, but only to 790 faecal coliforms per 100 g of clam meat which was over 3 times the acceptable limit.

The survival rate of the relayed clams was quite high. Although, there was a 40% drop in the number of small clams over the seven month period from $75/m^2$ to approximately $45/m^2$, the survival of the medium and large clams was very good (between 90 and 100%).

The economics of the transfer operation from the closed to the open areas was also favourable. Relaying over 92,000 clams cost $1,116 based on 93 hours at $12 per hour worked. This equated to a cost of 2 to 3 cents per clam relayed depending on whether the capital cost of the gear is included. If the relayed clams (based on mean size) had an annual survival rate of 70% and grew to the legal size of 44 mm (1.75 inches) the relayed crop would be worth $3,150. Therefore, if the clams were relayed and then subsequently harvested, the profit of the operation would be $199 if the gear is included or $1,489 if it is not. For the latter case, this equates to creating jobs at a rate of $10.79 per hour. The value of the resource (cost ratio) was about 2:1 to 3 :1 compared to the cost of relaying the animals from the closed area.

Overall, this project was a success. The harvesting of the clams from the closed area (Woodwards Cove) was not particularly difficult and although the efficiency of gathering the clams that were brought to the surface by the harvester could be improved, the operation worked quite smoothly. There appeared to be very low mortality rates through crushing or breaking of the shell. The substrate on Woodwards Cove could be described as a sandy-silt. Therefore, depending on the substrate, this type of harvester is probably best for the collection operation compared to a traditional clam fork which is relatively inefficient and causes much more damage. Although it was only a single test of the relaying proc-

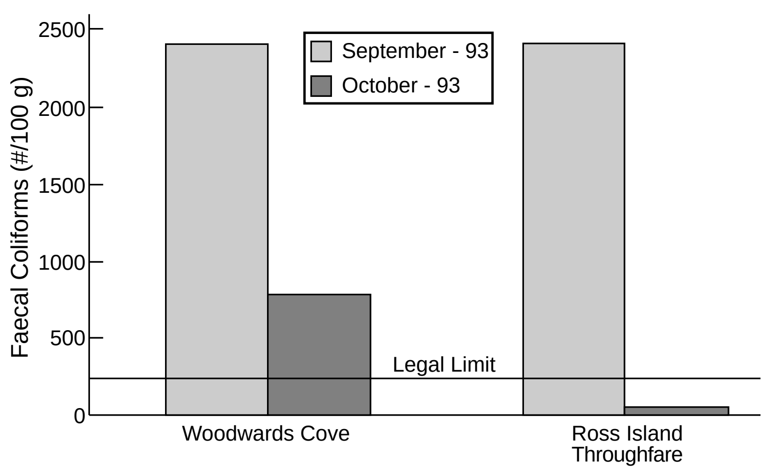

Figure 9: Faecal coliform bacterial levels per 100 g of clam tissue from the harvested beach (Woodwards Cove) and the planting beach (Ross Island Thoroughfare) sampled in September and October 1993. The dashed line indicates the maximum legal level for faecal coliforms in clam tissue

ess, the results confirm that this type of effort has potential and that other efforts should be supported. With enough successful trials, a strong case could be made to incorporate this strategy into the soft-shell clam management plan. However, this approach will only work if there are clean beaches available. The value of open beaches will increase and there will be more incentive to ensure they remain open.

Conclusions

The enhancement efforts which have been tried to date all seemed to have worked to a certain extent. Most of the trials have been done at an experimental scale and it is now time to try them at a larger pilot-scale. However, the efforts must be led by the industry members and the local communities. Enhancement of clam stocks appears achievable, but there has to be a shift in the philosophy of how to exploit and manage the stocks. Brushing and relaying both involve resources to be expended before the final harvest is achieved. Without a spirit of cooperation and consolidation within the present industry, none of these methods can be employed because no person will do all the work without some guarantee of receiving some of the benefits. This is the challenge for the communities and the managers of the resource.

Acknowledgements

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