Evaluation of a Prototype Design Stock Sampler for Soft-Shell Clams

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Executive Summary
During the summer and autumn of 2007, Clean Annapolis River Project (CARP) evaluated the effectiveness of a hydraulic stock sampler for determining population size and distribution of soft shell clams in the Annapolis Basin. Specifically, the project sought to assess the effectiveness and usability of a prototype stock sampler (1) against a conventional hand-sieving methodology; (2) in a range of sediment types (sand/gravel, clay, silt-mud) and (3) in the tidal conditions experienced in the Annapolis Basin (large tidal amplitude).

Historically, stocks of soft-shell clams have been assessed by hand digging and sieving, a methodology that while effective, was extremely labour intensive. The prototype stock sampler evaluated through this project was based on the design used in Kouchibouguac National Park (New Brunswick) and the ideas of Shawn Robinson (DFO-St. Andrews/Hunstman Marine Laboratory).

A 50 m x 50 m grid was laid out over approximately 3.5 ha of clam flats at Big Joggins, Annapolis Basin (Digby County). Within this grid, side-by-side comparisons of the hand digging and hydraulic stock sampler methodologies were made. From 14 sites, the two methods produced similar clam density estimates (26.3 clams/m^2 versus 21.4 clams/m^2, respectively) although the hydraulic sampler had a lower standard error. The hydraulic sampler retrieved clams across all size classes (5-9 mm to 65-69 mm). With the hand digging and sieving methodology, 48% of clams were broken during handling. Using the hydraulic sampler, 29% of the clams were broken, of these, most (>80%) could still have their length determined.

Careful records were maintained on the time required to collect clam samples by the two methods, in order to allow a comparison of productivity per unit effort. Using the hand digging and sieving methodology, 0.04 m^2 of beach was sampled per person-hour. This compared to 0.22 m^2 per person-hour for the hydraulic sampler. The hydraulic stock sampler thus achieved a five-fold increase in stock survey productivity.

The stock sampler was evaluated in a number of sediment types commonly found in the Annapolis Basin: stiff clay, soft silty mud and sand/small gravel. The equipment performed poorly in stiff clay with limited lifting ability. Based on past experience though, stiff clay does not provide good habitat for soft shell clams. The equipment performed well in mud sediments. In sand/small gravel sediments, the equipment performed extremely well, rapidly liquefying and lifting the sediment within the sampling ring.

Overall, the prototype hydraulic stock sampler performed well against all the criteria. No design modifications are envisioned at this time.

Introduction

The clam flats of the Annapolis Basin represent an important fisheries resources within Nova Scotia. This area has historically contributed up to 68% of all soft-shell clam landings within the province (Angus *et al*, 1985). The last Department of Fisheries and Oceans stock assessment of this resource was completed over 10 years ago (Thorpe *et al*, 1995). CARP undertook a stock survey of two beaches in the Annapolis Basin in 2006, requiring approximately 67 person-days for the sampling of 244 quadrats (Sullivan, 2007).

These stock surveys were conducted by hand, with the removal of a defined volume of sediment, followed by sieving to recover clams for enumeration. Given the size of the Annapolis Basin clam flats (approximately 1,960 ha) and the number of samples required for a valid population estimate, surveys in the past have been extremely labour intensive. This has resulted in a regular survey program being unsustainable.

In recent years, there has been growing concern over the current status and future of the soft-shell clam resource in the Annapolis Basin. Work has recently been underway by Clean Annapolis River Project (CARP), the Bay of Fundy Marine Resource Centre as well as the Digby and Annapolis Clam Digging Associations to develop a local management body for this resource. This group, the Annapolis Watershed Resource Committee, has been established to provide a balanced and fair opportunity for industry, government, and community to discuss and make well-informed decisions and recommendations on all issues related to the management of soft-shell clams and other resources, and to promote the sustainable use of resources and their surrounding environment in and around the Annapolis River Watershed.

The survey of current soft-shell clam stocks are seen by the Annapolis Watershed Resource Committee as an important step in the effective management of this resource, as it will facilitate the implementation of conservation, stewardship and enhancement efforts. There is widespread agreement among all stakeholders from industry, community and government, that up-to-date information on clam stocks is badly needed.

The Soft-shell Clam

The soft-shell clam (*Mya arenaria*) is a thin-shelled bivalve found in subtidal and intertidal sediments from the subarctic to the Carolina's (Maine Department of Marine Resources, 1993). The shells vary in colour from white to dark grey and blue, depending on the sediment in which they live. Most of their life cycle is spent in a burrow, which they dig using their muscular foot. Their long "neck", shown in Figure 1, is composed of an incurrent and an excurrent siphon and extends near the surface. The incurrent siphon is used to draw in water on which the clam filter-feeds. This important characteristic makes them particularly sensitive to pollutants in water. Microscopic plant and animal matter that is suspended in the water, such as algae and diatoms, are their main source of food; however clams can also accumulate toxins such as bacteria and toxic algae, making them unsafe for human consumption. The excurrent siphon is used to release fecal material as well as sperm and eggs during external fertilization (DFO, 1993).

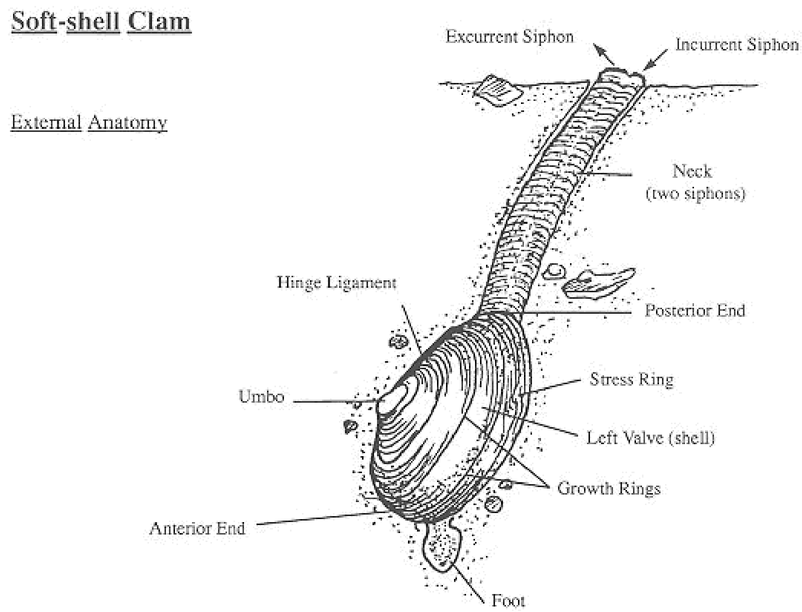

Figure 1: External anatomy of the soft-shell clam, *Mya arenaria*
(Source: Department of Fisheries and Oceans, 1993)

Spawning is onset by a combination of environmental factors, including the monthly tidal cycle and the water temperature. After the eggs are fertilized, larvae remain in the water for a period of approximately two weeks, after which they undergo a metamorphosis and settle on the bottom as juveniles. The clams then quickly begin to dig their burrow using their extensible foot. As juveniles age, they continue to dig deeper into their permanent burrow, usually to a depth of 10-15 mm (DFO, 1993). Previous studies in the Annapolis Basin have shown soft-shell clams to reach commercial size (44.5mm) in approximately 5½ to 6 years (Angus *et al*, 1985; Amaratunga, date unknown).

Background on Conventional Hand-digging and Design

Sullivan (2007) undertook a literature review of past stock assessments conducted in the area as well as in New Brunswick in order to identify survey methodologies and standard methods. The review showed no consistent methodology for the assessment of clam stocks both within the Annapolis Basin and beyond. Methods varied widely in terms of the placement of a sampling grid, the size of quadrat sampled as well as the mesh size used to sieve sediments (MacLeod and Hill, 1973; Angus *et al*., 1985; Rowell and Woo, 1990; Thorpe and Robinson, 1995; LeBlanc, 1997; LeBlanc, 2006).

In the absence of any standard methods, Sullivan (2007), in her survey of Karsdale and Deep Brook beaches, used the approach taken by Parks Canada at Kouchibouguac National Park (KNP), New Brunswick (LeBlanc, 2006). KNP is responsible for the sustainable management of a commercial soft-shell clam fishery within the park, and conducts annual stock assessments. The KNP methodology had been tested and refined over several years.

The sampling methodology involved placing a square grid consisting of a baseline and perpendicular transects over the beach in question. The baseline was positioned approximately parallel to the coastline and was marked every 50m with polyvinyl chloride (PVC) posts. The posts were coloured with bright paint and a short description of their purpose was written on them in permanent marker. The locations of the posts were recorded with a handheld global positioning system (GPS).

Each post along the baseline marked the location of a perpendicular transect line, along which samples plots were located at 50m intervals. The first sample was collected 10m from the baseline in order to capture narrow clam beds along the shore. All other samples were collected at 50m intervals along the transect. Sample locations were also recorded using a GPS.

Due to the varying shape of the coastline, the baseline was a distance away from the shore in large coves. In these instances, the transect line continued toward the high water mark, starting at 40m and then every other 50m.

At each sample location, a 0.0625m² quadrat was dug to a depth of 20cm. All contents within this area were placed in a bucket and carried to the water's edge. The contents were then sieved using a 5mm mesh. A diagram of the sampling grid is shown in Figure 2.

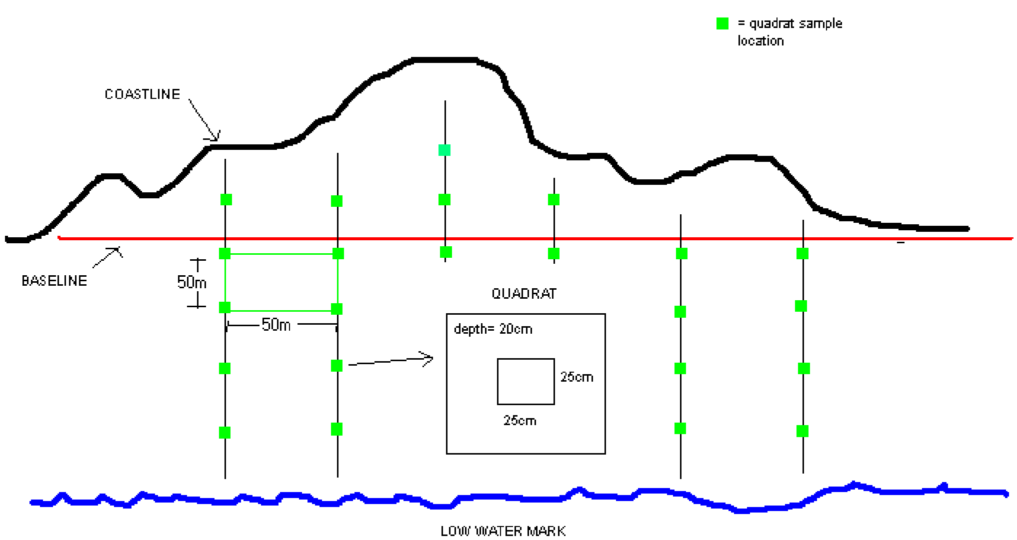

Figure 2: Sampling grid for soft-shell clam stock assessment

Project Objective

The purpose of this project was to evaluate and operationalize a soft-shell clam sampler that would significantly increase the rate at which stock assessments could be performed. The achievement of this objective would allow more beaches to be surveyed more often, allowing better management.

The evaluation assessed the effectiveness and usability of a prototype stock sampler:

- in the tidal conditions experienced in the Annapolis Basin (large tidal amplitude)
- in a range of sediment types (sand/gravel, clay, silt-mud) and
- against a conventional hand-sieving methodology.

Prototype Development

With support from the Nova Scotia Department of Fisheries and Aquaculture (Innovation Grant File Number T-00936), during the spring and summer of 2006, CARP consulted with a number of individuals on the appropriate design for a soft shell clam stock sampler. These included Shawn Robinson, Department of Fisheries and Oceans St. Andrews Research Centre; and Léophane LeBlanc, Kouchibouguac National Park. CARP staff visited Kouchibouguac National Park to study the soft shell clam sampler design and associated equipment used. Based on input from these individuals and others, as well as the literature review and site visit, a prototype sampler was constructed.

The prototype relies on water driven through a venturi to create hydraulic suction, which lifts sediment and clams. This bottom material is washed through a mesh, allowing retrieval of the clams. A gasoline powered water pump is used to pump water through the venturi creating the necessary suction. A round sampling ring with an area of 0.25 m^2 is used to provide a standard sampling area. Further information on the design and operation of the clam sampler is contained at Appendix A and B.

CARP had planned to undertake an extensive trial of the sampler during August and September 2006. Unfortunately, due to a number of unforeseen circumstances, CARP was unable to complete the trial of the sampler during this period. A limited evaluation was conducted at Deep Brook, Annapolis Basis in early October, where the prototype was found to work effectively. This report documents the evaluation of the prototype, undertaken in July, August and September 2007. This work was supported by the Nova Scotia Department of Fisheries and Aquaculture Innovations Fund (File #T-01002).

Results

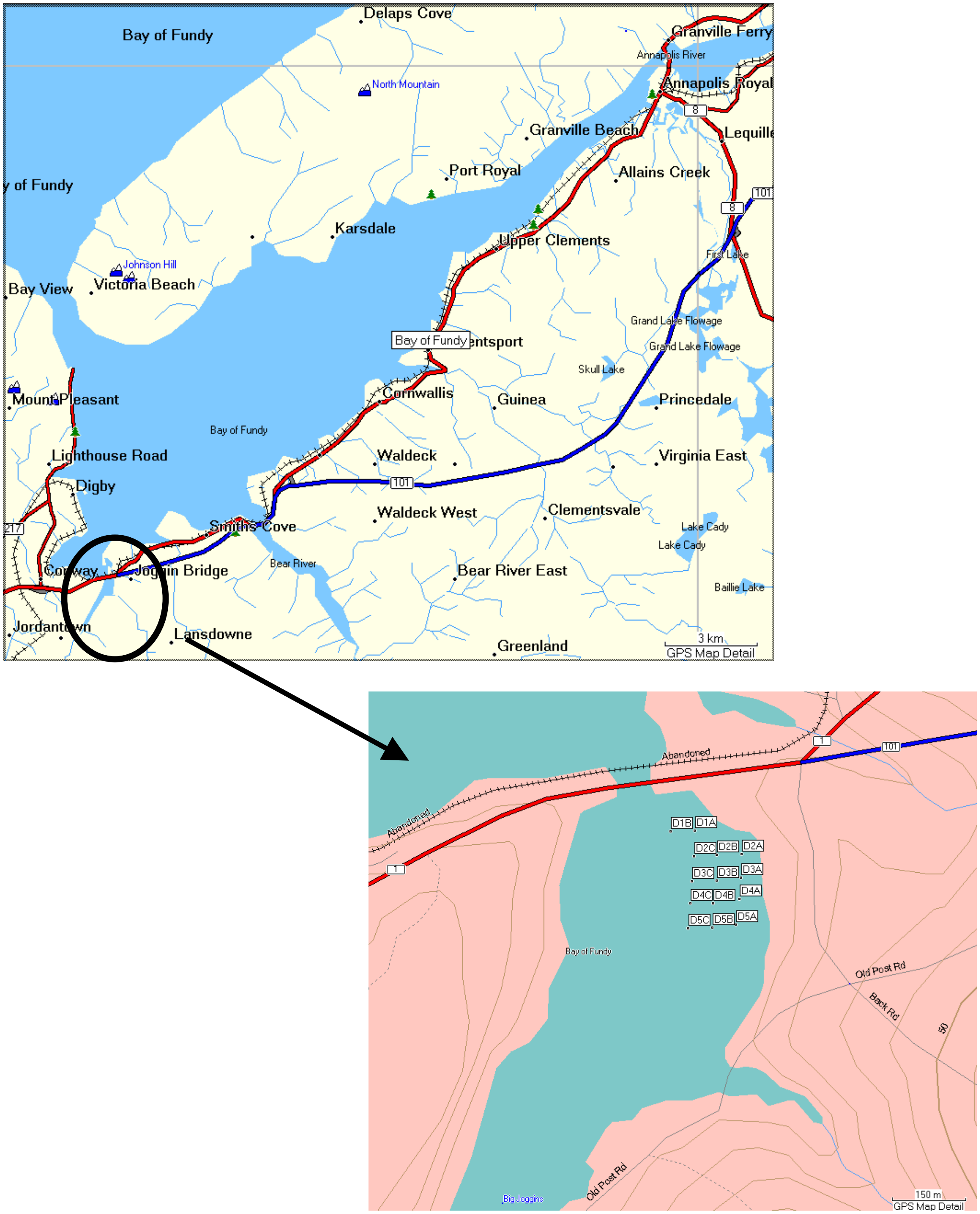

Figure 3: Annapolis Basin and location of sampling grid at the Big Joggins.

Recovery Rate – comparison of methods

Using the 50 m x 50 m grid arrangement described above, 14 side-by-side sites were sampled using the hand-sieving and pump methods. The grid covered approximately 3.5 ha, with the location shown in Figure 3.

Tallies were maintained on the number and size of clams recovered. A total of 23 clams were recovered using the hand method versus 75 using the pump. As the two methods excavated different areas (0.0625 m^2 (hand) versus 0.25 m^2 (pump)), the tallies had to be transposed to a per square meter basis. The results are shown in Table 1.

Table 1. Comparison of Recovery Rate.

Method	Clam Density	Standard Error
	(clams/m^2)	
Hand Digging & Sieving	26.3	13.4
Pump	21.4	8.2

A similar density figure was obtained from the two methods, although the pump result had a lower standard error, most likely due to the larger number of clams recovered. From Figure 4, it is evident that the pump recovered clams from across all the size classes. Most of the clams recovered by hand were in the smaller size classes.

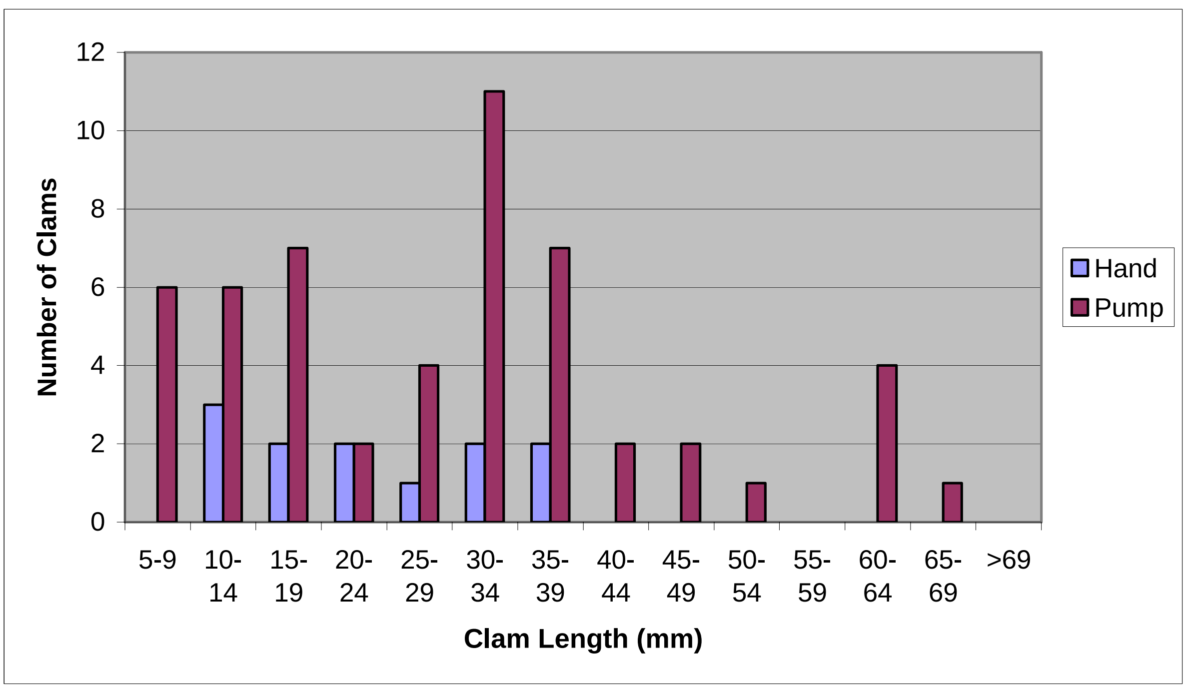

Figure 4: Size Comparison of Recovered Clams

Breakage Rate – comparison of methods
When clams were dug by hand and sieved on a 50 m x 50 m grid, 48% were broken during handling. Using the pump and stock sampler in 2007, 29% of clams were broken during handling. Of these broken clams, most (>80%) could still have their length determined. Overall, the clam stock sampler had a lower breakage rate than the conventional method.

Unit Effort – comparison of methods
The time required to collect and sieve samples using the conventional method (hand digging & sieving) and pumping using the stock sampler was closely monitored to assess the unit effort of the two methods. These results are presented in Table 2.

Table 2. Comparison of Unit Effort for the Two Methods.

	Person-Hours	Number of Samples	Samples per person-hour	Area per Sample (m^2)	m^2 Sampled per person-hour
Hand Digging & Sieving	12.75	19	1.49	0.06	0.04
Pumping	17.25	20	1.16	0.25	0.22

A slightly higher number of samples can be collected by hand, (1.49 versus 1.16 per person-hour. When the larger sample area of the stock sampler is taken into account (0.25 m^2 versus 0.06 m^2) though, a significantly greater area of the beach can be assessed. Using the stock sampler, 0.22 m^2 of beach was sampled per person-hour, versus 0.04m^2 by hand sieving and digging. Based on these results, a two-person crew working for a five hour period (e.g. one tide cycle) could hand dig and sieve 0.6 m^2 (15 samples), whereas use of the stock sampler would allow 2.2 m^2 (12 samples) to be assessed.

The above unit effort calculations do not take into account: travel to and from the work site, mobilization and demobilization of equipment on/off the site, and staking out of the sampling grid. These factors are assumed to be consistent between the two methods.

Effectiveness in various sediment types
The stock sampler was evaluated in a number of sediment types commonly found in the Annapolis Basin: stiff clay, soft silty mud and sand/small gravel. These results are reported in Table 3.

Table 3. Effectiveness of Stock Sampler in Various Sediments.

Sediment Type	Observations
Stiff Clay	• It was very difficult to press the sampling ring into the clay. Depths of 5 to 10 cm (as opposed to the 25 cm full depth) were typically achieved. • The suction unit was not able to hydraulically lift heavy/dense

	clay sediments. • Stones and cobbles present occasionally made it difficult to press the sampling ring fully into the sediment. • Based on past experience, stiff clay does not provide suitable habitat for soft shell clams.
Soft silty mud with cobbles	• The suction unit worked well in mud sediments. • Stones and cobbles present occasionally made it difficult to press the sampling ring fully into the sediment. • Sufficient vacuum was present to lift stones of 11 cm x 7 cm x 5 cm in size. These occasionally became lodged in the venturi chamber, requiring the pump to be turned off before the stones could be removed.
Sand/small gravel	• The suction unit worked very well in sand/small gravel, with sediment being rapidly lifted. • Much of this material was retained in the receiving mesh bag, resulting in it becoming rapidly very heavy and unwieldy to handle. In order to reduce the volume of material in the mesh bag, it was necessary for a second crew member to manipulate the bag in the water, allowing fines and sand to be washed out through the mesh. • The sampling ring was easily pressed into sand/small gravel to the appropriate depth.

Ideal team size and duties

To effectively operate the stock sampler, it was found that two individuals needed to be in the water at the same time – one operating the suction unit while the other maintains the boat position in relation to the sampler, guiding the intake and discharge hoses and controlling the pump. The minimum crew size would thus be two. In this scenario to maximize the sampling window, suctioned samples could be placed in labeled containers for later sorting and recording. Samples could be collected on a near continuous basis on the rising or falling tide, allowing only for the repositioning of the boat and suction unit at the next sample location.

When a third or fourth crew member is available, these individuals can sort and record the samples as they are suctioned. Crew sizes in excess of four are not effective.

Macro-tidal challenges

The Annapolis Basin and lower Bay of Fundy experience a tidal amplitude of +/- 8 meters. Working on clam flats in a macro-tidal environment such this presents a number of challenges. When compared to the prototype suction unit, hand digging and sieving requires considerably less equipment, all of which can be easily carried to the survey site. The equipment for the clam stock sampler was heavy and unwieldy and could not easily be carried to the beach. This necessitated the use of a small boat, both to bring the larger pieces of equipment to the site and provide a floating platform on the rising and falling tides.

In order for sufficient suction to be developed by the stock sampler, a minimum water depth of approximately 12 inches (0.3 m) was required. The maximum depth that the stock sampler could be practically used was approximately 30 inches (0.76 m). In order to maintain the stock sampler within this operating water depth, it is necessary to work shoreward on the rising tide and seaward on the falling tide.

Both the hand digging and stock sampler methods require access to water. On the wide, low gradient clam flats of the Annapolis Basin, only a limited window was available for collecting samples.

While there factors added complications to the use of the stock sampler, careful advance planning allowed them to be addressed. In particular, sample locations were located and mapped in advance, the order for sampling individual stations pre-planned, and movement of the boat onto the beach coordinated to ensure that it was not stranded on the falling tide.

Suggestions for layout of sampling grid

The distribution of clams at the Big Joggins beach, as well as others (Sullivan, 2007) was very patchy, with some areas supporting denser patches and other areas almost completely devoid of clams. The 50 m x 50m grid methodology does not focus sampling in dense patches, but rather the beach as a whole. Anecdotal evidence from clam harvesters suggests that the distribution of clams on the beaches have not historically been so patchy and that, in the past, clams were available over a much larger area (Kenneth Weir, personal communication, February 8, 2007). Focusing sampling within the denser patches would increase overall measures of density and better represent the reality of where harvesting occurs; however, it would not capture the historical changes that have occurred on the flats.

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Appendix A – Stock Sampler Components

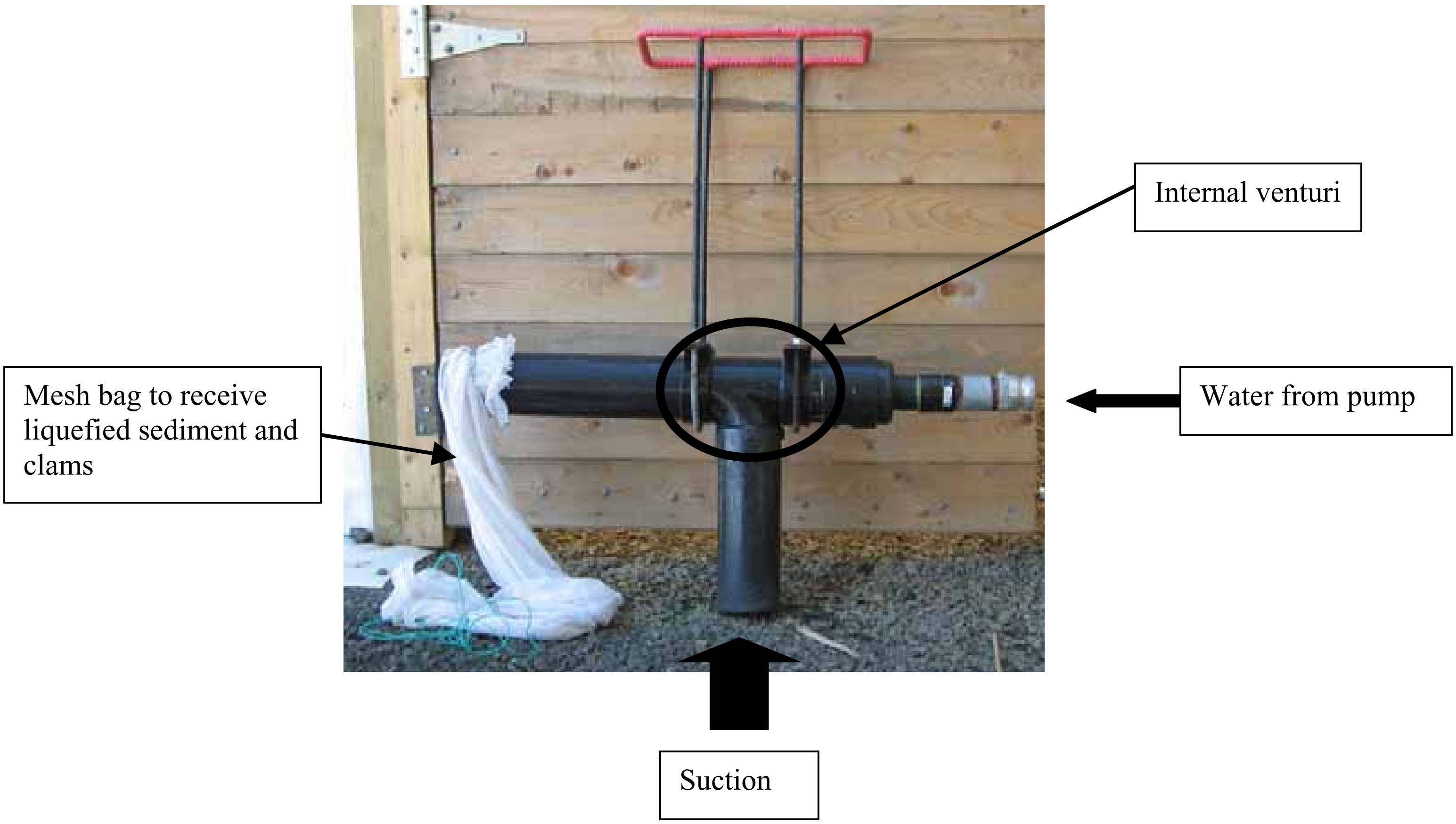
Intake Pipe
Length: 16 feet (5.0 m)
Diameter: 3.5 inches (8.5 cm) rigid pipe
Screen End: 7 inches (17.5 cm) x 5.5 inches (13.5 cm)
3/8 inch opening (1 cm)

Water Pump
OHV 200 4 stroke gasoline engine
Rated output: 4 kW
Engine speed:3600 rpm
Displacement: 0.196 L
KGP30 water pump unit
Continuous flow: 30 m^3/hour
Continuous head 13 m

Hose (between pump and suction unit)
Length: 17 feet
Diameter: 2 inches (5 cm)

Sampling Ring
Inside diameter: 22 inches (56 cm)
Construction: welded aluminum
Height: 10 inches (25.5 cm)
Area: 0.25 m^2
Rope: 4 feet with float

<u>Suction Unit</u>
Input pipe diameter: 4 inches (10 cm)
Height of venturi above bottom of input pipe 14.5 inches (37 cm)



Appendix B – Operation of Stock Sampler

Photo 1: Evaluation of the stock sampler on Big Joggins clam flat, Annapolis County – August 2007.

Photo 2: Boat is used in shallow water to support pump, showing intake and exit hoses

Photo 3: Suction unit being used in shallow water. Note sediment billowing out through white mesh bag.

Photo 4: Retained sediment from mesh bag is dumped into screened box (5 mm mesh).

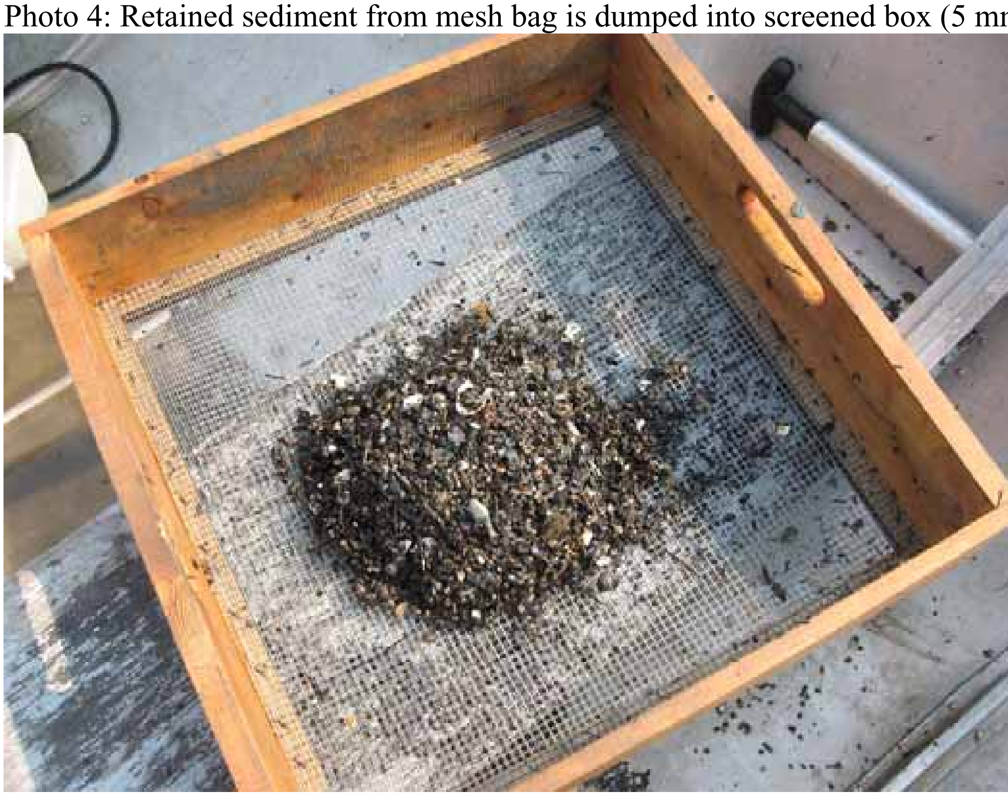


Photo 5: Sediment is picked through, clams removed and measured.