SEWAGE TREATMENT PLANT CONTAMINATION OF THE ANNAPOLIS RIVER

ECONOMIC IMPLICATIONS FOR THE SOFT-SHELL CLAM INDUSTRY

by

Christopher DeBow

Submitted in partial fulfilment of the requirements
for the degree of Master of Development Economics

at

Dalhousie University
Halifax, Nova Scotia
April 2013

DALHOUSIE UNIVERSITY
DEPARTMENT OF ECONOMICS

The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled "Sewage Treatment Plant Contamination of the Annapolis River: Economic Implications for the Soft-Shell Clam Industry" by Christopher DeBow in partial fulfilment of the requirements for the degree of Master of Development Economics.

Dated: April 24, 2013

Co-Supervisor: ________________________________

Co-Supervisor: ________________________________

Reader: ________________________________

DALHOUSIE UNIVERSITY

Date: April 24, 2013

Author: Christopher DeBow

Title: Sewage Treatment Plant Contamination of the Annapolis River: Economic Implications for the Soft-Shell Clam Industry

Department: Department of Economics

Degree: MDE **Convocation:** October **Year**: 2013

Signature of Author

DEDICATION

My great-grandfather was a fisherman. He made a living, supported his family, and stayed in his community because of the access he had to our province's natural resources. He was willing to get up before dawn and spend days working in harsh conditions, knowing that the only thing that stood between him and his livelihood was his determination.

Clam harvesters in the Annapolis Basin have demonstrated that same resolve for more than 400 years, yet a failure in the very basic structures and services of a modern society have disrupted their lives by restricting their access to a public good upon which their employment depends. Their numbers are small and their economics irrelevant to the broader economy, but it is to these hardworking people that I dedicate this thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The Annapolis Basin soft-shell clam fishery has been impacted by frequent closures due to sewage contamination from overflow at the Town of Digby sewage treatment plant. The harvesters that derive a livelihood from this traditional fishery have suffered economic losses that have not been widely acknowledged, addressed, or quantified.

For years, individuals and organizations in the Annapolis Basin area pushed to have the sewage treatment plant in Digby upgraded to remediate the environmental damage that its under-capacity was causing. The investment in the upgrade was estimated at $2.2 million, while the cost of doing nothing was never measured.

The objective of this thesis is to examine the economic implications for the soft-shell clam industry of the contamination of the Annapolis Basin using a simple cost-benefit framework. By isolating the interaction between the sewage treatment plant upgrade and the soft-shell clam fishery, the analysis identifies and estimates principal costs and benefits, measuring the net present value of the prevention of fishery closure resulting from the upgrade. Results of the analysis demonstrate that the investment in the upgrade is justified under a range of closure scenarios and deviations in key assumptions and variables.

LIST OF ABBREVIATIONS USED

STP	Sewage treatment plant
SSF	Small-scale fishery
HAB	Harmful algal bloom
US	United States
MEY	Maximum economic yield
CBA	Cost-benefit analysis
NPV	Net present value
TBOC	Treasury Board of Canada
WSOC	Weighted social cost of capital
ROI	Return on investment
AALV	Average annual landed value
TL	Total landings
AAVA	Average annual value added
TL	Total landings
NMW	Net meat weight
EI	Employment insurance
AANEIB	Average annual net employment insurance benefits
EIBR	Employment insurance benefit rate
UV	Ultraviolet
AOS	Annual operating-cost savings
AOC	Annual operating cost
FC	Fishing closed
CC	Capital cost
ANB	Annual net benefit
VAM	Value-added margin

ACKNOWLEDGEMENTS

I would like to thank the Dalhousie University Department of Economics for its patience and flexibility in the completion of a degree that began during the Clinton administration. I am quite grateful to have had the support and guidance of Barry Lesser, Teresa Cyrus, and Tom Pinfold. This could not have been completed without the persistence, kindness, and humour of Monique Comeau. Thanks to Gardner Pinfold Consultants for their generosity over the years.

I would like to acknowledge the Clean Annapolis River Project and Steve Hawboldt whose commitment to protecting and improving the Annapolis Basin and its fisheries has been the driving force behind this work.

A special thanks to my very understanding family – Patti, Mackenzie, and Ella – who have cheered, pushed, and allowed me the time to work. To my mother, Jan, and father, John, who lovingly supported me and, thankfully, rarely asked if I was finished. And finally, to my Aunt Judy, who is one of the few people who understood how difficult this process can be and always asked how it was going in just the right way.

CHAPTER 1. INTRODUCTION

The soft-shell clam fishery in the Annapolis Basin has represented an important source of livelihood for generations of harvesters who have relied on it as a sole source of income or part of a seasonal revenue diversification strategy. This environmentally sustainable fishery has formed the foundation upon which modern processing and marketing industries have developed in the region, providing a broader source of employment and income beyond primary harvesting. The leading shellfish processor and distributor employs approximately 30 people, achieves annual revenues of between $1,000,000 and $5,000,000, and exports product to the United States, Algeria, France, Hong Kong, and the United Kingdom (Government of Canada, n.d.).

1.1 The Issue

Despite the historic, cultural, and economic significance of the Annapolis Basin soft-shell clam industry to the region, the fishery has been adversely impacted by serious environmental and water quality issues resulting from the overflow of untreated sewage into the Annapolis River from the Town of Digby sewage treatment plant (STP). Limitations of the town's infrastructure and under-capacity at the plant have resulted in the discharge of untreated waste into the Annapolis River. Elevated levels of bacteria flowing downstream have infected the soft-shell clam population effectively closing the fishery for varying periods of time since 1973 (Sullivan, 2007a). Although the town and appropriate government departments are aware of the situation, no remediation of the problem or upgrade to facilities has occurred to date. In 2009, approximately $3.5 million in multi-level government funding to upgrade the facility has been approved.

1.2 The Objective

The objective of this thesis is to assess the economic implications of sewage contamination of the Annapolis Basin for the soft-shell clam industry. Assessing these implications involves estimating the economic value of the fishery to The Province of Nova Scotia and conducting a cost-benefit analysis of investing in the upgrade.

CHAPTER 2. REVIEW OF THE LITERATURE

In essence, this thesis is about the importance of small-scale resource-based industry to rural communities facing increasing pressure from a range of socio-economic factors. The Annapolis Basin area of Nova Scotia is part of a larger region known as the Annapolis Valley, which has faced increasingly difficult economic and demographic conditions. Population loss, business closure, and a high unemployment rate (Government of Canada, 2012b) have combined to create pressure for individuals and households in terms of creating and sustaining a livelihood. Since the mid-1800s, the soft-shell clam harvest in the Annapolis Basin has been an example of a resource-based industry that has provided a small number of fishers with an opportunity to diversify their income, face these increasing pressures, and remain in the region (Sullivan, 2007a).

2.1 Small-Scale Fisheries and Rural Economies in Perspective

Small-scale fisheries (SSF) remain an important economic activity in rural coastal communities around the globe. In both developed and developing nations, millions rely on these traditional industries as sources of employment, income, and nutrition (Teh, Teh, & Sumaila, 2011). This has historically been the case in the soft-shell clam fishery in the Annapolis Basin, where a commercial harvest has been in place since the mid 19th century.

> *"In the early years of the commercial fishery, clams were used as bait for more valuable fish species. Diggers would sell clams for cod bait off the Grand Banks and could make about $10 a day. At the time* [c. 1850]*, this was more than what most people would earn in a week."*
>
> (Sullivan, 2007a)

From a wider rural development perspective, SSFs can play a role in contributing to the economic well being of the community. Although SSFs like that in the Annapolis Basin are relatively small in terms of employment and production, their local economic impact is not insignificant. At the core of the industry are harvesters who land shellfish using shovels and rakes. The low level of capital required to enter the industry, coupled with the relatively low cost of harvesting, can lead to a greater portion of revenue remaining in the hands of producers (Johnson, 2012).

Broadly speaking, the core of small-scale shellfish fisheries is comprised of harvesters and processors. Peripheral industry participants include equipment suppliers (to both harvesting and processing), buyers, distributors, transportation, brokers, retailers, food services, administration, insurance, legal services, marketing, communications, and others (Salter & Marketing, 2002).

In their examination of the impact of SSFs, Bene et al. (2005) note that communities that participate in these export oriented industries contribute to local, regional, and national economies through the generation of foreign exchange and tax revenue. Aside from the direct impacts derived from the sale of product, the authors identify a range of both "upstream and downstream" indirect impacts, as follows:

Upstream – activities that supply inputs to the harvesting operations.

- Investment in equipment and materials.
- Labour.
- Financial and administrative services.

Downstream – activities that occur post-harvest.

- Investment in processing facilities and equipment.
- Variable operating costs of processing.
- Packaging
- Transportation.
- Marketing.

- Financial and administrative services.

It should be noted that not all of these indirect impacts occur in the community in which the harvesting and processing activity takes place. In the case of the Annapolis Basin soft-shell clam fishery, the bulk of labour-related impacts occur in proximate communities, as does much of the spending on basic equipment and materials. Investment in equipment, packaging, as well as financial and marketing services, most likely impact communities outside the immediate area.

Induced impacts are defined by the authors as the "income and employment effects from the changed levels of income and expenditure throughout the local economy as a result of direct and indirect impacts" (Béné et al., 2005, p. 19). The authors argue that the total impact of SSF activity can represent a major driver of economic activity in rural communities.

Shellfish aquaculture has been widely considered a powerful economic development tool for rural communities in both the developed and developing world. While major differences exist between shellfish aquaculture and wild fisheries, their scale and role in the rural economy is often similar. Halwart et al. (2003) observe the role aquaculture plays in rural development, noting that, like SSFs, aquaculture provides opportunities for "own-enterprise" employment, which can contribute to an increase in livelihood diversification and economic security.

Perhaps the most studied aspect of SSFs and rural communities is the role they play in poverty reduction. (2006) make the point that "[the] SSF sector plays an important role in contributing to the livelihoods of the poorest sectors of society in diverse ways, providing employment, fish for consumption and financial revenues from the sale of fish." Indeed, in many communities in both the developed and developing world, fisheries like that in the Annapolis Basin provide local fishers with an opportunity to diversify their often-fractional incomes with seasonal revenue from a renewable resource. In their examination of the sustainable livelihoods approach to poverty reduction in SSFs, Allison and Ellis (2001) observe that participation in industries like the Annapolis Basin soft-shell clam fishery is often an income diversification strategy designed to mitigate the unpredictable nature of resource-based employment rather than being an occupation of last resort, as is often assumed. Sustainable, well-managed SSFs can contribute to poverty reduction through four major channels (Walmsley et al., 2006):

1. **Livelihood**: SSFs provide employment and income that enable the consumption of other goods and services;
2. **Capability**: SSFs can contribute to an increase in an individual's capacity to derive a livelihood through access to a nutritious and plentiful protein source;
3. **Vulnerability**: SSFs that are protected from external shocks, such as sewage contamination, are less likely to suffer closure or collapse thereby reducing the vulnerability of the community to poverty. Access to SSFs also has the potential to decrease vulnerability by increasing an individual or community's food security;
4. **Participation**: SSFs are often co-managed and monitored by local harvesters' organizations or other community groups,[1] thereby increasing community capacity and helping ensure the sustainability of the resource.

Despite much evidence to the contrary, there is a general lack of acknowledgement in the literature of the important contribution SSFs make to rural livelihoods and economic development (Béné, 2005). In their study of the

[1] The Annapolis Basin soft-shell clam fishery is managed and monitored in part by the Digby County Clam Diggers, the CHA2 Clam Harvesters Association, and the Annapolis River Guardians.

socio-economic contribution of SSFs in Malaysia, Teh et al. (2011) observe that the undervaluation of SSFs has occurred because of a combination of their scale, geographic dispersion, and relatively insignificant contribution to the national economy. The authors estimate that the SSF in their study was undervalued by approximately 225%, despite the critical welfare role it played in the region.

2.2 Small-Scale Fishery Closures: Their Implications and Impact

The central issue of this thesis is the impact that temporary closures of a SSF have on the local economy. In this case, a series of closures has occurred because of sewage contamination from surrounding municipalities. Shellfish fishery closures are not uncommon in coastal communities throughout the world. They are often closed because of contamination, invasive species, over-fishing, and the presence of harmful algal blooms[2]. Closures of SSFs have immediate and significant impacts.

[2] "Algal blooms are a common occurrence in aquatic environments. A subset of these blooms poses environmental or public-health threats, and it is therefore referred to as 'harmful algal blooms', or HABs. Some HABs are harmful by virtue of their sheer biomass, whereas others are associated with algal blooms capable of producing toxins." (Backer & McGillicuddy, 2006, p. 1)

2.2.1 Soft-shell Clams and Escherichia Coli Contamination

Soft-shell clam fishery closures in the Annapolis Basin occur because of the presence of Escherichia coli (E-coli) bacteria in the shellfish as a result of sewage bypass at the Digby sewage treatment plant. Soft-shell clams obtain food by filtering seawater. Any E-coli bacteria present will accumulate in the shellfish at a concentration of approximately 20 times that of the surrounding water (Cabelli & Heffernan, 1970). E-coli bacteria do not kill soft-shell clams and are eventually filtered and eliminated once the contamination is no longer present in the surrounding water. This natural process of filtration is increasingly relied upon by seafood companies to market marginally contaminated shellfish through a process called depuration. In a depuration fishery, marginally contaminated shellfish are harvested and maintained in purified seawater until the bacteria is adequately purged (Department of Fisheries and Oceans, 2009). While soft-shell clams are able to quickly eliminate contamination under the controlled conditions of a depuration plant, the uncontrolled inundation of sewage into a wild fishery poses public health risks that result in fishery closures.

2.2.2 Economic Impact of SSF Closures

In their study of the impact of fishery closures due to harmful algal blooms (HABs) in the United States, Hoagland et al. (2006) collected estimates of the economic impact of HABs across four broad classes: public health, commercial fisheries, recreation and tourism, and monitoring and management. Of particular relevance are their findings about HABs and commercial fisheries where fishery closures, increased processing costs, and contraction in consumer demand were the result. Table 1 summarizes their key findings regarding commercial fishery closures (Hoagland, Anderson, Kaoru, & White, 2002, p. 826):

Table 1: US Commercial Fishery Effects Due to Closures, 1987 to 1992

Year	Industry Impacts	Number of States with Closures	Total Annual Estimated Effects (Millions of 2000 USD)
1987	• Clam, oyster, scallop, crab, finfish harvest losses and mortalities. • Lost recreational fishing revenue. • Clam fishery closures.	5	21
1988	• Lost recreational fishing revenue. • Clam fishery closures. • Scallop, crab, harvest losses and mortalities.	3	15
1989	• Farmed fish mortalities. • Lost recreational fishing revenue. • Clam fishery closures. • Scallop, crab, geoduck harvest losses and mortalities.	5	25
1990	• Farmed fish mortalities. • Lost recreational fishing revenue. • Clam fishery closures. • Scallop, crab, geoduck harvest losses	5	14

Table 1: US Commercial Fishery Effects Due to Closures, 1987 to 1992

	and mortalities.		
1991	• Farmed fish mortalities. • Lost recreational fishing revenue. • Clam fishery closures. • Scallop, crab, geoduck harvest losses and mortalities.	5	16
1992	• Farmed fish mortalities. • Lost recreational fishing revenue. • Clam fishery closures. • Scallop, crab, geoduck harvest losses and mortalities.	6	19

Source: Hoagland et al. (2002).

The authors estimate that average annual effects to commercial fisheries due to HAB were approximately $12 million (2000 USD). Losses to fisheries that could be considered analogous to the Annapolis Basin soft-shell clam fishery ranged from $130,000 to over $9 million. They conclude that "there is little doubt that the economic effects of specific HAB events can be serious and significant at local levels, although estimates of the scale of effects must still be regarded as uncertain." (Hoagland et al., 2002, p. 832). They acknowledge that, in the context of the overall production of the US commercial fisheries - $4.5 billion in 2010 (Van Voorhees & Lowther, 2011) – implications for the broader economy are insignificant.

Small-scale recreational clam fisheries have also been affected by closures due to bio-invasions, such as HABs. Although these fisheries are considered non-commercial, their scale and operation are very much like a commercial clam fishery. Along the Pacific coast of the United States, more than one-quarter of all potential razor clam harvesting days were lost due to beach closures resulting from toxic bio-invasions (Dyson & Huppert, 2010). Using expenditure data collected through surveys of recreational fishers, Dyson and Huppert estimated that the total reduction in user expenditure caused by a fishery closure of two to five days in length at the study area's four beaches was approximately $4 million (2008 USD). [3]

Although individual SSFs generate negligible economic impact on a macroeconomic scale, economic losses that can extend into the millions can have major implications for the livelihoods of people in rural communities that face considerable challenge as it is.

[3] The study area surveyed was comprised of four beaches with an average daily participation of approximately 3,000 recreational fishers (Dyson & Huppert, 2010).

2.3 Small-Scale Renewable Resource Industries and Rural Economic Development

Renewable resources play an important role in the economies of rural communities. The sustainable use of renewable resources is critical to their ability to serve as engines of long-term economic development to rural communities. Sustainable use can be defined as one that sets the total annual harvest equal to the rate of resource growth (McWhinnie, 2012). Extending this simple statement further, the optimal stock level of any resource occurs at the point of maximum economic yield (MEY), which incorporates the net value of harvesting the resource. As McWhinnie points out, MEY occurs where the gap between total revenue and total cost is greatest.

Another view of sustainable renewable resource-based economic development includes the further condition of mitigating the effects of economic activity on environmental quality (Barbier & Markandya, 1989). Barbier and Makandya state that “maximizing the net benefits of economic development, subject to maintaining the services and quality of the stock of natural resources over time, is an essential criterion for sustainable development.” (p. 2) They further argue that sustainable use of renewable resources requires:

1. utilizing renewable resources at rates less than or equal to the natural or managed rates of regeneration;
2. generating wastes at rates less than or equal to the rates at which they can be absorbed by the assimilative capacity of the environment;
3. optimizing the efficiency with which exhaustible resources are used, which is determined by the rate at which renewable resources can be substituted for exhaustibles and by technological progress. (Barbier & Markandya, 1989)

Traditionally, fisheries and agriculture formed the foundation of the local economy of the Annapolis Basin region. In the absence of external shocks to the ecosystem, soft-shell clams have provided fishers with a reliable, renewable source of income for generations (Sullivan, 2007a). In the case of soft-shell clams, the sustainability and reliability of supply requires harvesters to leave an adequate population of juvenile clams in the ground due, in part, to their high mortality rate (Sullivan, 2007b). Sullivan's survey of the Annapolis Basin revealed a relatively low clam density and concluded that the resource has not been harvested sustainably. Management efforts in the Annapolis Basin have included stock assessments, water quality monitoring, and occasional reseeding of clam beds ("Clean Annapolis River Project," n.d.).

2.4 The Use of Cost-Benefit Analysis in Project Decision Making

"Cost-benefit analysis (CBA) is a decision standard that is commonly used by policymakers to assist in determining whether a policy or project should be implemented. CBA monetizes the effects of a policy [or project] on individuals or groups in order to facilitate comparisons with the *status quo* or with other policies. In its basic form, CBA places primary weight on economic efficiency, but it can also be modified to account for adverse wealth distribution effects by appropriately weighting the costs and benefits to individuals or groups." (Trebilcock, Yatchew, & Baziliauskas, 2007, p. 1). In the context of this thesis, the objective of employing CBA is to measure the net provincial economic benefits or losses that would result from an upgrade to the Town of Digby sewage treatment plant as they relate to the Annapolis Basin soft-shell clam industry. CBA is a widely used approach in evaluating municipal projects and has been used in the context of sewage treatment in Nova Scotia as recently as 2000. GPI*Atlantic* conducted an analysis of the Halifax Regional Municipality's plan to build a sewage treatment plant to deal with the disposal of nearly 200 million litres of raw sewage that entered the harbor daily (Halifax Regional Municipality, 1996). In their study, they identify a set of environmental and economic outcomes of investing in sewage treatment plants (Wilson, 2000):

Environmental Benefits

- Less contaminated sediment and sludge build-up.
- Decrease in pathogens.
- Less biological oxygen demand.
- Regulated water temperature.
- Lower levels of toxic chemicals.
- Lower nutrient loading.
- Enhanced marine habitat.
- Return of native marine life.
- Maintenance and/or enhancement of current marine life (e.g. lobsters).
- Reduced chance of nuisance and toxic algal blooms (e.g. bluegreens, dinoflagellates).

Economic Benefits

- Increased recreational opportunities.
- Increased property values.
- Reduced human health risks.
- Enhanced attractiveness for tourism.
- Increase in commercial fisheries.

Economic Impacts

- Employment due to construction of STPs.

- Employment due to operation and maintenance of STPs.
- Employment due to increased recreation and tourism.

It should be noted that, although the authors make a distinction between environmental and economic benefits, an economic value could be estimated for many, if not all, environmental benefits of the project. While this framework is helpful in identifying potential factors to consider in the analysis, it goes beyond the scope of this thesis.

A critically important factor in any CBA is the selection of the discount rate that drives the results of the net present value calculation. Net present value analysis is a project valuation technique used to help decide whether or not to proceed with an investment. To calculate net present value (NPV), all expected benefits and costs from the investment, now and in the future, are identified. Future benefits and costs must be analyzed for their relevant value today and are, therefore, discounted to the present using an appropriate discount rate. The present value of total costs is then subtracted from the present value of all expected benefits to arrive at a net value. From an economic perspective, a project is considered feasible if the present value of future benefits outweighs the present value of the investment plus future costs. The discount rate allows for the comparison of costs and benefits that occur over a period of years. It is the "the rate at which society discounts future costs and benefits and converts them into present values" (Boardman, Moore, & Vining, 2008, p. 3). While the selection of a discount rate has generated much controversy in the literature, a common practice in public investment decisions in Canada has emerged. In evaluating federal government projects, two rates are conventionally applied to CBA: the private and social discount rate. "The [private] discount rate will be a weighted average of the costs of funds from the three sources outlined above: the rate of return on postponed investment, the rate of interest (net of tax) on domestic savings, and the marginal cost of additional foreign capital inflows. The weights are equal to the proportion of funds sourced from domestic private-sector investors, domestic private-sector savers, and foreign savers" (Treasury Board of Canada Secretariat, 2007, p. 37). "The social discount rate is defined as the minimum real rate of return that a public investment must earn if it is to be a worthwhile undertaking. It is intended to reflect the real rate of return foregone in the private sector when resources are shifted to the public sector" (Burgess, 1981, p. 383). The Treasury Board of Canada (TBOC) uses a private rate of 8% and a social rate of 3% based on the weighted social opportunity cost of capital (WSOC) (Treasury Board of Canada Secretariat, 2007). The WSOC is determined by computing the weighted average of the economic cost of funds from the following (Jenkins & Kuo, 2007):

1. The rate of return on postponed or displaced investment.
2. The social cost of new domestic savings.
3. The marginal cost of incremental foreign capital inflows.

Recent work by Boardman et al. (2010) suggests that the 8% WSOC used in federal CBA is too high for a number of reasons. The authors argue that the 8% rate is "not justified by the actual marginal private-sector ROI; the weights used to compute it put too much emphasis on displaced private-sector investment; the use of market-based proxies is problematic; and it does not account well for intergenerational issues," (p. 21). Spiro (2010) supports this contention with current TBOC guidelines and argues that the social discount rate should be reviewed annually to better reflect the volatility of global financial markets and, therefore, the true opportunity cost of capital. He points out that the financial crisis that began in 2008 drove interest rates to record lows in many industrial economies and that "in the future, real rates may rise again, if demand and supply conditions change, but for investment projects undertaken in the near term, it is appropriate to use a correspondingly low discount rate," (p. 9).

Although the arguments these authors make are compelling, the TBOC maintains their position on the 3% and 8% discount rates and these rates will be applied in the cost-benefit analysis in this thesis.

CHAPTER 3. METHODOLOGY

This assessment involves the analysis of a range of data gathered from current literature, stakeholder interviews, and consultation with community groups and government departments at all levels. This thesis will summarize findings from:

1. A valuation of the economic benefits derived from the wild soft-shell clam harvest in the Annapolis Basin.
2. A cost-benefit analysis of the proposed upgrade to the Digby STP.
3. A qualitative summary of the range of other socioeconomic implications of the contamination of the Annapolis Basin.

3.1 Economic Benefits

For the purposes of this thesis, economic benefits derived from the wild soft-shell clam harvest will be limited to the landed value of the fishery – that is, the amount paid to harvesters by processors for the clams they harvest; value added to the harvested clams through processing and packaging; the Employment Insurance benefits claimed by clam harvesters in the off season; and operational cost savings derived from the investment in the upgrade.

3.2 Cost-Benefit Analysis

The cost-benefit analysis involves estimating the costs and benefits of upgrading the STP as they relate to the soft-shell clam industry, its stakeholders, and The Province of Nova Scotia. The analysis is isolated to the interaction between the plant and clam industry, whereby costs will be expressed as those directly related to plant upgrade and operation, and benefits will relate directly to production and value-added activity resulting from the Annapolis Basin clam harvest.

3.3 Net Present Value Approach

The estimation of the economic implications for the soft-shell clam industry of sewage treatment plant contamination of the Annapolis Basin will be conducted using a net present value approach. Net present value analysis is a project valuation technique used to help decide whether or not to proceed with an investment. To calculate NPV, all expected benefits and costs from the investment, now and in the future, are identified and totaled. Future benefits and costs must be analyzed for their relevant value today and are, therefore, discounted to the present using an appropriate discount rate. The present value of costs is then subtracted from the present value of all expected benefits to arrive at a net value. From an economic perspective, a project is considered feasible if the present value of future benefits outweighs the present value of the investment plus future costs.

3.4 Accounting Stance

Accounting stance refers to the spatial frame of reference in which the benefits and costs related to the project occur. Standard practice in CBA is to set the spatial boundaries of the analysis based on where the bulk of the impacts will be felt (Riely & Rockland, 1988). In the case of upgrades to the Digby STP, it could be argued that the costs and benefits are almost entirely local. Because the project will be funded, in part, by the Province of Nova Scotia, the accounting stance taken in the CBA is provincial and only the provincial share of the cost is relevant to the analysis. Economic impact will therefore be assessed by identifying costs and benefits that accrue to the province and not beyond. In the same way, the federal portion of the total investment in the sewage plant upgrade will be deducted in order to isolate the relevant provincial share of the investment. Federal transfers, such as net Employment Insurance claims, are included as they are considered benefits to the province. If the CBA were to be conducted to assess the project's viability from a national perspective, the federal contribution to the cost of the project would be included, and Employment Insurance transfers would need to be removed, as their net effect would be zero. Likewise, CBA could be conducted from a federal perspective alone, which would require excluding the provincial contribution and treating Employment Insurance transfers as a cost.

3.5 Data Gathering

To assess the economic implications and impact of sewage bypass at the Digby STP for the Annapolis Basin soft-shell clam industry, primary data were gathered through consultations with key industry, community, and government stakeholders. Secondary research was conducted through the review of government documents, research reports, and the broader academic literature.

3.5.1 Interviews

Structured and informal interviews were conducted with individuals involved in harvesting, processing, fisheries management, regulation and enforcement, community organization, science and academia, as well as municipal, provincial, and federal government. No interview form was used, as each interview was unique in its objective, content, and data gathered.

3.5.2 Secondary Research

Current academic studies, government publications, and reports from independent consultants and non-governmental organizations were used in the review of the literature and to inform the methodology in the empirical analysis.

3.6 Assumptions

In conducting the economic analysis, the following assumptions were made:

1. The closure of the Annapolis Basin soft-shell clam harvest has been a direct result of sewage bypass at the Digby STP and the subsequent bacterial contamination of harvest areas.
2. Average annual soft-shell clam landings can be achieved over the project's economic life.
3. All open area harvesters pay Employment Insurance premiums and collect benefits between clam harvesting seasons.
4. All benefits and costs associated with the project will be isolated to those that are attributable to *The Province of Nova Scotia*.
5. The analysis will focus on benefits and costs that will occur in *The Province of Nova Scotia* with the STP upgrade but not without it. They

are, therefore, incremental to other economic activity that would occur in the absence of the project.

6. Project implementation is assumed to begin in 2012. Analysis was conducted for a 20-year period, which is the estimated economic life cycle of the upgrade.
7. Cost-benefit analysis was conducted using both 8% and 3% discount rates, as per the Treasury Board of Canada's 2007 guidelines.

Cost estimates for the STP upgrade have been confirmed and are relevant as of October 30, 2009.

CHAPTER 4. ECONOMIC ANALYSIS

The following analysis was conducted to determine the economic implications to the Annapolis Basin soft-shell clam industry of the decision to invest in an upgrade of the Digby STP. The question asked was whether the prevention of future fishery closures as a result of the STP upgrade would result in a net benefit or cost to the Province of Nova Scotia. This was answered by examining the net present value of a narrow range of principal costs and benefits associated with the upgrade and clam harvest.

4.1 Principal Benefits

The principal benefits that flow to The Province of Nova Scotia related to the upgrade of the Digby STP and a fully-operational soft-shell clam fishery include the landed value of the resource, value added to the resource by processors, net employment insurance benefits earned by harvesters in the offseason, and operational cost savings generated for two municipalities in the region. Calculation of each of these principal benefits is described in the following.

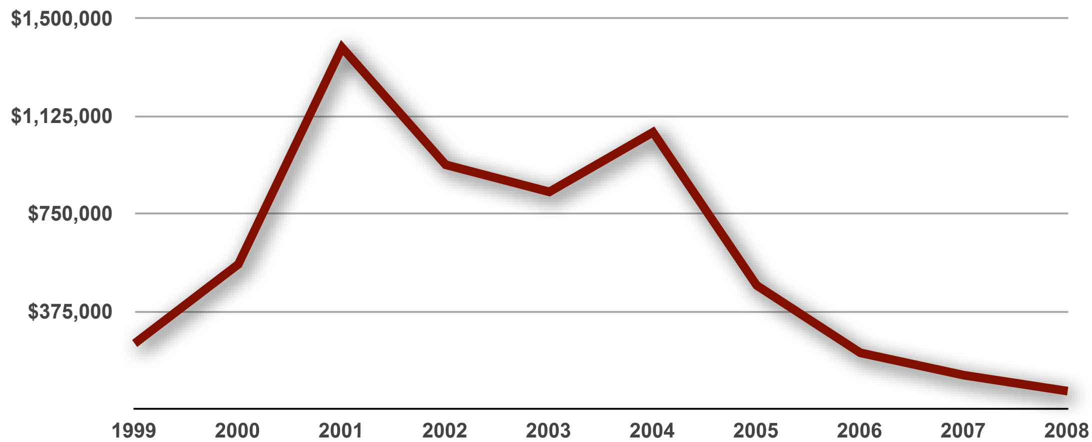
4.1.1 Landed Value

Landed value refers to the market value transferred from processors to harvesters through the buying of harvested whole soft-shell clams. The estimation of landed value is based on the assumption that the industry can achieve average landings experienced over the past decade. Although the soft-shell clam harvest has been subject to significant variation in landings from year to year, recent efforts have been made to establish more sustainable management practices which, if implemented, could have a positive impact on production going forward.[4] Furthermore, variability in landings has been due, in part, to mandated beach closures resulting from STP bypass. Should this problem be remedied, soft-shell clam landings can be assumed to regain consistency in the coming years.

Soft-shell clam landings in the Annapolis Basin varied widely from 1999 to 2008, ranging from a low of $69,000 in 2008 to approximately $1.4 million in 2001. Chart 1 below describes this trend:

[4] Clean Annapolis River Project. Personal interview. April 2009.

Figure 1. Annapolis Basin Soft-Shell Clams Landed Values, 1999 to 2008



While the exact causes of these fluctuations are not known, stakeholders describe a boom-bust cycle that has seen high, unsustainable levels of harvesting during years of strong market prices and high demand. These high-landing years are then followed by declining harvests and low production as depleted clam stocks take time to recover. Annual soft-shell clam landings in the Annapolis Basin from 1999 to 2008 are summarized in Table 2 below (Riely & Rockland, 1988):

Table 2: Annapolis Basin Soft-Shell Clam Landed Value, 1999 to 2008

	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08
Landed value ($000)	252	556	1,388	938	834	1,063	475	216	130	69

Average annual landed value (AALV) can, therefore, be calculated as follows:

$$\mathbf{AALV} = \left(\frac{\mathbf{TL_t}}{\mathbf{n}}\right) = \frac{\mathbf{\$5{,}921{,}000}}{\mathbf{10}} = \mathbf{\$592{,}100}$$

Where $\boldsymbol{TLt}$ is total landings over the time period studied, and ***n*** is the total number of years. Annual soft-shell clam landings in the Annapolis Basin averaged $592,100 from 1999 to 2008.

4.1.2 Value Added

Value added refers to activities undertaken by processors that add incremental value to the raw resource. Value-added activity in the Nova Scotia wild soft-shell clam industry is minimal, consisting, for the most part, of shucking, cleaning, packaging, and shipping raw product to distributors.[5] Harvesters and processors describe a fishery in which a small number of harvesters land live clams and sell them to a handful of local buyers. Clams are then either transported live in the shell or shucked and shipped to distributors and select retailers and food service companies.

---

[5] Innovative Fisheries Products. Personal interview. April 2009.

The value added to the Annapolis Basin soft-shell clam harvest is represented by the net margin processors and distributors attain post-harvest. The estimate is based on key stakeholder reports and known market data at the time of the study. In 2009, processors in the region reported that the value-added margin net of processing, packaging, and shipping costs was between \$8.00 and \$8.50 per landed shucked pound.[6] The meat weight[7] of Annapolis Basin soft-shell clams is reported to be "twenty-two pounds per one hundred whole clams."[8] The average market price paid for clams reported by fishers ranged between \$1.00 and \$1.20 at the time of the study.[9] The average annual value added (AAVA) to the Annapolis Basin soft-shell clam fishery is, therefore, calculated as follows:

$$\text{AAVA} = \left(\frac{\mathbf{AALV}}{\mathbf{p}}\right)(\%\mathbf{NMW})(\mathbf{m}) - \mathbf{AALV}$$

$$\text{AAVA} = \left(\frac{\$\mathbf{592{,}100}}{\$\mathbf{1.20}}\right)(.\mathbf{22})(\mathbf{8.00}) - \$\mathbf{592{,}100} = \mathbf{\$276{,}313}$$

---

6 Innovative Fisheries Products. Personal interview. April 2009.
7 Refers to the weight of raw clam meat removed from the shell.
8 Clam Harvest Area 2 harvester. Personal interview. April 2009.
9 The reported \$8.00 margin and \$1.20 market price paid to harvesters will be used to calculate annual average value added.

Where ***AALV*** is average annual landed value, ***p*** is the market price paid to fishers, ***%NMW*** is the percentage net meat weight upon which value is added, and ***m*** is the net margin attained by processors (in dollars).

The average value added to the Annapolis Basin soft-shell clam fishery is estimated at approximately $276,313 per year.

4.1.3 Total Industry Value

Based on an average of historical landings and stakeholder reported processing value added, the value of the Annapolis Basin soft-shell clam fishery is estimated at approximately $868,413 per year, as summarized in Table 3 below.

Table 3: Annapolis Basin Soft-Shell Clam Fishery Estimated Annual Value	
Average Annual Landings	$592,100
Average Annual Value Added	$276,313
Total Annual Industry Value	$868,413

It should be noted that this figure represents the value of the wild harvest only. There is a strong and active soft-shell clam aquaculture industry in the basin for which production data are unavailable.[10] Local stakeholders estimate production from this fishery to be at least equal to if not greater than that of the wild harvest.[11] Department of Fisheries and Oceans reported approximately $400,000 in clam aquaculture production in 2007, which supports the anecdotal estimate for that year.[12] Because the aquaculture industry is based on the process of depuration[13] and will function with or without the upgrade, it has been excluded from the cost-benefit analysis that follows.

4.1.4 Employment Insurance Benefits

Employment Insurance (EI) is a federal government program that provides temporary financial assistance to Canadian workers who are temporarily or permanently unemployed (Government of Canada, 2009). A special EI program exists for self-employed workers in fishing industries. EI fishing benefits are based on earnings reported from fishing activity, not hours of

[10] Aquaculture production statistics by district are suppressed by the Department of Fisheries and Oceans to protect the privacy of the processors in the area.
[11] Nova Scotia Department of Natural Resources staff. Personal interview. April 2009.
[12] Ibid.
[13] Refers to the process whereby contaminated clams are moved to seawater storage tanks for a period of time that allows contaminants to be filtered and removed.

work as in other EI programs. For fishers, total EI benefits are determined by factors that include reported earnings, length of season, and the unemployment rate in the region in which fishing occurred. Maximum weekly EI benefits are calculated as follows:

$$\textbf{Max Weekly EI} = \left(\frac{\textbf{Total Reported Earnings}}{\textbf{Minimum Divisor}}\right) \textbf{x 55\%}$$

The minimum divisor is a factor applied to total reported earnings and is based on the unemployment rate in the region in which employment was based (Government of Canada, 2012a). EI benefits are paid net of EI premiums, which are deducted from total pre-tax earnings.

Because the accounting stance taken in the assessment of impact is *The Province of Nova Scotia*, employment insurance claims must be considered an economic gain that results from soft-shell clam harvest activity. EI represents a significant and important source of income for clam harvesters during closure and off-season periods. It is assumed that harvesters' income in the wild fishery is gained through the sale of clams to secondary buyers or processors, and is, therefore, equal to landed values reported. Estimated average annual

EI benefits (AANEIB) derived from the Annapolis Basin soft-shell clam fishery are calculated as follows:

$$\text{AANEIB} = \left(\frac{\textbf{AALV}}{\textbf{MD}}\right)(\text{EIBR})(\text{WNF}) - (\text{AALV})(\text{EIPR})$$

$$\text{AANEIB} = \left(\frac{\textbf{592,100}}{\textbf{18}}\right)(0.55)(14.85) - (592{,}100)(0.0173)$$

$$= \$258{,}422$$

Where *AALV* refers to annual average landed value, *MD* is the minimum divisor, *EIBR* is the employment insurance benefit rate, *WNF* is number of weeks not fishing, and *EIPR* represents the employment insurance premium rate. The minimum divisor applied to the above calculation is determined by Service Canada as follows (Government of Canada, 2012a):

Table 4: Employment Insurance Benefit Minimum Divisor Calculation.

Regional Rate of Unemployment	Minimum Divisor
6% or less	22
6.1% to 7%	21
7.1% to 8%	20
8.1% to 9%	19
9.1% to 10%	18

Table 4:	Employment Insurance Benefit Minimum Divisor Calculation.
10.1% to 11%	17
11.1% to 12%	16
12.1% to 13%	15
13.1% or more	14

The unemployment rate in the Annapolis Valley region of Nova Scotia in 2009 was 9.2%. A minimum divisor of 18 would be applied to total earnings to determine eligible weekly earnings. 55% of eligible weekly earnings represent the maximum weekly EI benefit available to fishers (Government of Canada, 2012a). The employment insurance premium rate that was applied to reported pre-tax earnings was 1.73% in 2009 (Government of Canada, 2009).

Employment insurance benefits are calculated for the annual non-harvest period, net of premiums paid throughout the year. The Annapolis Basin soft-shell clam fishery is open a total of 261 days per year, leaving a potential 104 days (or 14.85 week) EI claim period. [14]

[14] It should be noted that eligible EI fishery claimants can collect EI benefits for up to 26 weeks. For the purpose of this analysis, it is assumed that fishers will collect benefits for the off-season period only.

4.1.5 Operational Cost Savings

It is estimated that the proposed upgrade of the Digby STP will result in operational efficiencies that will allow for cost sharing between Digby County and the Town of Digby, resulting in a cost reduction (benefit) of $107,000 per year.

4.1.6 Total Annual Benefits

The total principal benefits that flow to *The Province of Nova Scotia* related to the STP upgrade and a fully-operational soft-shell clam harvest uninterrupted by beach closures are summarized in Table 5 below:

Table 5:	Annapolis Basin Soft-Shell Clam Industry Estimated Annual Benefits
Landed Value	$592,100
Value Added	$276,313
Net Employment Insurance Benefits	$258,422
Operational Cost Savings	$107,000
Total Annual Benefits	$1,126,835

Total annual principal benefits resulting from the STP upgrade are estimated at $1,126,835.

4.2 Other Benefits

A project such as this will produce a range of impacts that cannot be easily valued using known costs or market prices. The complexity of estimating these nonmarket benefits associated with upgrading the Digby STP limits this analysis to the economic valuation of principal benefits. Nonetheless, it is expected that there are a number of other socioeconomic benefits that would accrue from the mitigation of sewage bypass at the Digby STP and that provide a rationale for the upgrade beyond pure economic efficiency. They include:

1. improved recreational use;
2. public health and safety;
3. the mitigation of possible interactions with other economically important fishing activities;
4. the improvement of aesthetic value;
5. the preservation of traditional livelihood;
6. the mitigation of negative tourism impacts;
7. the mitigation of negative impacts on other plant and animal species;
8. environmental preservation for future generations.

Benefits such as these are commonly estimated in CBA using direct nonmarket valuation techniques. These approaches to valuation attempt to measure the impact of a decision or investment on the utility or welfare of individuals or society (Committee on Assessing, Aquatic, & Related Terrestrial Ecosystems, 2004). The techniques used often involve complex survey-based research that is beyond the scope of this thesis. Furthermore, the value of benefits listed above would most likely be significant and would only strengthen the case that the upgrade of the STP is justified. For these reasons, measurement of other potential socio-economic benefits will not be conducted.

4.3 Principal Costs

The primary cost against which benefits are assessed is the investment in the Digby STP upgrade. In assessing the cost and viability of remediating the bypass problem at the plant, a number of upgrade options were proposed. After examining a number of options, a decision was made by the Town of Digby to make building and equipment upgrades to the existing plant and develop infrastructure that would allow the town to pump raw sewage to nearby Smith's Cove. Under this option, the existing sewage lagoon would be enlarged to handle increased volume pumped from the expanded treatment plant. The engineering study commissioned by the town concluded "this option showed the least cost over a wide range of financial conditions. It is also the most reliable, as lagoon systems offer better stability of the biological processes involved and have enough holding capacity to ride out power interruptions" (Hiltz and Seamone Co. Ltd., 2009, p. 1). Other key upgrades include:

- The addition of aeration and pumping capacity at the Digby STP.
- Construction of additional holding cells at Smith's Cove.
- Improved UV disinfection of sewage discharged into the Annapolis Basin.

The estimated capital costs for the upgrade are summarized in Table 6 below (Committee on Assessing et al., 2004):

Table 6: Digby Sewage Treatment Plant Upgrade Estimated Capital Cost	
Lagoons, Construction and Piping	$1,595,000
Buildings and Equipment	$1,041,000
Engineering and Contingency	$527,333
Additional Cell - Land Cost	$200,000
Total Capital Cost	**$3,363,000**
Less Federal Grant	($1,120,989)
Total Cost to Province of Nova Scotia	$2,242,011

4.3 Net Present Value Analysis

To date, sewage bypass at the Digby STP has resulted in harvest area closures of various lengths of time. In order to assess the economic impact of upgrading the Digby STP, a NPV analysis was conducted under three possible scenarios that model the prevention of a fishery closure of 65 days (25%), 130 days (50%) and 261 days (full closure) of the season. For the purposes of this thesis, analysis will be limited to these three scenarios. It should be noted that harvesting bans of less than 65 days have been experienced, while full closures have not occurred. Because the relevant frame of analysis involves identifying incremental impacts that would occur with the upgrade and not without, benefits accrue from maintaining operation of the fishery. Because all benefit calculations are based on the Average Annual Landed Value (AALV) estimated in Section 4.3, the AALV component of the NPV calculation is adjusted by the percentage closure examined under each scenario.

4.3.1 Annual Net Benefits (Costs)

NPV is determined by discounting to the present the future stream of estimated net benefits (or cash flows). The first step in the calculation is to determine the annual net benefits that result from the prevention of a 25% closure of the fishery due to an investment in the STP upgrade. Annual net benefits under Scenario 1 (ANB_1), Scenario 2 (ANB_2), and Scenario 3 (ANB_3) are calculated as follows:

$$ANB_i = (AALV + AAVA + AANEIB + AOS)(\%FC) - AOC$$

Where *AALV* is average annual landed value, *AAVA* is average annual value added, *AANEIB* is the average annual net employment insurance benefit, *AOS* is the annual operating cost savings, %FC is the percentage of the season the fishery is closed, and *AOC* refers to annual operating cost of the STP.

$$ANB_1 = (592{,}100+276{,}313+258{,}422+107{,}000)(.25) - \$148{,}000$$

$$= \$160{,}459$$

$$ANB_2 = (592{,}100+276{,}313+258{,}422+107{,}000)(.50) - \$148{,}000$$

$$= \$468{,}918$$

$$ANB_s = (592{,}100+276{,}313+258{,}422+107{,}000)(1.0) - \$148{,}000$$

$$= \$1{,}085{,}835$$

4.3.2 Net Present Value Scenario Analysis

As noted above, the NPV of future benefits (costs) that flow from the prevention of the closure of the fishery due to STP upgrade is determined by discounting to the present the future stream of estimated net benefits (costs) calculated in 4.3.1.

The NPV of future benefits (costs) under all scenarios is calculated as follows:

$$\text{NPV} = -\text{CC}_0 + \sum_{i=1}^{T} \left(\frac{ANB}{(1+r)^i}\right)$$

Where CC_0 is the initial capital cost of the project, *ANB* refers to annual net benefits resulting from the prevention of fishery closure in year *i*, and *r* is the discount rate applied in year *i*. Scenario 1 involves the hypothetical prevention of a fishery closure of 65 days, or approximately 25% of the season. Scenario 2 involves the hypothetical prevention of a fishery closure of 130 days, or approximately 50% of the season. Scenario 3 involves the hypothetical prevention of a fishery closure of 261 days, or full closure of the season. The NPV analysis will be conducted over a 20-year timeframe, with discount rates of 8% and 3% (Treasury Board of Canada Secretariat, 2007). Table 7 details the calculation of NPV under each scenario:

Table 7: NPV Calculation Under 3 Scenarios			
	Scenario 1 (25%)	**Scenario 2 (50%)**	**Scenario 3 (100%)**
Investment			
Capital Investment Year One	$2,242,000	$2,242,000	$2,242,000
Costs			
Annual Operation	$148,000	$148,000	$148,000
Benefits			
Annual Landed Value	$148,025	$296,050	$592,100
Annual Value Added	$69,078	$138,157	$276,313
Annual EI Benefits	$64,606	$129,211	$258,422
Op. Cost Savings	$107,000	$107,000	$107,000
Annual Net Benefits (Costs)	**$160,459**	**$468,918**	**$1,085,835**
NPV (3%)	**$1,533,834**	**$5,876,382**	**$14,561,480**
NPV (8%)	**$335,207**	**$3,157,029**	**$8,800,673**

4.3.3 NPV Analysis Summary

Table 8 below summarizes the net present value of preventing harvest season closures by investing in the STP upgrade:

Table 8: Digby Sewage Treatment Plant Upgrade NPV Summary		
	3% Discount Rate	8% Discount Rate
NPV - 25% Season Closure	$1,533,834	$335,207
NPV - 50% Season Closure	$5,876,382	$3,157,029
NPV - Full Season Closure	$14,561,480	$8,800,673

Assuming historical average landings are achieved over the next 20 years, the investment in the Digby sewage treatment plant upgrade has positive net present values at both 8% and 3% discount rates when preventing soft-shell clam fishery closures of 25% or greater. This indicates that, as it relates to the soft-shell clam harvest in the Annapolis Basin, the investment in the STP upgrade makes economic sense if it were to preventing as little as a quarter of the season being lost to closure. The STP upgrade has greater economic value the longer the harvest season is allowed to operate.

The above analysis uses real discount rates that account for inflation and nominal dollar values fixed at a point in time. While the CBA could be conducted with all numbers in real terms, the low inflationary environment[15] in

[15] Average annual rate of inflation over the period 1999 to 2009 was 2.3% (Government of Canada, 2013)

which this project was analyzed, the long-term nature of its impacts[16], and considerably positive NPV suggest that doing so would have little consequence in the overall analysis of the project.

4.4 Net Present Value Breakeven

The NPV breakeven point, or internal rate of return, refers to the discount rate that that must be applied to make the project's benefits equal its costs, or produce a NPV equal to 0. Finding the NPV breakeven point in this case provides a way to evaluate whether the discount rates of 3% and 8% are reasonable, given the low interest rate environment that currently exists in Canada. The NPV breakeven rate is calculated as follows:

$$\text{NPV} = -\text{CC}_0 + \sum_{i=1}^{T}\left(\frac{ANB}{(1+r)^i}\right) = 0$$

Where CC_0 is the initial capital cost of the project, *ANB* refers to annual net benefits resulting from the prevention of fishery closure in year *i*, and *r* is the discount rate applied in year *i*. To arrive at NPV = 0, values must be assumed for *r* until the sum of the discounted net benefits is approximately equal to 0

[16] Average annual rate of inflation from 2009 to 2011 was 1.8% (Government of Canada, 2013). The Bank of Canada reports inflation is expected to remain at 2% per year until 2021 (Bank of Canada, n.d.).

(Zerbe & Dively, 1994). The results for the Digby STP are summarized in Table 9 below:

Table 9: Digby Sewage Treatment Plant Upgrade NPV Breakeven Summary	
	Breakeven Rate
NPV - 25% Season Closure	10.02%
NPV - 50% Season Closure	29.48%
NPV - Full Season Closure	93.01%

The above analysis demonstrates that, under full and 50% season closure scenarios, the discount rate necessary to take the NPV to zero is so high as to be unrealistic. Under a 25% closure scenario, a breakeven discount of 10.02% is required to return an NPV of zero. While this rate is not that much greater than the upper bound of 8% in the NPV analysis above, it too is unrealistic given the low interest rate environment we are currently facing.

4.5 Sensitivity Analysis

Testing the robustness of the NPV analysis against a range of potential changes in variables is an important part of this study. Because the results of the analysis above indicate positive NPV values at both 3% and 8% under all closure scenarios, the sensitivity analysis will test downside risk only (i.e. downward pressure on prices and increases in cost). Sensitivity analysis was conducted in order to test the impact of potential changes in key variables on the results of this analysis. Key variables tested include:

1. Average annual landed value (AALV).
2. Value added margin.
3. Treatment plant construction cost.
4. Market price.

4.5.1 Average Annual Landed Value

Landed value is a function of both quantity harvested and market price paid to harvesters by processors. Changes in either of these factors would drive fluctuations in landed value. Decreases in average annual landed value of 5%, 10%, and 25% were tested. The results are summarized in Tables 10 to 12 below.

Table 10: Sensitivity Analysis - 10% Decrease in Annual Average Landed Value

Season Closure Avoided	Landed Value	NPV (3%)	NPV (8%)
25%	$133,223	$1,099,579	$53,025
50%	$266,445	$5,007,873	$2,592,665
Full Season	$532,890	$12,824,460	$7,671,945

Table 11: Sensitivity Analysis - 25% Decrease in Annual Average Landed Value

Season Closure Avoided	Landed Value	NPV (3%)	NPV (8%)
25%	$111,019	$448,196	($370,248)
50%	$222,038	$3,705,108	$1,746,118
Full Season	$444,075	$10,218,931	$5,978,851

Table 12: Sensitivity Analysis - 50% Decrease in Annual Average Landed Value

Season Closure Avoided	Landed Value	NPV (3%)	NPV (8%)
25%	$74,013	($637,441)	($1,075,704)
50%	$148,025	$1,533,834	$335,207
Full Season	$296,050	$5,876,382	$3,157,029

The above sensitivity analysis shows clearly that the NPV of the treatment plant upgrade remains positive under most closure scenarios and percentage decreases in landings tested. The NPV of the project turns negative under 25% closure scenarios with a 25% decrease in landings using an 8% discount rate, as well as with a 50% decrease in landings using both 3% and 8% discount rates. The likelihood of 25% or 50% declines in landed value sustained over the life of the project is minimal.

4.5.2 Value-Added Margin

Margins in the Nova Scotia seafood-processing sector are vulnerable to a range of supply- and demand-side pressures, including availability of raw material, fluctuations in foreign exchange rates for exports, labour and other input costs, and consumer demand for seafood products. A report produced for the Nova Scotia Department of Fisheries and Aquaculture stated that seafood processing value-added margins in Nova Scotia had been declining from 2002 to 2007 (Gardner Pinfold Consultants & Rogers Consulting, 2007). The authors explain that "margins are squeezed on both the cost and revenue sides of the market. Higher raw material costs and rising operating costs are driving production costs up. Revenues have declined mainly because of the decline in the value of the U.S. dollar (30 - 35%), but also because of increased competitive pressures from low cost producers and greater market strength of buyers and distributors" (p. 4). It is reasonable, therefore, to assume that fluctuations in value-added margin are likely in the future, driven by either changes in revenue or cost of production. A net value-added margin of $8.00 per shucked pound of clams was used in the NPV analysis above. The sensitivity of the NPV analysis was tested for declines in the value added margin of 10%, 25%, and 50%. The results are summarized in Tables 13 to 15 below.

Table 13: Sensitivity Analysis - 10% Decrease in Value-Added Margin (VAM)

Season Closure Avoided	VAM	NPV (3%)	NPV (8%)
25%	$47,368	$1,199,168	$117,739
50%	$94,736	$5,207,052	$2,722,093
Full Season	$189,472	$13,222,818	$7,930,801

Table 14: Sensitivity Analysis - 25% Decrease in Value-Added Margin

Season Closure Avoided	VAM	NPV (3%)	NPV (8%)
25%	$14,803	$697,170	($208,463)
50%	$29,605	$4,203,056	$2,069,689
Full Season	$59,210	$11,214,826	$6,625,992

Table 15: Sensitivity Analysis - 50% Decrease in Value-Added Margin			
Season Closure Avoided	**VAM**	**NPV (3%)**	**NPV (8%)**
25%	($39,473)	($139,493)	($752,133)
50%	($78,947)	$2,529,729	$982,348
Full Season	($157,893)	$7,868,173	$4,451,311

The above analysis demonstrates that the value of the treatment plant upgrade is more sensitive to fluctuations in the value-added margin processors can achieve. The NPV of the project remains positive under all scenarios with a 10% decline in net value-added margin. NPV begins to turn negative under a 25% closure scenario and with a 25% decline in margin using an 8% discount rate. With a 50% decline in value-added margin, the NPV of the project turns negative under a 25% closure scenario using both 8% and 3% discount rates. Under these conditions, the dollar value of margin is negative – processors are spending money to process clams, which is an unsustainable and unrealistic scenario.

4.5.3 Sewage Treatment Plant Construction Cost

The cost to the Province of Nova Scotia of constructing the sewage treatment plant was estimated by Hiltz and Seamone (2009) at over $2.2 million. Variations in the cost of municipal infrastructure projects are common. Construction cost estimates typically add 10% to the estimated budget for contingencies (Touran, 2003). To test the sensitivity of the project's NPV to potential overruns in construction cost, increases of 10%, 25%, and 50% will be used. The results are summarized in Tables 16 to 18 below.

Table 16: Sensitivity Analysis - 10% Increase in Construction Cost

Season Closure Avoided	Construction Cost	NPV (3%)	NPV (8%)
25%	$2,466,200	$1,316,164	$127,615
50%	$2,466,200	$5,658,712	$2,949,437
Full Season	$2,466,200	$14,343,810	$8,593,081

Table 17: Sensitivity Analysis - 25% Increase in Construction Cost

Season Closure Avoided	Construction Cost	NPV (3%)	NPV (8%)
25%	$2,802,500	$989,659	($183,774)
50%	$2,802,500	$5,332,208	$2,638,048
Full Season	$2,802,500	$14,017,305	$8,281,692

Table 18: Sensitivity Analysis – 50% Increase in Construction Cost			
Season Closure Avoided	Construction Cost	NPV (3%)	NPV (8%)
25%	$3,363,000	$445,484	($702,756)
50%	$3,363,000	$4,788,033	$2,119,066
Full Season	$3,363,000	$13,473,130	$7,762,710

The above analysis demonstrates that the project NPV turns negative under 25% closure scenarios for 25% and 50% construction cost overruns using an 8% discount rate in each case. NPV remains positive for all other combinations of fishery closure, construction cost increase, and discount rate.

4.5.4 Market Price

Data on historical market prices for Annapolis Basin soft-shell clams is scarce. Industry members interviewed cited a price in 2009 of between $1.00 and $1.20 per pound in shell. Prices as low as $.60 per pound were common through the 1960s and 1970s (Sullivan, 2007a). The model used in this analysis incorporated market prices in the calculation of the value-added margin only. Market price data could not be disaggregated from landed value due to lack of information on quantity harvested over time. While market price could be varied in the calculation of added value, it would not be reflected in landed value. Testing the sensitivity of the project's NPV, given the limitations of the data available, was not possible.

CHAPTER 5. DISCUSSION

5.1 Summary

The untreated sewage that flows into the Annapolis Basin has had an impact on the marine environment and the lives of fishers who derive a livelihood from the harvesting of soft-shell clams. In this case, remediation is simple: invest $2.2 million in an upgrade of the STP in the Town of Digby. Doing so would increase the town's capacity to handle sewage, end the cycle of fishery closures, and ensure ongoing access to this sustainable, local, SSF. The question this thesis posed was whether this investment could be justified.

A review of the literature on SSFs demonstrated the important role these resource-based industries play in rural economies. Whether full-time or seasonal, SSFs have represented critical poverty reduction strategies that provide income diversification and increased community capacity. Closures due to external shocks, such as sewage contamination, have had significant economic implications for fisheries and communities all over the world.

The economic implications for communities that harvest soft-shell clams from the Annapolis Basin have not been well examined to date. The goal of the economic analysis in this thesis was to measure the net effect of investing in the STP upgrade. The method used was CBA, which measured the NPV of the principal benefits and costs associated with the upgrade as they related to the soft-shell clam industry in the Annapolis Basin. Principal benefits included the landed value of soft-shell clams, any value added to the clams by processors, employment insurance benefits that flowed to harvesters in the offseason, and operational cost savings resulting from the upgrade; principal costs included the investment in the upgrade plus annual operating costs; principal benefits. CBA was conducted under three scenarios that estimated the NPV of an upgrade that prevented fishery closures of 25%, 50%, and 100% of the harvesting season.

The analysis demonstrated that the investment in the upgrade is justified under all three scenarios, and at both 3% and 8% discount rates, returning NPVs ranging from $335,207 to $14,561,480. Sensitivity analysis was conducted to test the impact of potential changes in landed value, value-added margin, STP construction cost, and market price. This analysis demonstrated that the justification for investing in the upgrade is sensitive to negative changes in the VAM that processors derive from the fishery, as well as decreases in AALV. The NPV of the project turns negative under the 25% closure scenario at an 8% discount rate with declines in either AALV or VAM. A 50% decline in AALV or

VAM or result in negative NPVs under 25% closure using both 3% and 8% discount rates. The project is least sensitive to 25% and 50% increases in construction costs and returns a negative NPV under the 25% closure scenario using an 8% discount rate.

Although the investment in the STP upgrade is sensitive to changes in benefit and cost variables, it is well justified by the positive NPV returned under almost all scenarios. Had the indirect and non-market benefits been included in the analysis, the justification for the investment would have been strengthened.

5.2 Implications and Concluding Remarks

Sewage contamination of the basin from the Digby sewage treatment plant has had a significant negative impact on the wild harvest of soft-shell clams through open area beach closures. Assuming historical annual average landings can be achieved going forward, the soft-shell clam industry in the Annapolis Basin will remain a significant generator of direct economic activity with an annual contribution of close to $1 million from the wild harvest alone. There is strong economic rationale for the $2.2 million investment in the STP upgrade under all closure-prevention scenarios. Beyond economic efficiency, there is a wide range of socioeconomic benefits that will be derived from upgrading the STP, eliminating sewage contamination, and ensuring the full operation of the soft-shell clam fishery. Small-scale fisheries are a critically important element of the economic fabric of rural Nova Scotia. As communities outside the Halifax Regional Municipality continue to depopulate, income diversification and sustainable resource-based enterprise will play essential roles in the lives of those who remain.

The analysis upon which this thesis is based is admittedly simple. CBA is a useful tool in examining how various elements of an economic relationship interact. It is far from comprehensive and fails to account for many of the not-easily-quantified values that communities place on resources and traditional industries. "In theory, it cannot comprehend important but priceless values, cannot escape the assumption that everything is for sale and can be traded off against everything else, and cannot accurately reflect the central role of uncertainty and the need for precaution in practice." (Ackerman, F., 2008, pp. 29–30).

Isolating the analysis to the link between the STP and soft-shell clam fishery provided a microscopic view into how a small-scale rural industry can be impacted by external factors and the failure to mitigate municipal engineering failures. Many other variables could have been included in the analysis, but would have most likely only served to strengthen the argument for the investment in the STP upgrade.

It should be acknowledged that the story of the Annapolis Basin soft-shell clam fishery is much richer and more complex than has been accounted for in this thesis. Issues of history, tradition, sustainable fisheries management, organizational capacity, government resource policy, and rural economic development remain largely invisible when looking through the microscope of CBA. Yet it is these complexities and nuances that define the communities around the Annapolis Basin and that add potency to the argument for an investment in better infrastructure. Regardless of what the numbers say; no matter how small an industry may be, preventable contamination of our province's natural resources and the destruction of rural livelihoods demands attention.

BIBLIOGRAPHY

Ackerman, F. (2008). *Critique of Cost-Benefit Analysis, and Alternative Approaches to Decision-Making*. England: Global Development and Environment Institute. Retrieved from http://www.ase.tufts.edu/gdae/Pubs/rp/Ack_UK_CBAcritique.pdf

Allison, E. H., & Ellis, F. (2001). The livelihoods approach and management of small-scale fisheries. *Marine Policy*, *25*(5), 377–388. doi:10.1016/S0308-597X(01)00023-9

Backer, L., & McGillicuddy, D. (2006). Harmful algal blooms. *Oceanography*, *19*(2), 94.

Bank of Canada. (n.d.). Bank of Canada. Retrieved April 23, 2013, from http://www.bankofcanada.ca

Barbier, E. B., & Markandya, A. (1989). *The conditions for achieving environmentally sustainable development*. London Environmental Economics Centre. Retrieved from http://www.mekonginfo.org/assets/midocs/0002776-environment-the-conditions-for-achieving-environmentally-sustainable-development.pdf

Béné, C. (2005). *Small-Scale Fisheries: Assessing Their Contribution to Rural Livelihoods in Developing Countries* (1008). Food and Agriculture Association of the United Nations.

Béné, C., Macfadyen, G., & Allison, E. H. (2005). *Increasing the Contribution of Small-Scale Fisheries to Poverty Alleviation and Food Security.pdf*. Rome: Food and Agriculture Association of the United Nations. Retrieved from https://www.cbd.int/doc/books/2009/B-03165.pdf

Boardman, A. E., Moore, M. A., & Vining, A. R. (2008). Social discount rates for canada. In *John Deutsch Institute Conference: Discount Rates for the Evaluation of Public Private Partnerships*. Retrieved from http://jdi-legacy.econ.queensu.ca/Files/Conferences/PPPpapers/Moore%20conference%20paper.pdf

Boardman, A. E., Moore, M. A., & Vining, A. R. (2010). The social discount rate for Canada based on future growth in consumption. *Canadian Public Policy*, *36*(3), 325–343.

Burgess, D. F. (1981). The Social Discount Rate for Canada: Theory and Evidence. *Canadian Public Policy*, *7*(3), 383–394.

Cabelli, V. J., & Heffernan, W. P. (1970). Elimination of bacteria by the soft shell clam, Mya arenaria. *Journal of the Fisheries Board of Canada*, *27*(9), 1579–1587.

Clean Annapolis River Project. (n.d.). Retrieved September 16, 2012, from http://www.annapolisriver.ca/projects_clam.php

Committee on Assessing, Aquatic, V. the the S. of, & Related Terrestrial Ecosystems, N. R. C. (2004). *Valuing Ecosystem Services: Toward Better Environmental Decision-Making*. The National Academies Press. Retrieved from http://www.nap.edu/openbook.php?record_id=11139

Department of Fisheries and Oceans. (2009, May 4). Fisheries and Oceans Canada | Pacific Region | Science and Research | Invertebrates| Depuration Fishery. Retrieved December 6, 2012, from http://www.pac.dfo-mpo.gc.ca/science/species-especes/shellfish-coquillages/clam-palourde/depuration-eng.htm

Dyson, K., & Huppert, D. D. (2010). Regional economic impacts of razor clam beach closures due to harmful algal blooms (HABs) on the Pacific coast of Washington. *Harmful Algae*, *9*(3), 264–271. doi:10.1016/j.hal.2009.11.003

Gardner Pinfold Consultants, & Rogers Consulting. (2007). *Nova Scotia Seafood Processing Sector: State of the Industry and Competitiveness Assessment*. Halifax: Nova Scotia Department of Fisheries and Aquaculture. Retrieved from http://www.gov.ns.ca/fish/marketing/reports/seafoodreport.pdf

Government of Canada. (2009). *Employment Insurance* (report). Retrieved from http://www.hrsdc.gc.ca/eng/employment/ei/index.shtml

Government of Canada. (2012a, February 26). Employment Insurance Benefits for Fishers. service,form,sound,guide. Retrieved October 27, 2012, from http://www.servicecanada.gc.ca/eng/ei/types/fishing.shtml#Where

Government of Canada. (2012b, February 27). Labour Market Monitor - Annapolis Valley - February 2012. report, statistics, fact sheet. Retrieved September 23, 2012, from http://www.hrsdc.gc.ca/eng/workplaceskills/labour_market_information/monitors/ns/ns-lmm-av-201202.shtml

Government of Canada. (2013, January 25). Consumer Price Index, historical summary (1993 to 2012). Retrieved April 23, 2013, from http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/econ46a-eng.htm

Government of Canada, I. C. (n.d.). Canadian Company Capabilities - Home. home page; dataset; home page; contact information; directory; first page. Retrieved March 15, 2013, from http://www.ic.gc.ca/app/ccc/srch/nvgt.do?sbPrtl=&prtl=1&estblmntNo=123456104482&profile=cmpltPrfl&profileId=501&app=sold&lang=eng

Halifax Regional Municipality. (1996). Halifax Harbour Solutions Symposium: Background. In *Chronology and Summary of Pollution Control*. Presented at the Halifax Harbour Solutions Symposium, Halifax Harbour Solutions. Retrieved from http://www.halifax.ca/harboursol/documents/sympback_001.pdf

Halwart, M., Funge-Smith, S., & Moehl, J. (2003). The role of aquaculture in rural development. *Review of the State of World Aquaculture, FAO, Rome*, 47–58.

Hiltz and Seamone Co. Ltd. (2009). *Town of Digby Sewage Treatment Plant Report*. Digby.

Hoagland, P., Anderson, D., Kaoru, Y., & White, A. (2002). The economic effects of harmful algal blooms in the United States: Estimates, assessment issues, and information needs. *Estuaries and Coasts*, *25*(4), 819–837. doi:10.1007/BF02804908

Hoagland, P., & Scatasta, S. (2006). The economic effects of harmful algal blooms. *Ecology of harmful algae*, 391–402.

Jenkins, G., & Kuo, C. Y. (2007). The economic opportunity cost of capital for canada—An empirical update. *Queen's Economics Department working paper*, (1133). Retrieved from http://www.queensjdiexec.org/publications/qed_dp_1.pdf

Johnson, J. (2012). FAO Fisheries & Aquaculture - Small-scale & artisanal fisheries. *Topics Fact Sheets*. Retrieved September 23, 2012, from http://www.fao.org/fishery/topic/14753/en

McWhinnie, S. (2012). Renewable Resource Economics. *Australian Economic Review*, *45*(2), 246–254. doi:10.1111/j.1467-8462.2012.00678.x

Riely, P. L., & Rockland, D. B. (1988). Evaluation of liming operations through benefit-cost analysis. *Water, Air, & Soil Pollution*, *41*(1), 293–328.

Salter, B., & Marketing, D. (2002). Shellfish Industry Economic Impact Analysis. *Victoria, BC. Prepared for: Vancouver Island Economic Developers Association*. Retrieved from http://www.investcomoxvalley.com/businessresources/documents/VIEDA Inbound-Aquaculture-ImpactAnalysisFinalJan03.pdf

Spiro, P. (2010). The Social Discount Rate for Provincial Government Investment Projects. In D. F. Burgess & G. P. Jenkins (Eds.), *Discount Rates for the Evaluation of Public Private Partnerships* (pp. 299–314). McGill-Queen's University Press.

Sullivan, D. (2007a). Digging Into the Past: Clam Harvesting in the Annapolis Basin. *Prepared For Bay of Fundy Marine Resource Centre as part of the Coastal Community University Research Alliance Project: 35 pp*. Retrieved from http://annapolisriver.ca/downloads/Digging_Into_the_Past_2007.pdf

Sullivan, D. (2007b). *A Population Survey and Resource Valuation of Soft-Shell Clams in the Annapolis Basin, NS*. Annapolis Royal: Clean Annapolis River Project. Retrieved from http://www.annapolisriver.ca/downloads/clam_population_2007.pdf

Teh, L. S. L., Teh, L. C. L., & Sumaila, U. R. (2011). Quantifying the overlooked socio-economic contribution of small-scale fisheries in Sabah, Malaysia. *Fisheries Research*, *110*(3), 450–458. doi:10.1016/j.fishres.2011.06.001

Touran, A. (2003). Calculation of contingency in construction projects. *IEEE Transactions on Engineering Management*, *50*(2), 135–140. doi:10.1109/TEM.2003.810824

Treasury Board of Canada Secretariat. (2007). Canadian Cost-Benefit Analysis Guide: Regulatory Proposals. Government of Canada. Retrieved from http://www.tbs-sct.gc.ca/ri-qr/documents/gl-ld/analys/analys-eng.pdf

Trebilcock, M., Yatchew, A., & Baziliauskas, A. (2007). Overview of Cost-Benefit Analysis and its Applications in Public Policy Decisions. CRA International. Retrieved from http://www.ieso.ca/imoweb/pubs/mear/CRA_Overview-of-Cost-Benefit-Analysis.pdf

Van Voorhees, D., & Lowther, A. (2011). *Fisheries of the United States 2010*. Government Printing Office. Retrieved from http://books.google.com/books?hl=en&lr=&id=tpvJ2mtfaeQC&oi=fnd&pg=PR4&dq=%22and%22+%22notes+at+end+of%22+%22Commercial%22+%22DOMESTIC+LANDINGS,+BY+SPECIES,+2009+AND+2010+(1)+-%22+%22-%22+%22and%22+%22or%22+%22trout+or%22+%22Commercial%22+%22DOMESTIC+LANDINGS,+BY+SPECIES,+2009+AND+2010+(1)+-%22+&ots=tCflqYgOWM&sig=1jnIEz_2SO7GHB0m0Wpvv4Ba6FI

Walmsley, S., Purvis, J., & Ninnes, C. (2006). The role of small-scale fisheries management in the poverty reduction strategies in the Western Indian Ocean region. *Ocean & Coastal Management*, *49*(11), 812–833. doi:10.1016/j.ocecoaman.2006.08.006

Wilson, S. (2000). *The Costs and Benefits of Sewage Treatment and Source Control for Halifax Harbour*. Halifax. Retrieved from http://www.halifax.ca/harboursol/documents/gpi_report_001.pdf

Zerbe, R. O., & Dively, D. (1994). *Benefit-cost analysis in theory and practice*. HarperCollins College Publishers. Retrieved from http://books.google.ca/books?id=XuPtAAAAMAAJ