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Feasibility of Producing Value added Products from Snow Crab Processing Waste in Cape Breton, Nova Scotia

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Acknowledgement

This project was made possible by the late John MacInnes of the Nova Scotia Department of Fisheries and Aquaculture. John's hard work and dedication to community development and sustainable fisheries are greatly missed.

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Summary

The snow crab fishery is an economic foundation and way for life for many Maritime regions, including Cape Breton, Nova Scotia. Fisherman, processors, plant workers and exporters all benefit from this lucrative fishery. However, the processing of snow crab produces a significant amount of waste each year that in turn presents disposal problems for snow crab processors. Approximately 25% of the snow crab that is processed becomes waste. Currently the majority of the seven crab processing plants on or in the vicinity of Cape Breton Island truck their waste to municipal landfills for composting. This disposal method is costly and under-utilizes the snow crab processing waste (SCPW). Variable composition and untraceable ingredients, resulting from the addition of the processing waste to the general municipal compost greatly limit its final use. At present, municipal compost is not sold for profit and is an expensive solution to the disposal problem. It is therefore important to examine alternative value added products and the feasibility of diverting the waste produced in the Cape Breton vicinity to value added products. Crustacean shell waste can be used to produce a great variety of such products, ranging from simple organic crab shell composts and fertilizers, to crab meals, and finally, to highly refined chitin products for pharmaceuticals, textile production and other uses.

In this report we present findings on current processing waste disposal methods, volumes and costs in the vicinity of Cape Breton Island. We then provide information on value added alternatives including the state of the industry, material supply and production, employment potentials, and associated issues and challenges. The findings suggest that investment in the production of crab meal or chitin products may become economically feasible in the future with further development of aquaculture and applications for derived polymers. At present competitive shipment costs and wages permit Asian buyers to dominate the market for dried shell and powders. In the short term, investment in the development of an organic compost or direct field application of SCPW may be avenues for investment. The volume of processing waste and the uncertainty of the sustainability of the snow crab fishery are major concerns to large-scale development. Utilizing SCPW for production of low-end value added products should be pursued as it can bring employment and income to Cape Breton communities while ameliorating environmental and economic disposal problems.

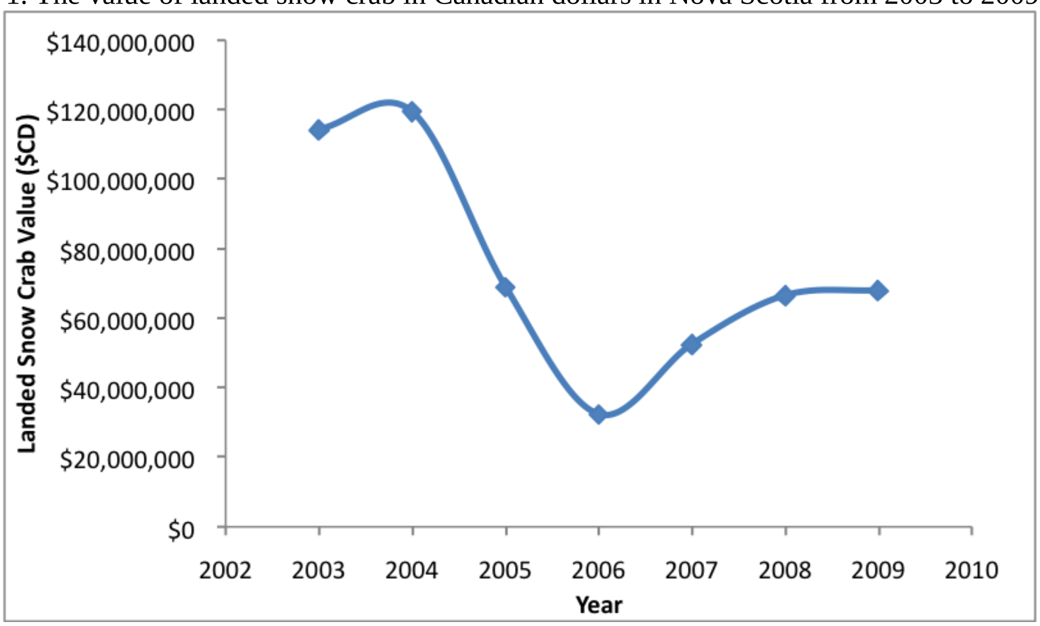
I Introduction

1. Background

The snow crab (*Chionoecetes opilio*) fishery has been prominent in Cape Breton since the late 1970's, with recorded landings going back to 1965. From the initial six the number of licenses grew to 61 in 1985 and eventually totaled 167 in 2009. Beginning in northwest Cape Breton on the section of Gulf of St Lawrence coast now known as Crab Fishing Area (CFA) 19, the area fished slowly expanded southward in the early 1970's along the west coast of the island into what is now know as CFA 18, and to the north east coast of the island to what eventually became the South Eastern fishery (formally CFA 20, 21, 22, and 23) (Appendix 1.).

The economic importance of the snow crab fishery has been felt for decades in Cape Breton, providing jobs for fishers, processors, plant workers, and exporters alike. Both the value of the fisheries and its quantity increased substantially in 2000. During this time Northeastern Nova Scotia landings increased considerably. The Nova Scotia snow crab fishery went from a landed value of $7 million in 1990 to a peak of just under $120 million in 2004. The value reached a low in 2006 and was just over $68 million in 2009 (figure 1.) (Pinfold, 2006; DFO data).

Figure 1. The value of landed snow crab in Canadian dollars in Nova Scotia from 2003 to 2009.



Today the Cape Breton snow crab fishery operates in eight areas, each with its own season, between the months of April and October. An offset in seasons helps to avoid conflict with the lobster season and allows processors a steady flow of crab. At present, nearly all the snow crab landed in Cape Breton is processed in one of six processing plants and then exported, primarily to Japanese markets.

The six processing plants include: A & L Seafood's and J.K Marine Services Ltd in Louisbourg, Clearwater Seafoods Ltd in Glace Bay, Petit De Grat Packers Limited in Arichat, Victoria Co-operative fisheries Ltd in Neil's Harbour and Pecheries Chéticamp INTL in

Chéticamp (Appendix 2.). Breakwater Fisheries Ltd in Aulds Cove is also processing snow crab and will be included in this study because of its close proximity to Cape Breton Island.

2. Issues

In this report we address the issue of disposal of snow crab processing waste (SCPW) in Cape Breton, Nova Scotia. Virtually all snow crab entering Cape Breton processing plants is processed into a single product: 'sections', or clusters of legs. A significant disposal problem is created as approximately 25% of the landed biomass is considered to be waste. Of the 5,013 t of snow crab processed in Nova Scotia Gulf region in 2008 it is estimated that 1,253.3 t of waste was generated.

With the growth of the snow crab industry a number of methods of discarding the waste have been employed: offshore ocean dumping, dumping in wooded areas, spreading on agricultural fields, and dumping at municipal landfills for burial and composting. Environmental regulations now make many of these disposal options expensive and difficult to obtain permits. Today, composting at municipal landfills has become the primary method of disposal. In recent years, however, many landfills have started refusing the SCPW due to odor, the large area it occupies, the attraction of pests, and the potential negative effects on local waterways. This has led to concentration of snow crab waste at fewer sites, and has increased shipping costs for plant owners required to transport their SCWP to more distant landfills. Currently the six snow crab processing plants on Cape Breton Island are forced to either truck their SCPW to three municipal landfills or dispose of it in an 'undisclosed' manner.

There are several problems associated with the disposal of SCPW at landfills. The large distance between processing plants and the differences in the timing of waste production causes many plants to ship independently of each other. This results in excess trucking or trucking of several day old and odoriferous waste products in order for plants to accumulate a full load. Once at the landfills the SCPW is added to the general municipal compost. Because the ingredients of the compost are untraceable and variable, its final uses are limited.

It is proposed that snow crab processing waste is being highly under-utilized in Cape Breton. When expressed as dry weight, SCPW is found to provide a rich mixture of protein (42.9%), lipids (14.8%), minerals (25.7%) and chitin (16.2%) (Beaulieu *et al*., 2009). It has been shown that SCPW can be economically recycled into a variety of useful value-added products ranging from simple organic crab shell composts and soil amendments, to crab meals, and to highly refined chitin products used in many applications.

3. Objectives and Purpose of Study

Unlike elsewhere in the Maritimes, in Cape Breton snow crab processing waste has been seen for many years as a disposal problem rather than a resource.

The objective of this study is to investigate the potential for economically and environmentally sound development of a value- added product from snow crab processing waste in Cape Breton, Nova Scotia. Such product development would provide employment and economic gains for the area while also reducing costs of SCPW disposal for plant owners.

By combining results of a comprehensive literature search with surveys and interviews of processers and individuals presently involved in the recycling of SCPW, this report represents the first step in providing interested investors with the necessary background in alternatives for value added disposal methods. An understanding of the associated benefits and pitfalls, and the markets, is essential for this “waste” to become a profitable commodity.

4. Contents of the Report

Chapter I provides an overview of the condition of snow crab resources, examining trends in snow crab stock landings and status. Chapter II describes the existing Cape Breton snow crab processing plants with details on the quantities of snow crab processed, plant-specific disposal methods and the current costs associated with SCPW disposal. The subsequent four chapters each address value-added products: a) crab meal, b) refined chitin extract and c) compost and d) direct agricultural field application. For each product, information on industry structure, raw material supply, production, employment and key issues and challenges are provided. Chapter VIII highlights the most feasible SCPW recycling methods for Cape Breton and gives suggestions for interested investors to move forward.

II Resource and Stock Status

By far, the most important component for the success of a value added industry based on snow crab processing waste is the long-term success of the snow crab fishery itself. The Atlantic Canadian snow crab fishery landings have been shown to be generally increasing over the last five decades (figure 2).

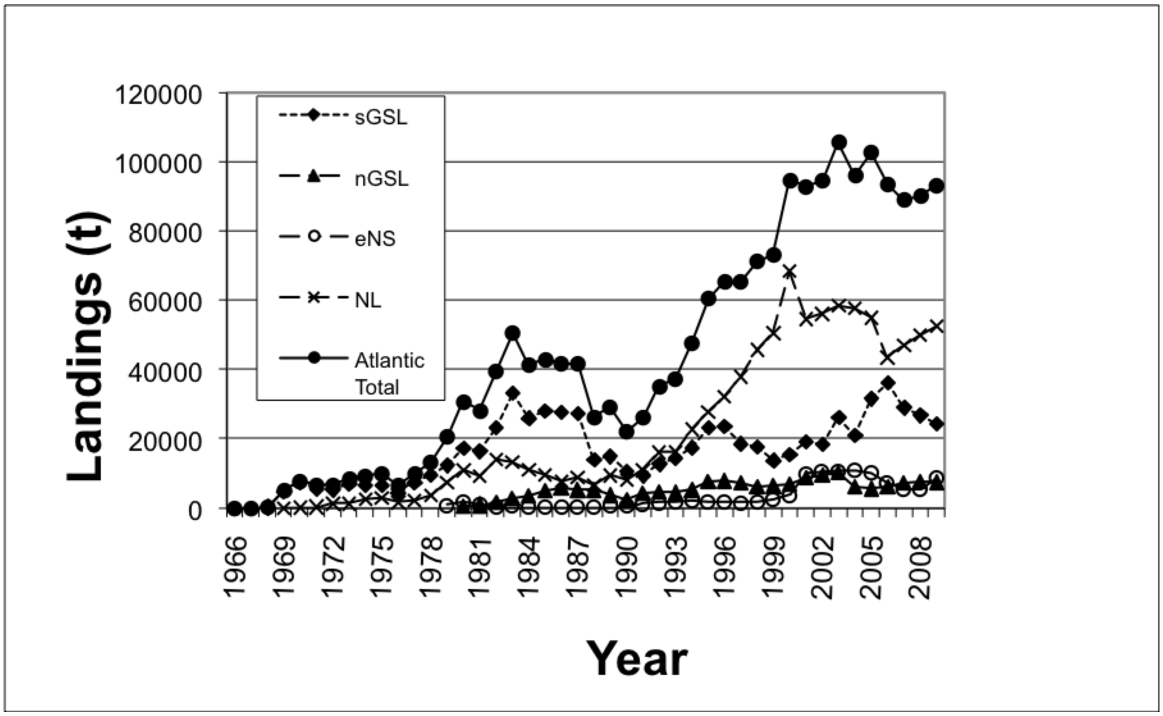


Figure 2. Atlantic Canadian snow crab landings (in metric tons) per region and totals from 1966 to 2008. Regions include the southern Gulf of St. Laurence (sGSL), northern Gulf of St. Laurence (nGSL), eastern Nova Scotia (eNS), and Newfoundland (NL) (source: DFO Atlantic Canadian snow crab landings data complied from the following sources; Biron *et al.*, 1999; Choi *et al*., 2008a; Choi *et al*., 2008b; Dawe, *et al*., 2008; Davidson *et al*., 1987; DFO, 2009a; DFO, 2009b; Dufour, 2004. Dufour, 1990. Elner, 1982; Hébert *et al.*, 2009; Taylor *et al.*, 2008; Tremblay *et al*., 1994.)

The average snow crab landings over the last thirty years for the Southern Gulf of St Lawrence (combined landings from Prince Edward Island, New Brunswick and a section of Nova Scotia) has been 21,036.2 t, with a minimum of 9,491 t (1990) and a maximum of 36,165 t (2005). A closer look at only the past decade would show that there has been a common decease in snow crab landings in the Maritimes. The total Nova Scotia landings (including the Nova Scotia portion of the Southern Gulf of St. Lawrence and the Scotia Fundy section) have generally been decreasing since 2004. Over the last decade Nova Scotia had a landing peek of 18,222.5 t in 2004 followed by a fall in landings to a low of 10,610.4 t in 2007 to a slight increase of 13,733 t in 2008 (figure 3) (DFO, data).

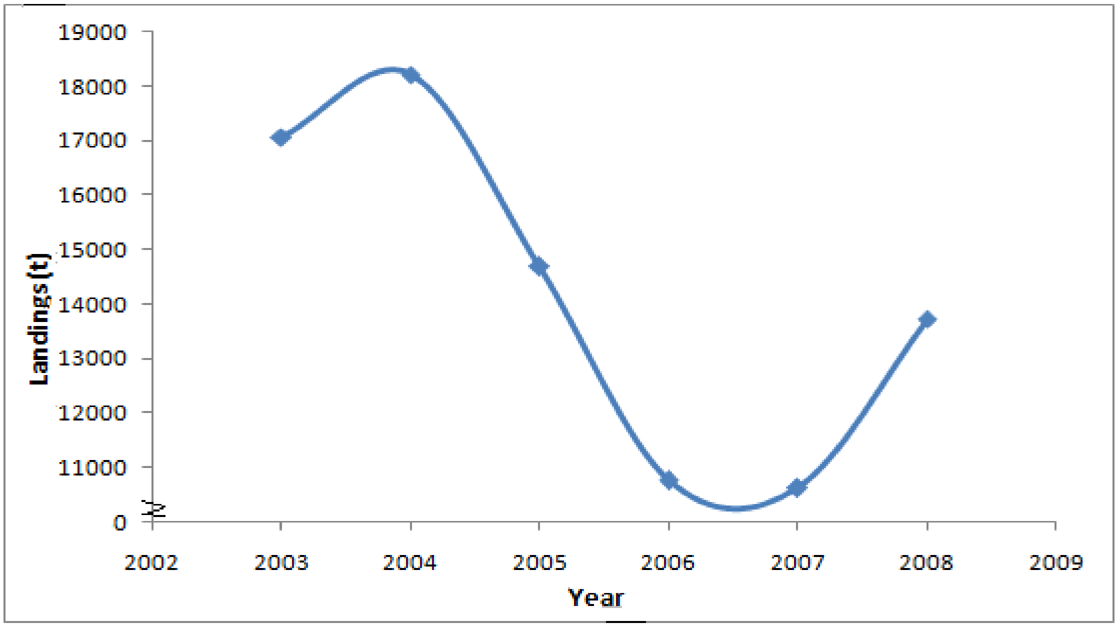


Figure 3. Total Nova Scotia Snow Crab Landings in metric tons from 2003 to 2008 (source: DFO Scotia Fundy and Nova Scotia crab landings data.)

Variability of snow crab abundance and the potential for over fishing of the resource is a serious concern that needs to be considered as a part of an investment decision. While landings have recently remained quite high there are other indicators that suggest that the fishery may be on the verge of a major decline over the next few years. The biomass of the commercial-sized adult crabs in the Southern Gulf peaked in 1994 at approximately 150,000 t. The biomass then declined until 2000, had a slight five-year recovery and has been declining again since 2006. Biomass of commercial adults was estimated in 2008 at 48,000 t, 16% lower than in 2007 (DFO, 2009c). The mature female abundance in the Southern Gulf has also been on the decline since 1990 and had its lowest years ever in 2006 and 2008. The recruitment in the fishery decreased in 2008 by 13% to 31,114 t compared to 2007 data. The recruitment has decreased by 58% since 2004 to 2008 and is projected to remain low for the foreseeable future (DFO, 2009c). Recruitment meaning the amount of fish added to the exploitable stock each year due to growth and/or migration into the fishing area.

North Eastern Nova Scotia (formally CFA 20, 21, 22) fishable catch, or adult male crab, is at an historic low. The fishable biomass (adult male crabs) in 2006 was approximately 720 t, which is a decline of approximately 50% relative to 2005. Female snow crab biomass in this area has had a slight increase over the last number of years. The stock abundance of the South Eastern crab fishery follows much the same patterns of decline.

Both internal fishery management decisions and external environmental changes will affect the sustainability of the snow crab fishery. Decisions concerning the total allowable catch (TAC), fishing practices (size and the handling of soft shell crabs), and the species tolerance to climate change and temperature are bound to strongly influence the fishery.

The overall trends of the crab fishery may well point to a declining catch, which would pose a serious limitation on large economic investment in shell waste recycling. This factor must be considered in considering the scale of financial investment of any recycling enterprise

III Cape Breton Marine Processing Plants and SCPW disposal

1. Overview

The marine processing sector has been slowly moving toward fewer and larger processing plants within Cape Breton. There are twenty-three Cape Breton marine processing facilities with licenses to process snow crab, however currently there are only six plants using these licenses.

The six processing plants handling snow crab in Cape Breton include; A & L Seafood's and J.K Marine Services Ltd in Louisbourg, Clearwater Seafoods Ltd in Glace Bay, Petit De Grat Packers Limited in Arichate, Victoria Co-operative fisheries Ltd in Neil's Harbour and Pecheries Cheticamp INTL in Cheticamp. Breakwater Fisheries Limited in Aulds Cove is also processing snow crab and will be included in this study because of its closeness to the island.

2. Quantity of processed snow crab

The quantity of snow crab being processed within Cape Breton varies slightly from year to year depending on quota. Not all landed crab is processed; a relatively small percentage of landings is either exported directly without processing or sold domestically without processing. These amounts can vary.

The amount of snow crab that is processed prior to export in all of Nova Scotia has remained relatively stable over the past eight years (figure 4).

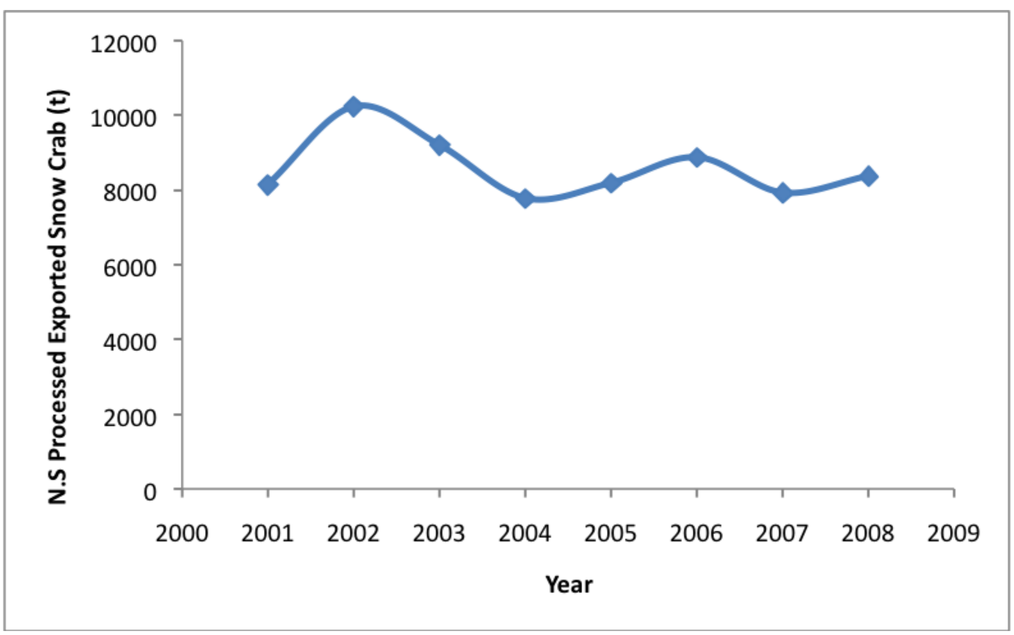


Figure 4. Exported snow crab in tones from 2001 to 2008 in Nova Scotia. Exports varied between a low of 7,779.16 t in 2004 to a high of 10,237.78 t in 2002.

As there are few license holders on mainland Nova Scotia, the large majority of these exports are processed on Cape Breton Island. Over each of the past five years, the total amount of crab being processed at the six Cape Breton plants and the plant in Aulds Cove has ranged from approximately 8,000 t to 10,000 t. The estimated quantities of Snow Crab processed at the those seven plants during the 2009 season is 9,480.08 t.

3. Current SCPW disposal methods

The current SCPW disposal methods for each plant were reviewed in order that costs of current disposal methods might be compared to value added alternatives. Disposal costs including trucking, crushing and containment of the waste were examined.

It was found that the plants differ in trucking arrangements, preparation of the waste, and available space for storage of waste at the processing site. Some plants transport the waste with their own trucks, while other share trucking with neighboring plants, or contract outside trucking services. Processing facilities that had crushers were able to reduce the frequency and costs of trucking though volume reduction. Plants differed in the available space for on-site temporary waste storage.

Four of the plants hired outside trucking for their wastes. The three that are located within relatively close proximity of one another, A & L Seafood's and J.K Marine Services Ltd in Louisbourg, and Clearwater Seafoods Ltd in Glace Bay have been sharing the trucking costs. Breakwater Fisheries Limited in Aulds Cove has been hiring outside trucking, while the remainders of the plants use their own trucks.

Except for the Aulds Cove facility, all the plants employ crushers to compact the SCPW before shipping, greatly reducing the volume of the shells and consequently the number of trips made to the landfill. The reduction in SCPW volume provided by crushing is approximately 30% but varies according to the machine that is used. On the other hand, volume reduction through crushing also leads to a longer storage time before a full truckload of waste is accumulated, and this may increase the associated odour issues

In addition to the previous factors, costs of transportation and disposal of SCPW are affected by the sometimes-significant distance to the nearest landfill site and the fee that is charged for dumping. The tipping fee at the landfills and composting facilities discussed here were found to range from $50 to $55 a ton.

We estimate that it costs each of the Cape Breton processing plants between $30,000 and $40,000 each crab season to dispose of their wastes in this way.

4. Existing Landfill and Composting facilities

On Cape Breton, three of the five municipal waste facilities continue to take SCPW: Sydney, Arichat, and Cape North. The municipal waste facilities in Inverness County (Kenloch) and Victoria County (Baddeck) no longer accept SCPW because of past odour issues. Nearby, the Guysborough municipal landfill is accepting SCPW from the plant in Aulds Cove. A privately owned composting facility in Afton, Antigonish County is also willing to accept SCPW to turn it into organic compost (Appendix 1.).

At the landfills, the SCPW is added to municipal compost. Unfortunately, the uncertainty and variation in the composition of the resulting compost severely limits its use and value. Compost produced at the Arichat landfill is used as capping material on old landfill sites, and Sydney landfill compost is either sold for fill for old mines or is given away a couple times a year. Cape North compost is also given to community members. The compost from the Guysborough facility is sold to community members and to local construction companies.

IV Snow Crab Processing Waste to Crab Meal and Dried Shells

1. Overview

Similar to fish meal, the interest in the production of crab meal has been growing over the last number of decades. Much research has been devoted to finding alternative economical nutrient sources for both industrial agriculture and finfish aquaculture. Crab meal has traditionally been marketed as an additive to livestock feeds as a protein source. The cost of feed accounts for more than half the expense of bringing beef, swine and poultry to market. To lower the costs large feed corporations often substitute different meal products into their feed mixtures. (Murray and DuPaul, 1981). Currently the use of crab meal in animal feeds is not always economical due to both availability and to the low cost of proteins from soybean production (Brown, 1981).

Snow crab (*Chionoecetes opilio*) processing waste is a valuable source of nutrients. Expressed as percent of dry weight, its approximate composition is: 42.9% proteins, 14.8% lipids, 25.7% minerals (mostly calcium carbonate), and 16.2% chitin (Beaulieu *et al*., 2009). The lipids are highly unsaturated. Of the lipid content Beaulieu *et al*. (2009) found approximated 50% mono-unsaturated fatty acids, followed by 20% polyunsaturated fatty acids and 15% saturated acids. This study also found a balanced composition of amino acids and small quantity of xantheum. The latter is used in salmon aquaculture for the development of optimal flesh pigmentation. A detailed breakdown of nutritional values for crab meal developed by St. Laurent Gulf Products Limited is provided in Appendix 3.

2. Production

Cooking and drying crushed SCPW produces both dry shells, and powdered crab meal. The latter is formed from the dried meat residual. These two products are typically used in different markets. The dried shells are most often sold for chitin and chitosan extraction. The price obtained on the extraction market increases with size and uniformity of the shell pieces. The dried powdered crab meal is versatile, used in fertilizers, Asian flavorings, and additives for agricultural feed.

Drying of processed waste can be either ‘direct’ or ‘indirect’. Direct drying is the most rapid and requires a flame or hot air to be passed over the meal itself as it is tumbled in a cylindrical drum. The temperature of the air or flame is maintained at about 500ºC and must be carefully controlled to prevent scorching of the meal.

Steam is used for indirect drying of the waste, and is considered as the more efficient method. Either a steam-jacketed cylinder (rotatube) or a cylinder containing steam heated discs (rotadisk) is utilized to tumble the meal at a temperature between 200^{o} and 400^{o} C. Skill is required in getting the drying conditions right. If the meal is under dried mold and bacteria may grow, if it is over dried the meal may be scorched and the nutritional content is diminished (Personal contact with Jim LeBlanc of W.E. Acres Crabmeal Ltd).

In the final stages, screening is used to remove any plastic waste that may have been processed with the SCPW, and to separate the meal and shell. Particle sizing is especially important if the shells are sold for chitin and chitosan extraction. Separated particle sizes are stored in silos for bulk delivery or in bags.

It is estimated that approximately 10% of initial weight of landed snow crab can be recovered as dried shells and meal. If all of the waste from processing had been directed toward the manufacture of these products it can be calculated that in the peak quota year of 2005 approximately 1,468 t of dried meal and shells could have been sold from snow crab landings in all of Nova Scotia. Because of the decrease in landings this quantity would have decreased to 1,373 t in 2008.

3. Costs of producing crab meal and dried shells

Jim LeBlanc of W.E Acres Crabmeal Ltd. provided an estimate for initial start-up costs for a basic crab meal facility of 1.0 to 1.5 million dollars. Fixed costs include purchase of a feeder and infeeder conveyors, rotary air locks, output and loading screw conveyors, vapor recycling ducts, refractory material, a front-end loader and a dryer with 2,658 square feet heating area (approximately $130,000). The estimate also included a 60' x 80'x 20' metal building with a concrete slab floor. The estimate does not include land, which varies greatly. See Murray and Dupaul (1981) for a more detailed break down of fixed and variable costs, and projected annual operation costs.

4. Local production of crab meal and dried shells

There are currently two New Brunswick plants that are successfully producing value-added products from crustacean processing waste. Both St Laurent Gulf Products Ltd in Caraquet and W.E. Acres Crab Meal in Portage collect crab and lobster waste, although the latter now uses primarily lobster shells for its products. Both of these facilities have been in operation for approximately 30 years, yield two to five million dollars in sales per year, and employ ten to fifteen people each. Crab and lobster meals are sold for similar uses to Asian markets. W.E. Acres Crab Meal Ltd. collects approximately 7,000 t of raw processing waste (primarily lobster) (Personal contact with Jim LeBlanc of W.E. Acres Crabmeal Ltd) while St Laurent Gulf Products Ltd collects 1,746.3 t of raw crab processing waste and produces 225 t of dried crab shells and 175 t crab meal (Personal contact with Julian Albert of St Laurent Gulf Products Ltd).

GAMS was able to visit W.E Acres Crab Meal Ltd., and finds a report of its operations valuable in the discussion of a potential Cape Breton facility. W.E. Acres Crab Meal Ltd. collects approximately 7,000 t of processing waste per year from 12 processing plants. Most of these plants are within 50 km of Portage, and four are located within 5 km, although waste is collected within a 160 km radius. W.E Acres owns 15 trucks that it employs in a well-organized system for waste pickup from the plants. A W.E. Acres driver leaves an empty truck each day at the plants for loading, and trades the full truck for an empty one when the load is complete. Typically W.E Acres charges $200 a day for this service, although costs are slightly more for the more distant plants, and slightly less for plants that provide their own transportation. On average the processing plants are in operation for 8 months a year, and the cost of waste disposal for each plant over this eight months runs between $45,000 and $55,000. We are unsure of how many tons of waste the New Brunswick plants are disposing of at that cost, therefore it is hard to compare to the amount paid by Cape Breton processing plants to dispose of their waste. Cape Breton plants pay between $30,000 and $40,000 each crab season to dispose of their waste; however this is over a shorter 4-month season.

The powder and the shells that are produced from the drying process at W.E. Acres are separately bagged into 20kg Japanese labeled bags. W.E Acres stores the bags until there is enough for a 14-15 t boat shipment to Japanese markets where the shells and meal are used in the manufacture of pharmaceutical and fertilizer products.

W.E. Acres Crab Meal Ltd operates twenty-four hours a day, with employees working in shifts. Employment averages ten workers, although during the winter months (January, February and March) the operation slows and the workforce is typically reduced to three to five full time employees. A stationary engineer (licensed individual to operate a boiler) must be on site at all times to oversee the boiler operation.

5. Crab meal and shell market

According to St Laurent Gulf Products Ltd, prices received on the Asian market for crab meal have been steadily increasing, from approximately $450 per metric ton in 2000 to approximately $800 per metric ton in 2006. Prices for dried crab shells over this same time period saw more fluctuation but also increased from approximately $520 per metric ton in 2000 to approximately $770 per metric ton in 2006.

Dried snow crab shells are also being produced and sold in the United States as organic soil amendments for gardeners. Typically these products have been seen selling from fertilizer companies websites for 4.5 kg to 9 kg bags being sold for about $30 to $50 dollars respectively. Not only high in calcium and essential nutrients (Nitrogen: 2.5; Phosphorus: 3.0; Potassium: 0.5; Calcium: 23), the chitin containing shells encourage the growth of chitinase producing bacteria. The presence of this enzyme in the soil provides a hostile environment for fungus, nematodes, and larval insects that have chitin structural components. The high-end marketing for natural organic products is growing, and the bio-pesticidal attribute is definitely an asset. In the United States, Neptunes Harvest sells a 5.4 kg pail of dried blue crab shells for $32.99. A similar product, Nature's Balance Organic Crab Shell fertilizer is produced in California by Connell Organics. Connell Organics typically sells to commercial organic farmers in quantities of 50,000 lbs or 10 tons for 10 cents a pound or $5,000. They also sell fresh ground crab, ground and loaded for $200 a ton, or ten cents a pound. The use of agricultural processing waste on a large scale is discussed in chapter VI, Direct Agricultural Field Application.

6. Issues and challenges in dried crab meal and shell production

The major areas of concern that pertain to the production of dried crab meal and shell from processing wastes include the following:

a. Variability of snow crab abundance;
b. Length and scale of the snow crab season;
c. Costs of transportation of SCPW from processing plants to the dryer site;
d. Air quality problems;
e. Energy prices;
f. Product marketability and price fluctuations, and
g. Competition.

Variability and Season

Variability of snow crab abundance, discussed in chapter one, is a serious concern to future investment in processing of snow crab processing waste. In addition to annual variation in stocks and future landings, seasonal variation in availability of processing waste volume related to the staggered timing of openings in the different areas in Cape Breton to snow crab fishing must also be addressed.

It seems that the single biggest difference between the New Brunswick crab meal plants and a projected Cape Breton plant would be the length of the total fishing season. The lobster in New Brunswick comes in over an 8-month period, while the crab in Cape Breton is all processed in a few short months.

Two alternatives are possible solutions to the seasonal changes in waste availability, each with advantages and disadvantages. A large-scale plant built to accommodate the approximate 3,500 t of crab waste from Cape Breton within a short 3 to 4 month season would remain idle for the rest of the year. A smaller facility could be designed to dry and prepare the waste if there were a means to store and preserve the SCPW. There are a number of obvious considerations that need to be addressed in waste storage, and only further research could determine which alternative would be most economical. In either case a proposed crab meal facility in Cape Breton would need to assure that it would be the sole disposal site of the SCPW in order to achieve the necessary volume.

Transportation

Transportation and location are related issues and bring interesting challenges. Ideally a drying facility would be central to all the operating snow crab processors to equalize transportation costs. Such a drying facility sited in the Baddeck area would be no further than 100km from any of the waste processing plants (Appendix 1). This might not be a very popular proposal for most crab processors, as it would mean shipping their waste substantially farther then they are currently. To make this option more acceptable, the crab meal facility would need to make it financially worthwhile for the plant owners to transport greater distances. It could choose to either waive the tipping fee, bear some of the shipping costs, or provide a pickup service at fees competitive to those plants are presently paying for waste removal. In current markets it is unlikely that a crab meal facility will be able to bear all the cost of transportation and so a balance would have to be found.

Air quality

A fourth challenge is odour and air quality. Heating SCPW would produce a smell and, depending on the emission system used, could emit particulates. W. E Acres Crab Meal Ltd handles these issues by owning many acres of the surrounding land and being located in a rural setting. W. E Acres Crab Meal Ltd also uses a “vapor recycling duct” during the hot summer months to degrade the smell and lower particulates. Minimizing storage time of SCPW is also essential important; drying the waste in a timely manner after initial processing further reduces the risk of odour pollution.

Energy

The single biggest operating expenses of a crab meal facility are the energy costs of running the dryer. St Laurent Gulf Products Ltd estimates that 60% of their operating costs is spent in fuel. It is interesting that many dryers are now adaptable for use with alternative sources of energy. The decision to purchase such equipment may allow investors to hedge against rising fuel costs in the future by incorporating bio-fuels or other alternative energy sources.

Marketability

As for any commercial venture, product marketability and price fluctuations must be fully analyzed. At present, finding a buyer for crustacean meal and dried shell does not appear to be an issue as the Asian market is strong. Japan is handling the bulk of the lobster meal, and many Chinese companies seek both snow crab meal and dried shells. Most of the exported shells are further processed for chitin extraction. Top price is paid for dried snow crab shells that have a chitin content of 20% or greater. It is reported that the chitin content of eastern Canadian crabs is approximately 16% (Tidmarsh *et al*., 1986). Further research would have to be done on price variability.

Competition

Because of transportation costs, there really is no competition for value added processing in the Cape Breton vicinity. However, that may change. It appears that Quinlan Brothers Ltd in Old Perlican, Newfoundland is in the process of starting up a multi-million dollar chitin extraction facility for snow crab shells and shrimp. If this is successful, it may corner the local market for dried crab shells. Newfoundland's snow crab landings are the highest of any Maritime region, totaling 52,587 t in 2008. Comparatively in 2008 the other Maritime provinces landed the following amounts, 13,733,6 t in Nova Scotia, 10,875.5 t in New Brunswick, 7,536 t in Quebec and 2,637.9 t in Prince Edward Island (DFO data). Newfoundland certainly has the greatest resource for attempting such a business.

If this facility is successful it possibly could present a market for bulk transport of SCPW from Cape Breton. Research on transportation costs and feasibility of a bulk storage facility in Cape Breton could be done.

7. Alternative production options

A possible alternative to a centralized crab meal facility could be small-scale dryer(s) at each processing plant, using existing boilers to provide steam for the drying process. The feasibility of this option would have to be assessed by each processing plant. In addition to the purchase price of dryers and associated equipment, space and configuration could be limiting factors. Bulk storage of dried product would be recommended, as equipment necessary for bagging would be prohibitive for small-scale production.

8. Recommendations for converting SCPW to crab meal and dried shells

As this survey illustrates, there are multiple factors that will directly determine the exact form of implementation of a value-added production facility for crab meal and shells in Cape Breton. There is a clear opportunity and need for such a project but the choices are interactive and numerous. A more in-depth feasibility study and subsequent business plan would need to be undertaken before starting up a crab meal facility. It would also be worth visiting existing facilities to have a more comprehensive idea of the operation. At an early stage in the planning process investors should partner with processing plants so that the supply will be secured in the event outside competition for the waste moves in.

IV Chitin production

1. Overview

The developing interest in environmentally friendly products has stimulated interest in the nontoxic and biodegradable polymers that can be derived from crustacean processing waste. Chitin is the structural biopolymer of all crustacean exoskeletons, and while comprising only about 16% of the dry weight of SCPW, it is currently its most valuable by-product. Chitin is used in virtually every sector of the economy and the market is growing both for chitin and more than 200 products that are derived from it (Sandford, 1989).

The chemical properties of perhaps the most versatile of these derivatives, *chitosan*, have encouraged its use in a multitude of biomedical, agricultural and industrial applications. Chitosan is used in drug transport and dietary supplements for reduction of lipid absorption, in agricultural seed and plant growth treatments, as a natural bio-pesticide, and in water purification filtration systems. One of its components, g*lucosamine,* is well known as a natural product used for the enhancement of human joint cartilage.

A partial list of current applications for chitin derivatives is remarkably diverse:

- Wound healing accelerators
- Stabilizers, thickeners and emulsifiers in foods, pharmaceuticals and cosmetics
- Fibers and films
- Binders for dyes, fabrics, adhesives and paper sizing and strengthening
- Seed and food preservatives
- Coagulants and flocculants for recovery of aqueous processing wastes
- Ion exchange resins and membranes for chromatography and electro-dialysis
- Flocculants in health care
- Cholesterol reducing medications
- Antimicrobial activity against bacteria and fungus
- Lubricants for the oil industry
- Production of chitinase (chitin digesting) enzymes
- Neutralization and metal removal of acid mine drainage

(from Sandford, 1989; Ravi, 2000)

It is therefore no surprise that the extraction of chitin from the shells of crustaceans is a growing industry. Worldwide the amount of chitin removed from shellfish waste was estimated to be approximately 37,300 metric tons in 1993 (Shaikh and Deshpande, 1993) and 80,000 t in 2000 (Patil *et al*., 2000). Waste volumes, capital costs and environmental considerations will need to be evaluated in order to determine economical feasibility of diversion of local snow crab processing waste into the production of chitin on the scale required.

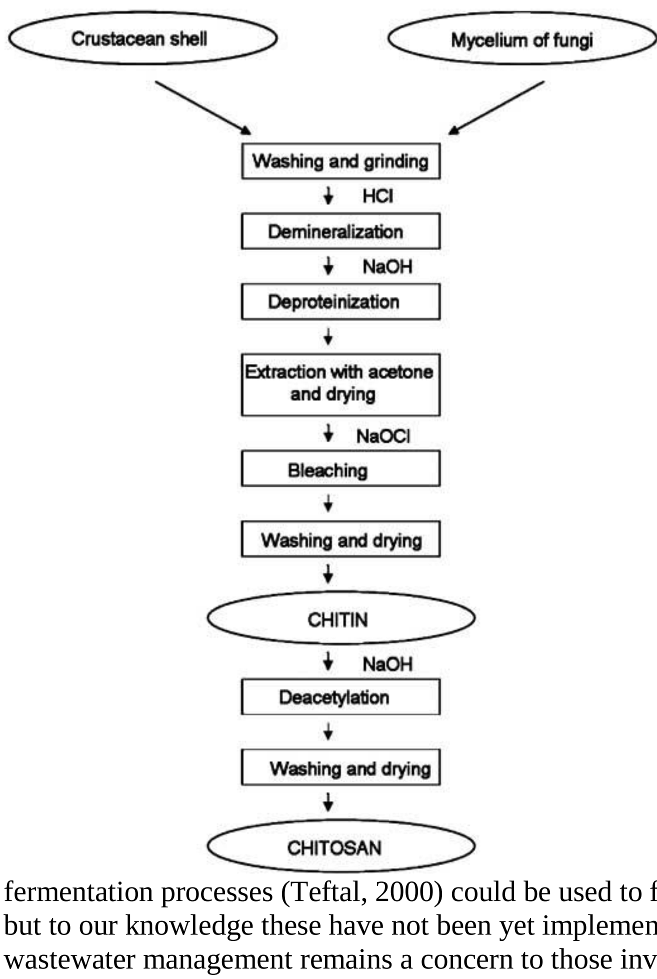
2. Production of Chitin from Crustaceans

Three local species are candidates for the chitin production: snow crab, shrimp and lobster. The first two are processed in abundance on Cape Breton at present, and although there is currently limited processing of lobster in Cape Breton it is a resource that could be considered for future planning.

Chitin is a polysaccaride with a chemical structure similar to that of cellulose, and is tightly bound to proteins in crustacean shells. Purification may be accomplished both chemically and biologically, with chemical removal currently the method of choice.

A number of steps are required to chemically isolate chitin from other shell components: grinding of shells to uniform particle size, protein separation (deproteinization), mineral removal (demineralization), and removal of lipids and pigments. The order of these steps is somewhat flexible.

Typically the chemical production of chitin starts by loading the SCPW into a hopper, where augers transport the waste to large holding tanks. A sodium hydroxide (NaOH) solution is then used to dissolve the flesh and stop decomposition of the shell. The shells are removed from the tank using a drag chain and washed. Next the shells are crushed into quarter-inch sizes and mixed with hydrochloric acid (HCl) to remove minerals (calcium carbonate). The shells are then put through a sieve screen and washed for a second time. They are then placed in a caustic solution (typically sodium hydroxide (NaOH) or potassium hydroxide (KOH)) with a somewhat higher temperature to liquefy the shell proteins and produce chitin. The chitin can then be screened, washed and placed in a boiler with alkaline solutions for acetate removal and conversion to chitosan. The chitosan then can be washed, dried, ground, weighed and bagged for sale (Rege and Block, 1999; Block, 2000). A diagram of the process is provided from Aranaz *et al.* (2009).



Other significant products can also be recovered during chitin extraction. Both proteins and lipids can be recovered in the stages before acid demineralization (Johnston and Peniston, 1982). Valuable carotenoid pigments can also be recovered and are typically used as a source of coloration used in salmonid aquaculture. Processing waste from crabs contains very similar quantities of carotenoid pigments (139.9 µg/g) to those contained in shrimp processing waste (147.7 µg/g) and could provide additional income (Shahidi and Synowiecki, 1991).

The waste products produced from the chitin extraction process are demineralized brine and dilute acids. The brine can be used as a neutralizing agent while the acids need acute treatment prior to being released as effluent. There are typically no gaseous emissions from chitin production. It has been proposed that environmental costs would be greatly reduced if biological fermentation processes (Teftal, 2000) could be used to fractionate the waste into its components but to our knowledge these have not been yet implemented on a commercial scale. Thus wastewater management remains a concern to those involved in chitin extraction. (Al Sagheer *et al*., 2009). It has also been suggested that both the cost and the environmental impact of chitin extraction could be successfully reduced with the substitution of less harmful organic acids (acetic and lactic) for caustic hydrochloric acid (Mahmoud *et al*., 2007).

In the nothing wasted category: a company on the Eastern shore of Maryland, 'Chitin Works America LLC', composts all solids that remain after chitin extraction of blue crab waste for subsequent sale as fertilizer.

3. Costs of Producing Chitin from Crustaceans.

A study exploring a possible chitin extraction facility in Prince Edward Island estimated the extraction facility would cost $5 million (Office of International Affairs., Policy and Global Affairs. 1999). In partnership with Memorial University and the Marine Institute a Newfoundland based company, Quinlan Brothers Ltd in Old Perlican, has also done a feasibility study on a chitin extraction facility for snow crab shells and shrimp. Similarly to the PEI report, the costs of the Newfoundland plant and the 3-year research and development initiative would be just over $5 Million dollars. A detailed report of the Quinlan Brothers Ltd proposed facility, research and development, environmental regulations, and operational plans can be found at their website listed in the reference section of this report (Quinlan Brothers Ltd, 2008).

A full-scale research and development study of the costs for a chitin extraction facility using Nova Scotia crab waste would be a long-term investment in the success of the project. Partnership with a local university or a private research company is recommended. As the wider aspects of such a study would be of benefit to others in the industry it is likely that such an undertaking would qualify for significant government funding. (Office of International Affairs., Policy and Global Affairs, 1999).

A detailed environmental impact assessment detailing the disposal methods and treatment practices for the effluent and solid material would be required to obtain a permit to operate a chitin facility. A building permit tied to the environmental statement would also be needed. The Food and Drug administration would also need to inspect the plant before operations begin. For the exportation of the product other certification may also require, additional certification such as a "good manufacturing practices" and "good laboratory practices". There are costs in all of these steps that must be determined.

4. Chitin Market

The potential uses of chitin products include the industrial food, health, pharmaceutical, oil, and biomedical sectors (Block, 2000) and within each, the prices obtained for chitin and chitosan products can vary substantially in market price. The low-end chitin market typically supplies water purification and the food supplements industries and obtains $10 per pound. High-end biomedical uses can draw $2,000 per pound (Ravi, 2000). Differences in quality of chitin set the prices for chitin between these extremes.

It was not within the scope of this study to explore the quantity of SCPW needed to economically run a chitin extraction facility, nor in turn, the quantities of chitin necessary to capture a significant market share.

5. Competition

Historically Japan had a monopoly on the production of chitin and chitosan. Currently many nations are producing these products, with China recently coming to the forefront. China's glucosamine (a derivative of chitin) output and exports have been growing very fast, with the annual growth rate at approximately 10%, and an average capacity of each producer at approximately 90% greater in 2008 than in 2005. In China, glucosamine is mainly produced from the shell of shrimp and lobster, while chitosan is most commonly produced from the imported snow crab shells (CCM International Limited, 2008).

The starting date for the proposed Quinlan Brothers Ltd chitin extraction facility in Newfoundland, referred to in the previous section was May 2009. However, as to our knowledge the project is not yet competed and we have found no alternative start date. Quinlan Brothers Ltd is the largest processor of snow crab and shrimp in Newfoundland and Labrador. The plant will receive crustacean waste from processing plants in Old Perlican and Bay de Verde and anticipates a volume of 13 million tons (initially mostly shrimp waste) of waste to be used in the first year.

6. Issues and challenges

The major problem areas perceived in chitin production are very similar to those for dried crab meal and shells:

a. Variability of snow crab abundance.
b. Length and scale of the snow crab season
c. Transportation costs of SCPW from processing plants to the chitin facility.
d. Degradation of SCPW between time of processing and chitin extraction
e. Market competition

The concern for a steady supply of raw materials in investment in recycling of SCPW has been previously discussed in chapter one. Further exploration of additional crustacean waste sources including lobster and shrimp might lead to solutions to reliable and steady supply problems.

For the production of the finest chitin products the shells need to be delivered to the extraction facility in good condition. (Rege and Block, 1999). Waste handling and holding procedures at the snow crab processing facilities would have to be reviewed and assessed to insure the highest quality chitin. As the SCPW should be transported immediately to the chitin extraction facility to avoid any decomposition, the distance from snow crab processing plants and conveyance costs become obvious concerns. Averbach (1981) believed that for a chitin facility to be profitable in North America, all the snow crab-processing facilities would need to be within an 80-kilometer radius of the chitin plant. This is a formidable challenge.

It may be possible to convert the waste at each processing site into a dry stable form. If the waste could be stockpiled until sufficient quantities were accumulated for large shipments, the region could supply a more distant chitin facility. It has been shown that shells can be dried, frozen or ensilaged in an alkaline environment to prevent deterioration. However, these processes are expensive: drying and freezing require large amounts of energy, while freezing also takes a cold storage facility. Ensilage would require grinding and storage containers at each processing plant (Office of International Affairs., Policy and Global Affairs, 1999).

As discussed in an earlier section, the length and scale of the snow crab season would present challenges for value added processers, including a chitin facility. The alternatives are the same: building a plant large enough to accommodate the anticipated 3000 t of crab waste within a short 3 to 4 month season that would remain idle for the rest of the year, or design a smaller facility with the means to store and preserve the SCPW. In 2009 on Cape Breton Island there was also 1,134 t of shrimp and 624 t of lobster processed. This subsequent waste could also be utilized for chitin extraction to extend the length to the processing season.

Investors in chitin extraction face competition on two fronts. China would be a tough competitor for a Canadian company trying to sell chitin on the world market. Chinese chitin facilities have access to cheap labour and chemicals and are subject to less stringent effluent discharge rules. In Canada disposing of chitin extraction effluent is costly. The proposed Quinlan Brothers Ltd chitin extraction facility would be expected to discharge 34,000 liters of treated effluent per day.

Chitin's high-end derivative, chitosan, must also compete with lesser quality synthetic polymers that are produced from hydrocarbons at a fraction of the cost. To compete in the larger volume markets the current cost of producing natural chitosan would have to be driven down. (Shahidi *et al*., 1999).

7. Recommendations

It is recommended that current markets for chitosan products be explored to determine if the prospects of return can justify the investment in a new facility. If the demand for products derived from chitin is large enough its extraction and processing would be considered profitable.

If each Atlantic province had a centralized drying facility, which could then contribute to one Atlantic Canadian chitin extraction facility it is possible that there could be enough crustacean waste to run a large-scale extraction facility. This effort would take an enormous amount of collaboration and cooperation between processors, drying facility investors and chitin extraction facility investors in each province, or the commitment of a large business venture. However, it could put Atlantic Canada at the forefront of this emerging industry.

VI Organic SCPW Compost

1. Overview

Composting is a natural process in which organic matter is biodegraded by microorganisms. Composting crustaceans is not a new idea: fisherman and their families have been composting lobster and crab shells for centuries to improve the soil and crop growth.

Snow crab processing waste makes excellent compost. Snow crab itself is a valuable nutrient source containing approximately 42.9% proteins, 14.8% lipids, 25.7% minerals, 16.2% chitin, all expressed on a dry weight (Beaulieu et al., 2009). The dry shells supply a superb organic source of nitrogen (6%), phosphorous (2%), potassium (1%), calcium (23%) and magnesium (1.33%) (ADAS UK Ltd. 2006). Manganese, copper, zinc, iron, cobalt and selenium are all also found as trace minerals in snow crab shells. In addition SCPW has an ideal pH of 6.67. The chitin in crab shells provides not only slow-release nitrogen but also suppresses the growth of nematodes and fungus. When crab shells are added to the soil the chitin promotes the growth of chitin digesting bacteria in the soil (Godoy and Morgan-Jones, 1983). The bacterial enzymes create a difficult environment for unwanted organisms in the soil like nematodes, insect grubs, and fungus all of which have chitin structures.

2. Production

The moisture and nitrogen content of SCPW is substantially higher then that of conventional compost material and thus requires a need for large amounts of bulking agents as carbon sources (Brinton & Gregory, 1992). If the carbon source is a material such as wood chips or sawdust from a known organic source, the compost can be classified as 'organic' and obtain a premium price.

There are many composting methods that can be used to compost SCPW. These methods are generally broken down into three categories; passive piles, turned or aerated piles and in-vessel systems. Within these categories lies many variations including but not limited to: Windrow composting, Ag-Bag composting, Bin or Drum composting, Aerated Static Pile method, High Fiber method, Mechanical Biological Treatment System (MBS) and Sheet Composting (Schaub and Leonard, 1996). All methods have varied costs, needed infrastructure and labor requirements. In general the high tech systems require more investment but give producers more control and produce higher quality compost.

When SCPW is composted in large quantities windrow composting seems to be cheapest but yet very effective method (pers. com., Terrance Boyle, Atlantic County Composting; Schaub and Leonard, 1996). The conventional aerobic windrow composting system requires immediate incorporation of the SCPW with a carbon based bulking agent. If the bulking agent is not added immediately the pile will soon emit unpleasant odors and attract fly breeding (O'Keefe *et al*., 1997). The aim is to have compost with a high percentage of SCPW while still having success at reducing odours. It is recommended to have a two-thirds carbon-bulking agent with one-third SCPW (pers. com., Terrance Boyle, Atlantic County Composting).

At first the pile will use huge amounts of oxygen and produce large amounts of heat. It is suggested to initially aerate the pile to prevent the onset of microbial imbalance and bad odours. Putting the mixture of shells and carbon over punctured perforated pipes (PPC) that are attached to a blower can do this initial aeration relatively cheaply (Schaub and Leonard, 1996). It is recommended to place a layer of wood chips under the perforated pipes to absorb excess liquid (pers. com., Terrance Boyle, Atlantic County Composting). Using a simple windrowing system a SCPW pile can stabilize within 21 days (Brinton & Gregory, 1992). After the pile stabilizes, frequent turning of the heap is essential and this can be done quite effectively with a loader. The frequency of turning will determine how fast or slow the compost matures.

The approval, licensing and monitoring of composting facilities, are the responsibility of the provinces and territories. In order to construct, operate, expand or modify a composting facility an interested person needs the approval of the minister. A detailed description of the proposed facility must be submitted. Investment is required in obligatory infrastructure such as an impermeable surface capable of containing 10,000 t of compost as well as surface, ground and wastewater treatment and monitoring. Obtaining a permit to do commercial composting is a very slow, expensive and rigorous process. Private and most municipalities composting facilities obtain permits for 9-10 thousand tones of compost (see Nova Scotia Environment and labour Composting facility guidelines).

3. Local production of SCPW compost

Atlantic County Composting in Afton, Antigonish County produces all sorts of compost including organic snow crab compost (site shown in Appendix 1.). The composting facility is certified for 9000 t of organics a year but currently only handles approximately 2000 t. The facility is highly engineered: the windrows lie on a 1% sloped asphalt slab, which sites at the top of a hill. Any runoff goes through a series of natural filtration ponds. The ponds contain 15 different species of swamp plants to effectively filtrate the water.

Atlantic County Composting composts many different materials at the facility. Waste that is composted is derived from Ocean Nutrition in Mulgrave, slaughterhouses, and a several other marketable organic sources. The snow crab compost is classified as category A (highest Canadian Council of Ministers of the Environment classification). To obtain this classification a nutrient (nitrogen, potassium and phosphorous) and temperature analysis of each pile is done before its sale. The compost is also classified as organic, as the SCPW is mixed with wood chips from a known organic source. The crab compost can be ready to sell in as little as 6 months, but improves in quality the longer it sits. Compost incorporated in fields too early can kill the crops by warming and delete the crop of oxygen.

Atlantic County Composting has not received SCPW from any of the Cape Breton plants for the last few crab seasons due to transportation costs. The facility is however very interested in composting Cape Breton SCPW if a feasible transportation matrix could be designed to lower costs.

Several private individuals have tried bulk snow crab composting in Cape Breton since the onset of the SCPW disposal problem. These private composting facilities are no longer in operation for a variety of reasons including strict and expensive environmental requirements, odor problems, transportation costs and other economic constraints. However, according to the Nova Scotia Department of Agriculture, there is a huge need for quality organic compost in Cape Breton. Oil prices are causing artificial fertilizers to become extremely expensive and farmers of field and row crops, vegetable gardeners, lawn caretakers, and ornamental gardeners to look for cheaper alternatives.

It should be noted that although the transportation of fertilizer for agricultural purposes is subsidized in Nova Scotia, the transportation of compost is not. Within Cape Breton Island the transportation of limestone is subsidized at a rate of $10 a ton in Inverness county, $13/t in Victoria county, $11/t in Richmond county and $15/t in Cape Breton county (Nova Scotia Farm Investment Fund Guidelines 2009-2010). A similar subsidy for compost could greatly improve the feasibility of a large scale, centralized SCPW composting.

4. Costs of a bulk composting facility

Costs associated with starting a brand new composting facility are quite high relative to returns. Essential materials needed are a large asphalt slab, an effluent treatment system, a machine such as a bulldozer, excavator or backhoe for mixing compost piles, and some type of aerator. A large area of land must also be obtained for the facility. In addition, a rigorous environmental assessment must be submitted to Environment Canada before an operation can commence composting.

An economic analysis study comparing the costs of ‘Ag-Bag’ and windrow composting of SCPW was done to assess these alternatives to landfilling (Wentworth et al., 2002). Ag-Bag composting is a method that utilizes plastic to contain the materials and uses forced aeration. The cost of producing Ag-Bag compost was $73,796/year and the cost of producing windrow compost was $53,533/year. Ag-Bag composting and windrow composting were compared for annual costs and profit analysis. Ag-Bag compost was sold for $109.80/t, while the windrow compost was sold for $63.08/t. Neither was found to be profitable. However, windrow composting had the smallest losses and became profitable when over 1,000 t of compost a year could be generated (Wentworth et al., 2002). If all the SCPW on Cape Breton was utilized well over 1,000 t a year could be produced.

5. SCPW compost market

The potential end-use of finished SCPW compost is soil conditioner, and potting soil. Sectors that could buy the finished product in bulk may include golf courses, landscaping companies, horticulture, agriculture, parks and athletic fields.

If bagging the compost were deemed feasible the market would significantly widen. Household gardeners and ornamental grower could be targeted at a substantially higher price. Of the companies in United States selling bagged SCPW compost, it was found that there were generally asking around $60 for a 23 kg bag.

6. Issues and challenges

Again, the issues are very much the same as for dried crab shell and meal production. In addition there are two specific challenges for compost production:

a. Finding substantial amounts of organic carbon on Cape Breton Island
b. Obtaining a compost facility approval from the province

The first issue pertains to all the SCPW recycling methods. See previous sections.

Finding substantial amounts of organic carbon on Cape Breton Island could be a challenge depending on where the proposed or modified compost facility is located. If all the 3000 t of 2009 Cape Breton SCPW was to be composted it would mean approximately 9000 t of carbon would be needed. Further assessment of feasible organic carbon sources would need to be investigated, including the proximity of lumber mill waste.

Obtaining approval for a new compost facility is an expensive and time-consuming process. It took two years for Atlantic County Composting to fulfill the needed requirements and obtain the permission of the minister. Experience and expertise in such a project might shorten this time frame somewhat but it would require significant funds for planning and studies.

7. Recommendations for SCPW compost

The high costs of setting up a brand new composting facility and relatively low returns would not encourage the construction of a new facility. However, if an existing Cape Breton municipal composting facility could be modified to handle SCPW separately from its municipal compost there may be greater economic gain. There may also be reason to pursue the development of a transportation matrix to ship SCPW to Atlantic County Composting in Afton.

An existing municipal landfill would need to bring in an organic carbon source to manufacture the compost. If suitable organic carbon sources could not be found, modified SCPW compost could easily be made with cardboard material. Cardboard is collected from fishing wharfs during the snow crab fishing season in large quantities. Local municipal landfills are currently having difficulty accommodating the quantity of cardboard that comes in during the snow crab season. Last season the cardboard at the Kenlock landfill facility was no longer recycled due to the large quantities. This cardboard would simply need to be shredded and incorporated into the SCPW just as any other carbon source. The finished compost could no longer be classified as organic, but its final uses would be greatly increased compared to current composting at municipal sites. This solution of using SCPW and cardboard generated from the snow crab fishery would produce a value added product from two major wastes of the industry, while contributing to the economic gain of municipal landfills.

The establishment of an agricultural compost transportation subsidy, much like the subsidy for the transportation of agricultural fertilizer, may substantially improve the feasibility of this option if approved.

VII Direct Agricultural Field Application

1. Overview

Of all the snow crab processing waste recycling methods, direct agricultural field application requires the least amount of planning and investment, but would directly benefit two major Cape Breton industries.

SCPW is likely to benefit farm fields in three ways:

a) contributing to the nutrient, lime and organic matter content of their soils: SCPW contains many of the essential nutrients for plant growth, with approximately 6% nitrogen, 2% phosphorus and 1% potassium. This ratio of nitrogen, phosphate and potash in the SCPW is approximately 2:1:1, ideal nutrient ratios for many crops.

b) maintaining a balanced soil pH: Typically chalk or limestone (types of calcium carbonate) is added to agricultural fields to prevent soil acidity. When there is a need to use chalk or limestone the material is typically spread at 5 to 10 t per hector, which yields 250 to 500 neutralising units. SCPW contains approximately 23% calcium carbonate and if spread at 25 ton per hector would yield approximately 250 neutralising units. SCPW would therefore be an effective liming material.

c) soil stabilization: SCPW also has necessary organic matter that stabilizes soil, improves the ease of cultivation, improves the soils water holding capacity and encourages biological activity in the soil (ADAS UK Ltd, 2006).

Organic manure is often applied to support growth and to replace nutrients removed by crops when they are harvested. Interestingly ADAS UK Ltd (2006) did an analysis comparing the major crop nutrients in crab processing waste and cattle manures (table 4). The analysis showed that crab waste was higher then cattle manure in dry matter, nitrogen, phosphate, sulphur and magnesium.

Table 4. Major crop nutrients comparison of crab waste and cattle manure, expressed in kg per ton of fresh weight (ADAS UK Ltd 2006).

	Dry matter %	**Total Nitrogen (N)**	**NH4-N**	**Phosphate (P2O5)**	**Potash (K2O)**	**Sulphur (as SO3)**	**Magnesium (as MgO)**
Crab waste	40	18.7	0.49	7.2	1.1	3.6	6.8
Cattle manure	25	6	1.1	3.5	8	1.8	0.7

SCPW has been used effectively as a soil conditioner with farmers traditionally spreading the material because of its liming value and slow release of nitrogen. However, as stated in the SCPW composting section previously, the chitin content is a valued component as a deterrent of harmful nematodes and fungus in a wide range of crops. Nevertheless, ADAS UK Ltd (2006) suggests that complete control is rare and the degree of chitins effects are unpredictable. It is recommended that farmers consider the beneficial chitin properties of SCPW as an added bonus and not modify their usual agrochemical application when spreading SCPW.

2. Procedure

In order for a farm to spread non-agricultural organic waste on agricultural land in Nova Scotia they must have a ‘nutrient management plan’ designed for the waste. Nutrient management plans are fashioned to reduce environmental risk and plan for effective use of the waste product. The nutrient management plan is developed in conjunction with an Environmental Farm Plan (EFP), which is a voluntary, free program that farmers can use to identify and assess environmental risk. The nutrient management component is also highly subsidized if the farm is a registered under the Farm Registration Act and actively farming. Farmers must submit an application to the Province and the service is provided on a first come first serve biases. A professional agrologist complies to the Nova Scotia Codes of practice for the application of non-agricultural organic waste and sets standards for the waste application (Langman *et al.*, 2005).

The logistics of finding interested farmers to take advantage of the nutrient rich SCPW for spreading could be accomplished in several ways. Individual snow crab processing plants could make arrangements with local farms with the help of the Cape Breton division of the Department of Agriculture. Another alternative could be to get all interested processing plants to submit an article seeking interested Cape Breton farmers in the monthly agriculture newsletter that goes out to approximately 400 farmers and people with an interest in agriculture. Presumably, other outreach methods could also generate interest at a very inexpensive cost.

3. Issues and challenges

Odour is always a concern when handling SCPW. Delivering the waste from the processing plant to the farm in a timely manner and then quick implementation of the SCPW into the soil will reduce odour issues significantly. Once the SCPW has arrived on the farm site adding a green waste such as straw, horse manure, grass cuttings, paper waste, poultry manure, wood waste or compost will also reduce any odors present. SCPW could be spread using rear discharge farmyard manure spreaders. The material should then be quickly incorporated into the soil by ploughing or discing.

Public perception can also be an issue when adding outside nutrient sources to agricultural fields. Ways to mitigate poor public perception may be to make sure the SCPW is finely crushed so that shells are not visible from the roads. It would also be important to reduce any plastic waste that finds it’s way into the SCPW as it can be visually offensive. It may also be wise to generate favorable local media coverage highlighting the benefits of using SCPW on agricultural fields.

Spreading of soil conditioners is generally limited to the period between harvest and sowing the next crop. Therefore spreading usually occurs between April and October**.** The timing of snow crab season and SCPW field application would then coincide very well. However, the summer months are a very busy time for farmers and if SCPW is received and there are no available fields or time for spreading, there could be major odour, and water contamination problems. Unfortunately this problem could prove to be very significant as there is little ability to control the handling of SCPW once it reaches the farm site. In warm weather, delay in adding green manure or in spreading would allow the generation of strong and offensive odours. Should this occur near residences, the resulting outcry and media response could seriously undermine local support for the use of SCPW, thus significantly reducing the program.

Spreading of SCPW should be very attractive to farmers. However, farmers will know that they are providing a service to the snow crab plant owners and will not likely be willing to pay for the waste. Selling it in bulk as a commercial product may offset this reluctance as it is replacing other sources of fertilizer. Perhaps an agreement could be made regarding transportation costs to reduce the price and make it both an attractive fertilizer alternative and an alternative to landfill disposal.

The farmers will likely see the largest disadvantage of using SCPW as the bulk of the material. The crab waste will have to be spread at approximately 25 t per hectare as opposed to 5 to 10 t per hector of an inorganic fertilizer. A larger, heavier tractor and spreader will need to be used, which may cause soil damage on heavier soil types, particularly if the soil is wet.

4. Recommendations

Aside from the necessity for nutrient management plans, field spreading is the simplest solution to the SCPW waste problem, and should be put into place immediately, as other value added alternatives are being developed

VII Ocean Dumping

Ocean dumping of SCPW is not a value added disposal method. However, we have chosen to discuss this method because it is a potential disposal alternative. Fish waste and other organic matter resulting from industrial fish processing operations is a waste included in Environment Canada's ocean dumping program. Two to three million ton of material is disposed at sea each year in Canada. Environment Canada has a permit scheme controlling the disposal of waste at sea. The permits are obtained once the applicant submits a detailed assessment and associated fees. Information needed for the assessment include such details as the location and area of disposal, the equipment and methods to be used, methods of packaging and containment, rate and frequency of disposal, an environmental impact assessment, chemical, biological and physical assessment, and proximity of disposal sites to sensitive areas.

The initial application fee of $2500 is to be paid each application year and is non-refundable. If the ocean dumping is approved there is a monitoring fee of $470 per 1000 cubic meters of waste. This number may be easily calculated for other industrial waste such as dredged matter, however for SCPW, this fee is more difficult to determine. The measurement of SCPW by 1000 cubic meters will vary substantially depending on its state. Disposing of highly crushed SCPW will be much less costly then disposing of SCPW that has not been compacted after the initial processing.

Ocean dumping may be an alternative disposal method but does not sustain a value added industry. Whether ocean dumping is cost effective for individual snow crab processing plants to undertake will have to determined by interested applicants. Obtaining and running a proper barge for dumping will most likely be the most costly component of the operation.

VIII Final Recommendations

The benefits and pitfalls of creating value added SCPW products through crab meal, chitin extraction, compost, and direct field application have all been discussed. Producing crab meal or chitin will require significantly more investment, with greater returns. The high-end products will also require a greater amount of planning, market assessment and employee skill. The low-end value added products require much less investment and planning but have lower returns.

Direct field application is the best alternative to value added composting at municipal landfill sites as it solves the disposal problem while directly benefiting the processing plants and local farmers. It is the only option that does not require establishing or modifying infrastructure. This option seems to be a win-win situation with the least amount of risk, but with local benefits. Field application would not necessarily require transportation coordination between plants to a centralized location. Rather plants could coordinate dumping times and locations with local farmers. Unlike the other recycling options, if the supply of the crab decreases there is little financial risk because money has not been invested. If investment did come through or the market substantially improved for one of the other high-end recycling methods SCPW could more easily be diverted from direct field application than other options. This option could probably be implemented quite quickly.

However, production of SCPW compost is the most reasonable short-term option for creating a value added product that can benefit Cape Breton and the region. It also addresses the disposal problem without major investment in place. This option could be developed as direct field application is implemented with field application eventually phased out.

The choices of composting at a centralized site, at municipal landfills, or at an existing composting facility are difficult to assess without further detailed study. The parameters interact in ways too complex to completely analyze in this report. But what is clear from this study is that some form of composting is the best balance available at present to Cape Breton snow crab processors.

High quality compost can generate substantial revenue. However, establishing a new composting facility is expensive and requires compliance with stringent environmental regulations. Using existing private composting sites or modifying existing municipal composting sites to provide an area exclusively for SCPW compost is the most cost effective alternatives. This option would require shipping SCPW to a centralized facility. Thus a detailed transportation matrix would be recommended to reduce trucking costs. Establishing an agricultural compost transportation subsidy, much like the subsidy for the transportation of agricultural fertilizer, may substantially improve the feasibility of this option. Composting facilities, unlike the high-end SCPW products, can easily adapt if the supply of SCPW were to decrease by accepting other forms of underutilized organic wastes for composting. ,

For longer-term development options we recommend crab meal and dry shell production as a value added product. Two Maritime companies, St Laurent Gulf Products Ltd and W.E. Acres Crab Meal have long-standing crab meal operations and with the proper investment and business plan it is possible that Cape Breton could also develop such a facility. The market for crab meal is increasing in Asia as uses for the product continue to grow. Considerable investment and planning is needed to produce this value added product. It is therefore a longer-term investment and comes with greater risk. The variability of snow crab abundance is the greatest concern for the success of a crab meal project, with transportation costs and the length of the snow crab season also posing obstacles. If a reliable source of shrimp and lobster shells could be found to augment that of SCPW the feasibility of this option increases.

The production of chitin from snow crab shells is the most lucrative of the recycling options but is for now a distant reality for Cape Breton. Canadian environmental regulations, employee wages and product knowledge are all limiting factors when trying to compete with Asian producers. This market needs time to grow. Further Canadian research and development would help bridge the gap between the Asian competitors and us. However, for now chitin production is expensive and, with unstable crab shell supplies, would be a risky business venture.

No matter what SCPW recycling method an investor decides to pursue at an early stage he or she should approach the processors to engage them as partners. This partnership is crucial to avoid major problems with supply or competition later on. Depending on the SCPW recycling option, investors need to research potential provincial or federal funding. The next section highlights contacts to expedite project development.

Useful contacts for interested SCPW Recycling Investors;

1) Canada Business Service Centre's – provide logistical support for Canadian business start-ups, including a central information and referral gateway on government services and programs. *www.cbsc.org*.

2) Industry Canada – provide resources and information related to all aspects of environment, including eco-efficiency, sustainable development and corporate social responsibility. Visit the program and services section of Industry Canada website: *www.ic.gc.ca*.

3) Composting Council of Canada (www.compost.org) a non-profit organization that serves as the central resource and network for the composting industry in Canada.

4) Nova Scotia composting facility regulations and guidelines:
http://www.gov.ns.ca/nse/waste/docs/Composting_Facility_Guidelines.pdf

5) Canadian Council of Ministers of the Environment (CCME) document
Guidelines for Compost Quality, All compost is classified in accordance with the criteria:
http://www.ccme.ca/assets/pdf/se_ssd_1386.pdf

6) Agrapoint has many consultants that work with farms, processors, industry associations, governments and other companies servicing the agriculture and agricultural food community. They offer production advice, product and research trials, nutritional services, and food safety and quality assurance training. http://www.agrapoint.ca/eng/

7) Nova Scotia Nutrient Management Planning Subsidy;
http://www.gov.ns.ca/agri/prm/programs/BMP24.pdf

8) Environment Canada's Disposal at Sea Program;
http://www.ec.gc.ca/seadisposal/main/index_e.htm

9) RRFB Nova Scotia Program Funding, funding for diverting waste from municipal landfills.
http://www.entreprisescanada.ca/servlet/ContentServer?cid=1083346989887&lang=en&pagename=CBSC_NS%2Fdisplay&c=Finance

10) Nova Scotia Department of Fisheries and Aquaculture, Innovations Program. Provides technical and financial support for the development of projects that introduce new and innovative technology to the industry. http://www.gov.ns.ca/fish/marine/innovations/index.shtml

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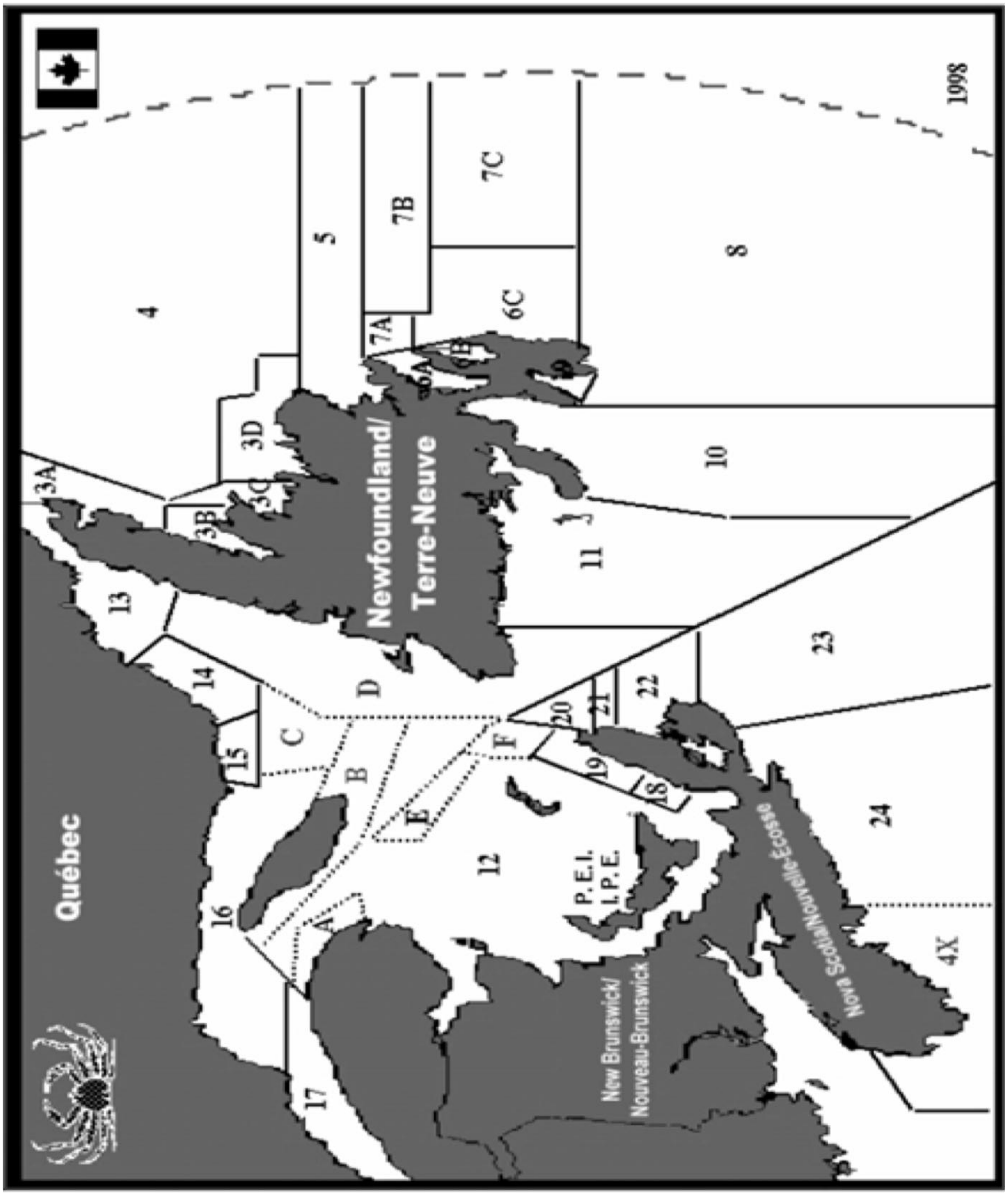
Appendix 1.

The Maritimes snow crab, Crab Fishing Areas (CFA) (Map was obtained from the Department of Fisheries and Oceans web site.)

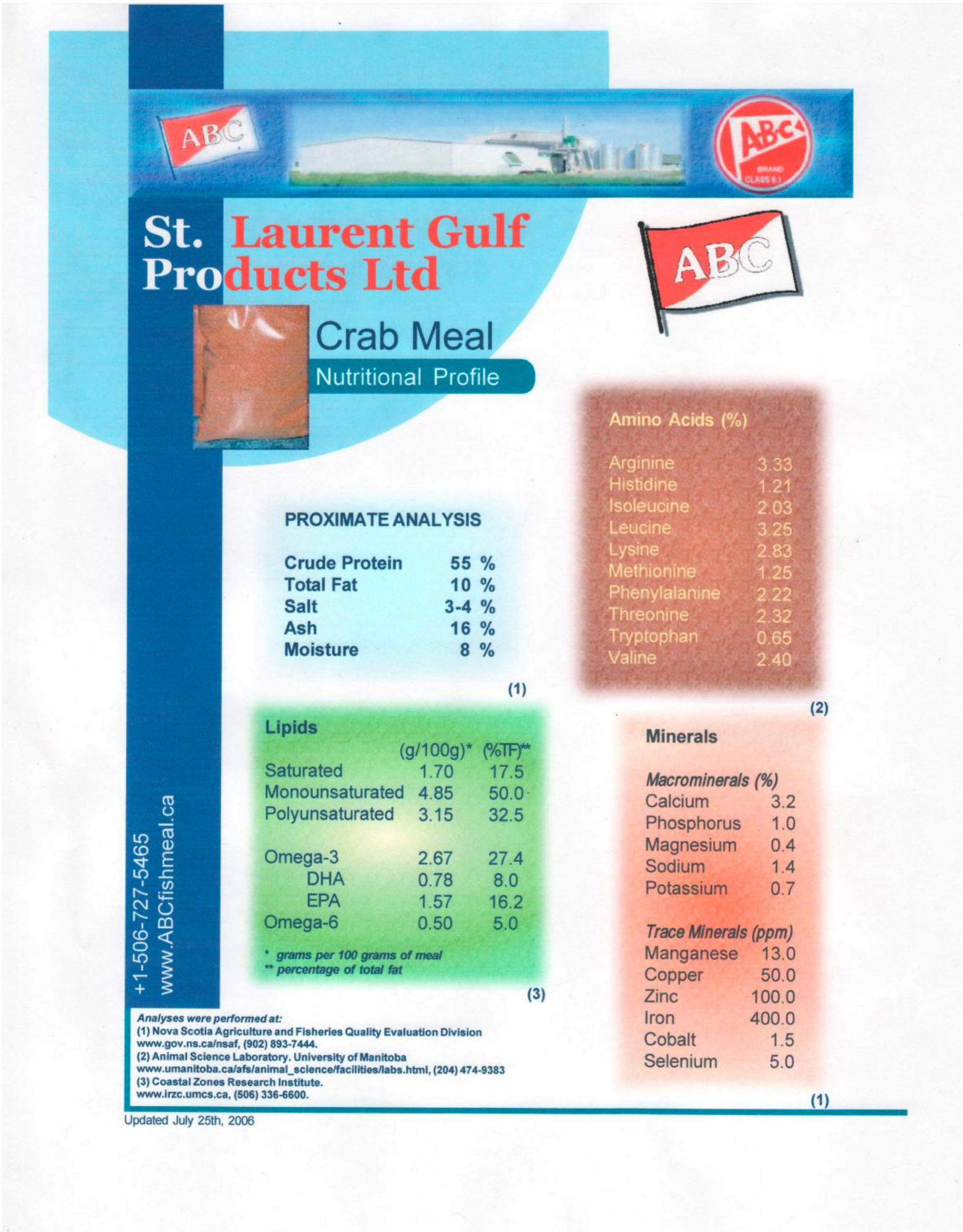


Appendix 2.

The landfill and composting sites currently accepting SCPW (blue) and not accepting SCPW (yellow) relative to the snow crab processing plants (red).

Appendix 3.

St. Laurent Gulf Products Ltd snow crab meal nutritional profile.



ABC

St. Laurent Gulf Products Ltd

Crab Meal

Nutritional Profile

PROXIMATE ANALYSIS

Crude Protein	**55 %**
Total Fat	**10 %**
Salt	**3-4 %**
Ash	**16 %**
Moisture	**8 %**

(1)

Amino Acids (%)

Arginine	3.33
Histidine	1.21
Isoleucine	2.03
Leucine	3.25
Lysine	2.83
Methionine	1.25
Phenylalanine	2.22
Threonine	2.32
Tryptophan	0.65
Valine	2.40

(2)

Lipids

	(g/100g)*	(%TF)**
Saturated	1.70	17.5
Monounsaturated	4.85	50.0
Polyunsaturated	3.15	32.5
Omega-3	2.67	27.4
DHA	0.78	8.0
EPA	1.57	16.2
Omega-6	0.50	5.0

** grams per 100 grams of meal*
*** percentage of total fat*

(3)

Minerals

Macrominerals (%)	
Calcium	3.2
Phosphorus	1.0
Magnesium	0.4
Sodium	1.4
Potassium	0.7

Trace Minerals (ppm)	
Manganese	13.0
Copper	50.0
Zinc	100.0
Iron	400.0
Cobalt	1.5
Selenium	5.0

(1)

+1-506-727-5465
www.ABCfishmeal.ca

Analyses were performed at:
(1) Nova Scotia Agriculture and Fisheries Quality Evaluation Division
www.gov.ns.ca/nsaf, (902) 893-7444.
(2) Animal Science Laboratory. University of Manitoba
www.umanitoba.ca/afs/animal_science/facilities/labs.html, (204) 474-9383
(3) Coastal Zones Research Institute.
www.irzc.umcs.ca, (506) 336-6600.

Updated July 25th, 2006

Appendix 4.

Survey used to collect data from snow crab processing plants;

Gulf Aquarium and Marine Station Cooperative

C.P (Box) 697, Chéticamp, Nova Scotia B0E 1H0 ✦ Tel. : (902) 224-1623

Email: gams@cbreton.net ✦ Fax: (902) 224-3864 ✦ www.cmag-gams.org

October 8th, 2009

Dear Processing Licenses owners,

The GAMS Marine Station Cooperative is currently investigating the feasibility of recycling snow crab shells. This initiative will be focused on the snow crab processing waste (SCPW) produced in Chéticamp, as well as the whole of Cape Breton. We realize that at present the disposal of snow crab-processing waste is a costly and environmentally unsound problem.

Presently our goal is to find a cost effective alternative to landfilling SCPW. It has been shown that SCPW can be economically recycled into a variety of useful products. These products range from simple crab shell composts and fertilizers, to crab meal, to highly refined chitin products for pharmaceuticals and textile production.

We would love to hear from you about your plants SCPW disposal methods. We are looking to gather information such as:

1. How many tones of SCPW do you dispose of annually?
2. Where the SCPW is being disposed?
3. Your annual shipping and dumping costs for the SCPW?
4. Would you be interested in recycling your SCPW?

We would appreciate discussing your plants disposal information and anything else you believe would enhance the project. We can be contacted via phone, e-mail, fax or traditional mail; addresses are located at the top of this letter.

The Gulf Aquarium and Marine Station Cooperative (GAMS) has been established to promote collaboration between the community, fishers and scientists. Our main goals have been to: engage the public with hands-on educational programs, provide marine research space for students and researchers, and enhance the association of fishers, government, universities and the greater community. GAMS is currently conducting its efforts in Chéticamp, Cape Breton.

Sincerely:

Gina Stewart, Project Coordinator

GAMS is a Charitable Status Cooperative organization (# 3038649)

Please fill out and fax back this short questionnaire.

How many tones of Snow Crab Processing Waste (SCPW) does your plant dispose of annually? What time of year are you disposing of the SCPW?

Where is your plant's SCPW being disposed? Does your facility have storage space for the SCPW? Do you crush the SCPW before shipping?

What are your annual shipping and dumping costs for disposing of the SCPW? Are you using your own company trucks to dispose for the SCPW?

Does your plant process any other marine products? (Yes / No). If yes, which marine products are you processing, in what quantities and at what time of year? How are you currently disposing of this waste?

Would you be interested in recycling your SCPW to produce a value added product? Have you considered using value added disposal as a sales pitch?

Additional Comments;