Rural Community Development Through Waste Diversion Management

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EVST 4950

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Exploring Rural Identity

A person's identity is created by his surroundings. Every different daily encounter will shape the way he views and is viewed by the world. Living in certain regions will provide various directions in which to follow and different insight towards situations. Living in different environmental conditions produces mixed results as to a person's character. A production of one's environment is exemplary of living in both an urban environment, and a rural one. Urban life is often described as one that is suited to a fast-paced environment that caters to availability and access of products and services alike. "Urbanity would be so constituted by *something* that comes from the city, from the street, from the building, and is appropriated to some extent by people" (Vieira de Aguiar, 2013, p. 2). Which can otherwise be referred to as a product of the socio-economic human environment. Catering to the needs of the product and servicing industry, Urbanity gains the ability to provide a more accessible community that offers an array of work and leisurely activities. This way of life defines an extension of a modern-day people-oriented lifestyle that promotes economics as a social mechanism. The distinction between urbanity and rurality lies in the orientation of modern living and the environment that encompasses it.

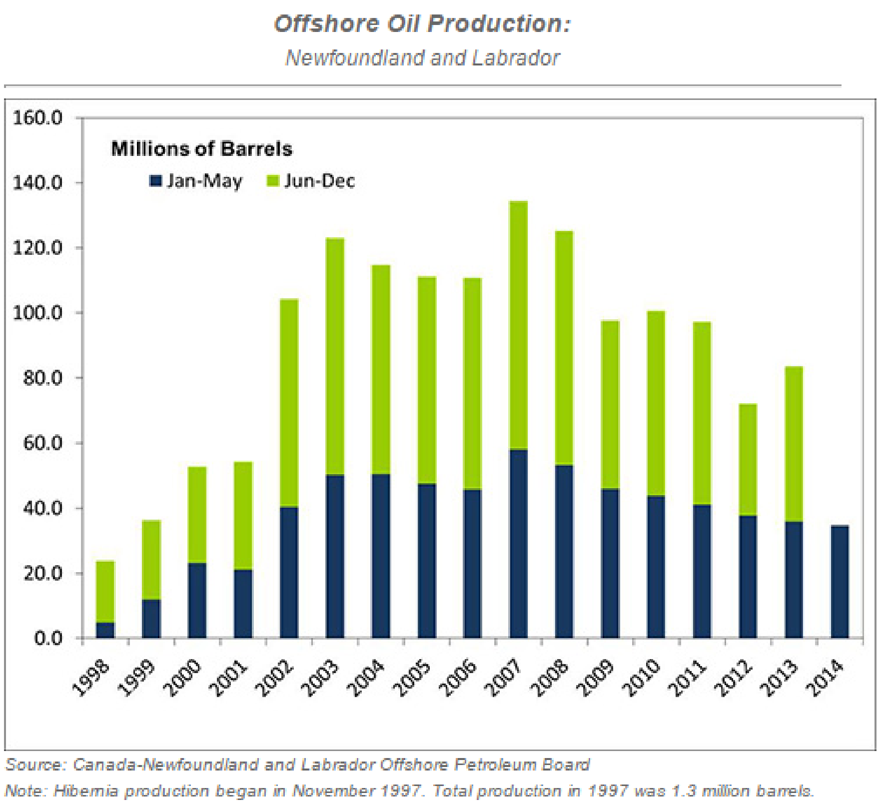
Rurality however, has a centered focus on the natural bio-physical environment and portrays a standard view of traditional values. This shows that the focus of modern day living in rural communities is culturally rooted, rather than economic like that of urban environments. Rurality is a complex word as there is no universal definition. "The term 'rural' conjures widely shared images of farms, ranches, villages, small towns, and open spaces. Yet, when it comes to distinguishing rural from urban places, researchers and policymakers employ a dizzying array of definitions" (Cromartie, 2008). Rurality, as summarized by Chris Atkin's study entitled *Rural Communities: Human and Symbolic Capital Development, Fields Apart* (2010), has six defining characteristics. According to this study Rurality must be small in scale, isolated, a product of the environment, strong in community feeling, conservative and have traditional values, as well as participating in a slower, less pressured way of life. An overlying theme is embodied by the three final points that represents a strong cultural connection to the processes that create the rural experience. To be smaller in size means to have less variety and access to products available for redistribution; which confirms that "[g]overnment policy simply assumes that rural people are willing recipients of lifelong learning, and any difficulties in participation are therefore a product of access and availability" (Atkins, 510). This case is also found when associated with isolated communities. These certain populations have adapted to entrust their livelihoods to the immediate production of the surrounding environment such as fisheries, or agricultural practices. A community based on an economic system that is determined by the pre-existing geographical features portrays one that has minimal available alternatives, and diminished access to any alternatives had any been possible. "As in all small communities that survive on natural resources, there is a ripple effect in the economy when that industry experiences setbacks or shutdowns" (Borgen, 2002, p. 119). Although the characteristics of rurality promote a healthy cultural significance, they have an apparent lack of accessible and available alternative options in terms of economic diversification.

The effects of the previously mentioned lack of accessibility and availability have heavily impacted the economic sector. Its growth and development were dependent upon diversity amongst product and service industries to guarantee the stability of the economy in the event of a disastrous occurrence such as the Newfoundland moratorium on Cod. The deficiency in financial diversification played an important role in the potential wealth and the capacity of rural towns to achieve the full potential benefits. With little ability to provide a growing market worth investing in, rural communities are provided with a significant decrease in their financial support from the provincial government. "Increasingly in the past two decades, hard questions have been asked about why government monies should go to remote places for expensive infrastructure or social support. What services do such communities offer the nation?" (Ommer, 2002, p. 21). Due to a lessened degree of local financial support, municipalities rely upon the contribution of provincial and federal funding. Unfortunately these contributions provide insignificant attention towards the improvement of rural well being. The most well-known federal funding project which focused on rural stability in Canada was Employment Insurance (EI) (Blake, 2003, p. 190). As it was previously intended to assist workers in the event of a downturn in their financial state, it is now a commonplace for most workers among one of the most recessive provinces in Canada (p. 193).

More recently, Newfoundland has increased its oil and gas production and exportation revenues. This current resource provides substantial aid to the well-being of many residents of Newfoundland for the time being. As verified by many scientists, oil and natural gas reserves in Canada are substantial, but finite. " Total Canadian proven oil reserves are estimated at 173 billion barrels, of which 168 billion barrels are found in Alberta's oil sands and an additional 5 billion barrels in conventional, offshore and tight oil formations" (NRCAN, 2014, April 9). This proves to be a major source of the out-migration of young workers due to the high volume of workers necessary to process and facilitate such large quantities material for energy consumption (StatsCan, 2014). Despite creating an alternative source of employment for the province, it does not guarantee job stability. Volatility tends to be present in the market especially when concerning products that are finite. Although it may be abundant today, its existence cannot be assured forever. Table 1 represents Newfoundland's annual production from 1998 -2014 which demonstrates the decline in extracted resources. While oil and gas is still a major contributor to

Newfoundland and Labrador's Economy, it is evident that its exhaustion will occur within our lifetimes. (StatsCan, 2014, May). Newfoundland's economic longevity will be determined by the exploitation of renewable resources in a sustainable manner so future generations may live in similar or better conditions.

Table 1. Newfoundland and Labrador Offshore Oil Production



This inability to produce sustainable, diverse and active businesses has led to "the continued out-migration of youth from the rural areas for education or employment opportunities" (p. 194). This trend is particularly significant when pairing it with low fertility rates, demonstrating that not only will there be fewer people in the rural areas but that the population will also be older (p.194). Considering that Newfoundland had little options to begin with in terms of economic diversification, this is concerning for the long term well-being of the province's populous.

"The ‘new’ approach, created by to rural and regional economic development coming out of all the various studies recommended that the province be divided into 20 zones with a regional board for each" (p. 206). Although this provides a prospective alternative to the previous system(s) it fails to account for the relatively low population of many rural regions. "The fisheries crisis and the various programs to deal with the moratorium (including The Atlantic Groundfish Strategy, TAGS) fragmented many rural communities" (p. 207). Officials have acknowledged that for the new strategy to have functioned properly, it would have required a cooperative effort at public education about the new approach and by generating greater community involvement. Although alternative economic sourcing is more diverse than ever it is still evident that Newfoundland's communities, especially rural ones, depend upon the fisheries sector.

<u>Newfoundland Fisheries</u>

As Keith Hutchings noted in the Annual Report of 2013-14,"The Government of Newfoundland and Labrador recognizes the substantial economic contribution of Newfoundland and Labrador’s $1.1 billion fishing and aquaculture sectors, and is dedicated to promoting continued success. The industry remains a vital economic driver for the Newfoundland and Labrador economy, and with careful stewardship, strategic investment, and collaboration with industry, our collective success will continue to grow" (DFA, 2014, September, p. I). Well over 18,000 jobs are created from this sector alone, 1000 of which have been in rural communities (2014). Facilities across the province have a considerable amount of harvested material to process. Landings of species varied from 83,000 tonnes of shrimp, to 50,000 tonnes of snow crab, with an overall total of 168,000 tonnes of shellfish harvested in 2014 (SYIR, 2014, p. 9).

As previously mentioned, the fisheries sector creates a considerable amount of wealth for the province though it is not without its expenses. By further developing the large quantities of shellfish processing waste, rural communities are provided with a more profitable and sustainable alternative to disposal. Processing of this material into exportable product generates a lot of waste products that must be effectively handled to ensure a stable and manageable resting spot. As of current, disposal options are limited including disposal as a compost, land-based waste disposal sites, and ocean-based disposal regions (GD-PPD, 2004, p. 2). The magnitude of these expenses are augmentative in that they compound to form a great deal of annual costs. Disposal in each particular situation requires a permit from Environment Canada for dumping of fish offal and has circumstantial proceedings in which to follow. "Offal may not spread within 90 meters of any well or public water supply and may not be spread on the watershed of any community water supply system. [It] may not spread within 30 meters of any watercourse/body and, considerations shall be given to neighbouring properties and land use" (p. 3). Noxious odours from decaying material, hungry rodents and seabirds, among other scavengers, and local geological features, such as soil conditions, play important roles in determining the location and disposal method. As an annual occurrence options for efficient dumping decrease.

The lack of efficiency in the processing subsector combined with the sheer volume of material harvested annually provides an intriguing perspective of the amount of exploitable material extracted. As is the case with most harvests, if the product is not being exported whole, then it must be processed for meat. "The northern shrimp is harvested by industrial trawlers and machine peeled in large factories where the meat is separated from the shells. The meat recovery is about 25% (w/w) while almost 40% is solid waste", final percentages are accounted for in lipids and water (Hagen Rødde, 2008, p. 388). "Generally, the head, shell and tail portions of shrimp are removed during processing and these account for approximately 50% of the volume of raw materials" (Islam, 2004, p. 104). This distribution of profitable material to waste product demonstrates an opportunity for increased marketable development. The percentage of waste material ranges from 35%-90% depending on various species and their individual ecosystems. Newfoundland's top harvested species include Pandalus Borealis Shrimp (Northern Shrimp), Queen-Snow Crab, Clams, and lobster (DFO, 2012). This is particularly significant when considering their waste percentages. "Shell constitutes 65% of mussel weight and 85% of oyster" (Rao, 2000, p. 808). "In addition, more than 70 percent of crab is considered processed waste material" (Burrows, 2007, p. 103). On average, waste bulk constitutes 58% of the total landings (Islam, 2004, p. 105). This waste material provides an opportunity for the further development of by-products. "Helping industry maximize the value of provincial shellfish and minimize production waste is a key objective for the Provincial Government" (Hutchings, 2014, p. 30). During Keith Hutchings' time as Minister of Fisheries and Aquaculture for Newfoundland and Labrador, (2013-14), his provincial standing sought to effectively use the most amount of material to generate marketable products. Further production of shellfish waste can be processed into a multi-use product derived from chitin. Shrimp waste in tropical regions contains 10-20% calcium, 30-40% protein, and 8-10% chitin, with higher percentages in colder regions, due to the need of a thicker shell (Rao, 2000, p. 808). "It was determined that shrimp (*Pandalus borealis*) contain about 17-32.2% chitin while the isolation from crab (*Chionoecetes opilio*) contains 26.6% chitin" (Bolat et al., 2010, p. 227). This provides a possible alternative source for economic stability.

Chitin and Productional Value

Chitin is a polysaccharide formed by N-acetyl-D-glucosamine units. This means that it is a carbohydrate composed of many molecules that create bonds the same way that glycosidic (sugar) molecules would. It is the second most abundant organic compound, secondly only to cellulose, and it is present in invertebrates, insects, marine diatoms, algae, fungi and in crustacea like crab, shrimps and lobsters (p. 227). "The three main components of crustacean shells together with chitin are minerals (mainly calcium carbonate) and proteins. These three components exist closely associated and account for about 90% of the dry weight of [shrimp] shells" (Ferrer et al., 1996, p. 56). A derivative of this compound is chitosan, which removes the acetyl group from the compound. Although the composition of chitosan is quite similar to chitin, it is more useful in cosmetics as it becomes more easily soluble in weaker acids without the presence of an acetyl grouping. Several methods have been reported although the most common being a chemical procedure involving a few major steps (Hajji, 2014, p.298). Chemical isolation of chitin from crustacean shells involves demineralization and deproteinization which may cause depolymerization and de-N-acetylation of the chitin (Hagen Rødde, 2008, p. 389).

Isolation requires a deproteinization bath in an acid, most commonly hydrochloric acid (HCl). Once dried the crude chitin material must undergo a demineralization, in which an alkaline solution, generally sodium hydroxide (NaOH) or potassium hydroxide (KOH), removes the rest of the material creating the final N-acetyl -D-glucosamine material, or chitin. The transformation of chitin into chitosan involves a de-N-acetylation bath requiring a higher concentration of alkaline solution for a longer period of time (Bolat et al., 2010, p. 227; Burrows, 2007, p. 105; Muhammed Tijani et al., 2010, p. 75). Optimal deproteinization treatment involves a 1% concentration of KOH for the use of shrimp shells and 2% KOH for crab shells. The process requires a 90^{o}C soak for 2 hours with a shell to alkali ratio of 1:20 (weight:volume) (Shahidi, 1991, p. 1527). "Optimal demineralization conditions require 2.5% HCl bath at 20^{o}C for 1 hour with a solid to solvent ratio of 1:10 (w/v)" (p. 1528). Between each solvent wash, the material must be dried to ensure accurate and efficient chemical reactions. The deacetylation process was carried out by increasing the concentration of the alkaline solution to 50% for 30 minutes at a solid to solvent ratio of 1:15 (w/v) (Bolat et al., 2010, p. 228). Interestingly enough, an alternative to the chemical solvent process involving a manufactured acid, HCl, is found amongst organic and environmentally occurring products such as whey or lactic acid. In a 1:10 (v/w) ratio of waste product to whey powder and lactic acid, the waste ferments for 24 hours to up to 96 hours to effectively remove all the excess proteins (Cira, et al. 2002, 1562). Although this process takes longer it offers an organic alternative for the more environmentally conscious consumer. Extraction of chitin becomes a furthered procession of the fisheries sector's marketable products that provide multitudes of applications outside of annual dumping into the finite spatial available existence.

Uses

The extent of chitin/chitosan's potential uses is diverse. "Like cellulose, chitin is essentially derived from replenishable resources, biodegradable and therefore does not pollute the environment; they are biocompatible not only in animal but also in plant tissues; are nontoxic and biologically functional, probably also due to their ability to exhibit polymorphism (changes in crystallinity)" (Srinivasa, 2007, p. 63). Biocompatibility of chitosan allows its use in various biomedical applications. Chitosan can be applicable in many different sectors proving it to be a diverse and effective use of crustacea waste.

Animal feed: Nowadays, the use of food wastes as animal feed is an alternative of high interest, because it stands for environmental and public benefit besides reducing the cost of animal production (Westendorf et al., 2000). Offal from the fishing industry could be used as a feed ingredient, as it represents a valuable source of high-quality protein and energy. (Arvanitoyannis, 2008, p. 728). Together with other materials such as wheat, soybean, bran, spinach, vitamins, fish powder, the animal feed is produced.

Fertilizer: Chitin has considerable production value in terms of its nutritional composition. The dry shells supply a superb organic source of nitrogen (6%), phosphorous (2%), potassium (1%), calcium (23%) and magnesium (1.33%) (GAMS, 2010, p. 19). The fertility ratio outlines the three main nutrients required for plant growth; nitrogen, phosphorus, and potassium (or potash); and their corresponding percentages of composition. This ratio of nitrogen, phosphate and potash in the SCPW is approximately 2:1:1, ideal nutrient ratios for many crops "The calcium content (3000 mg/100 g) was higher than those of phosphorus (400 mg/100 g), sodium (270 mg/100 g) and magnesium (100 mg/100 g) while manganese and iron were present in trace amounts. The total content of free amino acids of the processing by-products (2000 mg/100 g) was 15% higher than that of the edible parts (1700 mg/100 g). Major free amino acids were taurine, threonine, leucine, tryrosine and phenylalanine" (Min-Soo, 2003, p. 235). Chitosan increases photosynthesis, promotes and enhances plant growth, stimulates nutrient uptake, increases germination and sprouting, and boosts plant vigor (Burrows, 2007, p. 107). "When used as seed treatment or seed coating on cotton, corn, seed potatoes, soybeans, sugar beets, tomatoes, wheat and many other seeds, it elicits an innate immunity response in developing roots which destroys parasitic cyst nematodes without harming beneficial nematodes and organisms" (Smiley, 2002; Linden et al., 2005). Agricultural applications of chitosan can reduce environmental stress due to drought and soil deficiencies, strengthen seed vitality, improve stand quality, increase yields, and reduce fruit decay of vegetables, fruits and citrus crops. (Linden et al., 2007, p. 301). As found on many agricultural properties, organic manure is often applied to support growth and to replace nutrients removed by crops when they are harvested. Table 2 outlines the nutritional value of crab waste compared against the more traditional use of cattle manure.

Table 2. Major Crop Nutrient Comparison of Crab Waste and Cattle Manure (Kg/ton of Fresh Weight)

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

As noted above, crab waste material produces a higher fertility ratio as compared to the traditional manure varieties. This alternative provides the benefits of many trace elements aiding in the growth of a full nutritional diet for the organisms.

Biogas: Biofuel has become increasingly popular as the search for a cheap, renewable and ecofriendly alternatives to fossil fuels continue.

> The yield of the produced fuel was 95–96%, after filtration and primary and secondary treatments. The obtained oil was found to have suitable properties for use in diesel engines, such as almost identical higher heating value (10 700 kcal kg)$^{-1}$) and density (at 15^{o}C, 0.87 g cm)$^{-3}$), lower flash and pour points (37 and 16^{o}C, respectively) compared with commercial diesel fuel, no production of sulphur oxides, lowered or no soot, polyaromatic and carbon dioxide emissions. (Arvanitoyannis, 2008, p. 730)

The produced biogas can be used directly in a burner to produce thermal energy or, following depuration, can be employed as fuel in a cogeneration plant to produce thermal and electrical or mechanical energy (p. 734).

Pharmaceuticals: Due to its excellent biocompatibility with the human body tissue, chitosan was found to be effective for all forms of skin dressing, suture thread in surgery, as implants or gums cicatrisation in bone repair or dental surgery (Srinivasa, 2007, p. 67). In dental creams, it extends the paste shelf life, and it also helps in regenerating the gums that are defective. (Burrows, 2007, p. 109). "Mucoadhesivity of chitosan and cationic derivatives is recognized and has been proved to enhance the adsorption of drugs especially at neutral pH" (Rinaudo, 2006, p. 622). "Additionally, [chitosan membranes] are impermeable to serum proteins and they might be unique in offering the advantage of preventing entry of toxic metals into the blood stream, as it currently happens using other artificial membranes" (Srinivasa, 2007, p. 66). Chitin and chitosan versatility is accurately demonstrated throughout a breadth of areas in the biomedical industry providing a realistic environmentally friendly alternative to current practices.

Food Preparation: Consumer demand for foods without chemical preservatives has led to the discovery of new natural antimicrobial agents, which significantly inhibit the growth of various spoilage and pathogenic organisms (Srinivasa, 2007). Chitosan can be used as a food coating/preservative to increase the lasting time of fruits and vegetables to up to 20 days before signs of decay (Sahidi, 1999, p. 40). "The antifungal effect of chitosan on in vitro growth of common post-harvest fungal pathogens in strawberry fruits was studied by El Ghaouth et al. (1992). According to that study, chitosan (with 7.2% NH2) reduced markedly the radial growth of *Botrytis cinerea* and *Rhizopus stolonifer*, with a greater effect at higher concentrations" (p. 41). After 14 days of storage, "chitosan coating at 15 mg/mL reduced decay of strawberries caused by the same fungi by more than 60%", and also observed that coated fruits ripened normally and did not show any apparent sign of phytotoxicity. The production of chitosan from crustacean shells obtained as a food industry waste is economically feasible, especially if it includes the recovery of carotenoids.

Plastics: Being a biopolymer, chitosan can be turned into biodegradable plastic film that can be used on any whole foods. "The use of edible films and coatings to extend shelf life and improve the quality of fresh, frozen and fabricated foods has been examined during the past few years due to their ecofriendly and biodegradable nature" (Srinivasa, 2007, p. 69). The preparation of chitosan and chitosan-laminated films with other polysaccharides has been reported by various authors; these include chitosan films (Butler, 1996; Chen, 1996; Kittur, 1998), chitosan/pectin laminated films (Hoagland, 1996) and chitosan/methylcellulose films (Srinivasa, 2003; Shahidi, 1999). Due to its ability to form semipermeable films chitosan can be expected to modify the internal atmosphere as well as decrease transpiration loss and delay the ripening of fruits (Kittur, 1998). Chitosan films are prepared by dissolving chitosan in dilute acid and spreading on a leveled surface and air-drying at room temperature. Films are also prepared by drying at 60^{o}C in an oven by spreading the solution on polypropylene film plexiglass (Butler, 1996). Biodegradable film is an important product to consider as it allows for the return of nutrients to the earth once the plastic has been tossed away.

Water Purification: Better awareness of the ecological and health problems associated with heavy metals and pesticides and their accumulation through the food chain has prompted the demand for purification of industrial waste waters prior to their discharge or use. "Use of chitosan for potable water purification has been approved by the United States Environmental Protection Agency (USEPA), up to a maximum level of 10 ppm" (Srinivasa, 2003, p. 64). "Chitosan, carboxymethyl chitosan, and cross-linked chitosan have been shown to be effective in removing Cd+2, Cu+2, Hg+2, Ni+2, and Zn+2 from waste water and industrial effluent" (Mckay, 1982; Muzzarelli, 1977; Srinivasa, 2003, p. 65). It has been found to remove many toxic metals from the water providing a clean environment for all organisms. "The arsenic concentration of contaminated waters was lowered to levels accepted by the Canadian Department of Health and Welfare and the World Health Organization upon treatment with the mixture and, furthermore, the copper and sulfate levels were also reduced" (Elson, 1980, P. 1307).

Cosmetics: In cosmetics, the main application of chitosan is that it helps to keep water in the product, and helps to form a film over skin that keeps water and other essential molecules at the desired point of action. Shampoos, facial creams and nail polishes can all contain chitosan. "Indications show that SHPH could suppress dehydration – induced denaturation of myofibrillar protein by hydrated water stabilisation, decreased Ca-ATPase inactivation and increased monolayer absorbed water and multilayer absorbed water of myofibrillar" (Arivantoyannis, 2007, p. 731). The use of chitosan in cosmetics provides many improvements to the already known products of industry.

Others: Chitin has a variety of purposes including, but not limited to, enzyme immobilization, fiber production, optometric principles, and heavy metal remover. "Chitin is widely used to immobilize enzymes and whole cells; enzyme immobilization has applications in the food industry, such as clarification of fruit juices and processing of milk when a- and b-amylases or invertase are grafted on chitin" (Rinaudo, 2006, p. 606). Chitin is known to be the second most abundant source of fiber. "Chitin can be processed in the form of films and fibers: fibers were first developed by Austin (1997) and then by Hirano (2001). The chitin fibers, obtained by wet-spinning of chitin dissolved in a 14% NaOH solution, can also result of blending with cellulose or silk. They are nonallergic, deodorizing, antibacterial and moisture controlling (Kanke et al., 1997). Regenerated chitin derivative fibers are used as binders in the paper making process; "addition of 10% n-isobutylchitin fiber improves the breaking strength of paper" (Rinaudo, 2006, p. 611). Contact lenses have been "made from [the] partially depolymerized and purified squid pen chitosan, and they are clear, tough, and bear good tensile strength and tear strength" (Majeti, 2000, p. 10). Chitin also has absorptive properties that allow it to be a more abundant natural amino polysaccharides which is important in the remediation of waste wood treated with the newest formulations of organometallic copper compounds and other water-borne wood preservatives containing copper (Gandhi, M.R., et. al. 2011). "Remediation with a solution containing 2.5 g chitin for 10 days removed 74% copper, 62% chromium, and 63% arsenic from treated sawdust" (Kartal, 2005, p 389). This process allows for more wood products to be reused throughout their industrial livelihoods. Table 2 shows the marketable functionality of chitin by-products and other varying applications.

Table 3.

Principle Properties and Applications for Chitosan

Principal properties of chitosan in relation to its use in biomedical applications

Potential Biomedical applications	Principal characteristics
Surgical sutures Dental implants Artificial skin Rebuilding of bone Corneal contact lenses Time release drugs for animals and humans Encapsulating material	Biocompatible Biodegradable Renewable Film forming Hydrating agent Nontoxic, biological tolerance Hydrolyzed by lyzosyme Wound healing properties Efficient against bacteria, viruses, fungi

Principal applications for chitosan

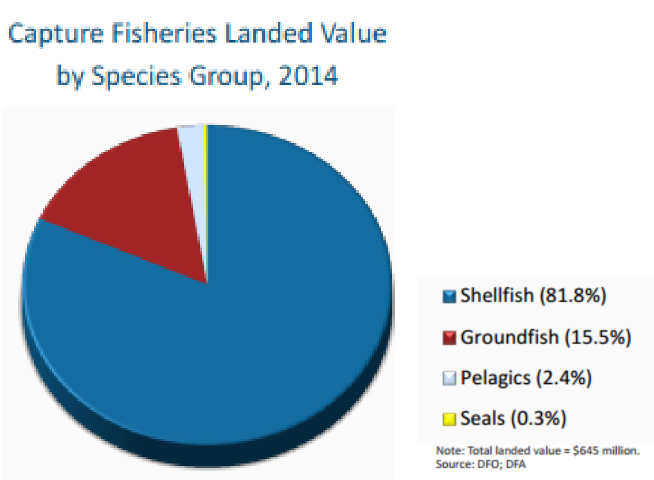
Agriculture	Defensive mechanism in plants Stimulation of plant growth Seed coating, Frost protection Time release of fertilizers and nutrients into the soil
Water & waste treatment	Flocculant to clarify water (drinking water, pools) Removal of metal ions Ecological polymer (eliminate synthetic polymers) Reduce odors
Food & beverages	Not digestible by human (dietary fiber) Bind lipids (reduce cholesterol) Preservative Thickener and stabilizer for sauces Protective, fungistatic, antibacterial coating for fruit
Cosmetics & toiletries	Maintain skin moisture Treat acne Improve suppleness of hair Reduce static electricity in hair Tone skin Oral care (toothpaste, chewing gum)
Biopharmaceutics	Immunologic, antitumoral Hemostatic and anticoagulant Healing, bacteriostatic

Relevance

Current Potential: As of current, the industry perceives shellfish waste to just that, a waste product. It should, however, be perceived as an opportunity to generate wealth in an environmentally friendly manner. This organic compound has the possibility to be produced in large quantities as it depends primarily on the amount of shellfish waste is produced. As previously mentioned Newfoundland's fisheries comprise a $1.1 billion dollars industry, $645 million of which is contributed by capture fisheries alone (see Figure 1.); while the remainder of revenue is produced by the aquaculture/farming subsector (SYIR 2014). As the graph shows, shellfish comprises 81.8% of the $645 million, equating to $528 million produced from captured shellfish in 2014.

Assuming that shellfish is anywhere between 35-90% waste, or 10-65% useable, industry can expect to harvest a large amount of material for minimal gains to produce its revenue; whereas using a higher percentage of the material provides opportunity for more gains without having to analyze disposal factors. Chitin is not only an opportunity to reduce the amount of waste generated by industries and consumption of resourceful space but it will also create possible economic possibilities for communities in the future.

Figure 1. Capture Fisheries Landed Value by Species Group 2014



"Out of the total solid waste landing in the USA, 50-90% is from shellfish processing discards, the total global annual estimates of it is around 5.118x10^6 metric tonnes" (Shahidi, 1999, p. 37).

Industrial Ecology is a growing term amongst industry and consumers. This is the concept of environment awareness as to where a product begins from extraction and ends in a landfill or marine system. The importance of this lies in the lifecycle of naturally occurring products such as chitin. As noted throughout this document it apparent that chitin has the ability to withstand many apparent applications while still maintaining a considerably short degradation time. "Under aerobic conditions in water environment 88–93 % of particulate chitin was mineralized to CO_2 within a few days. The highest degradation (≈ 30 % of chitin) was observed after 1 [day]" (Flieger, 2003, p. 38). This fact shows promise when faced with the amount of plastics that currently are found floating in marine systems. Utilization of a biopolymer for mass production allows industry to oversee the regeneration of future harvests without taking up more of the diminishing finite space. This oversight portrays an active involvement in the Life Cycle Assessment (LCA) process (EPA, 2014, May, 8). Ensuring the safe return of exploitable resources comfortably into the Earth as nutrients, industry and consumers are able to create an environmentally friendly economy that contributes towards many sectors of business.

Future Potential: As Canada's fisheries have seen in the past, invasive species have often been a problem with detrimental effects. Currently fisheries are seeing an increase in the amount of green crab invading waters. "In WNA, our work has shown that green crabs in field enclosures will prey on a wide range of species found in taxonomic groups similar to those found in the native range" (Grosholz & Ruiz, 1995; Grosholz, 1996). While having a wide variety of prey green crab is also known for its relatively low nutritional value and high composition of shell (Colautti, 2006). Due to this fact, green crab would provide an excellent source of chitin production. Current practices involving the capture of this species requires that it be killed so as not to harm any native species (DFO 2013). These two factors demonstrate that green crab, alongside other potential invasive species, may provide an increased purpose in Newfoundland fisheries.

Figure 2 depicts where licensed fish processing plants are located in Newfoundland and Labrador, for 2014. Provided that each processing plant produces waste, there becomes a large potential for economic production in many rural communities. This relation demonstrates that the economic stability of the province can be more accurately distributed amongst rural and urban communities.

Figure 2. Newfoundland and Labrador Licensed Fish Processing Plants in 2014

Discussion

Throughout the research of this paper many sources of literature arose however very little information was available of chitin/chitosan processing specific to Newfoundland. The idea has however, been assessed in three different projects surrounding Newfoundland's costs. One proposal was created by Quinlan Brothers Ltd. for the community of Bay de Verde (DFA, 2010). The project was to be a chitin processing constructed in Bay de Verde, next to the Quinlan Brother Ltd. shrimp and crab processing plant. It was deemed to be unfit for the town, by public consultation, as members were wary about the handling of chemicals in large supply and the effects this may have on their town in the event of a spill. "The people are scared. It's this acid," [Councillor Jennie Riggs] added (Roberts, 2011, March 22). Although the decision was against construction the problem could be remedied by storing the processing waste to several locations rather than the single centralized location. By redistributing the processing waste it spreads out the acid so that it will never be present in excessive quantities. This issue can be addressed by spreading the wealth to other towns in the sense of decreasing factory size. More facilities of lesser size produce more jobs across the province.

Another proposal has recently surfaced from within a company in Twillingate. Shell-Ex is a marine biorefinery that is "designed to separate organic materials into value streams, such as crustacean shells, protein meals, oils, and other compounds, and process them as ingredients. Our supplier is located 4 km from our plant, we receive product every hour, and process while shell is fresh and pure" (Shell-Ex, 2015). Shell-Ex produces chitin using fresh shrimp by-product from shrimp head. This company marks the beginning of an era of environmental economic sustainability, starting with Newfoundland at the forefront.

Conclusion

By further developing the large quantities of shellfish processing waste, rural communities are provided with a more profitable and sustainable alternative to disposal. It is evident that the further development of waste products has a diverse application to many fields of daily practices while also producing a green economy that produces a more effective outcome. Chitin can be found in a multitude of renewable resources creating a breadth of benefits to both urban and rural communities. This enhancement of production provides both environmental and economic benefits as well as societal. Chitin by-product production provides an alternative means of economic sourcing for the province by reducing the amount of waste product being disposed of, and minimizing disposal expenses, while creating jobs in a variety of sectors. The impact of such projects can be found in the reduction of waste, which in turn creates an increased efficiency, while also maintaining the goal for eco-friendly products that can be developed sustainably. The active appearance of benefits in both these regions produces societal benefits. The effect felt on the economy will be felt across the nation as it creates wealth for the province and in turn for the citizens. By increasing the amount of products processed for marketable value diversifies the financial reliance of the province in the event of an economic downturn. If Newfoundland were to generate a fraction of its potential amount of chitin by-products it would set a precedent of sustainable industrial economics for the other provinces of Canada and nations around the globe.

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