Enginuity Inc.
219 Herring Cove Rd
Halifax, Nova Scotia
B3P 1L3

902.431.7931 tel
902.446.7584 fax
info@enginuityinc.ca
enginuityinc.ca

CANADIAN LOBSTER
THE LOBSTER COUNCIL OF CANADA

enginuity
With assistance from
tech marine

Project: Lobster Product Enhancement Study

Report: Final Consolidated Report

By: Enginuity Inc. with the assistance of Tech-Marine Ltd.

Revision: 02 – Final For Issue

Date: 14th March, 2014

Revision	Date	Written	Review 1	Review 2	Review 3
Issue for Review	03/11/2014	AT	LM	BG	GB
Issue for Release	03/14/2014	AT	LM	BG	GB

Enginuity Inc.
219 Herring Cove Rd
Halifax, Nova Scotia
B3P 1L3
902.431.7931 tel
902.446.7584 fax
info@enginuityinc.ca
enginuityinc.ca

1 Executive Summary

This report provides a consolidated view of the current potential for automation in the Canadian lobster processing industry. This report has been preceded by 5 Individual diagnostic reviews supplied to the following processors:

- Seafood 2000 Limited, Georgetown, PEI
- Royal Star Foods Limited, Tignish, PEI
- Paturel International, Deer Island, NB
- Westmorland Fisheries Limited, Cap Pele, NB
- BA Richard Limited, Sainte-Anne de Kent, NB

Each site was visited, processes were observed and interviews were conducted to understand each plant's history relating to process automation. Brief manufacturing analyses were conducted to provide each processor with a prioritised list of processes that would offer the most cost effective potential for automation and process improvement.

The Canadian lobster processing industry is at a crossroads. Close international competition in the form of the Maine processing industry is on the rise. Temporary Foreign Workers (TFW) are abundant in the industry and a costly resource to maintain while being susceptible to changes in government policy.

A combined prioritised list is included to provide future automation direction, individual processor's priorities may differ depending on the product line, number of employees, product mix and other operational parameters. Priority is based upon an automation index governed by the complication of the process combined with the ready availability of relevant automation technology.

For processors not included in the study, this report aims to offer automation direction, insight into individual processes and 'lessons learned' from the study.

Applicable technologies have been identified from 28 technology suppliers, suppliers and systems integrators, these are described.

Four industry consortia have been identified and described.

Enginuity Inc.
219 Herring Cove Rd
Halifax, Nova Scotia
B3P 1L3
902.431.7931 tel
902.446.7584 fax
info@enginuityinc.ca
enginuityinc.ca

1.1 Recommendations for Processors

1. Develop a plan for the 'plant of the future'
2. Develop a Plant Engineer/Industrial Liaison Role
3. Automation Priorities

Industry Priority List	Workers Currently Utilised	Annual Labour Cost	Automation Index	Potential Annual Savings (based on 75% labour reduction)
Packaging	150	$3,332,511	6	$2,498,884
Leg meat extraction	180	$4,047,917	5	$3,036,438
Tail handling	114	$2,496,345	5	$1,872,510
Knuckle meat extraction	135	$2,987,361	4	$2,240,771
Claw meat extraction	115	$2,524,967	4	$1,893,976
Butchering	76	$1,582,792	2	$1,186,594
Meat inspection	58	$1,241,970	2	$930,728
	828	**$18,213,863**		**$13,659,901**

1.2 Recommendations for the Lobster Processing Industry

4. Establish an LCC Process Automation Steering Committee
5. Investigate a co-operative approach to Research and Development
6. Extend the technology supply chain reach and availability
7. Adopt a Design Team approach to Research and Development projects
8. Instigation of a systematic methodology for machine/automation design.

Contents

2 Introduction

Where lobster processors are having increasing difficulties in staffing their facilities, they are increasingly relying on temporary foreign workers to make up staffing gaps. Initially, the role of temporary foreign workers was to shore up the Canadian workforce, making up for small shortfalls. However, in some plants, temporary foreign workers currently make up more than half of the workforce in the plant. There is inherent risk in maintaining this approach to staffing, as operators are vulnerable to changes in both Federal and Provincial immigration policy.

In addition, there are large capital outlays required when bringing in a large foreign workforce. Therefore, mechanisms to reduce labour requirements in lobster processing are continuously being explored: process automation being one of those means.

Another consideration is that most Canadian processors rely heavily on imported Maine lobster in order to maintain production levels and reduce lag associated with local lobster seasonality. In New England, there are moves to expand local (US) production that will potentially cause a reduction in production demand for and raw material export to, Canada[1].

In this spirit, the Lobster Council of Canada, along with NRC-IRAP and the five processors mentioned have sponsored an industry-based research project with the goal of ascertaining the current level of process automation in lobster processing facilities in the Maritime Provinces. In parallel, an assessment of previous attempts to automate, reasons for failure, lessons learned and knowledge sharing have been explored. The ultimate goal of this project is to identify key processes within lobster processing facilities that would offer some benefit to plant operators either by:

- reducing labour requirements
- increasing processing capacity
- improving process reliability
- increasing product yield or
- Providing better quality or new product (for previously unattainable markets)

References are provided where available and appropriate.

Direct quotes from industry associations and politicians are provided in quotation marks as follows: "Sample".

Industry comment and anonymous quotations are displayed in single quotation marks as follows: 'sample'

[1] http://www.businessinsider.com/shucks-maine-lobster-processing-facility-tour-2013-9?op=1

3 Scope

The purpose of this document is to provide an overview of the current level of process automation in a cross-section of the region's processing capability as well as those operators' degree of involvement in R&D activity. In addition, key processes where additional automation could benefit plant operations are identified. Detailed machine-design and specific automation routes are outside of the scope of this report, though general strategic guidance in automating these key processes are offered. All points and references under discussion herein stem from interview and plant visits conducted in June and July, 2013, as such all data is based upon observations made during the visits, coupled with industry research and the authors' previous experience in this sector and complimentary industries.

Recommendations provided are a combination of lessons learned from wider industry consultation, site specific data and available technologies from other industries.

3.1 Summarised Product Breakdown of Processors studied

Product Throughput	39,500,000lbs
Sold Live	12,350,000lbs
Processed for meat	24,350,000lbs
'Popsicle' (Whole, brine frozen, individually packaged lobster)	2,800,000lbs

Table 1 - Product Breakdown (annual basis)

3.2 Summarised Employment Breakdown of Processors studied*

Butchering	76
Claw Meat Extraction	115
Knuckle Meat Extraction	135
Leg Meat Extraction	180
Tail Handling	114
Meat Inspection	58
Packaging	150
Total Employees	828

* NOTE – These employee numbers were those reported at the time of plant visits and may vary.

Table 2 - Employee breakdown

4 Industry Challenges

4.1 Temporary Foreign Worker Program

The Federal Temporary Foreign Worker Program [2] was introduced to address "genuine and acute labour needs" in the market that could not be filled by Canadian workers. It has become critical in the lobster processing field as the local labour force is less willing or available to perform the function required of the processors. In the eyes of the Federal government the Lobster Industry use of TFW is not "ideal" as the jobs are low/minimum wage functions and in many places the local workforce may be "available for work". Like any Federal Program, the TFWP is at risk of relatively sudden changes based on changing policy, direction and the priorities of the government of the day. Rumours of impending change are frequent in the press.[3] It is evident that changes may be introduced that would effectively prevent many lobster processing from starting up in any given year. For this reason processing automation must be considered a priority in order to reduce the reliance on TFW.

"I have no interest in fast-tracking LMO [Labour Market Opinion] applications for foreign workers to come into low-paying jobs in areas of high unemployment," …. "But I do have an interest in ensuring that where there is clearly a demonstrable scarcity of skills, that we make the program available as a last resort."
Jason Kenney, Minister of Employment

At the time of reporting, of the 828 workers employed by the five study group plants 317 (38%) were Temporary Foreign Workers.

4.2 Competition from Maine

Another consideration is that some Canadian processors rely heavily on imported Maine lobster in order to maintain production levels and reduce lag associated with local lobster seasonality. In New England, there are moves to expand local (US) production that will potentially cause a reduction in production demand in Canada[4].

There have been news reports and anecdotal evidence circulating, surrounding political attempts to develop the processing side of the lobster industry in Maine in an effort to retain the "value-added" processing rather than exporting[5]. This focus on the 'value add' associated with processing at the point of production is likely to become an overarching theme impacting the Canadian lobster industry in coming years. Therefore, every effort should be made to quickly and aggressively establish a modern, lean, reliable and above all, dominant Canadian lobster processing sector.

It is clear that the marketing dollars injected into the Maine industry by high profile investors have changed the landscape at a brand level. Last year's awarding of the Marine Stewardship Council's MSC certification[6] is now being used to market specific processors' product. In this light, it is crucial that the

[2] http://actionplan.gc.ca/en/initiative/temporary-foreign-worker-program
[3] TFW Changes
[4] shucks-maine-lobster-processing-facility-tour-2013-9?op=1
[5] maine-moves-capture-lobster-processing-market

[6] MSC Certification

Canadian Industry pulls together to reduce costs, improve marketing, increase efficiency and reduce any threat associated with industry-wide advances in Maine.

5 Research & Development History

Over the years many attempts at automation have been made to automate specific lobster processes. Like all R&D projects in all industries, there have been both failures and successes.

5.1 The Processors' Perspective

Typically a single processor identifies a process on the line that they wish to automate. They search for an available solution, try it and implement it or customise it to fit their own requirements. In many cases they reject the tool based upon trial performance. In certain cases processors research prototyping themselves and work with a fabricator to design a one-off machine.

Below are some examples that came to light following interviews with the sample group of processors. This is not designed to be an exhaustive list but more for illustration purposes, in some cases:

Process	Implemented	Customised	Rejected	Comment
Steam cooking			X	Due to difficulty in cleaning
Steam cooking	X			Commercially available
High pressure shucking			X	Lack of market for raw product for some processors
High pressure shucking	X			Successful for some processors
Partially automated Claw-Scoring/cracking	X			Commercially available
Leg Cutting			X	Reduced yield/Maintenance issues
Live Grading	X			Most processors adopted
Tail Grading	X			Most processors adopted
Knuckle Meat Extraction		X		
Knuckle Meat Extraction			X	No Productivity Gain
Thorax meat extraction	X			Produced mince is low value, process could be improved

Table 3 - Automation Examples

5.2 The Equipment Producer's Perspective

There are many engineering and fabrication companies in New Brunswick, PEI and Nova Scotia that, among other clients, also serve the lobster processing industry. As part of this study several fabricators, engineering shops and designers were interviewed to gain some perspective from the local technology supply chain.

Fabricators are reluctant to speculatively design and build machinery as the lobster processing industry is small and return on research investment is highly limited. There is also the matter of research risk, where designers and fabricators feel exposed. It is also a highly competitive industry and every fabricator interviewed was immediately concerned about Intellectual Property (IP) protection as 'new ideas travel fast' in a small industry.

In general all designers and fabricators are willing to support automation efforts by the industry, as long as the work remains local to the region and that it is 'a level playing field'.

Below is a summary of previous automation efforts discussed by the companies interviewed:

Machine	**Success**	**Failure**	**Comment**
Various steaming and cooking Machines	X		'Highly developed and readily available'
Leg Cutter/Meat Extraction	X		'Successful design was immediately copied and brought to market by other fabricators'
Guillotine leg cutter/gill brush		X	'Project discontinued due to lack of funding'
Pre-cook Stunning System	X		'Highly developed and readily available'
Machine Vision based Automatic sorter			Currently under development in Lobster industry, but similar processes exist in other industries
Claw scoring	X		'Machine works, reduces labour while reducing breakage and improves product'
Butchering		X	'Stalled following economic analysis. Development cost estimated at $1.5M'
Machine Vision Meat Inspection		X	Still in development, not yet commercialized

Table 4 - Summary of Automation History

6 Processes involved

The total labour force involved in processing lobster products in the five plants at the time of reporting is ~828 employees. This varies both daily and seasonally dependant on production level requirements. At the time of reporting, 38% of the work force at those plants that employ temporary foreign workers are from the immigrant work force employed through the Temporary Foreign Worker (TFW) Programme.

The labour analysis has been broken into three streams and has focussed on the most labour intensive processes in each.

The most labour intensive plant operations include the following:

6.1 Up-stream processing

6.1.1 **High Pressure Shucking**

One of the plants included in the study group has invested in two Avure High pressure shucking machines. This process was transitioned from automated oyster shucking and first implemented in one of the Maine processing plants. The device pressurises batches of live lobster, the high pressure treatment separates the raw meat from the shell, kills pathogens in the meat, but keeps the shell intact. The implementation of high pressure shucking has a downstream affect on the rest of the process in the plant that successfully uses it, as all meat is extracted raw. High pressure shucking was trialled at one other plant but was rejected as the plant could not find a viable market for raw product.

6.1.2 **Butchering**

Butchering is the separation of the lobster into base components, namely the tail, head, thorax, legs, claw and knuckle. Butchering is typically conducted by hand with different steps, teams and custom benchtop fittings to assist in the process. Processors approach butchering in different ways. In the case of the high pressure shucking site butchering is conducted using the raw, un-cooked product of the pressure shucking process. Some other processors butcher the lobsters live while others steam cook whole lobster in batches, prior to processing. One processor uses a locally made stunning technique to render the lobster unconscious prior to cooking.

6.2 Mid-stream processing

6.2.1 <u>Meat Extraction</u>

6.2.1.1 **Claw meat** - This process includes liberating meat from the main claw as well as the attached articulating portion (thumb). Across the study group 115 workers were performing this task at any one time. The thumb of the claw is simply torn away and the meat is removed by hand. In the main claw, meat removal is accomplished manually by partially cleaving the claw at mid length and rolling the cleaver to complete the removal of a portion of the claw shell. This exposes the meat and allows it to drop free from the remaining claw shell. This process is high-impact, highly repetitive and has caused repetitive strain injuries in the wrist, thereby exposing the producer to potential employee liability. For this reason alone claw meat extraction should be considered for automation, this process has been partially automated in one plant in the study group.

6.2.1.2 **Knuckle meat** - This process is entirely manual where workers use small hand-tools to poke meat from the knuckle into bins. There are at least 135 workers performing this task on any given day across the study group. One plant has developed a machine and has successfully reduced worker requirements for this process.

6.2.1.3 **Leg meat -** Leg meat removal is the highest scorer in terms of workers required for the function. 180 workers were employed at the time of the study; manually feeding cooked legs into 'leg rolling' machines, where meat is automatically extruded from the shell. This is another highly repetitive manual operation and is considered to be among the least profitable activities in the plant. This is a function of the worker intensity of the extraction operation combined with the relative value of leg meat.

6.2.1.4 **Minced meat** – The remaining thorax section is fed into a deboning machine that minces and separates the meat from shell. This produces a low value meat paste that is used in food processing for flavour. There is opinion in the industry that this process could be automated to an extent that would make the produced meat more valuable.

6.3 Down-stream processing

6.3.1 **Inspection and Packaging of Bulk Meat**

At the time of writing, bulk meat (claw, knuckle, leg meat) is mostly inspected and packaged by the same team of workers. When this process is broken down into component tasks, workers are performing several functions.

- Spreading of meat – meat is typically spread onto a customised workstation
- Identification of unwanted inclusions (Shell, cartilage and foreign objects)
- Diversion and defect concentration
- Weighing and batching of bulk meat
- Final packaging and labelling

This report deliberately de-couples Inspection from Packaging in order to fully assess potential efficiency gains from each process.

6.3.1.1 **Meat Inspection**

All meat that is produced in the plants has to pass relatively stringent, but labour intensive, quality control processes. Bulked liberated meat is meticulously inspected by both visual and manual means. Inspection is conducted in order to ensure that small pieces of shell and cartilage entrained from butchering and meat extraction are removed from the final product prior to packaging. There are nearly 60 workers involved with meat inspection.

6.3.1.2 **Packaging**

Packaging of product for distribution is a complex and labour intensive process. In the study group 150 workers were occupied on the packaging line. Certain products require manual weighing, counting and packaging while other products are sorted mechanically and packaged by hand.

By way of example:

6.3.1.2.1 **Bags and Buckets mixed-meat -** In this process the claw, knuckle and leg meat is manually weighed out to verify content, batched and then placed in packaging. Individual packages are then manually weighed, sealed and labelled.

6.3.1.2.2 **Snap and Eat Claws -** are manually placed into packaging and relocated to frozen storage areas prior to delivery to customers.

6.3.1.2.3 **Whole Tail (in shell)** – Tails are typically graded using an electronic size grader and packaged in line with specific product contract requirements.

The bulk meat process was identified as one that is highly manual and could relatively easily be automated such that the process was faster and more effective.

The following table summarises the process steps along with an evaluation of the level of complexity of the step and the potential for automation.

Stage	Process	Step	Complexity Level	Automation Potential
Upstream	Butchering	Limb/Thorax Separation	Med	Med
		Debanding	Low	Med
		Claw/Knuckle Separation	High	Low
		Tail/Thorax Separation	High	Low
Midstream	Meat Extraction	Claw Meat	Med	Med
		Knuckle Meat	Med	Med
		Leg Meat	Med	High
Downstream	Packaging	Meat Inspection	High	Low
		Mixed Meat Packaging	Low	High
		Tail Handling	Low	High

Table 5 - Breakdown of process steps with complexity level and automation potential

7 Generalized Plant Economics Summary^

The following is a breakdown of minimum labour costs for the key processes incurred over one season of operation. This data considers the following:

- Mean work-day
- Mean work week
- Mean months of operation per year
- Mean hourly wage of processing staff.
- Overhead costs of 25% of basic wage.

	Worker count	Mean Burdened Rate ($/hr)	Annual Labour Cost $CDN	Potential Annual Savings* $CDN
Butchering	76	13.126	$ 1,582,792	$ 1,186,594
Claw meat recovery	115	13.126	$ 2,524,967	$ 1,893,976
Knuckle meat recovery	135	13.126	$ 2,987,361	$ 2,240,771
Legs meat recovery	180	13.126	$ 4,047,917	$ 3,036,438
Tail meat recovery	114	13.126	$ 2,496,345	$ 1,872,510
Meat inspection	58	13.126	$ 1,241,970	$ 930,728
Packaging	150	13.126	$ 3,332,511	$ 2,498,884
	828		**$ 18,213,863**	**$ 13,659,901**

^ All data based on information received at time of plant visits

*based on 75% labour reduction – refer to Automation Assumptions

Table 6 - Financial Breakdown

In addition to the standard 25% burden, there are transportation and immigration costs for the temporary foreign workers in the order of $3,000 per worker (Employer administrative costs notwithstanding). As the study group plants employ roughly 317 foreign workers, there is a combined initial start-up labour cost of approximately $951,000 prior to lobster processing season.

Based on the above data, a reasonable estimate for the cost of one full time worker is calculated at $28,600 per year. Removal of even a small number of individuals per line through automation represents significant potential for savings while also potentially improving capacity and product quality. Therefore, there are indeed considerable gains to be made by automating these key processes and significant R&D investments are justified in most cases.

8 Process automation

8.1 Automation Assumptions

The authors have been involved in many research efforts and development projects focussing on automation and efficiency improvements in a variety of food harvesting and processing applications.

Specifically, the authors have developed automation proposals and successfully delivered automation projects in:

1. Crab processing
2. Herring processing plant improvements
3. Clam harvesting and processing
4. Lobster scanning and processing including butchering and meat recovery
5. Sea cucumber processing
6. Shrimp processing (Louisiana/Gulf of Mexico)
7. Scallops harvesting and processing and,
8. Various white fish processing, packaging and inspection projects

Although specific data regarding the level of labour reduction achieved with these previous projects is considered confidential, we estimate that 75% is a fair average and a realistic assumption to be used for a first-cut evaluation. Actual reduction for specific projects will depend largely on the level of automation determined and considered economically viable through a cost:benefit study for each project. Such study entails, among several components, the formulation of a concept design that examines the various steps of the process to be automated, and assigns cost estimates and labour requirement estimates, such study is outside the scope of this report.

9 Available Technologies

In this section we will discuss some of the available technologies which may make possible the automation of tasks what would have been a dream only a few years ago with respect to the areas of identified earlier.

The field of vision-guided robotics (VGR) is probably the technological arena which has seen the greatest advances in recent years with regard to seafood processing. Commonly, the most difficult aspect in the design of a processing machine is in the placement of the product so that the desired operation can be performed upon it. The reason for this is quite obvious when one considers the relative complexity of the work carried out by the worker compared to that done by the machine.

For example, in lobster leg meat extraction, the leg is picked from a random position and oriented in a pan and its tip is placed at the extraction rollers which then take over. Obviously, the actual extraction of the meat by the rollers is a very much simpler operation than that performed by the worker, i.e. visually locating, picking, orienting and placing, all of which require brain power for decision making and motion control. A quite similar operation is currently and routinely carried out by vision-guided robots that pick small bottles from a random lot in a bin or conveyor belt, orient them and line them up in a single file on another conveyor belt, at faster than human speed.

Such systems, as offered by system integrator **Motion Control Robotics, Inc., (Fremont, Ohio, USA)** among others, are custom assembled from readily available off-the-shelf main components (in this case a **Fanuc®** robot and **iR Vision®** controller and associated software) together with custom grippers, conveyors, etc. as well as customised control software. These systems can manipulate 100 to 500 pieces per minute. This equates to a ten fold improvement over human processing when considered in lobster processing.

To meet the demands of the food processing industry, all major manufacturers of industrial robots (including **Fanuc**, **ABB, Motoman, Kawasaki** et al) offer wash-down versions on many models. Going one step further, **JMP Engineering Inc. (London, Ontario)** has recently introduced an automatic robotic wash-down option in which the robots in a cell used in food handling are also used to wash themselves, the surrounding equipment, and other robots. This eliminates the risk of a user damaging the sensitive areas of the equipment, among many other benefits.

Although the economics of any application would need to be verified, it is evident that a real potential exists. Small units capable of carrying out relatively simple pick-and-place and other operations, such as the Fanuc LR 200ib 5p 6-axis tabletop model, are available from $15,000 including the necessary controller, while larger and more sophisticated systems can reach upwards of $100,000.

Another potential application of VGR is in the separation of the whole lobster into its various parts, i.e. butchering. Already utilized around the world in poultry processing for the cutting up of chicken into parts (legs, breast, wings) the system developed by **KUKA Roboter GmbH** (Germany) uses 4 individual robots to cut up the chicken carcass while it is continuously moving on a conveyor chain at 17 cm/s. A research project being carried out at the Georgia Tech Research Institute aims at deboning chicken breasts for maximum yield and avoiding bone and cartilage fragments[7]. Feed-back sensors that detect the extra resistance presented by the tougher material help guide the cutting blades so that only tender meat is cut away from the carcass. Additional savings are achieved by eliminating the need for post-processing bone and cartilage detection. Commercially available thigh and leg deboners in the same field are now available from **Mayekawa** (Tokyo, Japan)

Perhaps one of the biggest challenges in any animal processing automation attempt is accurately gauging the position and orientation of major components of the animal on a moving conveyor system. Many companies have developed rapid scanning systems with customizable shape-recognition algorithms, and some combine these with the aforementioned robotic systems to truly automate the optimization of meat extraction from animal processing.

Another German company, **GEBA Roscherwerke** (www.roescher.de) has made significant advances in fish slicing machinery, using structured light vision techniques. These techniques simplify the process of positioning points in 3d space (a major challenge in seafood handling). They project a beam of light with a known geometry onto a scene (an object of interest, such as a lobster); and a camera then observes the shape of the resulting image, allowing surfaces to be rapidly reconstructed in Cartesian coordinates (digitized) in the machine memory, this data then feeds commands to the robot process.

In New Zealand, a country with 20 times more sheep than people, lamb processing has been taken to new levels of productivity with the use of robotic cutting machines guided by images of the bone structure detected by x-rays and other available sensor technologies.

The technology, application and equipment was developed in a joint program named **Ovine Automation Consortium**, that includes two research organisations and nine meat processing companies working together with **RealCold Milmeq**, a major New Zealand based developer and manufacturer of meat processing machinery. The project, estimated at $15M CDN, was funded in equal parts by industry and government, and is an excellent example of successful industrial collaboration. The key takeaway from this project was the fact that companies that regarded themselves as highly competitive in the local market recognised that a greater threat existed internationally. This prompted high levels of collaboration and ultimately 2 new mechanised solutions were developed that all participating producers benefitted from. Additional solutions are planned from the same collaboration.

[7] http://www.gtri.gatech.edu/casestudy/robot-3d-imaging-sensor-based-debone-poultry

> “We are bringing together hundreds of years of experience in the meat industry, and combining it with world class researchers. We have a nine-member board plus an independent chair, which works very well.”
>
> “Increased automation potentially means reduced reliance on labour and improved productivity, as well as quality improvements – the fewer hands on the carcass, the better the microbiological footprint, he says. And that means longer shelf life for the product.”
>
> “The more competitive our industry is across the board, the better it is for everyone – processors, farmers and marketers.”
>
> **Richard McColl, Consortium Manager, Ovine Automation Consortium**

Although past attempts at developing defect detection equipment for meat and claws has met with varying levels of success, it does not mean that it cannot be done industry-wide. It simply means that, as anticipated, it is not an easy task to perform. Nonetheless, a great deal of expertise and experience is available from companies and academic research organizations in diverse sectors, from all over the world who specialize in this type of work. Hard particles in coarse-ground meat products may include bone chips or fragments, cartilage and dense connective tissue, all of which are considered undesirable to the consumer. Various commercial systems, which are classified as central removal and periphery removal systems are in common use in the meat industry, and may offer potential for adaptation.

A video showing the level of automation possible in this realm is available from **Scott Technology Ltd**, viewable on YouTube at: http://www.youtube.com/watch?v=za2dsB0qrMg

For example **Meyn Food Processing Technology B.V**. of the Netherlands offers a range of systems under the brand name of BoneScan that uses x-rays to detect bone fragments and other foreign bodies in meat such as chicken breast. The system can inspect up to 20,000 pieces/hour. This is significantly more efficient than the equivalent human powered operation.

Enginuity Inc (Halifax, Nova Scotia) has developed some significant ability, in-house with respect to the integration of smart camera systems for the detection of small particles/undesirable flaws in scallop meats. The system, developed in Halifax used a **Cognex 5400CS**-based, real-time analysis of 8 simultaneous lanes of product flow; and detected very small flaws for diversion or secondary inspection.

The most recent development in this area is at Packopale (Boulogne-sur-Mer, France) where a scallop line has recently gone live incorporating an **Ishida IX-GA-4075** high-performance X-ray inspection system. This system accepts frozen scallops and is capable of identifying grit, shell fragments and more importantly low levels of more rare contaminants such as metal, stones, rubber and glass. This setup is also significant as it incorporates an assisted learning capability from Ishida that allows for operator assisted training of the machine for known contaminants. This gives the processor an advantage in the detection of multiple contaminants, particularly useful when the feedstock is potential coming from many sources.

As previously discussed, the measuring and blending of the various meat components (knuckle, claw, leg) in meat packaging is a very labour intensive process, but one that lends itself to partial, if not complete automation, in spite of the difficulties presented by the wet and sticky nature of the meat.

Undoubtedly, most, if not all of the technology needed to deal with this issue exists in various pieces that need to be consolidated and applied to the industry.

For example, interesting options in product conveying and metered delivery are offered by vibratory conveyors that operate at very high frequencies such as those manufactured by **KEY Technologies** (Seattle, WA, USA). Their Iso-Flo® Smooth-Cycle™ Scale Feed Vibratory Conveyor is specifically designed for frequent stop/start and can resume product flow in less than one second. Other possibilities include a combination of volumetric measurement for approximation and actual weighing for reaching target. Larger pieces such as claws and broken tail could be batched using a mini version of multi-head weighing systems (**Yamato, Ishida, Masipack**) that combine 4 or 5 portions selected to add up to the target weight.

One additional option for packaging, based upon recent trends in other food processing sectors is Thermoforming. Full thermoform vacuum packaging is becoming predominant in meat packaging as shelf life is significantly longer than traditional packing methods. This approach offers plant flexibility as the product being packaged can be changed easily without complex retooling.

10 Lobster Specific Automation

During the investigation process the authors met with several engineering, fabricating and automation specialists available in the local market. Many have been involved in automation projects directly related to the lobster industry, most also supply the necessary conveyors, workstations, cookers and automation fixtures currently in use in the region. The next section focuses on automation options directly available and applicable to the industry, based upon the background given above.

10.1 Butchering

Producing a fully automated butchering machine represents a large iterative R&D project, requiring significant time and investment. There would also likely be large plant integration costs associated with such a machine, as a significant portion of the production floor would be affected. Crude butchering approaches are not technically difficult, however the subtleties of how the meat is handled manually are quite significant.

There are many slight variations and differences between animals and between groups of animals depending on the season, region from which they were fished, length of time stored before processing, etc. A trained factory worker can make rapid initial butchering decisions based on visual information; and then subtly adjust grip positions, forces, twisting and shearing motions with both hands (and even individual fingers) on the fly, based on almost instantaneous feed-back from both feel and visual cues. Maximum meat yield is always a priority during the butchering processes, and manual operations achieve this 'relatively easily'. It is not a simple task to even match, let alone improve, the meat yield reached by a trained manual operator using an automated machine.

There are several examples of automated butchering for different seafood processes. The most notable being a crab butchering setup from **Charlottetown Metal Products** (Charlottetown, PEI) and, in 2009, the Department of Fisheries in Newfoundland and Labrador assisted a processer (Quinlan Brothers Ltd.) with the development of an "Automated Crab Butchering Machine"; and according to published results the trials of a commercial iteration of the prototype in 2010 was successful at the Bay Verde plant.[8]

Similarly, many processors will be familiar with the Baader Food Processing Machinery Company, who advertise crab and other shellfish butchering machines with impressive throughput and low waste percentages.

While efforts have been made at automating butchering of lobsters, this remains at the concept stage and requires industry buy in and a solidified project approach to continue development[9].

While direct cross-over from crab experience is useful there are significant challenges associated with lobster as outlined above. There is no doubt that the experience and know-how exists to solve the butchering issue but the challenges to produce a cost-effective and profitable solution are significant.

[8] Quinlan Crab Butchering
[9] Interview with Steve Kelly CMP Engineering Sept 10th 2013

10.2 Meat extraction

10.2.1 Claw

Claw preparation has been tackled by some processors with the use of locally available machinery (Charlottetown Metal Products) but these machines still rely on manual orientation and placing of claws to allow the automated scoring, meat removal is also manual.

10.2.2 Knuckle and Leg Meat

Similarly, knuckle and leg meat extraction have been semi-automated in some plants, but all attempts still rely on processors handling every section by hand, manipulating both the shell and the extracted meat. This is therefore an area where automated (robotised) manipulation and subsequent extraction should be pursued

10.3 Inspection

Automated meat inspection represents a significant technological challenge, as the various components (meat, shell, and cartilage) are difficult to physically differentiate. These tissues have differing density, diffractive and reflective properties over different wavelengths of light. While testing, verifying and ultimately exploiting these properties is a long-term academic exercise in itself, similar projects have successfully been achieved in other seafood processes. Integrating the sensors, programming the operating parameters and triggering conditions of equipment and developing equipment to adequately separate out bulked meat to work well with the scanning portion of the machine is another significant challenge.

Lizotte Machine Vision (Riviere Verte,NB), has developed X-ray based inspection equipment that claims to detect cartilage in lobster meat, and allow for detailed sorting and grading. It is unclear whether they have been able to take this equipment to the next level, which would be integration of image processing and robotic handling to eliminate the need for a human to process the images. Discussions with Lizotte in the course of this review identified that there were still some significant challenges remaining in the integration of this technology; but images showing the detection of cartilage vs good meat are impressive in their accuracy and detail.

10.4 Packaging

10.4.1 **Popsicle Preparation**

The Popsicle preparation process is relatively straightforward where whole lobsters are individually bagged, a little brine is added and the bag is sealed prior to freezing. This process could be relatively easily automated with the inclusion of a modified vacuum packaging line, such as those manufactured by VC999 (Quebec City,QU/Mississauga ,ON), MDC Engineering (Sarasota, FL) Webomatic (Bochum Germany) ULMA (Taunton,MA).

Where plants rely heavily on Popsicle as part of the product line, automation should be considered.

10.4.2 **Tail packaging**

Tails are high value and easily handled, they are therefore 'low hanging fruit' when examining which processes to automate. As tails are typically aimed at the consumer and restaurant market high value packaging such as thermo-form should be investigated if it is not already utilised.

10.4.3 **Bulk Meat**

Bulk meat is the highest priority for automation. This process is largely manual in most plants, involving hand weighing and manual addition of meat to ensure bags are adequately packed. This process should be investigated as a high priority. Again, it is the opinion of the authors that this could be developed using off-the-shelf multihead scales incorporated with high impact marketable packaging solutions that are currently used in many other food industries.

10.4.4 **Specialty Products**

Most plants offer some form of specialty product based upon their available market, consumer driven need and commercial client requirements. These products include marinated or prepared lobster products for onward cooking or reheating, salad products for consumer consumption or the 'naked' lobster previously referred to. All of these products (if the volume of production is high enough) should be examined for automation with the above mentioned technologies based upon prevailing market requirements. Ie. Consumer, restaurateur etc.

11 Recommendations

The opportunities for automation in the lobster processing industry are many and varied with differing degrees of technology input. The mandate for this report is to focus on the availability and potential use of new and recent technological advancements to reduce the intensity of manual labour required.

Recommendations are divided into two sections.

1. Recommendations given to processors, to suggest ways in which their operation can remain competitive in both the local market and international markets.
2. Secondly, recommendations are suggested to the wider Canadian Lobster Processing Industry, focussed on cooperation and knowledge sharing.

11.1 Recommendations for Processors

Given the results of this research the prioritised list provides a target for processors to isolate particulate process steps that can be treated as the 'lowest hanging fruit' to automate. The following recommendations should also be considered within the context outlined above.

11.1.1 **Develop a plan for the 'plant of the future'**

As has been identified, most automation projects examine one particular process step and try to improve performance or quality, usually in isolation. It is recommended that this philosophy changes to ensure consistency of approach and that all upstream and downstream elements are taken into account. This approach can be as simple as a quick review of performance improvement impacts on other parts of the line, but it is recommended that it also encompasses standardisation on components (pumps, motors, gates, bins, conveyors etc)

This paves the way for greater integration in key processes as the process line morphs into 'the plant of the future'. An example of this approach is in poultry processing with the consolidated approach taken by technology providers like Meyn. Where machines can be purchased and used individually but they also perform consistently as part of a series in production.

11.1.2 **Develop a Plant Engineer/Industrial Liaison Role**

Some plants have included the role of 'Plant Engineer'. This is usually an internally focussed role ensuring the continuous running of the line. This report recommends the expansion of the role to include the continuous improvement of the process, to champion the plant of the future plan and to act as an industry liaison as described below.

In certain cases, it may make sense to take on a recent graduate in Industrial Engineering, funding may be available to assist in the hiring process of such a role. The new hire would observe all aspects of the production process for an extended period in the same vein as many other graduate hiring schemes. This kind of process exposure will provide relevant and varied knowledge to the individual, which will prove invaluable to the processor. Following the observation component, attention should focus on areas for improvement, realisation of automation potential already identified, maintaining corporate knowledge on processing trends, and changes in technologies etc. If taken on, this role could also act as the plant liaison on any future Steering Committee based Design Improvement Project Team.

11.1.3 **Automation Priorities**

It is clear from the labour and economic data presented that a large reduction in operating costs could be achieved for plant operations in automating the following key processes in the plants studied.

The processes are ranked by priority here:

Industry Priority List	Workers Currently Utilised	Annual Labour Cost	Potential Annual Savings (based on 75% labour reduction)
Packaging	150	$3,332,511	$2,498,884
Legs meat extraction	180	$4,047,917	$3,036,438
Tail handling	114	$2,496,345	$1,872,510
Knuckle meat extraction	135	$2,987,361	$2,240,771
Claw meat extraction	115	$2,524,967	$1,893,976
Butchering	76	$1,582,792	$1,186,594
Meat inspection	58	$1,241,970	$930,728
	828	$18,213,863	$13,659,901

Table 7 - Automation Priorities for Processors

11.2 Recommendations for the Canadian Lobster Processing Industry

In order to make the most of available public money and locally available fabrication and engineering resource; but also to provide most benefit to the industry as a whole, it is recommended that the industry approaches Research and Development on a cooperative basis. It should be noted that these recommendations were presented in the individual processors reports as part of this project.

11.2.1 **Establish an LCC Process Automation Steering Committee**

It is recommended that LCC establish and sponsor a Process Automation Steering Committee. Terms of reference should be to conduct a thorough review of the recommendations laid out below, to produce a long term strategic plan for the industry and to develop the framework by which the plan will bring about robust change in the industry.

11.2.2 **Investigate a co-operative approach to Research and Development**

This approach has worked successfully in the New Zealand based, Ovine Automation model. This could allow for shares to be offered on an opt-in basis across all processors, allows arms length project management and consolidated design where all included members receive the rewards of the project in improved performance and enhanced competitiveness in the wider market.

11.2.3 **Extend the technology supply chain reach and availability**

Recognition that the available supply chain extends beyond the region and while local fabrication is highly valuable it is important to ensure a balanced mix of fabrication experience, sector experience, wider food processing knowledge, technology availability and robust engineering support. Past collaborative projects have sometimes been affected by scope creep, requirements changes and lack of design methodology.

11.2.4 <u>**Adopt a 'Design Team' Approach to Research and Development projects**</u>

It is recommended that for future improvement projects initiated by a single processor or multiple processors that a design team be formed to oversee the project. This design team approach should adopt a standardised approach to project management and the design process as outlined below. The team should include a single representative from the processor(s), the engineering company, fabricator, sector experienced consultants and if required, the external funding partner (eg NRC-IRAP, ACOA etc)

11.2.5 <u>**Instigation of a systematic methodology for machine/automation design.**</u>

One reason for failure is generally because of a lack of methodology in the research and development process. There are many established methodologies to assist, but they are all consistent in that they typically follow a stepped process. This ensures the project is realistically defined, properly managed and the results are both fit for purpose and appropriately adopted by the processing staff.
It is therefore recommended that at the very least, projects follow and take into consideration the following steps:

Initiation	Problem identification - what problem is being solved?
	Establish the Project team, as above
	Budget – establish project budget, costs and Return on Investment metrics
	Identify success factors, what performance characteristics must be incorporated, number of roles eliminated?
	Identify limiting factors eg. size, power, consumption, Establish the germination and nurturing of correct ideas.
Research	Evaluate current process, desired results, food science factors, biological factors, market research.
	Experience outside the sector, have similar problems been solved in other seafood plants or other production facilities outside the seafood sector.
Design/Development process	Concept Development and Validation
	Design and Engineering
	Prototype and initial testing* - including processing/operational staff
	Iteration
	Final product Design and Build
Testing/Evaluation and Acceptance	Factory Acceptance Testing (FAT)*
	Site Integration Testing (SIT)*
	User Acceptance Testing (UAT)*
	Full Production Line Testing (PLT)*

* All test steps should include production line staff for operational feedback

12 Conclusions

It is important that efforts be made to rapidly modernize lobster processing in Eastern Canada. This is driven by the following:

1. Emerging regional competition in processing from Maine, that will likely be well funded and highly automated.
2. This industry is exposed to potential changes in immigration policy that puts the local lobster processing industry in a precarious situation, as labour requirements absolutely necessitate the employment of temporary foreign workers.
3. Processes have been identified and prioritised where implementation of technology is low risk and would yield significant reduction in labour requirements
4. Other processors in the lobster and wider seafood processing industry have successfully implemented automation projects focussed on reducing headcount, increasing efficiency or improving recovery ratios. Therefore precedence for collaborative or individual automation projects exist.
5. Changes in innovation strategy have been recommended that will allow processors to work alone or collectively with the industry and other processors to facilitate change to drive competitive advantage.

13 Appendix One – List of Automation Technology Providers

Company	Speciality	Sector Experience	Location	Phone	Website
ABB	Process Automation	Process automation Systems Integration	Brampton Ontario	+1 905 460 3000	new.abb.com/products/robotics
Dupont Teijin Films Worldwide	Mylar™ Cook	Packaging Material	Mississauga, Ontario		usa.duponteijinfilms.com
Ishida	Packaging Inspection	Automated Weighing Materials Handling Conveying Inspection	Delta, B.C	+1 604 517 1556	www.ishida.com
JMP Engineering Inc.	Systems Integrator	Food Production Wash down systems	London, Ontario	+1 519 652-2741	www.jmpeng.com
KEY Technologies	Process Automation	Conveying	Walla Walla, WA, USA	+1 (509) 529-2161	www.key.net
Laitrum Machinery	Process Automation	Cooking Grading	New Orleans, LA, USA	+1 504 570 5299	www.laitrammachinery.com/
Marel	Process Automation	Butchering Grading	Lenexa, KS	+1 913 888 9110	www.marel.com
Masipack	Packaging	Packaging Weighing Conveying Materials Handling	Lakeland, FL	+1 (863) 644 3900	www.masipack.com
MDC Engineering	Packaging	Thermoforming Tray Sealing	1701 Desoto Rd Sarasota, FL 34234	+1 941-358-0610	www.mdcengineering.com

Meyn Food Processing Technology B.V.	Process Automation	Poultry processing	Amsterdam, Netherlands	+31 20 2045 000	www.meyn.com
Milmeq	Equipment Design/Supply	Food Processing Chilling/Freezing Materials Handling	Auckland, New Zealand	+64 9 526 5943	www.milmeq.com
Motion Control Robotics, Inc.,	Systems Integrator	Robotic - Packaging	Fremont, Ohio, USA	+1 419 334 5886	www.motioncontrolrobotics.com
Multiva	Packaging	Thermforming Tray Sealing	6 Abacus Road Brampton, ON L6T 5B7 Canada	+1 (905) 264-1170	ca.multivac.com
Scott Technology	Process Automation	Butchering Inspection VGR	Dunedin, New Zealand	+64 3 478 8110	www.scott.co.nz
ULMA	Packaging	Frozen Bagging Thermoforming	175 John Quincy Adams Rd, Taunton MA	+1 (508) 884-2500	www.ulmapackaging.com
Webomatic	Packaging	Vacuum packaging Thermoforming	Maschinenfabrik GmbH Hansastraße 119 D-44866 Bochum	+49 2327 3099-0	www.webomatic.de
VC999	Packaging	Thermoforming Tray Sealing Slicing	153 Sylvestre, Saint-Germain-de-Grantham, QC, J0C 1K0	+1 819-395-4555	home.vc999.com/
Yamato	Packaging	Automated weighing	Milwaukee, Wisconsin	+1 262 236 0000	www.yamatoamericas.com

14 Appendix Two - List of Additional resources

Robotics suppliers

Company	Sales Location	Phone	Website
Fanuc	USA	+1 800 477 6268	www.fanucrobotics.com/ppp
KUKA Roboter GmbH	Mississauga Ontario	+1 905 670 86 00	www.kuka.com
Kawasaki Robotics	Wixam, Michigan, USA	+1 248 446-4100	www.kawaskirobotics.com
Mayekawa	Mississauga, ON	+1 905-564-0664	www.mayekawa.ca
Yaskawa Motoman Robotics	Pointe Claire, QC	+1 514 693 6770	www.motoman.com

Industry Consortia

Company	Location	Specialty	Website
Ovine Automation Consortium	New Zealand	Lamb	http://www.mia.co.nz
Red Meat Profit Partnership	New Zealand	Beef and Lamb	http://www.beeflambnz.com
Health Food Consortium	Quebec	Agrifood	http://www.quebecinternational.ca
Food-Processing Initiative e.V.	Germany	Food processing	www.foodprocessing.de

Local Fabricators, Designers and Engineering Resources (Interviewed as part of the study)

Company	Area of Expertise	Location	Website
Charlottetown Metal Products Limited	Machine Design Production	Charlottetown, Prince Edward Island	www.cmpequipment.com
Enginuity Inc.	Process Automation Concept Development Machine Design	Halifax, Nova Scotia	www.enginuityinc.ca
Lizotte Consultants Limited	Process automation Machine Vision	Riviere Verte, New Brunswick	www.lizotteconsultants.ca
P& E Manufacturing	Design Fabrication	Cap-Pele, New Brunswick	www.pemanufacturing.com
South East Welding	Fabrication	Cap-Pele, New Brunswick	
Tech Marine	Process Automation Equipment Design	Dartmouth, Nova Scotia	www.tech-marine.com

Page Left Intentionally Blank