A COMPARATIVE STUDY OF THE THEORETICAL AND ACTUAL METHODS OF ESTABLISHING STANDARD TIMES FOR CRAB PROCESSING

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by

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ABSTRACT

Snow Crab processing is a labor intensive industry in Atlantic Canada having a comparatively short history. The present industry practices in Newfoundland for the catching, transportation and processing of crab are described with details also provided on the early years of industry development.

Time Study and Methods, Time, Measurement techniques of work measurement were used in two Snow Crab processing plants: Ocean Harvesters Ltd., Ship Cove and Beothic Fish Processors Ltd., Valleyfield. Some of the processing operations in each plant were studied and the similarities and differences in each are discussed. Normal and standard times and output performances for the operations studied were calculated and compared using both work measurement systems.

An example of a wage incentive system is proposed which is based on the use of work measurement techniques. Also, recommendations are made for the increased mechanization of processing techniques and improvements suggested for processing problems.

ACKNOWLEDGEMENTS

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1:00 INTRODUCTION:

1:10 BRIEF HISTORY OF THE SNOW CRAB INDUSTRY IN THE ATLANTIC PROVINCES:

1:11 GENERAL:

The commercial harvesting of the Snow Crab (Chionoecetes Opilio) is a comparatively new activity dating from the mid 1960's. Prior to this time, a limited scale of fishing occurred in all Atlantic Provinces with consumption restricted primarily to the catching areas concerned.

Figure 1:1 shows a typical male Snow Crab.

There are a number of reasons for the development of this industry in Eastern Canada.

(1) The area is in close proximity to the United States of America, the worlds largest producer and consumer of crab products. (Crab Review, 1973).

(2) Commercial sized stocks were found to exist in various areas of the region.

(3) Crab fishing could extend the fishing season for the inshore demersal and pelagic fishermen.

(4) Crab processing is a labour intensive enterprise which provides jobs in an area of Canada in need of job opportunities.

(5) Since Snow Crab inhabit the coastal waters throughout the year, the catching and processing can be maintained at a fairly uniform level.

NOTE: In freezing weather, fishing operations have to be curtailed. When the pots emerge from the sea the water on the crab freezes which kills the animals. The legs on the animals will then drop off with the slightest touch. Federal Government Fisheries Regulations prohibit the processing of dead crabs since the crab meat spoils quickly after the animal's death.

In 1967, a rather sharp decline occurred in the total production of crabs in the United States. The catch fell from 312,000,000 pounds in 1966 to 269,130,000 pounds in 1967. (See Table 1:1).

This decline occurred primarily in the popular Alaskan King crab catch and it was natural that alternate sources and species of crab would be sought to fill the market void. With suitable conditions existing in Atlantic Canada it was natural that a Crab Industry would develop.

In 1965, experimental fishing by the Nova Scotian Department of Fisheries showed that there existed a potentially commercial sized stock of Snow Crab off Cape Breton Island. This was the first real attempt at harvesting Snow Crab and it was the start of the fishery as it is known today.

Various experts from the West Coast of Canada and the United States were engaged by the Federal Department of Fisheries to assist in the instruction of fishermen and processors in the correct methods of catching, preserving and processing Snow Crab. All this assistance and guidance has resulted in an industry which today embraces areas in all the Atlantic Provinces and contributes millions of dollars to the economies of these areas in wages to plant employees and to fishermen. Table 1:2 gives a review of the Industry's growth in the years 1969 to 1973.

1:12 <u>NEWFOUNDLAND'S SNOW CRAB INDUSTRY; AN EXAMPLE OF THE INDUSTRY'S DEVELOPMENT</u>:

Newfoundland's Snow Crab Industry is indicative in many ways of the kind of growth which has occurred in all other Atlantic Provinces.

The Provincial Department of Fisheries of Newfoundland in co-operation with the Federal Department of Fisheries embarked upon a large inshore fishing vessel construction program in the mid 1960's. This involved the building of 30 to 65 foot wooden longliner/gill net vessels. It was thought that these boats would give the fishermen more flexibility in the number of species of fish which could be caught and in the areas which they could fish. In the early years of this program, the fishermen using these vessels experienced an eldorado harvesting virgin stocks of demersal fish species which inhabit the coastal waters.

It was during this early fishing period that stocks of Snow Crab were encountered by the gill net fishermen. If gill nets were unattended for prolonged periods of time in an area where crabs existed, the fish in the nets would be consumed by the crabs. When the nets were eventually hauled, the crabs proved to be a real nuisance as each had to be "picked" individually from the nets.

Trinity Bay (see Figure 1:2) was one area in Newfoundland where crab entanglement in gill nets was a problem. There existed a large stock of Greenland Turbot in this bay which could be caught very efficiently by use of gill nets, but as the Turbot fishery expanded in various areas of the bay, Snow Crab were encountered. It was considered impractical for these crabs to be discarded after their capture because many were damaged as they were taken from the nets and were not likely to survive when returned to the water.

To overcome this problem, a pilot processing plant was started in 1967 at P. Janes and Sons Limited, in Hant's Harbour. (see Figure 1:2). This facility was established with assistance from the Federal and Provincial Departments of Fisheries and the venture proved to be successful.

Mr. and Mrs. S.L. Simpson, British Columbia crab processing specialists, were engaged by the Industrial Development Branch of the Federal Department of Fisheries to provide the necessary expertise in the processing of the crabs. Figure 1:3 shows the floor plan of the crab plant established at Hant's Harbour.

Much of the crab for this plant originally came from Trinity Bay, but as the capacity of the plant grew it was found that crabs from Conception Bay (see Figure 1:2) were required to meet the plant's requirements.

In 1968, the Industrial Development Branch of the Federal Department of Fisheries, in an effort to determine the stocks of Snow Crab in Newfoundland, undertook a program of exploratory fishing. This program spanned the years from 1968 to 1970 and covered the areas from Port Aux Basques on the provinces south coast to St. Anthony on the north east coast. Some fishing was also done on the Labrador, but not enough to provide conclusive results. Figure 1:4 shows the map of the areas studied which outlines the results of the expeditions.

From the start at Hant's Harbour, more processing facilities were constructed and more boats brought into the fishery. In 1969, a second plant was opened at Bonavista by Bonavista Cold Storage Company, Ltd. and in 1970, a third facility was added at Valleyfield by Beothic Fish Processors.

Table 1:3 gives statistics which show the growth of the Newfoundland Industry.

In 1974, approximately 60 vessels landed more than 10,000 lbs. each using crab pots. Also, 31 vessels landed smaller catches using gill nets, crab pots or a combination of both. There were 17 facilities in Newfoundland purchasing crabs in 1974, but only 9 purchased more than 100,000 lbs. (Miller, 1975)

The Crab resource has, however, finite bounds. The maximum sustainable yield is estimated to be somewhere from 10 to 15 million pounds annually. (Miller, 1975). This would be from present known areas of crab stocks and includes estimates for other stocks known to exist. As can be seen from Table 1:3, much of the crab now being taken is from the Avalon Peninsula with Conception Bay, Cape St. Francis and the southern shore being the largest producing areas. The production from these areas is expected to soon level off with Conception Bay and the area east of Cape St. Francis yielding two million pounds annually.

The major underexploited area remaining in the island is the region of the Baie Verte Peninsula. (White Bay, Horse Islands and Green Bay). Also, early exploratory fishing reported crabs in Port Au Choix on the North West Coast of Newfoundland to the Quebec North Shore.

Certainly more fishing activities in various areas may reveal some still unknown stocks, but areas now presently being fished can not be expected to yield much more crab than they are at present.

1:20 **BIOLOGY OF SNOW CRAB (CHIONOECETES OPILIO):**

1:21 **GENERAL:**

The Snow Crab is a member of the Spider Crab group. It has eight walking legs and two claws with the abdomen folded underneath the carapace. (see Figure 1:5).

In the North West Atlantic area this crab ranges from the Gulf of Maine as far north as the West Coast of Greenland. Figure 1:6 shows the general distribution and intensity of the population throughout this area.

1:22 BREEDING AND GROWTH:

The male and female crab copulate in deep water with the female having the ability to store sperm in her body for up to a period of a year. This sperm is stored in sacs to which are attached the ovaries. The Ova pass through the sacs to become fertilized and are then passed through the genital pores to become attached to the females abdomen. The eggs remain attached for a period of a year during which time they go through various stages of growth.

When the larva is released it is planktonic and remains so during the next four months of life.

Moulting is the process used by crabs for growth and involves the shedding of the old shell and growing into a larger one. The rate of moulting decreases with the age of the animal. For example during the first year of life a crab may moult as many as six times, whereas, when the males have reached a carapace width of four inches this moulting is reduced to an annual or bi-annual occurrence.

The first moult for the juvenile crab occurs at the end of the four month planktonic stage. This first moulting produces the discernible crab shape and causes the animal to sink to the ocean floor.

As the crab enters the moult cycle it grows a paper thin second shell underneath the old. As the cycle progresses, the crab does not eat and loses weight. Finally, the animal sheds the old shell by lifting the old carapace and withdrawing its body back through the old shell. The crab next stays in mud for a period of time and fills its new shell with water which causes it to expand. The animal now begins to feed and grow into its new shell displacing the water.

Because the crab is full of water when it is growing into its new shell, it is of no commercial value. It can take six months before sufficient meat has developed to make the animal marketable. As there is no particular time in the year when all moulting occurs, it is difficult to prescribe closed seasons for commercial fishing. The soft shell crab is easily detected by fishermen because of the clean bright appearance of the shell and is translucent when held to light. Fishing gear is generally moved when the percentage of soft shell crabs in the catch becomes large.

The male and female Snow Crab have very definite size constraints. The males can obtain a maximum carapace width of six inches where the female can only reach a maximum width of three inches.

Figure 1:7 shows the male and female Snow Crab. It will also be noted that the female has a much wider tail than the male.

The female and male become sexually mature at a carapace width of about two inches. As the minimum size of crab which can be economically processed is from three and a half to four inches, it would seem that the fishery can be self perpetuating. The female can not be processed at all because of size limitations and the male is reproducing before becoming market size.

1:23 PHYSIOLOGICAL NEEDS OF SNOW CRAB:

Generally, crabs spend most of their adult life on muddy sandy bottom. Figure 1:8 shows a graph of distribution of crabs caught on various types of bottom during one of the experimental fishing programs conducted by the Federal Department of Fisheries in 1970. When the juvenile crab settle to the bottom after the planktonic stage they inhabit the rocky areas. The crabs remain principally on this type of bottom during early development. Data collected shows that crabs smaller than two and three quarter inches remain in these areas where as the large animals (males primarily) move to muddy bottom when they exceed this size.

The Snow Crab also has preference in the depth of water at which they inhabit. Figure 1:9 shows graphical relationship.

between water depth and catch density. This data was collected during exploratory fishing by the Industrial Development Branch of the Federal Department of Fisheries in 1970. The water temperature at this depth is almost constantly at 0°C. to 1°C.

The movement of crabs is difficult to trace because of the moulting of the animals. However, in 1969, 3,000 crabs were tagged in Trinity Bay and as late as 1974, 1,000 were returned and all from Trinity Bay. Also, tagged crabs were released in Conception Bay and with a hundred tags returned, only one was caught outside the bay. These results indicate that there are no major migrations of crab into or out of the bays and this fact makes possible an assessment of the stock. (Miller, 1975).

1:30 MARKETING:

1:31 GENERAL:

Newfoundland Snow Crab products are produced in frozen and canned forms.

The frozen varieties are usually two forms:

(1) "Salad Pack" (100% broken meat).

(2) "Combination Pack" (40% whole leg meat, 60% broken meat).

These two packs are five pound blocks frozen in contact plate freezers. The combination pack usually has the whole legs on the bottom, sides and top of the block with salad meat sandwiched in between the legs.

Various other packs are also produced in frozen form. For example, 100% whole leg packs are processed in five pound blocks and smaller consumer items are made by sawing the five pound blocks after they are frozen.

With the canned crab there is generally one main size and type produced. This is a five ounce (drained weight) pack contained in a circular can. The products consist of portions of whole leg meat and broken meat.

1:32 MARKET LOCATION:

All crab products are luxury items and as such are consumed mainly in the areas of the world which have high standards of living. The United States of America and Western Europe are the largest importers and consumers of crab products and these areas are the main outlets for the Canadian products. In Europe, the Canadian products are in competition with Japanese, American, Russian, Taiwanese and other far east countries for a share of the trade. Tables 1:4 and 1:5 show the countries to which Canada exported its crab products and the amount of the trade with each. It can be noted that the United States is by far the main customer for Canadian crab.

1:33 MARKET PRESSURES:

All crab products are subject to severe market pressures. For example, in 1973, market speculation in most world commodities created fictitious shortages of some articles and caused prices to be pushed upward. The Arab oil embargo on many large industrial nations at that time was partly the cause of this speculation, but the industrial nations were also at the end of a long boom period in their economies. Crab like many other articles of food was pushed to prices which were unrealistic in a short period of time during 1973. On the United States market the price of "Combination Pack" Snow Crab went to an average of $3.25 per pound and "Salad Pack" Snow Crab was at the $2.25 per pound level.

As these higher prices were reflected on the consumer level, resistance grew and consequently consumption and demand dropped. In 1974, production continued in Eastern Canada, but inventories built up to record levels as market prices fell quickly. A crab surplus developed on the world market and almost all the processing plants in Eastern Canada had to cease operations early in the fall of 1974. Prices continued to drop and record low prices were recorded. "Combination Pack" for one example was sold at $1.60 per pound, but the average price for "Combination Pack" was about $2.00 per pound. With such depressed markets, some processors were willing to cut their losses and move the crab into the market. With prices such as these, most operators were unable to recover their production costs. The average direct cost of production in Newfoundland plants in 1974, was approximately $1.90 to $2.00 per pound.

In 1975, very few crab plants are open. Those who are have either a local dependable market for their products, or they are speculating on the market making a rebound and they will have some product produced for that time. The current price for "Combination Pack" Snow Crab on the United States market is about $2.25 per pound. The market demand for "Salad Pack" Snow Crab is very doubtful even with the low prices. It's very difficult for processing plants to realize a return on their investment at such prices and for this reason most are closed.

1:34 MARKET OUTLOOK AND DIRECTION:

At present market conditions and situations most Snow Crab plants in eastern Canada are not viable without strong market demand and good prices in the United States. Right now the "Salad" and "Combination" frozen products and the five ounce canned crab are the "Bread and Butter" of most plants. The five pound frozen blocks can be cut into smaller portions for a direct consumer item, but the problem still exists of a high price article in a depressed market place.

More diversification of product into articles like crab paste, crab salads and other prepared or semi-prepared items would provide the processor with more market outlets. Besides, these types of articles would be attractive in Canada as such manufactured consumer items are subject to high tariff restrictions in the export market.

There still exists a market for the Snow Crab, but the problems lie in the price which these markets can pay. Government subsidization is now being made to the processing industry in an effort to stimulate the operation of the plants. This assistance, however, is temporary and does provide the processor with a floor price for his product. With this situation many processors are unwilling to operate their plants and place large amounts of working capital into inventory.

Increased mechanization would help in the lowering of the product cost, but the quality of the product produced has to be similiar to that presently achieved by manual shucking operations. Market conditions make these demands on the processor to produce a high grade article which is quite understandable. However, there has to be a fair return to the processors to entice activity at his level.

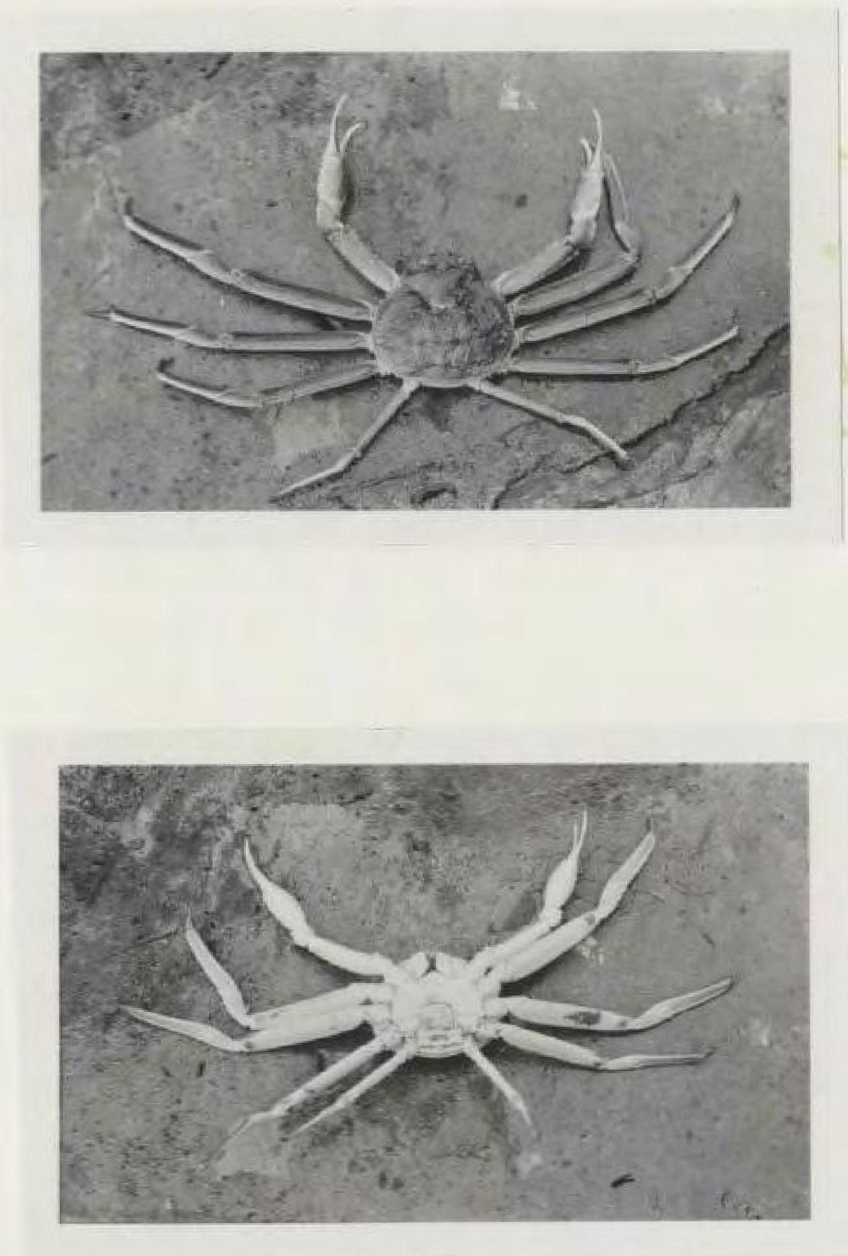


Figure 1:1 Typical Male Snow Crab.

Table 1:1

U.S. PRODUCTION AND IMPORTS OF FRESH AND FROZEN CRABS, 1960 - 1972

Year	Production 1/	Imports: Crabs	Imports: Crab meat	Imports: Total	Total production and imports
	Thousand pounds 2/				
1960	199,049	1,224	1,278	2,502	201,551
1961	204,895	1,546	608	2,154	207,049
1962	203,428	892	1,390	2,282	205,710
1963	211,887	1,022	1,130	2,152	214,039
1964	234,174	1,266	482	1,748	235,922
1965	285,271	1,262	220	1,482	286,753
1966	312,173	484	180	664	312,837
1967	269,130	1,022	234	1,256	270,386
1968	232,425	1,926	6,678	8,604	241,029
1969	228,593	1,108	11,007	12,115	240,708

Table 1:1

U.S. PRODUCTION AND IMPORTS OF FRESH AND FROZEN CRABS, 1960 - 1972

Year	Production 1/	Imports: Crabs	Imports: Crab meat	Imports: Total	Total Production and imports
	Thousand pounds 2/				
1970	248,566	1,281	6,588	7,869	256,435
1971 3/	257,658	1,664	13,046	14,710	272,368
1972 3/	266,896	1,725	13,028	14,753	281,649

1/ Total catch less canned production.
2/ Live weight.
3/ Preliminary.

NOTE: Factors used to convert to a live weight basis: Imports pounds, fresh and frozen crabs x 1.50, crab meat x 4.50.

NOTE: (Taken from Crab Review, 1973).

Table 1:2

CANADIAN CRAB LANDINGS

"OOO POUNDS"

	1969	1970	1971	1972	1973
Total - Canada	23,210	18,897	17,334	16,963	24,780
Total - Atlantic Coast (mostly Snowcrab)	19,500	17,339	15,370	15,096	22,300
Total - British Columbia (Dungeness)	3,710	2,548	1,964	1,867	2,580
Newfoundland	935	1,966	3,042	3,273	5,838
P.E.I.	146	—	—	—	436
Nova Scotia	237	385	296	130	286
New Brunswick	14,031	11,049	10,280	10,131	13,952
Quebec	4,166	3,810	1,819	1,707	2,520

NOTE: (Taken from Crab Review, 1973).

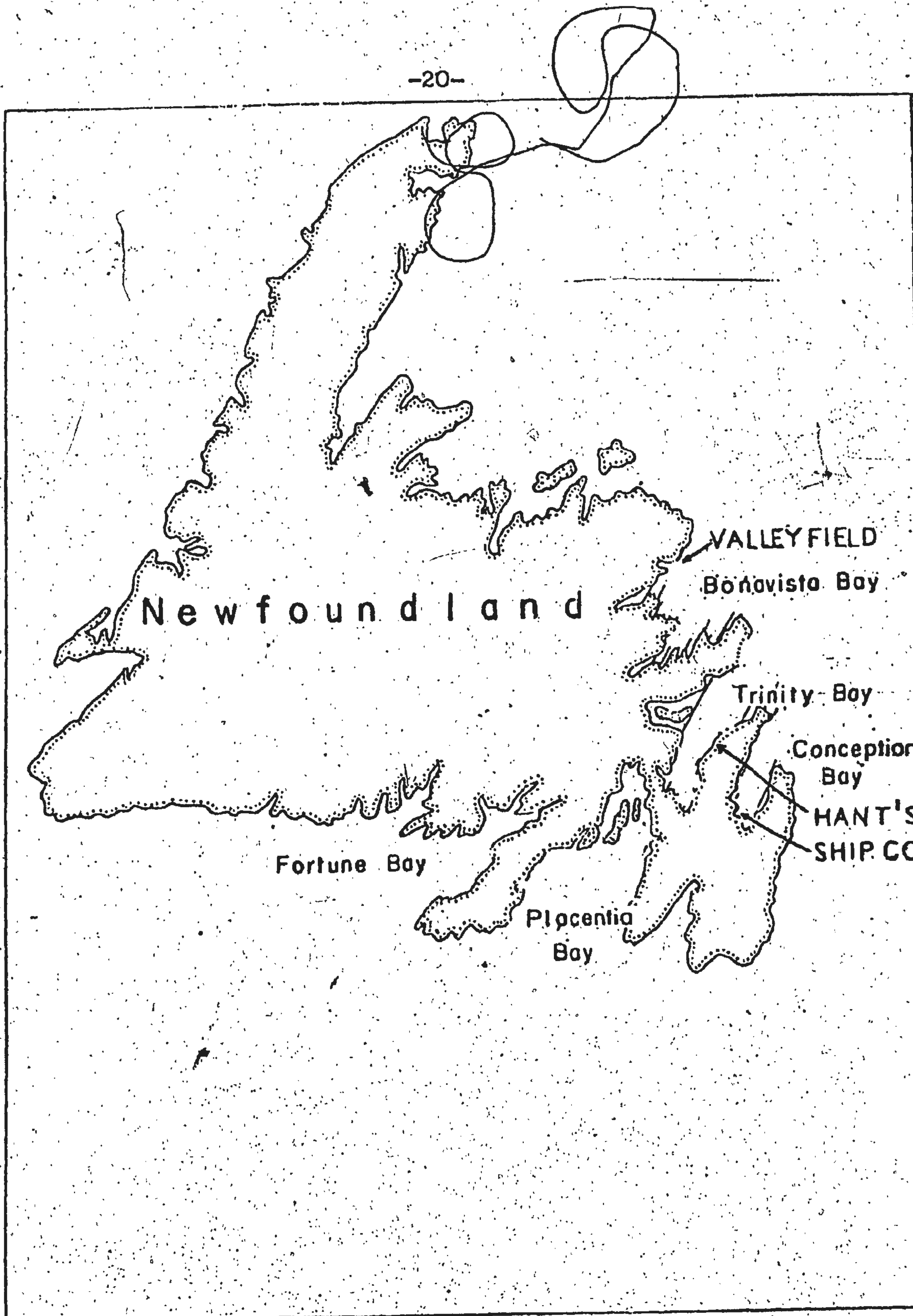
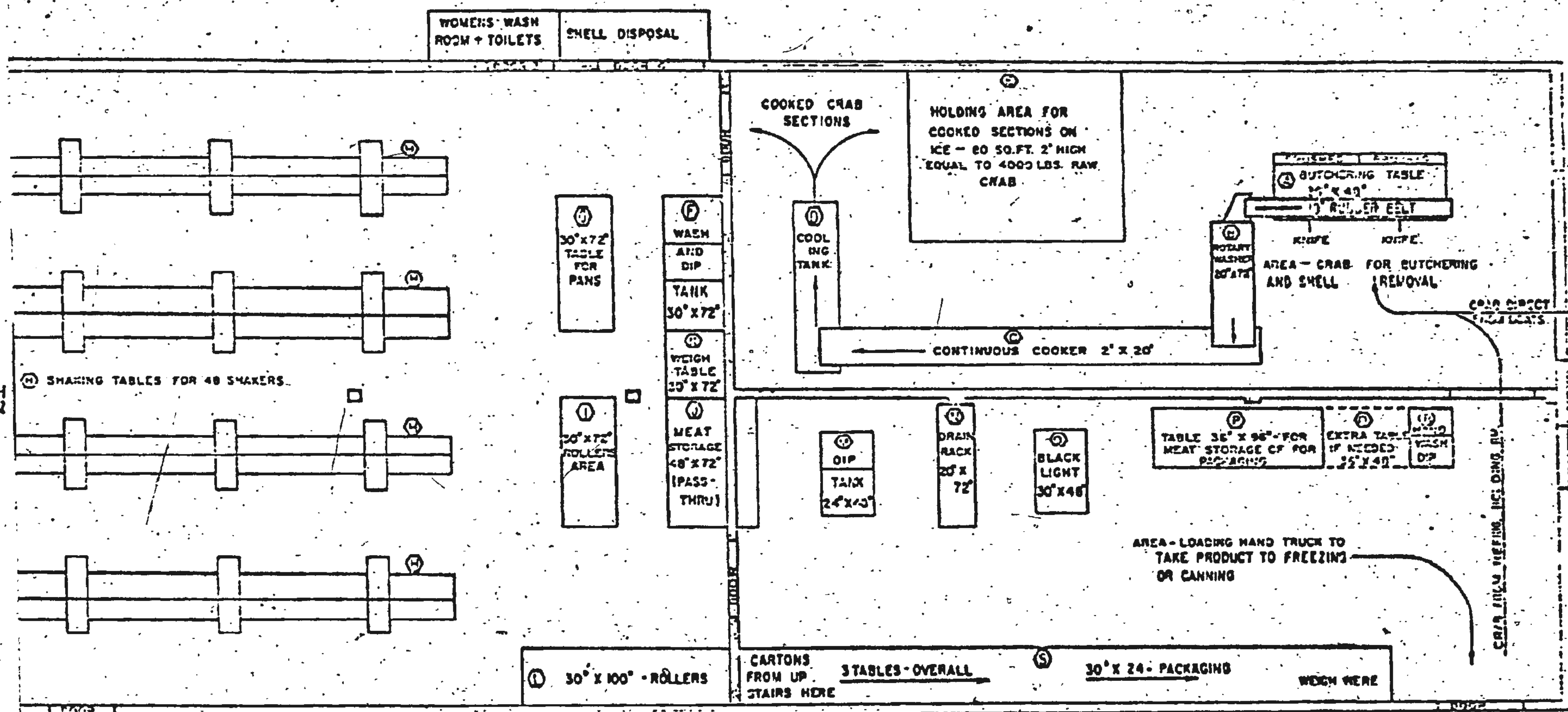
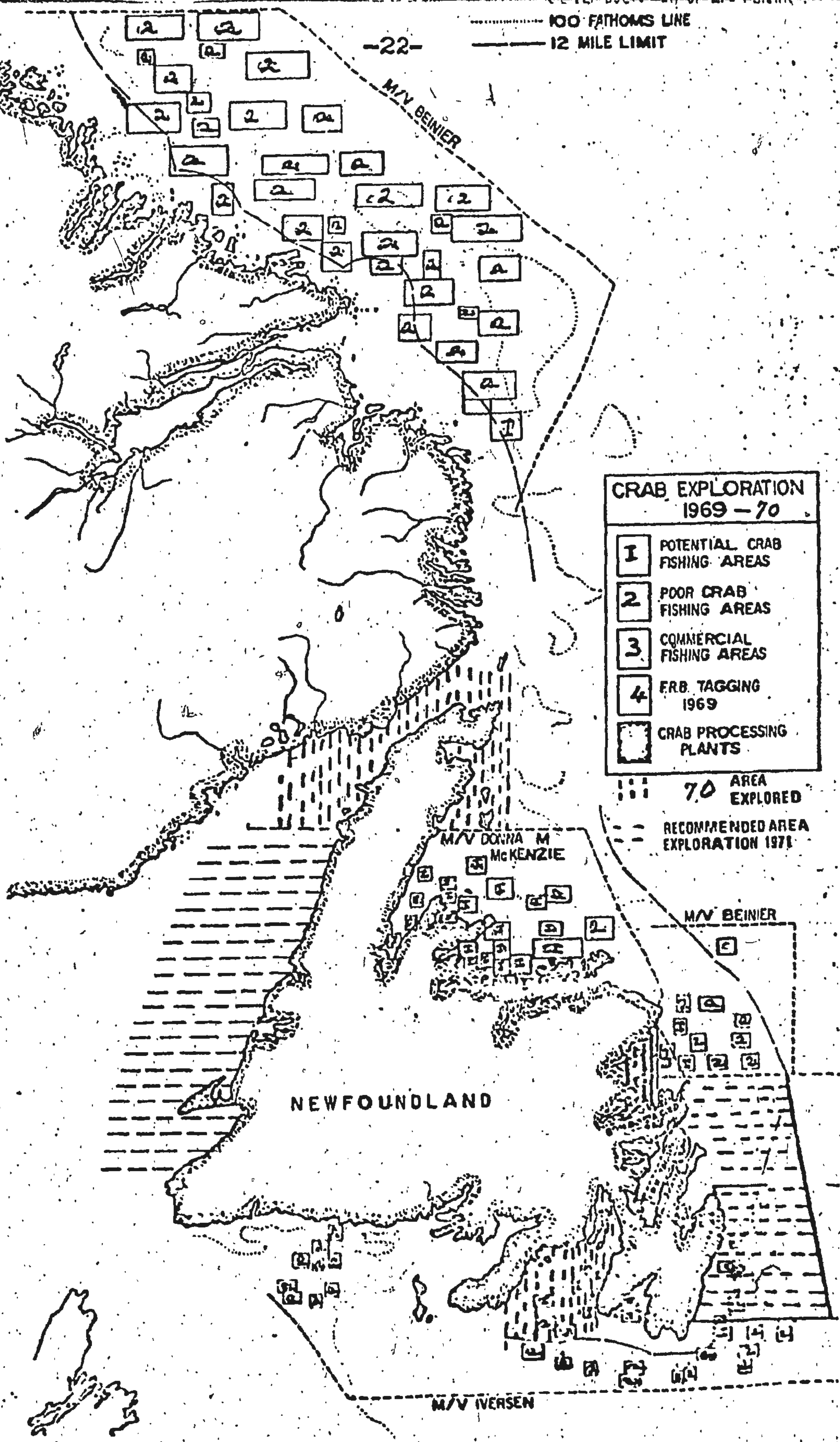


Figure 1:2 Map of the island of Newfoundland.

Figure 1:3 Floor plan of first Snow Crab processing plant in Newfoundland, P. Janes and Sons Ltd., Hants Harbour, 1967.

(Taken from: Project Report No. 19, I.D.S., Dept. of Fisheries, Canada, 1968)





(Taken from: Hinds, 1970, Bonavista Bay, West and Northeast Coast, Nfld.)

Figure 1:4 Map of exploratory fishing for Snow Crab in Newfoundland from 1968 to 1970.

Table 1:3

Newfoundland Crab Industry Statistics 1967 – 1974

Year	Total Caught	Caught Area	Average price Paid to fishmen per/lb.	product produced	Product value
1967	1100,000[1]	Trinity Bay			
1968	200,000[1]	Trinity Bay			
1969	500,000[1]	Trinity Bay			
	500,000[1]	Bonavista Bay			
	1,000,000	Total		173,370[2]	162,488[2]
1970	200,000[1]	Trinity Bay	7.5¢[3]	332,627[2]	514,427[2]
	700,000[etc.]	Bonavista Bay			
	800,000	Conception Bay			
	1,700,000	Total			
1971	500,000	Trinity Bay			
	700,000	Bonavista Bay	8¢	649,848[2]	990,070[2]
	1,600,000	Conception Bay			
	100,000	St. John's (Cape St. Francis)			
	2,900,000	Total			

Table 1:3

Newfoundland Crab Industry Stastics 1967 - 1974

Year	Total caught	Caught area	Average price paid to fishermen per/lb.	Product produced	Product value
1972	200,000	Trinity Bay			
	200,000	Bonavista Bay	9¢	583,370	998,068
	1,700,000	Conception Bay			
	1,000,000	St. John's (Cape St. Francis)			
	100,000	Notre Dame Bay			
	3,200,000	Total			
1973	100,000	Trinity Bay			
	400,000	Bonavista Bay			
	1,700,000	Conception Bay			
	1,800,000	St. John's (Cape St. Francis)			
	1,300,000	Southern Shore			
	100,000	St. Mary's Bay & Placentia Bay			
	200,000	Notra Dame Bay	14¢	1,073,983	2,853,027

Table 1:3

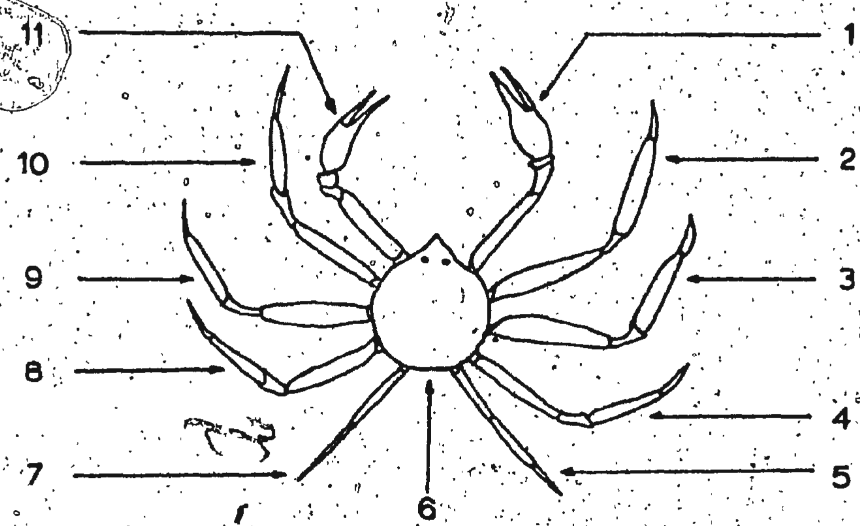
Newfoundland Crab Industry Stastics 1967 - 1974

Year	Total caught	Catch area	Average price paid to fishmen per/lb.	Product produced	Product value
	100,000	White Bay			
	5,700,000	Total			
1974	6.0	Avalon Peninsula	17¢	N.A.	N.A.
	1.3	North of Avalon			
	7.3	Total			

[1] Dr. R.J. Miller, Research Scientist, Newfoundland Biological Station, Federal Research Board, St. John's, (Personal Communications).

[2] Statistics Branch, Fisheries and Marine Service, Environment Canada, Pleasantville, St. John's.

[3] Crab Review 1973, May 1974 by Fisheries and Fish Products Division Agriculture, Fisheries and Food Products Branch, Department of Industry, Trade and Commerce, Ottawa.



LEGEND

1. 1st claw
2. 1st leg
3. 2nd leg
4. 3rd leg
5. 4th leg
6. Carapace
7. 5 th leg
8. 6 th leg
9. 7 th leg
10. 8 th leg
11. 2 nd claw (pincer)

A. Claw
B. Knuckle
C. First leg
D. Shoulder
E. 2 nd leg (tip)

Figure 1:5 Detailed Description of Snow Crab.

(Taken from: Blackwood, Varga, Dewor, 1969)

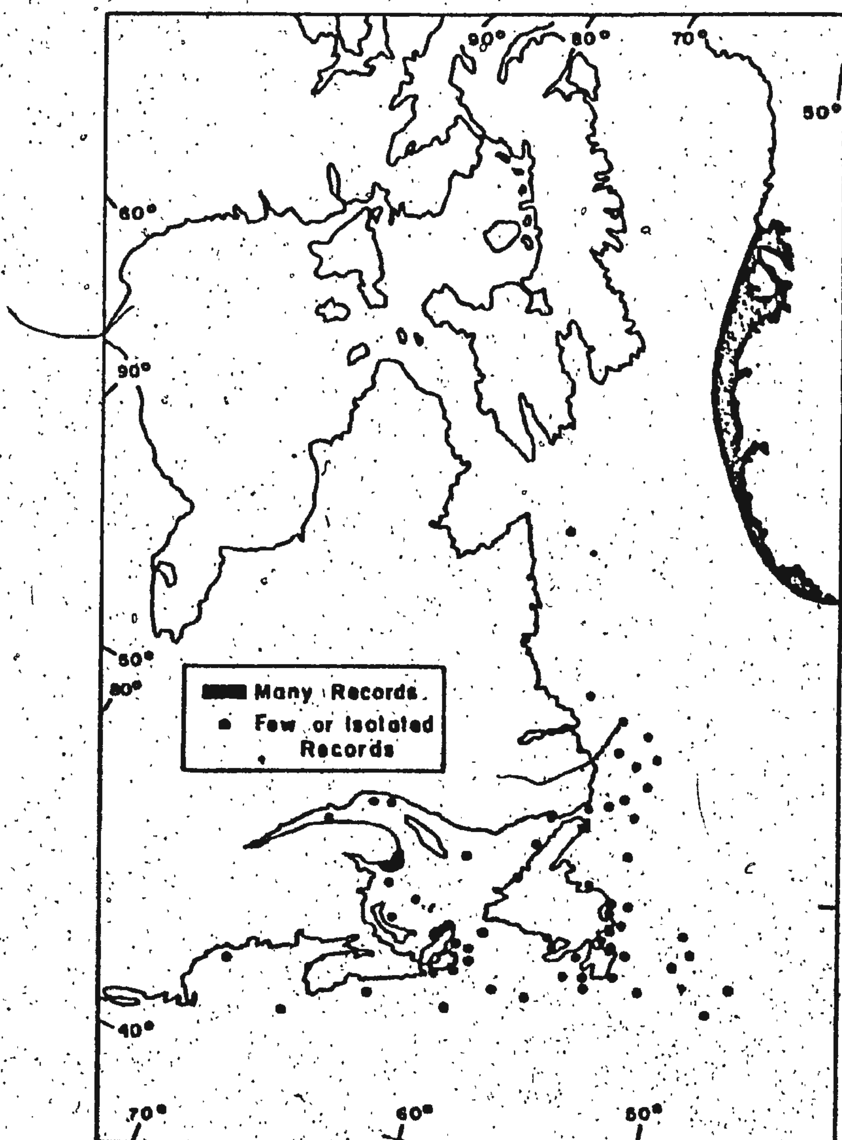


Figure 1:6 General Distribution and intensity of the population of Snow Crab in North West Atlantic.

(Taken from: Watson, Simpson, 1969)

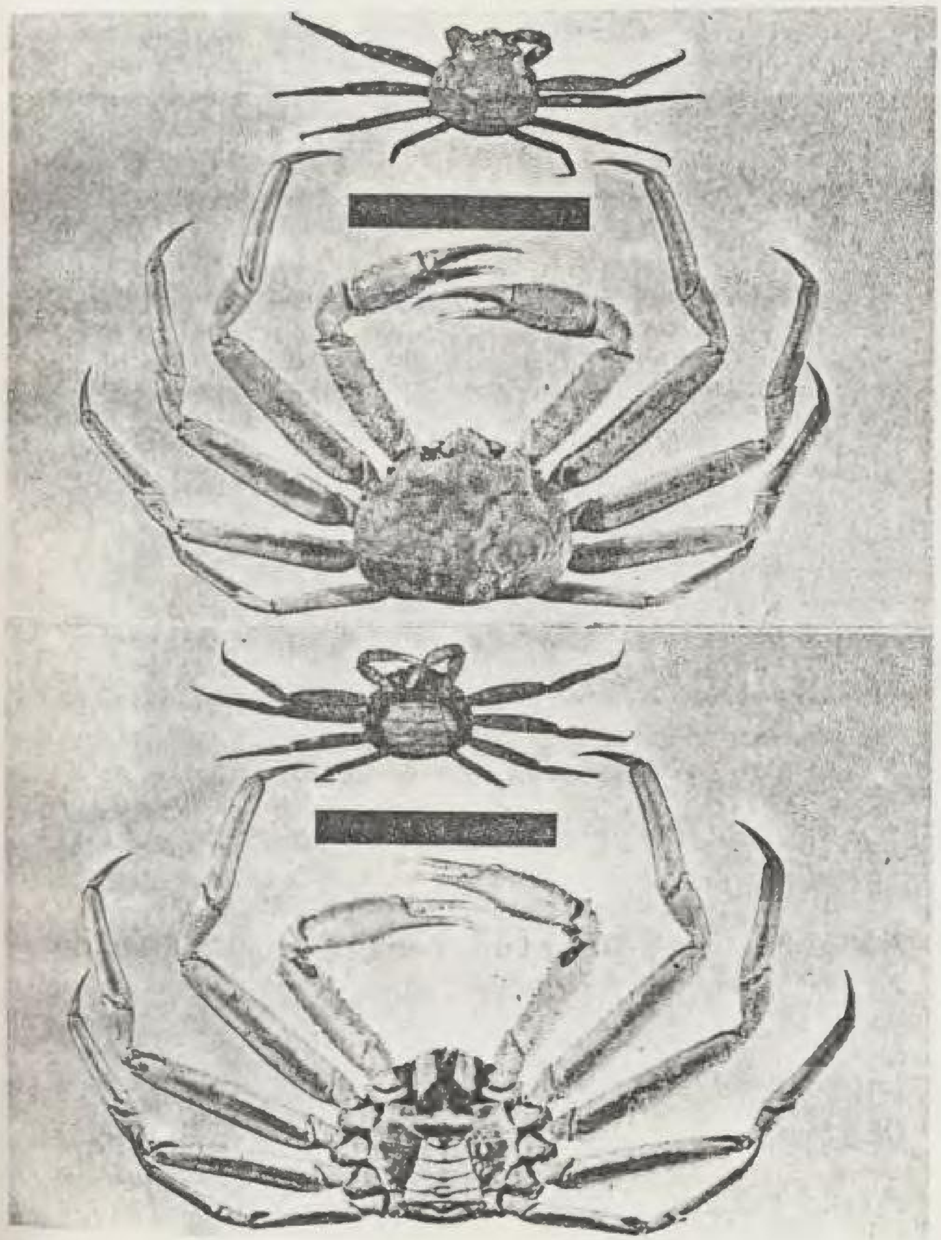


Figure 1:7 Male and female Snow Crab.

(Taken from: Watson and Simpson, 1969)

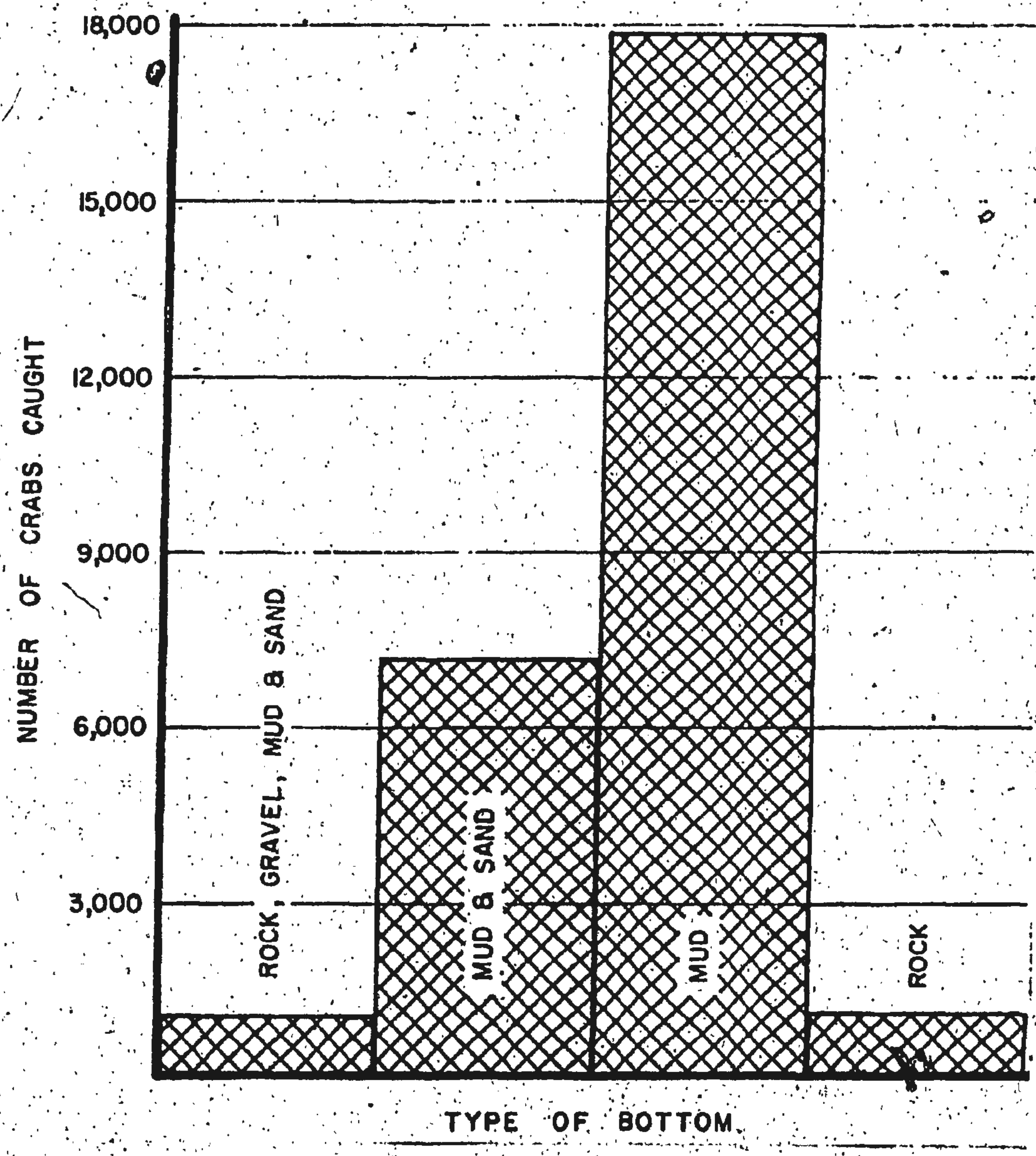


Figure 1:8 **Distribution of Snow Crab in relationship to the type of bottom.**

(Taken from: Hinds, 1970, Placentia Bay)

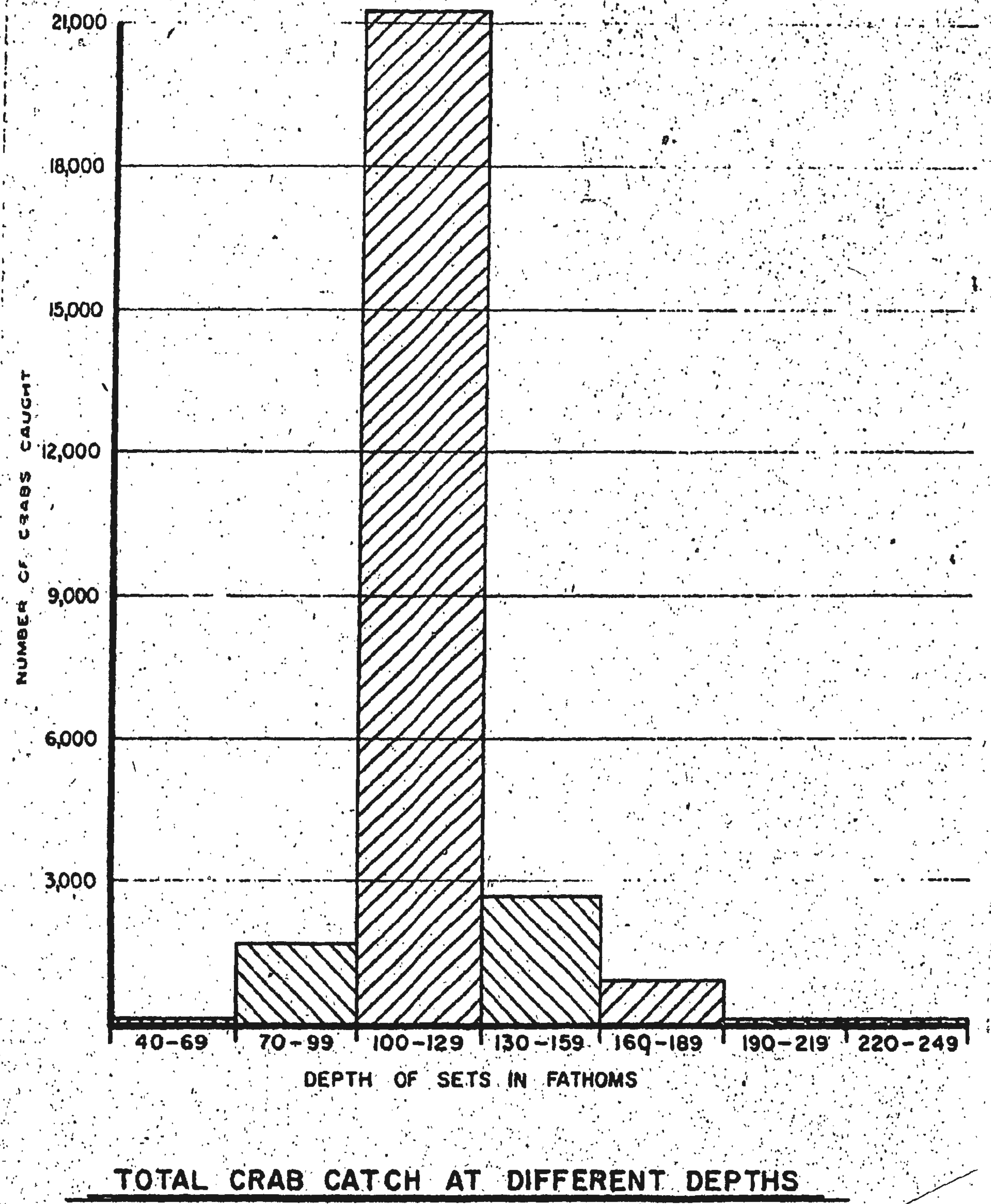


Figure 1:9 Distribution of Snow Crab in relationship to the depth of water.

(Taken from: Hinds, 1970, Placentia Bay)

Table 1:4

CANADIAN EXPORTS OF CANNED CRAB

(HUNDRED POUNDS)

	1971	1972	1973
Total - All Countries	9,822	5,724	11,100
Major Markets			
U.K.	1,233	1,827	317
U.S.	2,829	1,566	2,182
France	901	767	4,713
Sweden	1,365	524	458
Belgium	429	470	371
Holland	1,338	218	2,424
Denmark	724	131	417
Norway	501	109	45
Others	502	112	173

NOTE: (Taken from Crab Review, 1973)

Table 1.5

CANADIAN EXPORTS OF CRAB - FRESH OR FROZEN OR CRABMEAT

(HUNDRED POUNDS)

	1971	1972	1973
Total - All Countries	31,249	23,634	29,417
Major Markets			
U.S.	24,194	20,000	21,052
Sweden	1,242	1,564	3,296
U.K.	1,360	1,014	1,584
France	1,062	161	1,829
Belgium	124	123	448
Denmark	322	79	370
W. Germany	616	160	197
Holland	1,828	344	151
Norway	66	-	157
Japan	-	-	154
Others	435	189	179

NOTE: (Taken from Crab Review, 1973)

2:00 CRAB PROCESSING AND CATCHING TECHNIQUES:

2:10 FISHING AND HOLDING TECHNIQUES:

2;11 FISHING EQUIPMENT:

When exploratory crab fishing experiments were conducted in Newfoundland, one purpose was to ascertain the correct type of fishing techniques and equipment which could be used. There were two main types of crab pot tested.

(1) The Japanese conical trap (Figure 2:1).

(2) The large Canadian square trap (Figure 2:2).

The Japanese trap is smaller than the Canadian trap and is set in a "Fleet" of 10 or more pots. Figure 2:3 shows the technique used for the setting of this type of pot. The mesh netting on these traps is drawn together in the middle of the bottom of the pot by means of a string. When the string is loosened, the whole bottom of the pot is opened and the contents can easily be removed. Also, with the string loosened, the pots can be stacked on top of each other in a conical shape. This particular feature allows a small forty foot boat to carry as many as seventy-five to one hundred pots to the fishing grounds.

The Canadian square trap is usually much larger than the Japanese pot. Figure 2:4 shows that there can be variations in the positioning of the entrance to this trap. The clean out is performed by means of a door on an opposite side to the entrance tunnel. The square trap is set singly as is shown in Figure 2:5 and its main advantage is its ability to hold more crabs than the conical pot and would therefore be very useful in areas of dense crab populations. Due to the size and weight of the pot, the fishing craft has to be rather large to provide the deck space needed to work the gear.

The most widely, if not exclusively used pot in the Newfoundland crab fishery is the Japanese conical trap. The features which make the pot more desirable are:

(a) Light weight and manageable aboard ship.

(b) Less costly.

(c) The longline fleet of pots gives the fishermen the ability to cover more fishing areas.

Various types of bait can be used for crab fishing, but primarily either Herring, Mackerel or Squid is used. The bait is hung from the center top frame of the pot on wires or in sacks. When the pot reaches the bottom it settles as shown in Figure 2:3. The crabs are attracted by the bait odor and crawl up the sides of the pot and drop into the pot through a large opening at the top.

2:12 STORAGE OF CRAB ABOARD FISHING VESSEL:

For the best quality meat to be produced, the crabs should be alive when processing commences. This requires that care and concern be practiced during the various stages of fishing, holding and transportation. In this regard, various experiments have been done to test ideas which would prove practical and economical in the industry.

During the initial experimentation in the Atlantic provinces by the Industrial Development Branch of the Federal Department of Fisheries tests were conducted on board vessels using flooded sea water tanks for the holding of live crab. These tanks were of two types:

(1) A refrigeration system was used to maintain a constant temperature of the water below 45°F. in the tanks.

(2) Surface sea water was circulated in the tank.

These systems had various advantages and disadvantages for some areas of fishing endeavours, however, they have never been greatly used in Newfoundland because the crab stocks now being fished are in close proximity to the coast and the fishing trips are usually of a one day duration. This short period of time from when the crabs are taken on board the vessel and when they can be delivered to shore does not warrant the capital investment in flooded sea water tank systems. Instead, the Newfoundland fishermen have adopted a much more simple holding technique.

If the vessel is of adequate size, the crabs are stored in boxes in the fish hole. This practice allows for less handling of the animals when they must be unloaded from the boat. Figure 2:6 and Figure 2:7 show two techniques incorporating the use of ice and polyethylene sheets which are now being more widely used in Newfoundland. The ice provides a chilling effect to the crabs and maintains a humid environment, which lessens the shock to the animals when taken from the cold environment of the sea bottom. The polyethylene sheets act as a vapour barrier and reduces heat circulation and thus retards the melting of the ice.

2:13 STORAGE ON BOARD THE VESSEL:

When the crab pots are hauled and contents discharged, the first operation is the culling of the catch. Undersized crabs with a carapace width less than 3 3/4 inches, (1974 acceptable size), female crabs and soft shell crabs are picked out and placed immediately into the water. These crabs are commercially unattractive and their return to the ocean helps to maintain a healthy crab population in the fishing area.

When boxes are used aboard vessel they are usually of the plastic stackable type. These boxes can be stacked when full without crushing the contents of the container. When empty, they can be nested one into another which reduces the storage space required. Also, the boxes have side drainage on bottom which prevents drippage from the top boxes going into the boxes underneath. Without this drainage feature, the bottom layer or two of the crabs tend to die in the melting fresh water. Crabs store better if they are all turned on their backs in the box. This allows the fishermen the benefit of getting more crab into each box, but the practice is not used when the crabs have to remain in the boxes for a long period of time and is only used on short fishing trips.

2:14. TRANSPORTATION TO THE PLANT AND STORAGE BEFORE PROCESSING:

Most of the Newfoundland crab plants are located on the Avalon Peninsula and along the North East Coast. (See Figure 1:2). Because the crabs are being fished in various regions it has become necessary at certain times of the year that they be trucked from the catching vessel to the processing plants. To preserve the crabs in as lively a state as possible, the precaution which was taken aboard the catching vessel must be maintained as closely as possible in the land transportation vehicle. This is accomplished by the use of insulated truck bodies and the addition of ice to the floor of the truck body. The crabs are stacked into the truck on the ice in the same boxes which were used on the boat for storage. As an added precaution, the polyethylene sheet is placed over the top layer of boxes and more ice is added to envelope the whole package.

Truckage of crabs short distances (150 to 200 miles, maximum) is possible using this technique, but when longer distances are involved or when delays in transit are anticipated, it is advisable that a refrigeration system be incorporated into the truck box which will allow a constant temperature at approximately 34-35°F. throughout the whole trip.

At most plants in Newfoundland, the crab are stored prior to processing in bulk on ice. When the crabs arrive at the plant in boxes they are usually on their backs, but when the boxes are tipped to be emptied, they become right side up again. Since conditions are usually better controlled in the plant, direct icing of the crab is possible. This is accomplished by dispersing the ice throughout the crabs as they are being stored in bulk. A polyethylene sheet is then used to cover the top layer of crab and more ice is added to completely immerse the crab bed in ice. This method is useful when crab arrive at the plant in a weak condition and they must be held an extra day before processing.

Figure 2:8 shows the unloading of Snow Crab at the processing plant from a catching vessel which has stored its catch on board in bulk.

2:20 <u>PROCESSING PLANTS STUDIED:</u>

There are at present approximately eight facilities in Newfoundland with the capacity of processing an excess of 100,000 pounds of raw crab annually.

For the purposes of this report two facilities were studied. Both crab processing plants already had the capability of processing demersal fish species, but the crab equipment was installed to provide extra throughput for the enterprises. One plant is located at Valleyfield, Bonavista Bay and the other at Ship Cove, Conception Bay.

The crab plant at Valleyfield is operated by Beothic Fish Processors Limited and when opened in 1970, it was the third crab processing plant in Newfoundland. Figure 2:9 is the floor plan for this plant. In 1974, the plant employed approximately 170 people for a work period of about 7 months. However, due to poor and uncertain market conditions the plant had to cease operation prematurely in the year. This plant has the capability to process approximately 20,000 lbs. of raw crab during an eight hour work period. Valleyfield plant produces frozen as well as canned products and has markets developed in the United States of America and in Europe. In 1974, the plant produced 140,000 lbs. of frozen products and 33,750 lbs of canned products.

The Ship Cove plant is owned by Ocean Harvesters Limited and it began operation in June of 1974. Prior to this time, the operations at the facility had been restricted to demersal fish species with a work period during the summer months of the year only. It was anticipated that the crab processing capability would allow the plant a longer working time. However, due to the market conditions in 1974, this plant like Valleyfield and all other crab plants in Newfoundland had to cease operation early in the year. During 1974, the crab plant employed 165 people on two eight hour shifts and purchased a total of 914,155 lbs. of raw crab. The Ship Cove plant produces only frozen products, but a canning facility is planned for some time in the future. As with the Valleyfield operation the main markets for the Ship Cove plant are in the United States and Europe.

Figure 2:10 shows the floor plan of the Ship Cove facility.

2:21 PLANT SIMILARITIES AND DIFFERENCES:

Figure 2:11 shows a simple operation chart of a crab processing plant. It shows the basic steps which must be performed from the live crab stage to the finished package product. Figures 2:12 and 2:13 are detailed operation charts for Valleyfield and Ship Cove respectively. It will be noted that there are differences in the processing techniques employed.

2:22 STORAGE OF LIVE CRAB:

Earlier in this section various practices for the holding of live crab prior to processing were discussed. Both plants in this study applied the technique of placing the crabs in holding pens and covering them with ice, (see Figure 2:8).

When extended holding periods prior to processing were anticipated, polyethylene sheets were placed over the crabs.

2:23 BUTCHERING:

Butchering is the technique used to kill the crabs, and in so doing, separate the portions of the animal containing the meat from the unwanted body of the animal. Figure 1:5 shows the portion of the animal which contains the meat.

The butchering is accomplished by holding the crab tightly by both leg clusters and smashing the body of the animal down over a steel anvil, (see Figure 2:14). This breaks the body away from the leg/shoulder sections. The sections are next knocked firmly against the edge of the waste flume which runs underneath the anvil. The sections are then held against revolving nylon brushes which remove the gills and entrails of the crab from the shoulder. Finally, the cleaned sections are placed on a conveyor belt to be taken to the crab cooker. Figure 2:14 shows pictures of the butchering operation in progress at the Ship Cove plant which is also very similiar to the practice at Valleyfield.

2:24 COOKING AND COOLING:

There are two entirely different systems used in these two crab plants. Valleyfield employs a batch cooking method, whereas, a continuous system is used at Ship Cove.

With batch processing the butchered sections are placed in stainless steel open mesh wire baskets and are placed by means of an overhead crane into a cooking tank. Figure 2:15 shows a sketch of a typical crab cooking basket and the cooking tank. Cooking time is usually seven minutes at a temperature of 212°F. To ensure a uniform cooking throughout the whole basket, it is raised and lowered once or twice during the cooking time. Upon cooking, the basket of sections is immersed in water. The water temperature here is maintained as low as possible to provide a shock effect to the meat which causes it to contract in the shell. This contraction makes the extraction of the meat from the shell possible. Figure 2:16 shows the cooking and cooling operations in progress at Valleyfield plant.

With the continuous cooking systems used at Ship Cove, the raw sections are allowed to drop from the conveyor of the butchering table onto another belt which is moving through a vat of boiling water. This water is at 212°F. and the speed of the belt through the tank is variable. At Ship Cove, the cooking time is also seven minutes. After passing through the cooker, the sections drop into a chill tank of water for cooling. Stainless steel baskets similar to those used at Valleyfield are placed in this tank to catch the cooked sections. When the sections are sufficiently cooled, the baskets can be removed from the chill tank by means of an overhead crane and taken to a sorting and distribution table.

Figure 2;17 shows the continuous cooker and cooling tank employed at the Ship Cove plant.

With the continuous method of cooking some sections become trapped in the eddy of boiling water which can occur in the cooker as the steam moves through the water. These trapped sections become overcooked and discolored. When they finally do move through the cooker and on to the shucking area, the shuckers have to be careful that they reject the sections. This type of dark meat is undesirable in the finished product. This is a drawback to the continuous cooking technique and is eliminated by using batch cooking, as all the sections which are placed in the basket for cooking emerge again when cooking is finished. However, with batch cooking a problem of ensuring a uniform cooking throughout the whole basket occurs. When the sections are placed in the basket they must be packed in tightly. Cooking time is measured from the point when the water begins to boil in the cooking vat to after the crabs are added. This generally takes a few minutes to occur. As mentioned above the baskets must be raised and lowered during cooking to ensure uniform cooking by circulating the boiling water through the basket.

The temperature and cooking time is important to eliminate a condition which can occur in the sections known as blue/black discoloration. At a cooking temperature approximately 150°F. to 160°F. certain enzymes in the crab are active and in the presence of oxygen an oxidation process occurs and the blue/black compound is formed. Actual plant production has shown that if crab parts are cooked over seven minutes at a temperature of 212°F. then this problem does not occur. For this reason, this time and temperature has become standard through the industry.

The best medium for the cooking of crab is water. Steam cooking causes bleaching of the red pigment which is just underneath the shell of the animal. Also, steam cooking lowers the yield of the crab and causes problems with the shucking of the meat from the shell as the meat has a tendancy to stick in the shell.

Overcooking of crab sections either by the batch or continuous method is undesirable because of the discoloration problems and because there is a low yield. The over cooked meat fibers are easily broken and have lost much of the natural juices which result in a loss of yield.

After cooking, the sections have to be immediately immersed in cold water. This treatment causes a shock to the meat fibers in the shell and it contracts. This contraction makes the shucking of the meat easier as it slides away from the shell.

2:25 SHUCKING (MEAT EXTRACTION FROM SHELL):

From the operations charts for each plant it can be seen that there are very definite differences in the processing methods used in the plants.

At the Valleyfield plant the workers are required to shuck all the various parts of the whole section with the exception of the legs, tips and the small legs. A bonus is paid to the workers and for this reason the weight of the sections given to the workers and the weight of the meat extract is all recorded. The shuckers are supplied with 35 pound lots of whole section and a bonus of 20 cents per pound is paid to the individual shucker for each pound shucked over 50 pounds while maintaining a 35 percent yield of meat from the whole section.

There is a routine for shucking which experienced shuckers have adopted. Firstly, the shoulder meat is removed by forcing open the shell surrounding the meat then turning the section to firmly knock it against the wall of a meat holding pan. Next, the tips and small legs of the section are removed and placed in a separate container for their delivery to a tip roller unit which rolls the meat out. After the tips are removed the knuckles are shucked and then removed. The balance of the section is broken up into pieces. The shoulder portions are discarded while the claw leg with claws are separated from the large legs. The claws and claw legs are shucked, by breaking open the shell and jarring it on the sides of the holding pan to loosen the meat. Finally, each leg is shucked individually with care being exercised so the leg meat is unbroken. The legs are shucked by breaking away small pieces of the shell near the bottom of the leg and then holding the leg in a position which points the exposed leg meat at the meat holding pan. The hand containing the leg is then jarred against a rigid surface on the table to loosen the meat in the leg. The leg meat should slide out after such action. The whole leg pieces of meat are laid in the shucking pan separated from the broken meat. Figure 2:18 shows manual meat shucking at Valleyfield.

When all the sections are shucked in like manner, the meat is taken to be weighed and packed and a new box of sections started.

In the Ship Cove plant, the sections are broken into their various elements before being taken to the workers for shucking. This operation is performed after the crabs have cooled and involves the removal of all tips and claw and claw leg from the other section elements. After breakup there are three distinct parts or groups of parts of the crab section. The tips are taken to the tip roller for meat extraction, the claw legs and claws are sent to one group of people who shuck only this type of crab parts and the remaining portion consisting of the shoulder, remaining legs and knuckles is taken to a third group of people for shucking. The shoulder and knuckles are shucked in a manner similiar to that described above at the Valleyfield plant. The legs are removed from the other parts and placed in a separate container for delivery to leg slitting units. Figure 2:19 shows the operations of the section division into the various elements and the actual shucking in operation at the Ship Cove plant.

2:26 <u>LEG SLITTING</u>:

The mechanical extraction of crab meat from the shell has been for a long time a desire of members of the crab processing industry. However, this extraction must be done in a manner which produces a product with the least amount of damage to the meat.

Crab meat is separated into broken meat and leg meat. Leg meat is the meat in the crabs leg and is the most desirable and flavourable portion of the animal. The market demand has always been for the production of <u>whole</u> <u>undamaged</u> leg meat which would enhance the appearance of the combined product. Broken meat is just as the word implies; it is all the meat in the crab with the exception of the whole unbroken leg meat.

The extraction of the whole leg meat by manual method is a very tedious and demanding exercise and even then it can produce a leg meat in damaged condition due to uneveness in cooking and cooling.

Since the whole crab leg is the most desirable portion of the crab, any means of mechanical extraction must ensure that the number of damaged or broken legs be kept to the very minimum.

In 1973, the Engineering Department of Memorial University was asked to investigate the problem of crab meat extraction from the crab legs. Various tests were conducted using vacuum sucking of meat from the leg and water or air jets to force the meat out of the shell. Figures 2:20 and 2:21 show the techniques employed for these experiments. Still other tests using a device which would slit the shell of the crabs leg showed that the shell could be completely cut open and that the meat was exposed for extraction by hand without damage.

The slitting unit appeared to be promising and a prototype of production unit was constructed at the university. Ocean Harvesters Limited became aware of the success of the slitting machines and arranged for the construction of five prototype units which were used in their plant at Ship Cove when it began operation in the summer of 1974.

The slitting machine proved to be very successful in producing very few broken legs. The capacity of the manual shuckers was increased as they did not have to spend time at shucking of the crab legs. The removal of the leg meat from the slit leg is not critically tied to the cooking of the crab as is the manual operation. With manual operation it is important that the meat not stick to the shell and therefore be easy to slide out of the shell. Using the slitting technique, the meat is simply lifted out of the shell when the cut is made down the leg and the shell opened. On frozen and thawed cooked legs, the slitting technique was again very effective due to the fact that the meat is lifted from the shell and does not have to slide out as in the manual shucking operation.

Generally, slitting will produce a higher percentage of whole leg meat (Amaria, 1974 - Report No. 5). The cutting and opening of the shell made possible the full removal of all meat from the leg.

Figures 2:22, 2:23 and 2:24 show the slitting unit itself, while Figure 2:27 shows the unit in operation and the meat being removed from the slit legs.

2:27 ROLL LEG TIPS AND SMALL LEGS TO REMOVE MEAT:

Figure 2:26 shows a sketch of a tip rolling unit and a unit in actual operation. The complete tip rolling assembly used at the Ship Cove and Valleyfield plants were identical. Each had six such roller units incorporated into a complete table arrangement which provided areas for the holding of the storage pans and stands for the operators.

At Ship Cove, the leg tips and small legs were segregated before being brought to the roller unit. The leg tips and small legs were rolled on separate units as the distance between the revolving rollers had to be adjusted to compensate for the different thicknesses of the leg tips and small legs. At Valleyfield, the leg tips and the small legs (see Figure 1:5) were not separated, but rolled as one element.

The operator directs the leg tip or small leg into the revolving rollers until it grasps the shell. As the shell moves through the rollers, the meat is pressed back out through the open end of the tip or leg into the hand of the operator. The operator must be careful to squeeze this meat slightly as it will be lost as it moves through the rollers if it is not held. When the meat has been removed the operator deposits the meat in a storage pan in front of the roller unit.

2:28 PACKAGING AND FREEZING:

As outlined earlier in this chapter, the Valleyfield plant has the capability to produce canned as well as frozen products. The Ship Cove operation, however, is restricted to frozen products only.

The two plants produce the same type of frozen items. "Salad" pack consists of 100% broken meat and "Combination" pack consists of 60% broken meat and 40% whole leg meat. Both packs are frozen in five pound unit blocks with the

"Combination" pack having the layers of legs on the bottom, top and sides of the blocks with the broken salad meat in the middle. The red pigment on the exterior of the crab leg provides vivid color to the finished product.

The crab is prepared for packaging when it has been inspected for shell, washed and soaked in a mild brine solution which adds flavor to the meat. Only the broken meat is inspected for pieces of shell before packaging. At the Valleyfield plant a brine flotation system was installed, but was not in use when the material for this report was gathered. Management at the plant felt that this technique was not really necessary to remove the shell fragments from the broken meat. Instead, only the "black light" inspection conveyor of the brine floating system was used.

Figure 2:27 shows a sketch in a brine flotation tank, the purpose of which is to remove pieces of shell, gills, fat and other detrimental materials. A divider in this tank causes motion in the brine and some shell fragments settle to the bottom. The meat is not left any longer then two minutes in the brine and is moved out onto the "black light" inspection conveyor. The "black light" causes a blue fluorescence in the shell and is thus distinguished from the white crab meat. With this color difference the shell is easily removed.

At Ship Cove plant only the "black light" with the meat inspection conveyor was used. However, experiments were conducted with a Baadar 694 fresh fish bone separator (see Appendix A) to remove the shell particles. Two sizes of drums were used (3 and 5 m.m.) and the experiments were successful in removing the shell fragments, but, the fibers of the products produced were not long enough to gain full market acceptability especially since tight markets prevailed.

Figure 2:28 shows the weighing and packaging of the five pound blocks of fresh crab meat at the Ship Cove plant.

The five pound blocks of crab are frozen in aluminum pans which can hold seven such blocks. These pans are then placed in contact plate freezers at a temperature of approximately -40°F. for a period of two to two and one half hours. After freezing, the blocks are removed from the pans and the carton surrounding the product is stripped off and the frozen blocks are glazed in water at 34 to 35°F. This practice coats the block with a thin layer of ice approximately one sixteenth of an inch thick. This helps to stop dehydration of the blocks when left in cold storage for extended periods of time. As an added precaution the blocks are placed in plastic bags then into five pound attractively printed cartons and finally placed into a master carton containing ten, five pound blocks.

Storage of the frozen crab meat should be in an area of -10 to -20°F. Fluctuations in the temperature of the cold storage are undesirable and near constant temperatures maintain the quality of the product.

The canning operation at Valleyfield gives more production flexibility to the plant. If market or inplant production demands are such, canned crab can be packed separately or at the same time as the frozen products.

Valleyfield plant produces one size of canned crab product, it is a round can containing 5 ounces (drained weight) of crab. The product contains both broken meat and cut sections of whole leg meat. The can is fitted with a parchment sheet which completely envelopes the meat when the can is filled. The cut sections of whole legs are placed on the bottom and top of the can with the broken meat in the center. It is ironic that such a great deal of emphasis is placed on the removal from the leg shell of whole unbroken leg meat and yet when this type of can is used, the legs must be cut to make them fit. It would be more desirable that a rectangular or oval type be introduced which would enable the whole leg meat to fit into the can. However, this idea would need to be checked for market acceptability and economic feasibility.

To enhance the flavor of the canned product 1/6 of 5% NaCl pickle is added per ounce of meat in the can. Citric acid in the ratio of 0.1% to the total weight of the can contents is also added to the meat. The citric acid helps to prevent the occurance of struvite (Mg NH_4 PO_4 $6H_2$ O) crystals in the cans. The citric acid increases the solubility of struvite and thereby prevents the crystal formation.

The citric acid also helps to prevent blueing and"smut" formations in the crab meat. If the crab section is not allowed to bleed properly after butchering, the blood will remain in the meat and the copper contained in this blood will react with the protein in the meat to produce a blue discoloration of the meat. It has been found that a higher incident of this substance will occur if the crabs being canned are weak or dead. The blood of these animals is close to being coagulated in the meat. For the best results for canning, the freshest crab possible should be used. The second problem which will occur with the canned product is the formation of a iron sulfide compound known in the industry as "smut". This is a very dark substance and occurs when the iron in the can is allowed to come in contact with the crab meat. The cans in use today are all plastic or enamel coated to ensure no contact of the meat and the can. Also, the parchment liner is an added precaution which completely separates the meat from the container.

2:29 BRINE FREEZING:

Both the Valleyfield and the Ship Cove plants use brine freezers for freezing of surplus cooked sections. Figure 2:29 is a sketch of a typical brine freezer similiar to those used at the plants.

The brine freezer is intended to be utilized to freeze and stockpile sections on days when there is a surplus of crab available for processing, but which can not be shucked at that particular time. The crabs are butchered, cooked and cooled then placed in stainless steel baskets (see Figure 2:15) and taken by overhead crane to the freezer. The whole basket is lowered into the tank for freezing.

The optimum salinity of the sodium chloride brine is 88.3 degrees which permits a brine freezing point of -6 degrees F. The freezers, however, are equipped with circulators which moves the brine around the coils and causes an approximate lowering in temperature of 10 degrees F. to -16 degrees F. At a salinity above or below the 88.3 degrees optimum a rapid increase in temperature occurs and a salinity of 84 degrees to 88 degrees is maintained in practice at the plants. A temperature range of -3.0 degrees F. to -5.8 degrees F. can be achieved at these degrees of salinity.

After freezing of the section they must be glazed in chilled water which coats the complete section with a film coating of ice to retard dehydration of the section. The baskets are raised and lowered in the tank to give a uniform glaze. After this they are emptied quickly and stored to be withdrawn later for processing. The thawing of the frozen sections is accomplished by soaking them in a vat of hot water for a period of 5 to 10 minutes.

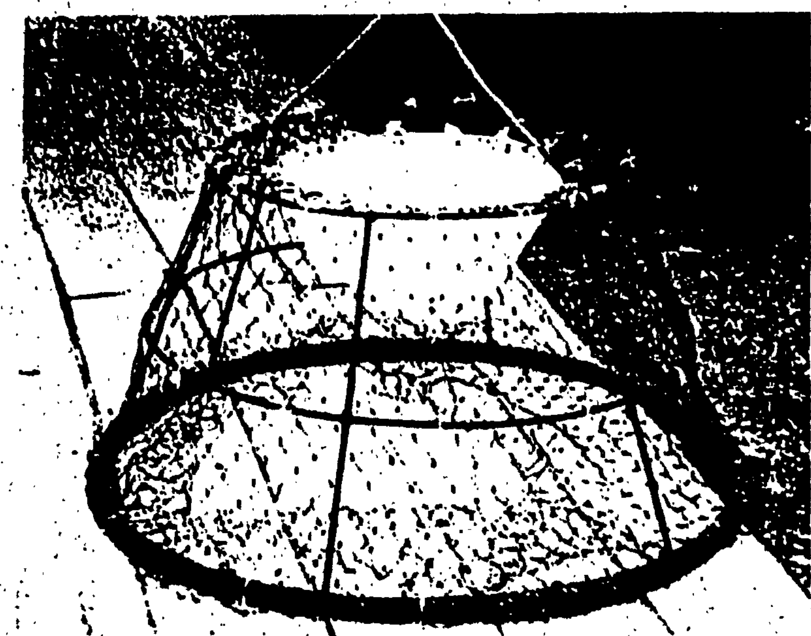


Figure 2:1 The Japanese Conical trap.

(Taken from: Watson and Simpson, 1969)

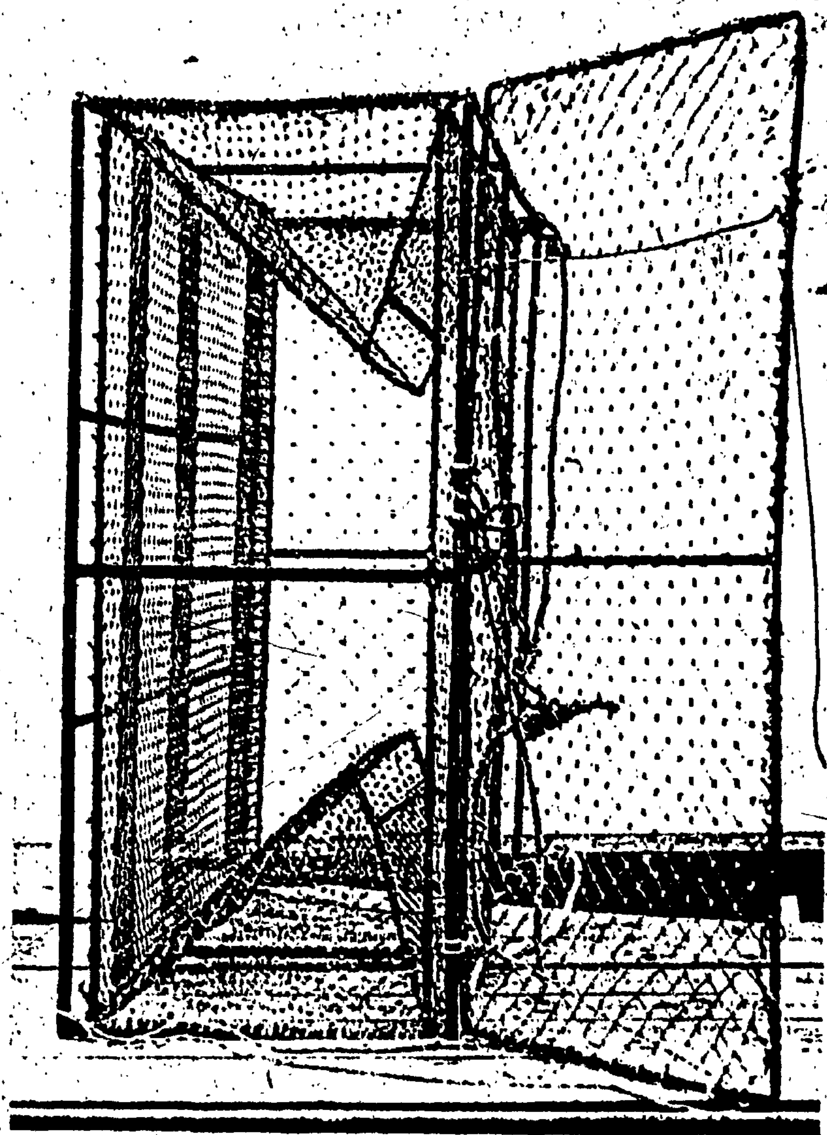


Figure 2:2 The large Canadian Square trap.

(Taken from: Watson and Simpson, 1969)

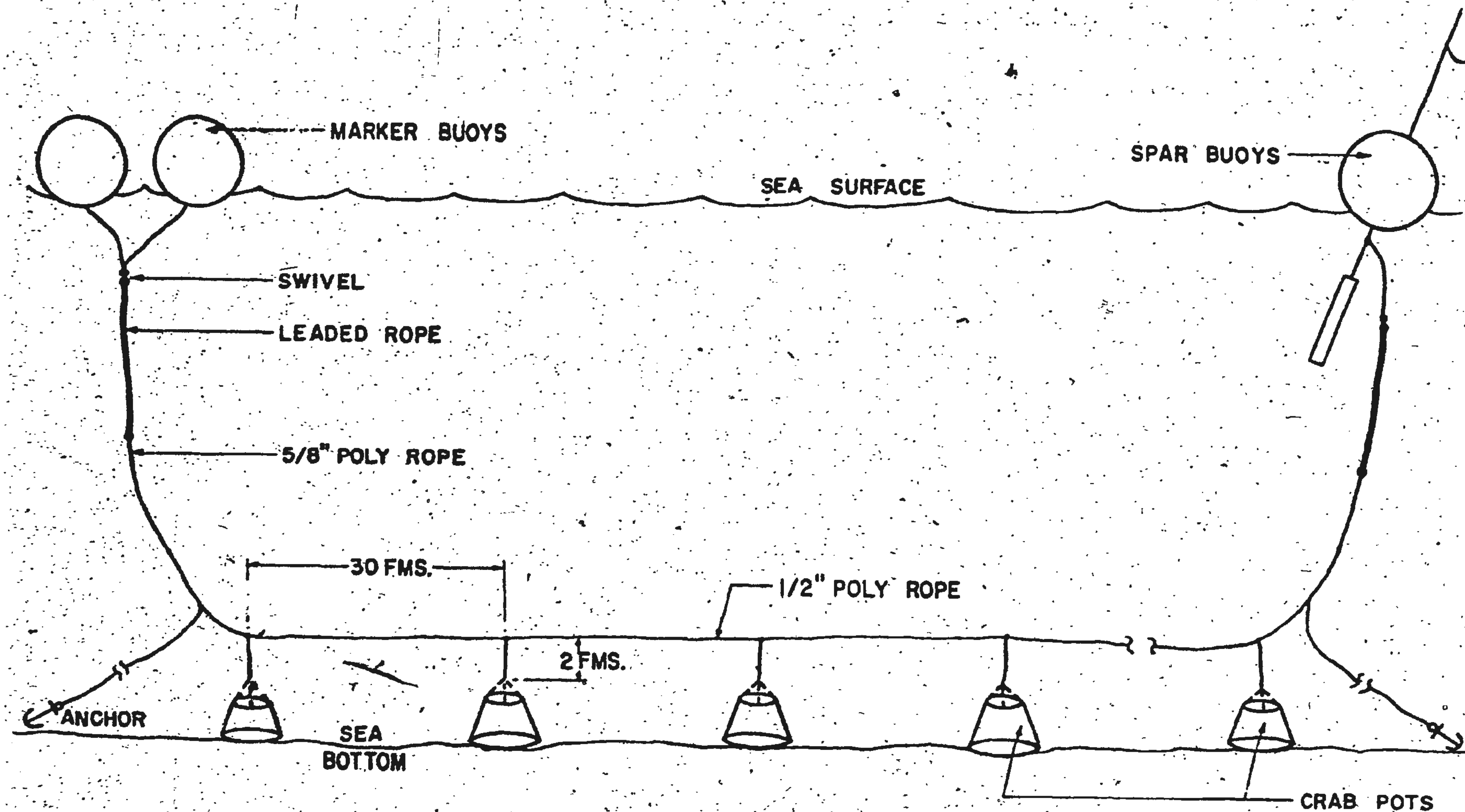


Figure 2:3 Method of setting Japanese Conical trap.

(Taken from: Hinds, 1970, Placentia Bay)

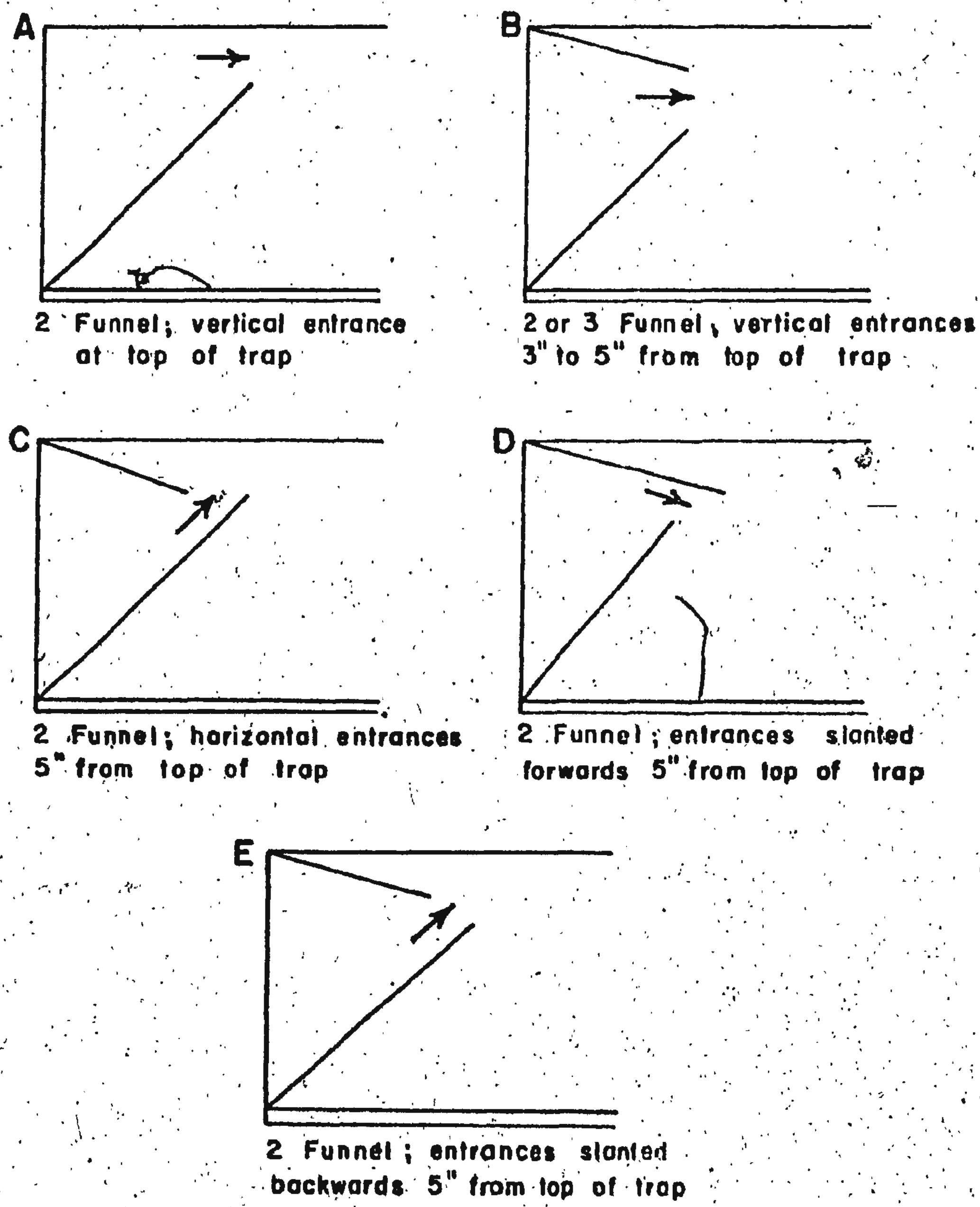


Figure 2:4 Variations in the position of the entrance for the large Canadian Square trap.

(<u>Taken from: Watson and Simpson, 1969</u>)

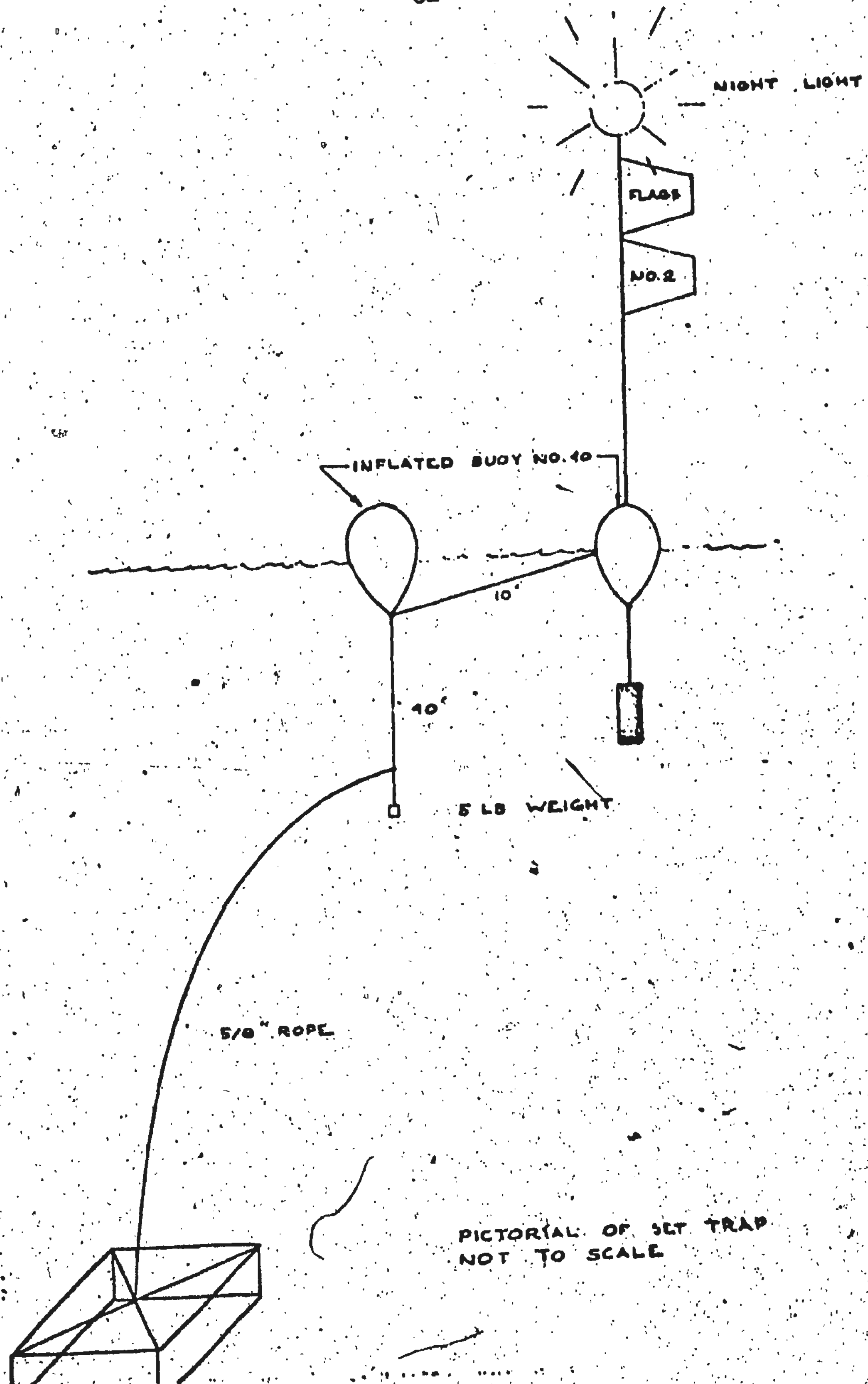


Figure 2:5 Method of setting large Canadian Square trap.

(Taken from: Hinds, 1970, Bonavista Bay, West & Northeast Coast, Nfld.)

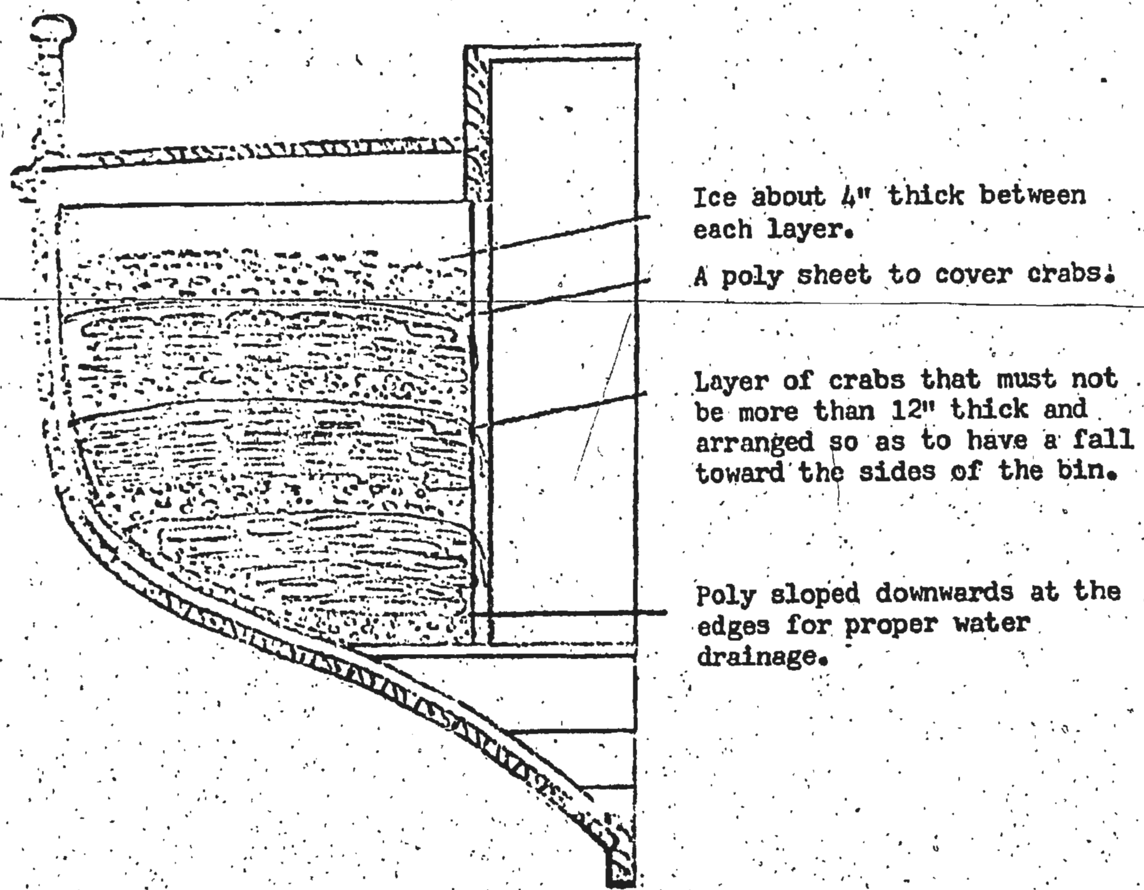
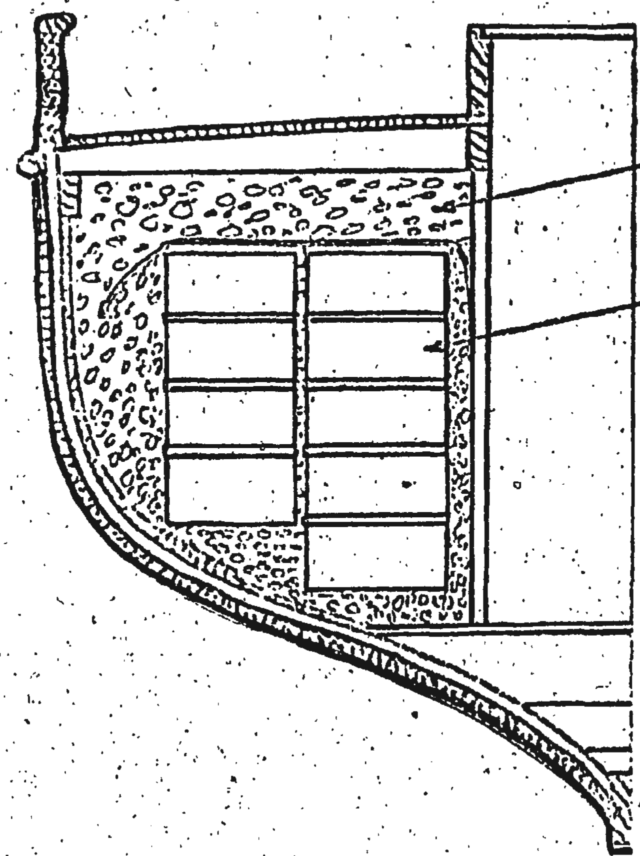


Figure 2:6 Bulk storage of Snow Crab on fishing vessel.
(Taken from: Course notes, Crab Processing, Feb, 1975)



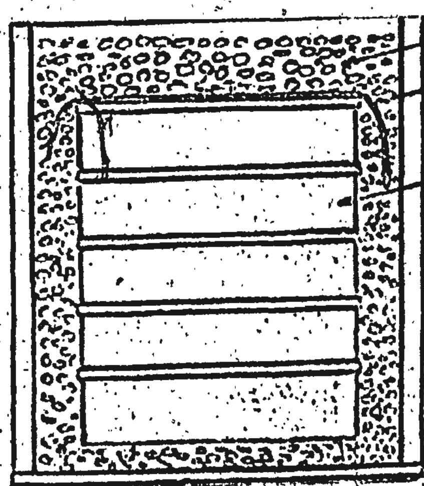
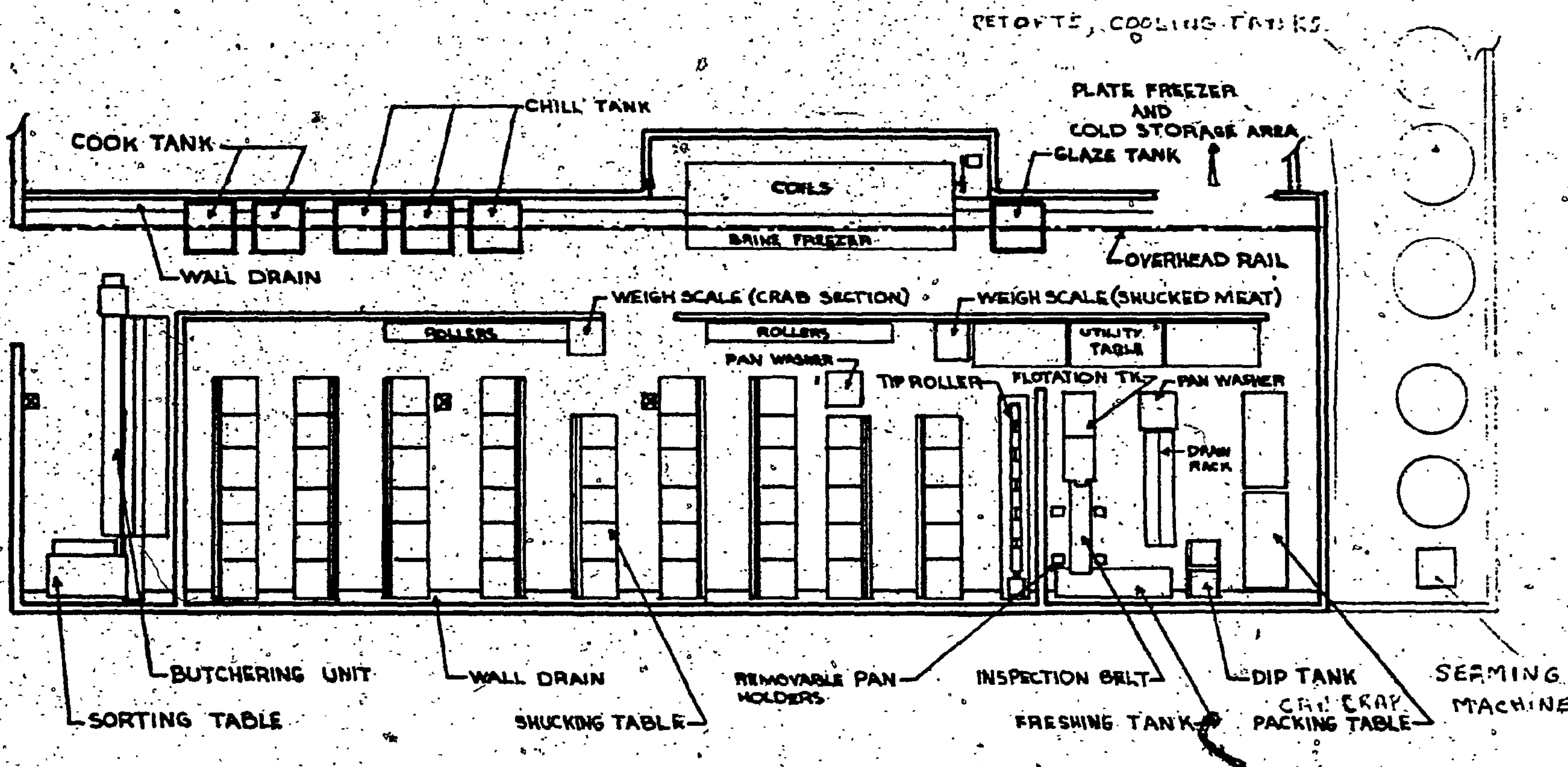


Figure 2:7 Containerization of Snow Crab on fishing vessel.

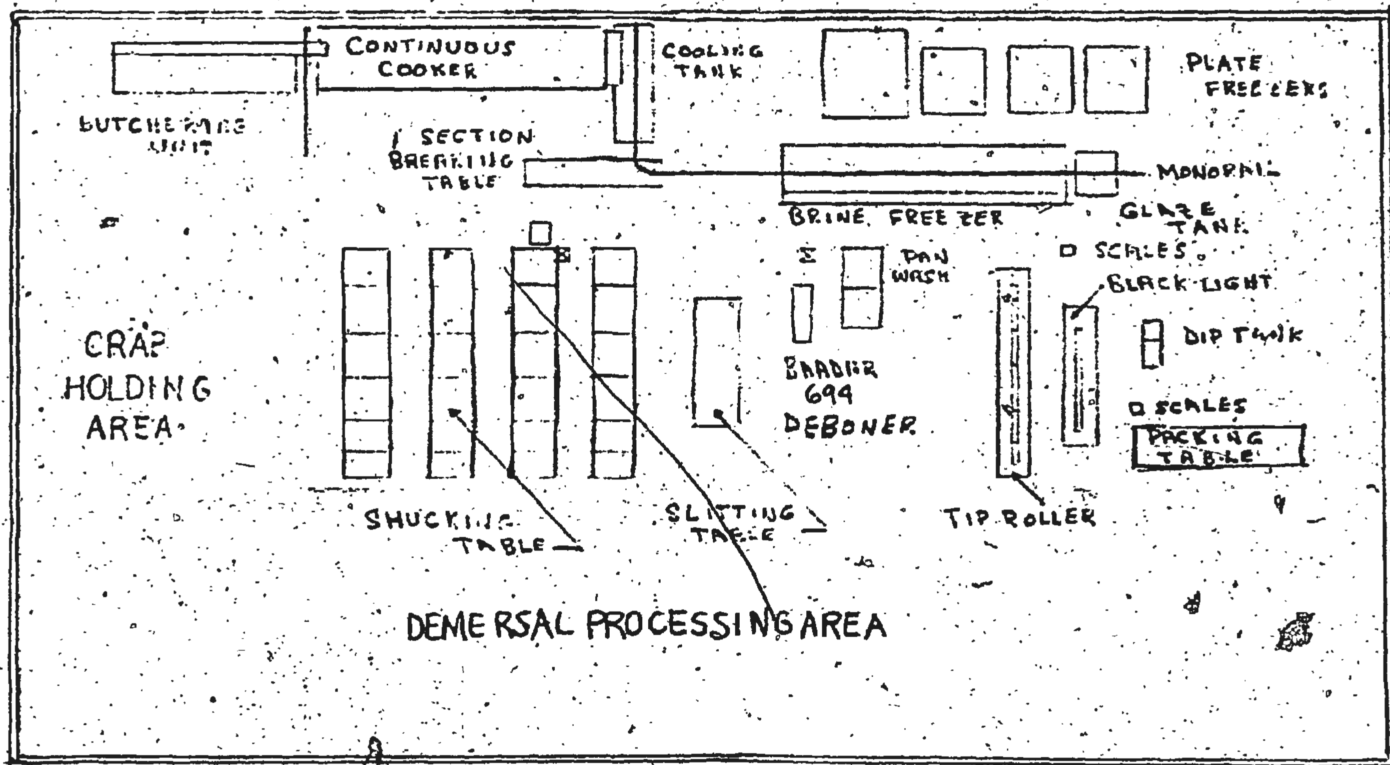
(Taken from: Course notes, Crab Processing, Feb., 1975)

Figure 2:8 Unloading of Snow Crab which was stored in bulk on catching vessel at Valleyfield, Bulk storage of crab in processing plant, Ship Cove.

BEOTHIC FISH PROCESSORS LTD.
VALLEYFIELD B.B. NFLD.



OCEAN HAVESTERS LTD
SHIP COVE C.B. N.F.L.D.



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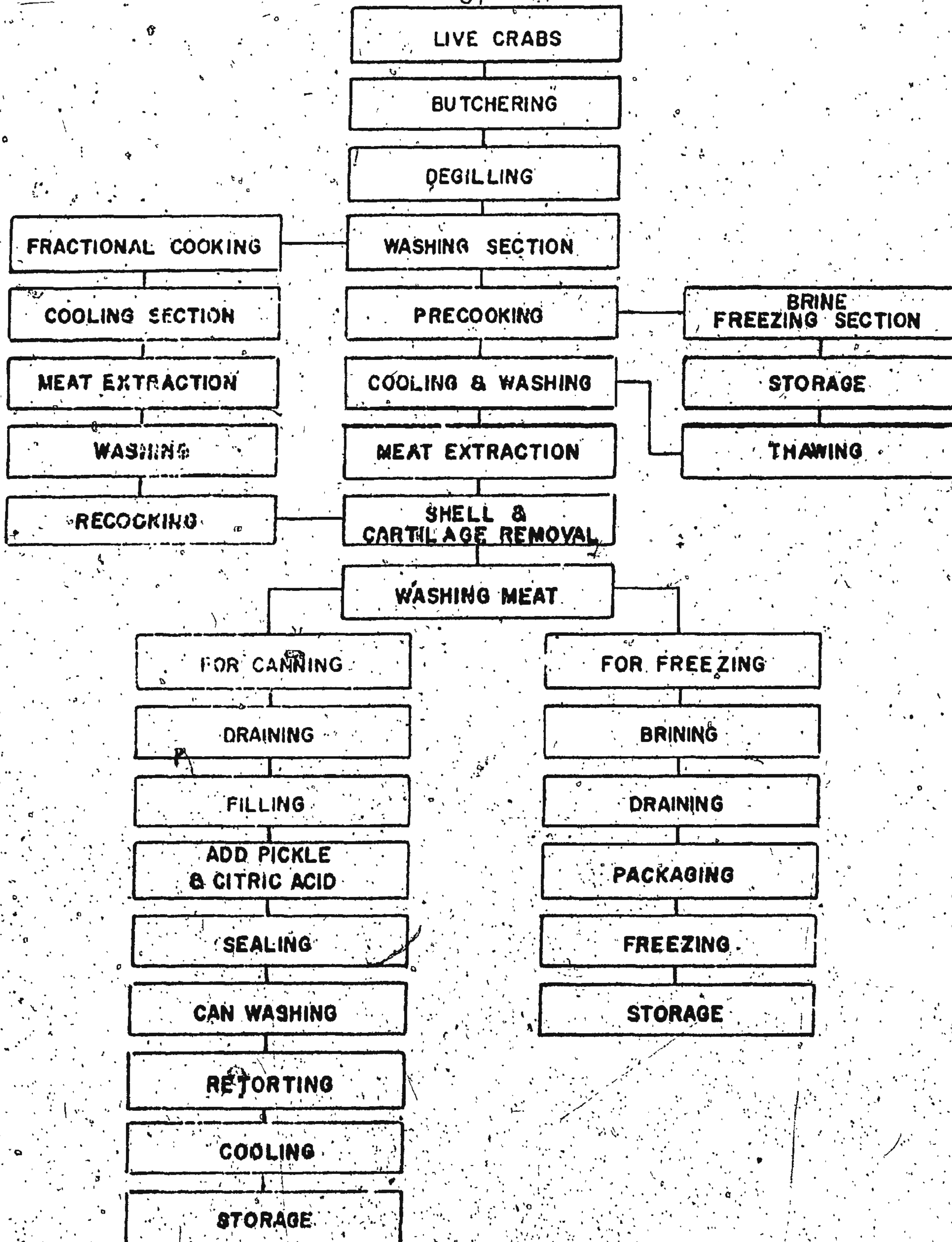


Figure 2:11 Simple operation chart for a crab processing plant.
(Taken from: Blackwood, Varga, and Dewor, 1969)

Operations Chart for Crab Processing

Valleyfield

Beothic Fish Processors Ltd.

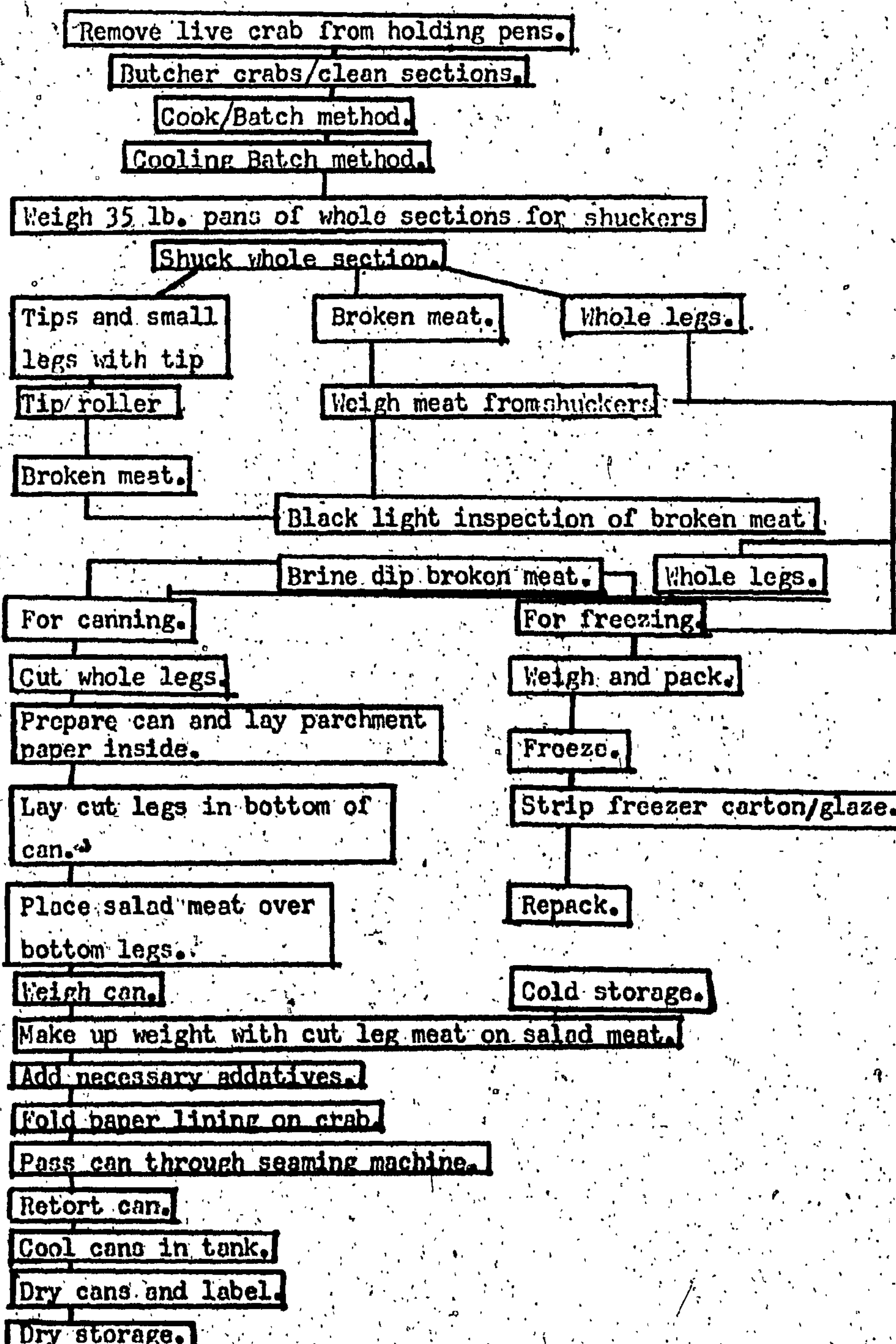


Figure 2:12 Detailed Operation chart, Valleyfield, C.B.

Operation Chart for Crab Processing

Ship Cove

Ocean Harvesters Ltd.

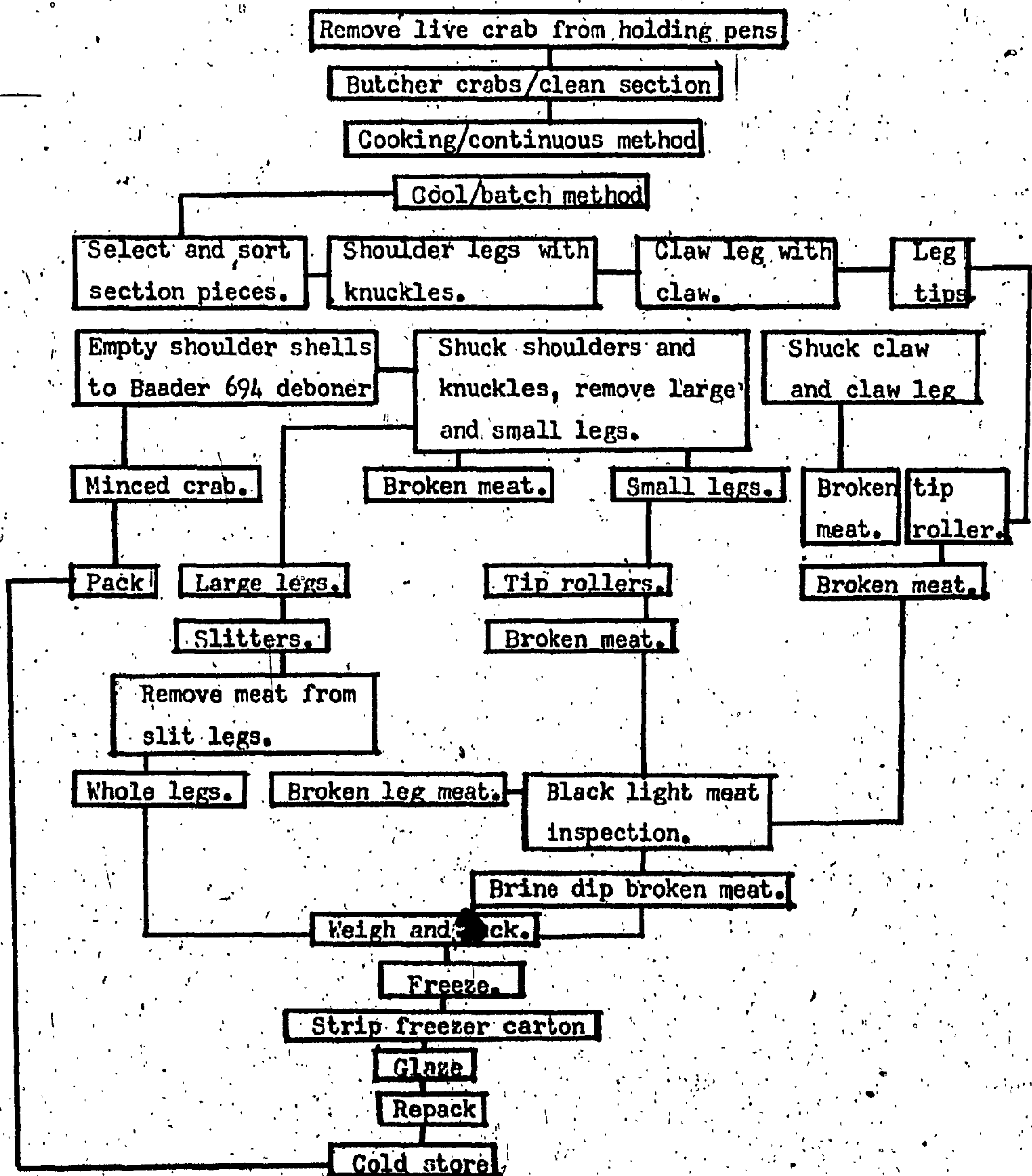
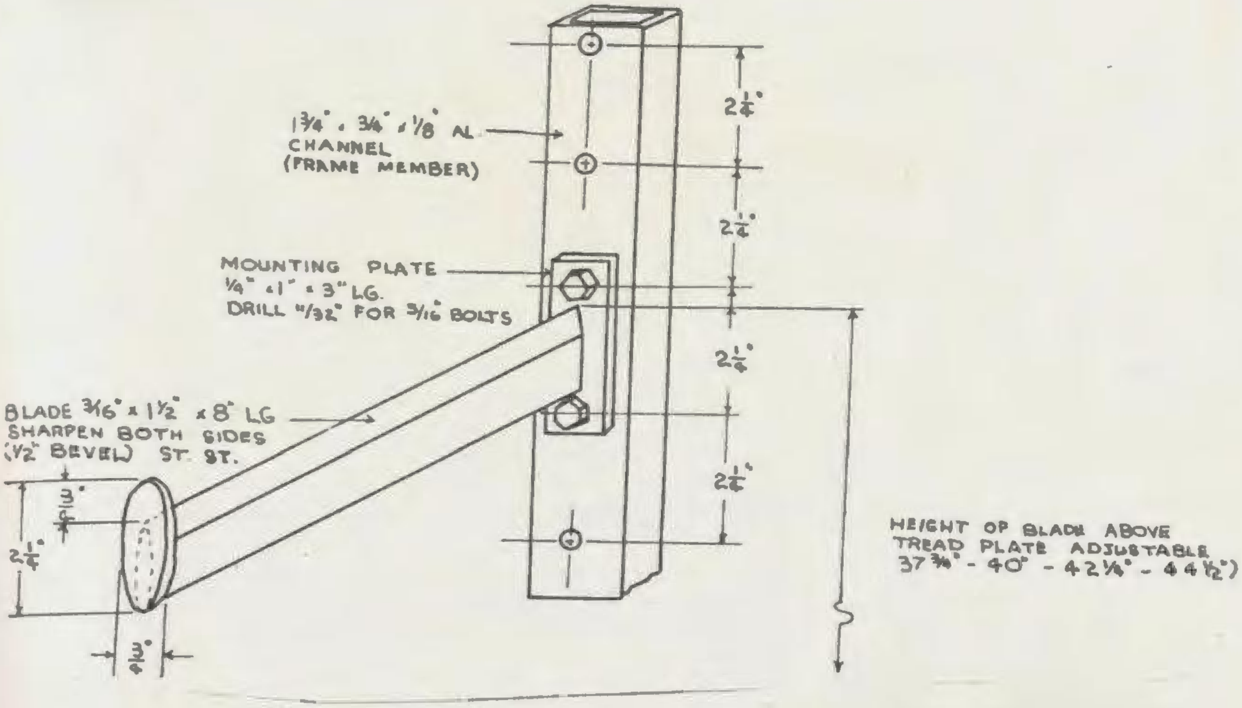
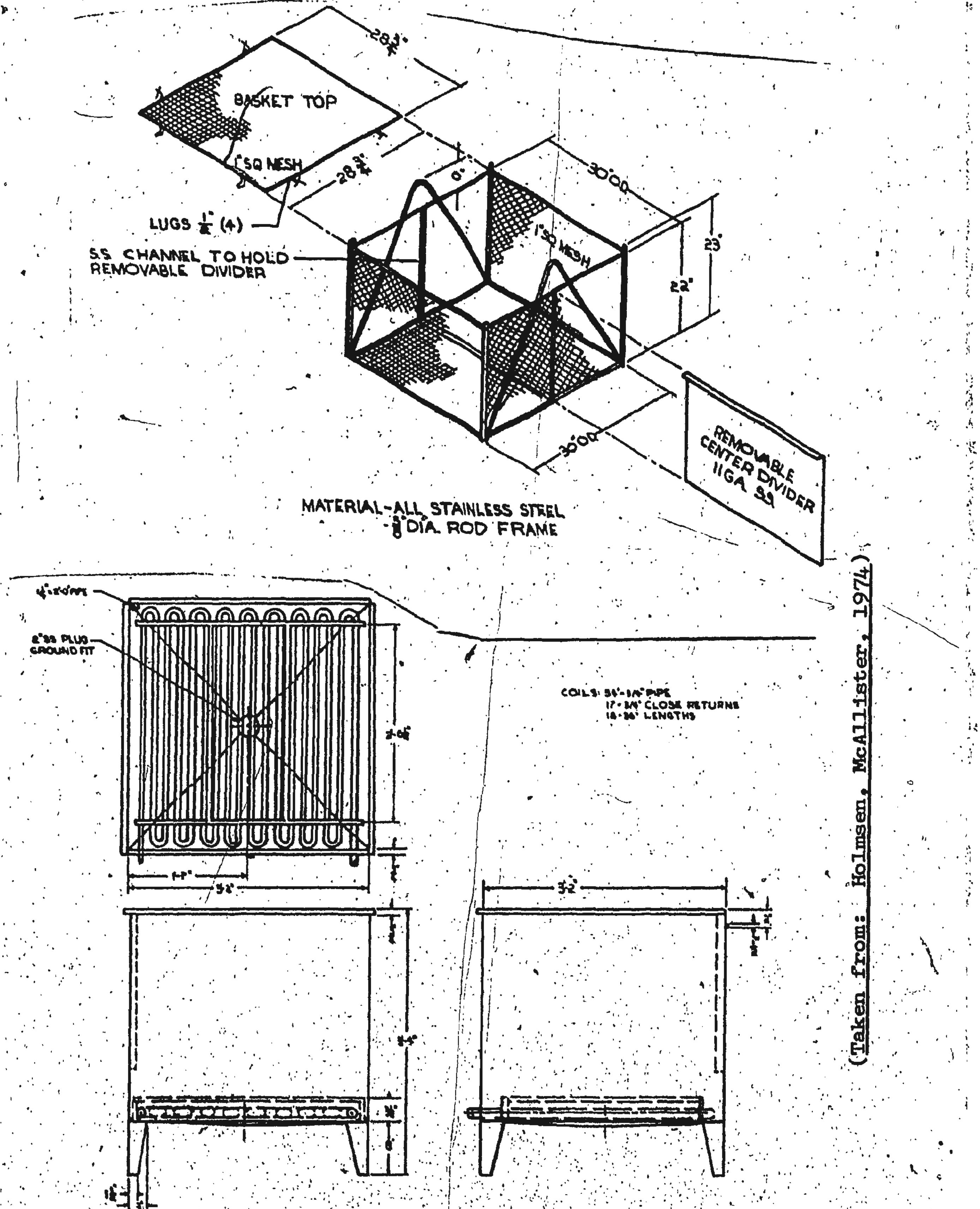


Figure 2:13 Detailed operations chart, Ship Cove, C.B.



(Taken from: Holmsen and McAllister, 1974)

Figure 2:14 Butchering of live crab.



(Taken from: Holmsen, McAllister, 1974)

Figure 2:15 Sketch of typical batch cooking basket and cooker.

Figure 2:16 Cooking and cooling of Snow Crab sections at the Valleyfield plant.

Figure 2:17 Continuous cooker and cooling tank, used at the Ship Cove plant.

Figure 2:18 Manual meat shucking at the Valleyfield plant.

Section division

Shuck shoulders, knuckles; Remove legs.

Shuck claw and claw leg.

Figure 2:19 Section division and actual shucking of part at Ship Cove plant.

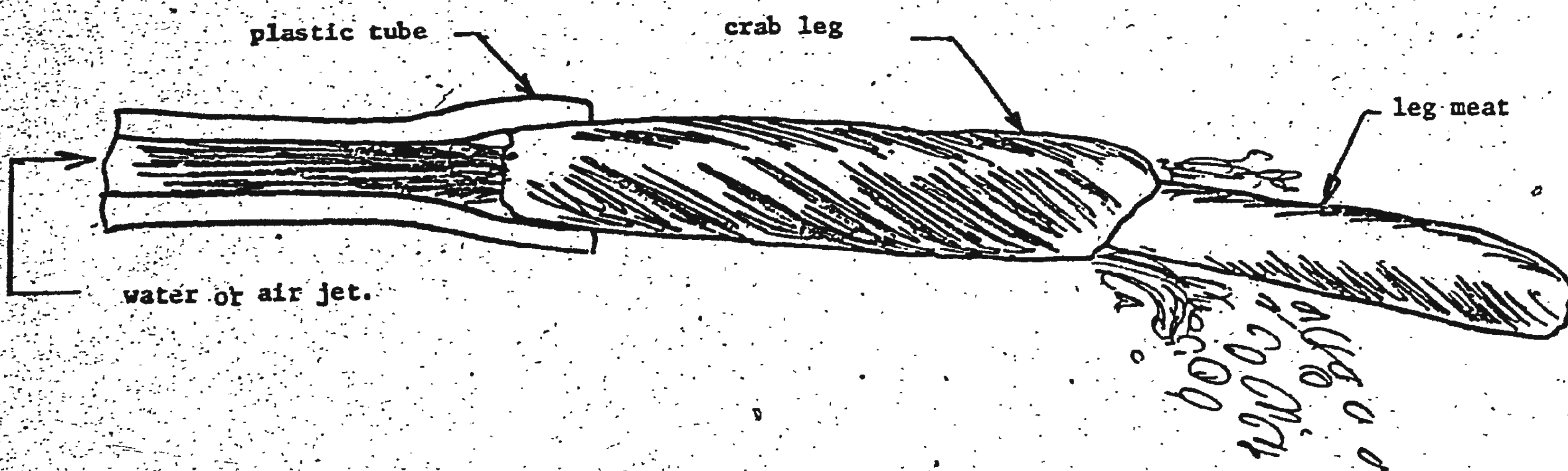


Figure 2:20 Blowing of leg meat from crab leg shell by water or air jet.

(Taken from: Amaria, Research Report No. 5, Sept., 1974)

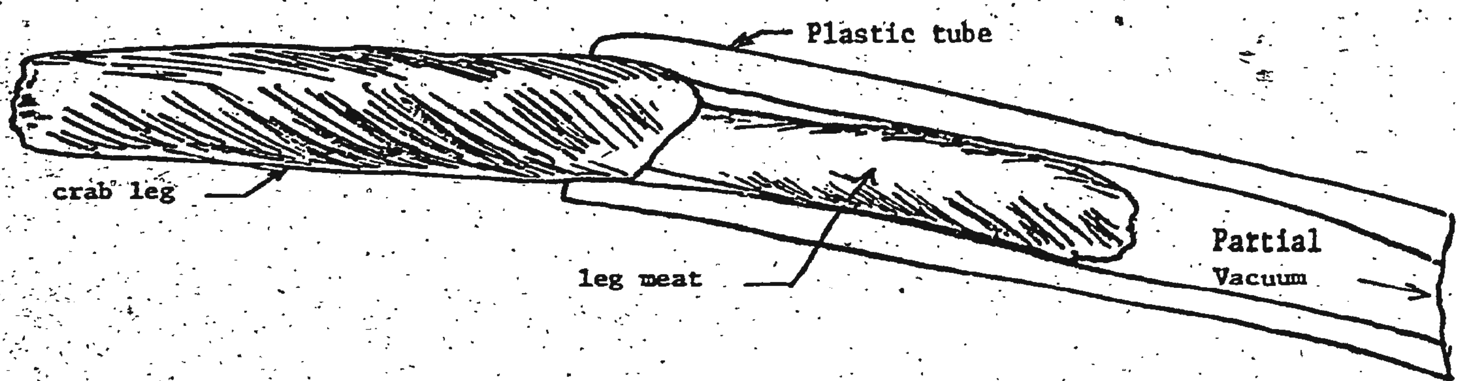


Figure 2:21 Vacuum sucking of meat from crab leg shell.

(<u>Taken from: Amaria, Research Report No. 5, Sept., 1974</u>)

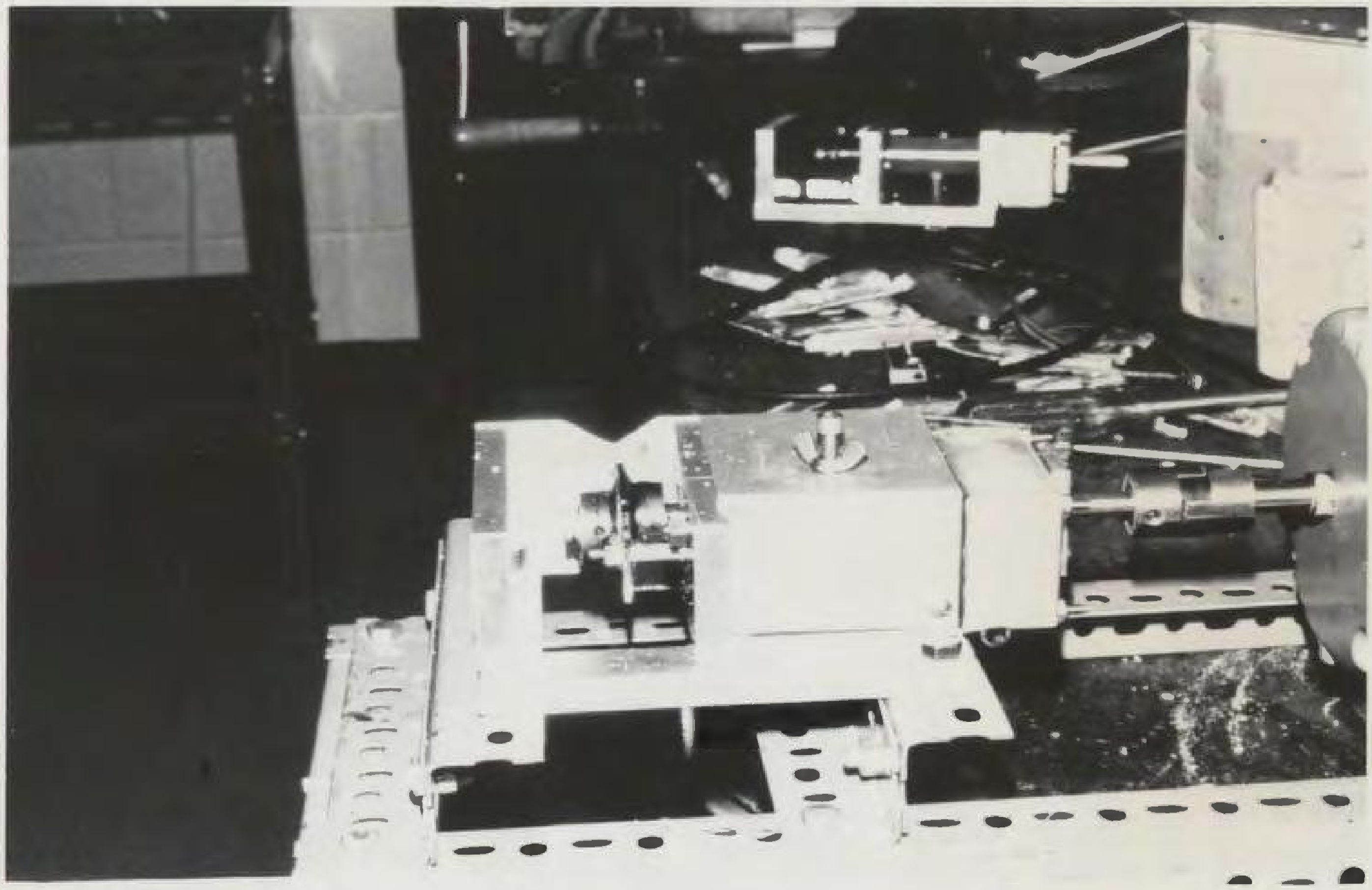


Figure 2:22 Crab leg slitting machine.

(NOTE: Production model)

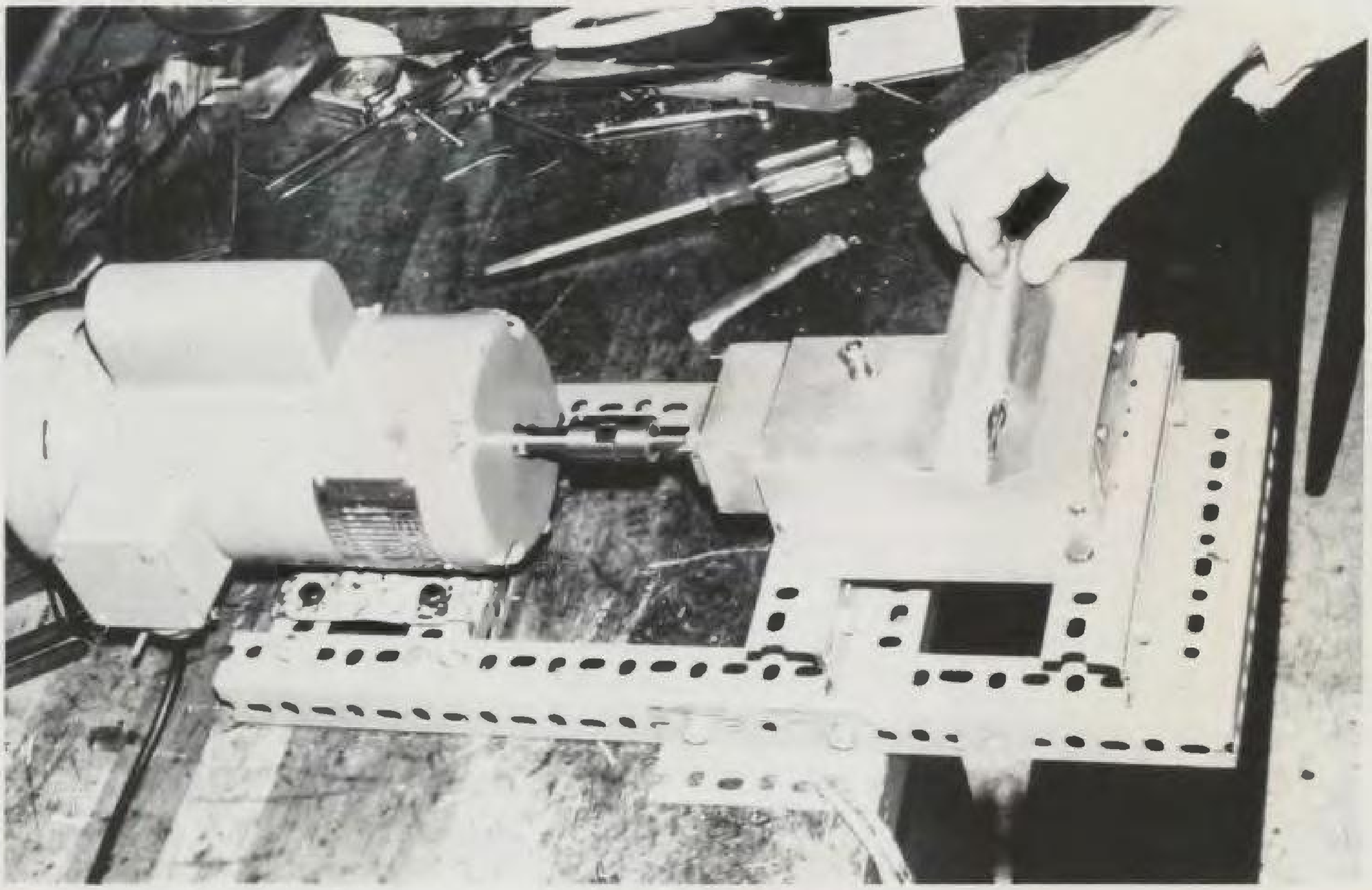


Figure 2:23 Crab leg slitting machine being fed with a crab leg.

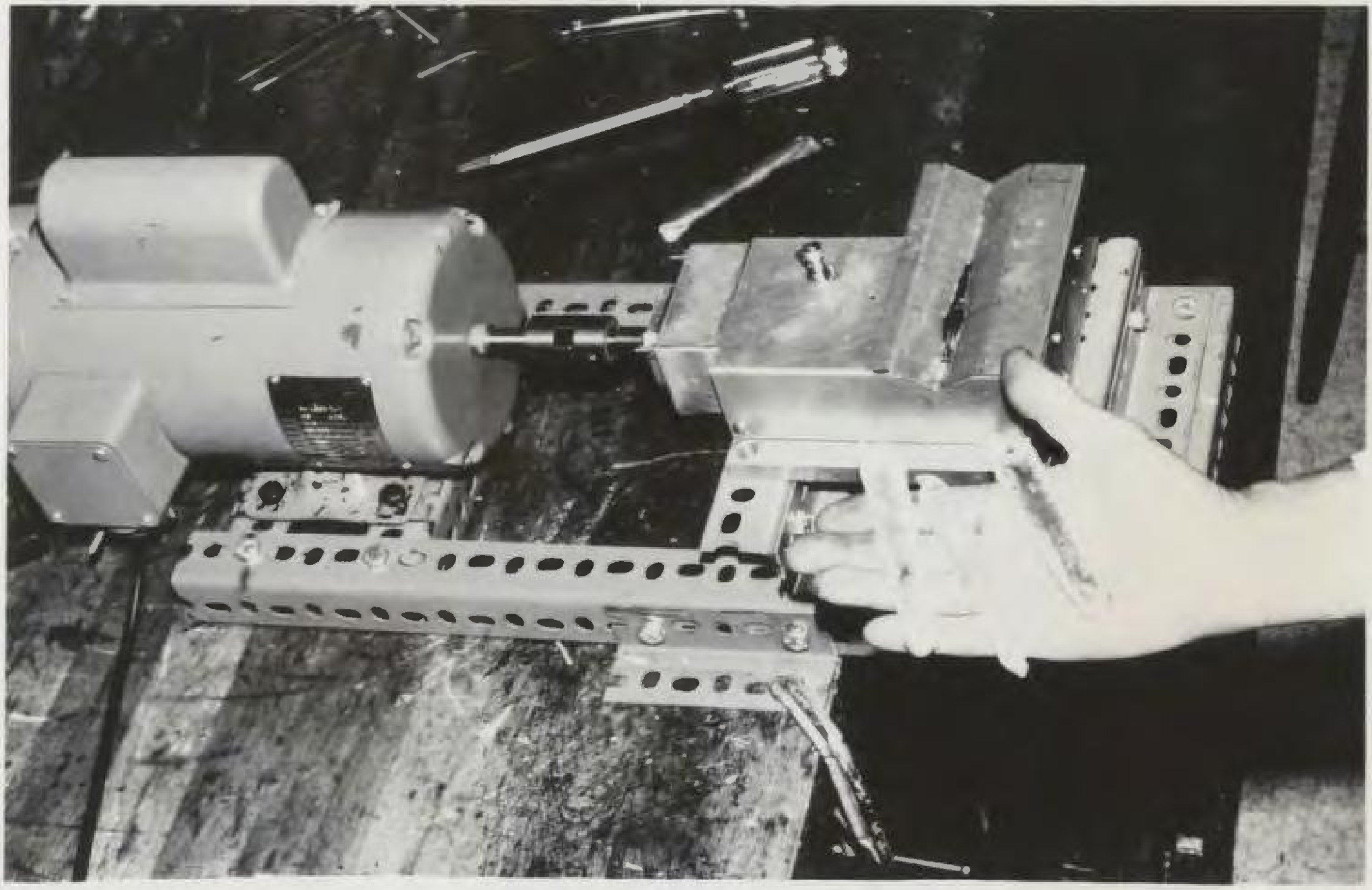
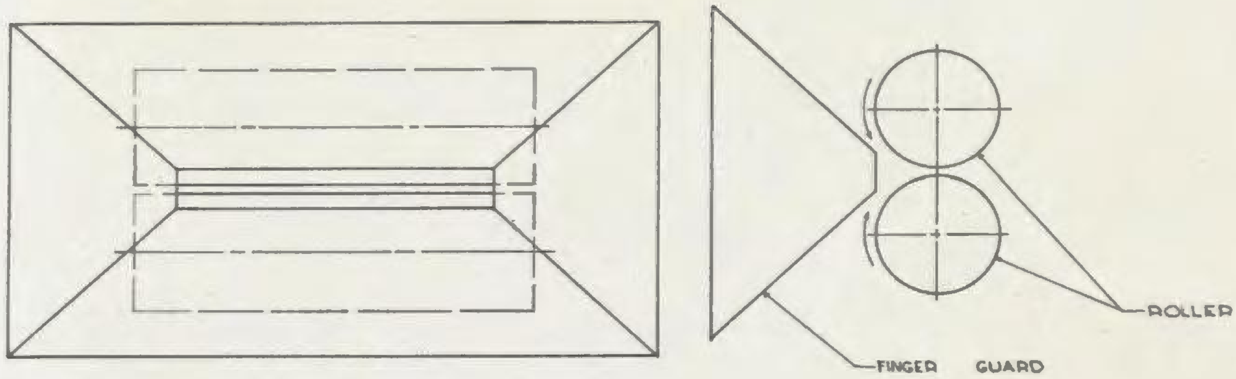


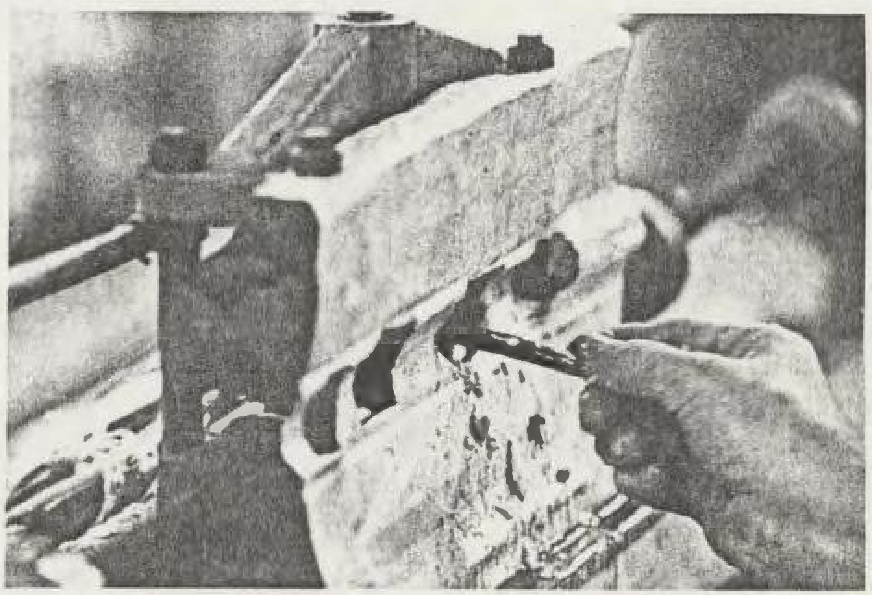
Figure 2:24 Results of slitting machine operation.

(NOTE: Both sides slit in this example)

Figure 2:25 Slitting machine in operation at Ship Cove and the removal of leg meat.

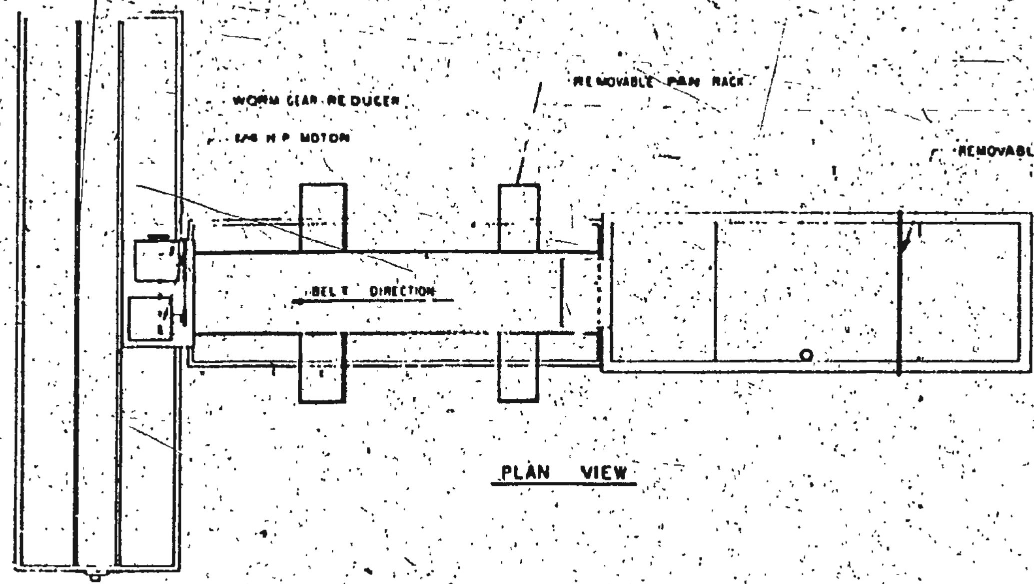


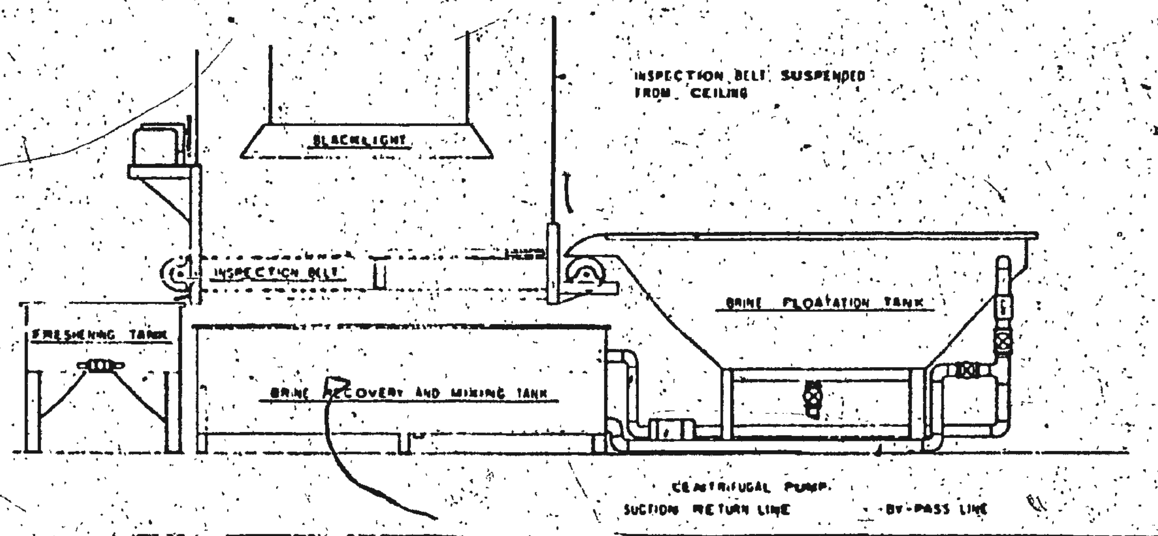
(Taken from: Holsen and McAllister, 1974)



(Taken from: "Fisheries of Canada," Feb., 1969)

Figure 2:26 Sketch of tip roller and rolling unit in actual operation.





(Taken from: Holmsen and McAllister, 1974)

Figure 2:27 Brine flotation system similar to that at the Valleyfield plant.

Figure 2:28 Weighing and packaging 5 lb. of crab meat at the Ship Cove plant.

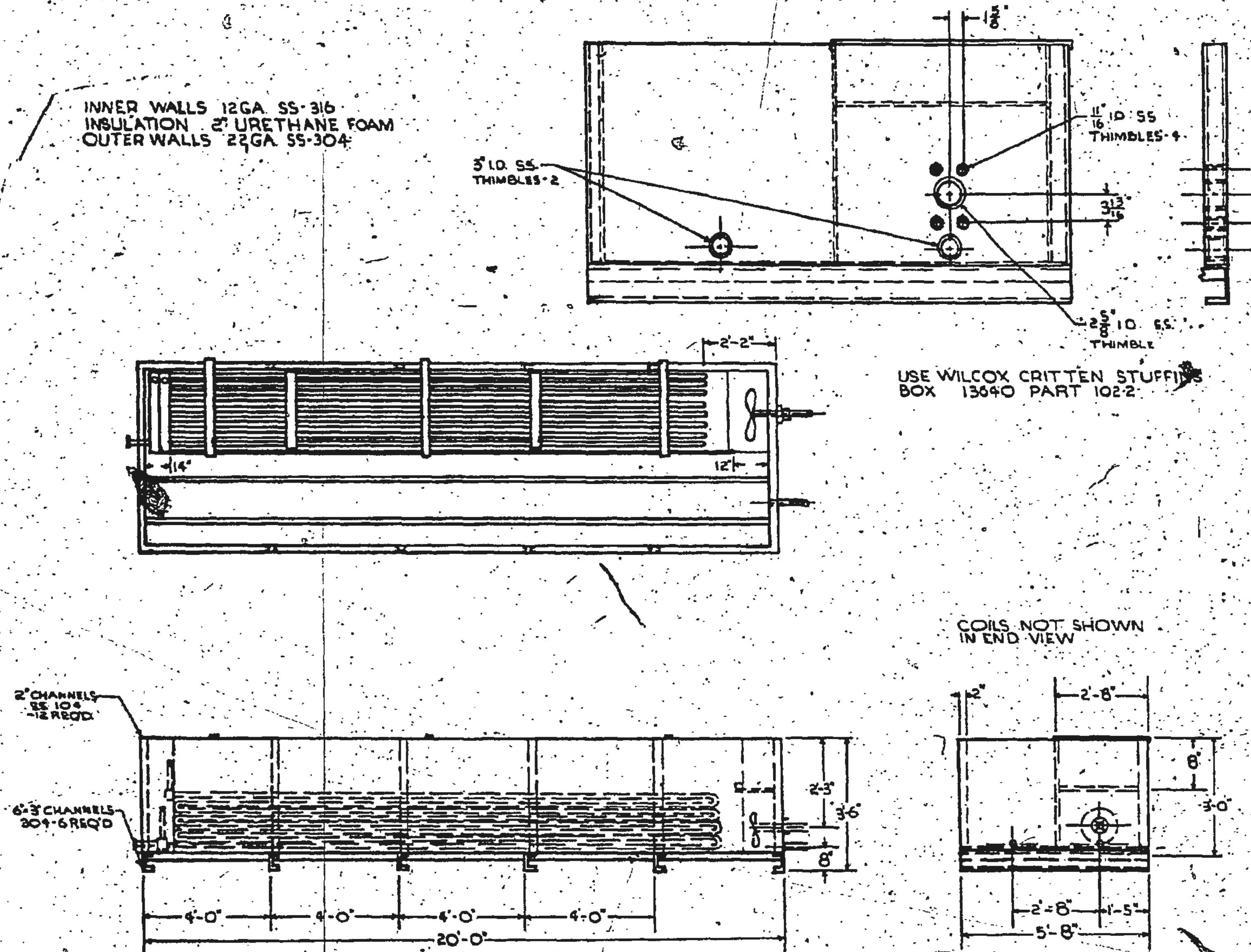


Figure 2:29 Brine freezer unit similar to those used at Ship Cove and at Valleyfield.

(Taken from: Holmsen and McAllister, 1974)

Chapter -3-

3:00 OBJECTIVES AND PURPOSES:

3:10 THE NEED FOR WORK STUDY IN A CRAB PROCESSING PLANT:

As stated earlier, the processing of Snow Crab meat is a very expensive enterprise. In 1974, the average yields of crab meat from the live crab varied between 20% to 25% in the Newfoundland plants. The price paid to the fishermen for these crab was fourteen to sixteen cents per pound depending on the distance the processing plant was from the fishing area. These facts result in an average cost of meat (does not include labour or overhead) to the processor of approximately 56 to 80¢ per pound. Coupled with this high raw material cost is the fact that a large amount of manual labour is necessary to extract the meat. For example, Ship Cove plant employed on an average shift in 1974, 87 workers and produced an average of 1,800 to 2,100 pounds of crab with an average cost for labour per pound of meat at 90¢ to $1.00.

With statistics such as these it is of the utmost importance that the management of the processing facility be concerned with the elimination of waste; ie. waste time, waste skill, waste material, waste capacity and waste movements. A reduction or elimination of any of these will result in an increase in productivity in their operations.

Because of the costs involved with crab processing, it is necessary that management of the plants use their efforts and skills to ensure that increases occur in the production per unit of time and consequently reduce the unit cost of the product produced. For management to analyze the operations in the plant it must be capable of understanding the human and physical limitations of the systems concerned. It must also be able to determine the potential of the existing systems and this can be done by studying the various work activities in the plant and making observations. Work standards must be found for the different work tasks.

There exists a need in some Newfoundland crab processing plants that this type of indepth job analysis and study be undertaken. Rates of output should be found and standards established for the existing layouts and improvements made which would help to increase production and improve working conditions.

A tool which has been used very successfully in many manufacturing and processing industries to increase productivity is Work Study. There are two components of Work Study:

(1) Method Study

(2) Work Measurement.

3:11 METHOD STUDY:

Method study is defined as:

"The systematic procedure for subjecting all direct and indirect operations to close scrutiny and introducing improvements resulting in making work easier to perform and allowing work to be done in less time and with less investment per unit" (Niebel, 1962).

This study is concerned with the work center where the product is produced and way in which it can be analyzed for reason of improvement.

3:12 WORK MEASUREMENT:

Work measurement is defined as:

"The application of techniques designed to establish the time for a qualified worker to carry out a specific job at a defined level of performance" (Work simplication course, College of Fisheries, 1974).

The work measurement is established after the method to conduct the task has been defined by a detailed analysis of operation. The time study or measurement will establish time standard for the job, it shall be based upon measurement of the work content for the particular methods used and shall make allowances for fatigue and personal and unavoidable delays.

A close association exists between the functions of the time study and the motion study. Although the objectives of both studies are different, motion analysis must be concluded before the time study should be attempted. Value of the time study will only accrue to the enterprise when the methods upon which the study is based are taught and enforced to the employees who shall be performing the task.

As stated above when the best method of performing the task is established then a time study can be undertaken. There are usually eight steps required for a sucessful time study, (Amaria, Research Report No. 1, 1974).

(1) Secure and record information about the operation and operators being studied.

(2) Divide the operation into elements and record a complete description of the method.

(3) Observe and record the time taken to perform the work by the operator.

(4) Determine the number of cycles to be timed.

(5) Rate the operators performance, (This is considered a very important factor in establishing standards).

(6) Check to make certain that a sufficient number of cycles have been timed.

(7) Determine the relaxation allowances.

(8) Determine the time standard for the operation. This shall be explained fully in section 3:312 of this chapter.

Before any operation or task can be properly studied, the concept of the endeavor must be thoroughly understood. The purposes for the scheme and the desired final results must be known. After an appreciation of the task is noted, then a complete description of all the operations called the "elements" of that activity are listed. The shorter the elements of the job are made the closer examination can become and better shall be the results of the overall time study.

When the time study is undertaken, measurements of the actual time to perform the various tasks have to be observed. This recording must be done by a watch of some sort and the introduction of such a device into the job situation must be fully explained to all those involved. This would include the plant management, the workers and/or worker representatives. All three should be brought together and discuss the object of the study and how the resulting information can be useful to both the workers as well as management.

As the time study is to be undertaken by properly trained personnel, careful attention will be given to the number of cycles which will give data that is indicative of that job. The times required to perform the elements of the operation is expected to vary slightly from cycle to cycle, but the trained study man shall be confident that the information gathered shall be representative of the job situation. The study must analyze in some detail what allowance must be given from work time lost due to delays caused by breakdown of equipment or from outside uncontrolable forces. Fatigue which the operator experiences due to the complexity of his task has also to be noted and a reasonable human allowance made.

When the elements of the operation are under study, the analyst must compare the workers performance with his own concept of a normal performance. Because of this dimension to the time study, the observer has to be highly trained such that his interpretation of a normal performance is correct. Basically, the idea of a fair days pay for a fair days work has to be understood as it underlies the whole work study approach to a job analysis. It has become the accepted standard that a 100% performance is equivalent to a speed of walking 3 miles per hour or dealing a pack of cards into 4 equal piles in thirty seconds. If a worker performs at such a pace then he should conceivably be working at a level which he can maintain during the work period and his output shall be what his employer can reasonably expect. These bench marks have sucessfully been used in many manufacturing companies in Europe, North America and Japan.

3:20 PREDETERMINED TIME SYSTEMS:

Broadly speaking a predetermined time system can be defined as a standardization of times required to perform basic human motions. These systems were based upon tested scientific principals when it was established using statistical mathematical research that variations in the times required to perform the same motions are small for different people when they have had adequate practice.

The following is a refined explanation or definition of a predetermined time system.

"A predetermined time system is an organized body of information, procedures and techniques employed in the study and evaluation of work elements performed by human power in terms of the method or motions used, their general and specific nature, the conditions under which they occur and the application of predetermined times which their performances require" (Karger and Bayha, 1965).

There have been a number of such systems developed since the discovery of the mathematical relationships between motions and time in a statistical manner. However, in this report the most widely applied system is used. It is the Methods Time Measurement (M.T.M.) and was developed in the United States and first published in 1948. It was developed at Methods Engineering Council, Pittsburg, Pennsylvania, by Messrs. Harold B. Maynard, Gustave J. Stegemerten and John L. Schwab and was based on extensive motion picture studies of work activities at the Westinghouse Electric Corporation.

This system is a procedure which analyzes any manual operation or task into basic motions which are required to perform it and assigns to each motion a predetermined time standard which is based on the nature of the motion and the conditions under which it is performed.

A unit of time used with this system is called the Time Measurement Unit or TMU is equivalent to one hundred thousand of an hour:

Thus, 1 T.M.U. = .0001 hr.

1 T.M.U. = .006 minutes.

1 T.M.U. = .036 seconds.

The basic motions considered by this system are:

(1) Reach: The basic hand or finger motion employed when the predominant purpose is to move the hand or the fingers to a destination.

(2) Turn: The basic motion employed to rotate the hand about the long axis of the forearm.

(3) Move: The basic hand or finger motion employed when the predominant purpose is to transport an object to a destination.

(4) Crank: The motion employed when the hand follows a circular path to rotate an object with the forearm pivoting at the elbow and the upper arm essentially fixed.

(5) Apply pressure: An application of muscular force to overcome object resistance accompanied by little or no motion.

(6) Grasp: The basic finger or hand element employed to secure control of an object.

(7) Release: The basic finger or hand motion employed to relinquish control of an object.

(8) Position: The basic finger or hand element employed to align, orient and engage one object with another to attain

a specific relationship.

(9) Disengage: The basic hand or finger element employed to separate one object from another where there is a sudden ending of resistance.

(10) Eye motions and allied topics: Eye travel and eye focus are the only two actions of which the eyes are capable in work performances. Eye focus is defined as:

"The basic visual and mental element of looking at an object long enough to determine a readily distinguishable characteristic.

(11) Body, leg and foot motions: These motions are those which relate to the movement of the human body other than the hands and the arms. Time measurement units are allocated for body turning, foot and leg movements, walking and other positions which the body can assume in the completion of a particular manual task.

3:30 RATING SYSTEM EMPLOYED IN THIS REPORT:

There are a number of rating systems which are available and which could be used in this type of report. However, the most widely used system of rating namely "Performance Rating" has been adopted. Using this system a single factor is rated which is the operators speed, pace or tempo. The rating factor is usually expressed in percentage or in points per hour. For this report the normal performance is expressed as 100% (three miles per hour) and the workers studied were rated above or below this standard.

As previously stated the job analyst must be a highly trained person as the results of the study depend on his judgement. The training of these persons is done in such a manner that there exists a near uniformity of a normal performance. This fact makes possible the establishment of a consistent standard for all time study work.

3:31 ESTABLISHING WORK STANDARDS USING THE PERFORMANCE RATING SYSTEM:

When the rating of the task has been established, then a normal time and finally a standard time can be calculated for the job involved.

A normal time is the time to perform a job when working at a normal pace. Normal pace is defined as:

"The effective rate of performance of a conscientious, self-paced, qualified employee when working neither fast nor slow and giving due consideration to the physical, mental or visual requirements of the specified job". (Niebel, 1962)

In equation, normal time is as follows:

$$\text{Normal time} = \frac{\text{Actual time x observed rating}}{\text{Normal rating}} \quad \ldots\ldots\ldots \; 3:1$$

(a) Actual time is the stop watch value recorded for the work period.

(b) Observed rating is the average of the ratings made by the analyst during the work period.

(c) Normal rating is established as 100%.

A standard time can be established when the relaxation allowances are considered for the particular job. Standard time is defined as:

"The time required for an average operator fully qualified and trained and working at a normal pace to perform the operation". (Niebel, 1962).

The average worker has to be allowed relaxation allowances.

In equation form standard time is expressed as:

$$\text{Standard time} = \text{Normal time} \times \frac{100}{100 - \text{Percentage allowances}} \quad \ldots 3{:}2$$

(a) Percentage allowance is established by the time study analyst for the particular job under observation.

There are three types of allowances of time which can cause interruptions to production and they may be classified as follows: (1) Personal allowances, (2) Fatigue allowances, or (3) Delay allowances.

3:32 PERSONAL ALLOWANCE:

A worker on a particular job shall be allowed time to attend to his personal needs. The amount of this allowance will be dependent on the individual more than on the type of work involved, but it is a fact that employees need more personal allowance when the work is heavy and done under unfavourable conditions such as hot humid atmosphere. For light work, the average person working 8 hours per day without organized rest periods will require 2 to 5% (10 to 24 minutes) per day for personal allowance (Barnes, 1966).

3:33 FATIGUE ALLOWANCE:

As technological advances have taken place in the construction of factories and in the amount and types of materials handling equipment used, fatigue has been greatly reduced. Fatigue is the result of mental and physical exertion and where intense activity is required for the performance of a job then allowances must be made.

In most companies the best solution to the problem of fatigue allowance is to provide organized rest periods during which no employee is permitted to work. These periods usually occur once during the morning work period and once during the afternoon period and they can vary in length from 5 to 15 minutes depending upon the nature of the work.

3:34 DELAY ALLOWANCE:

Unavoidable delays caused by the machine, the operator or some outside force can occur during the work period and these must also be realized in calculation of the standard time for the task. The length of this kind of allowance can be determined from deducted time studies to ascertain exactly the extent of the interruption.

Figure 3:1 is the type of list of personal and fatigue allowances which can be made for particular plant operations. A table such as this can be used for the determination of allowance in jobs of similar physical or mental activity.

The normal and standard outputs of a workers activity can be determined when the rating of the task has been determined and the respective normal and standard times known.

$$\text{Normal output} = \frac{\text{Sample weight}}{\text{Normal time}} \quad \ldots\ldots\ldots\ldots \quad 3:3$$

$$\text{Standard output} = \frac{\text{Sample weight}}{\text{Standard time}} \quad \ldots\ldots\ldots\ldots \quad 3:4$$

3:40 OBJECTIVE STATEMENT:

With the background provided above, this report shall compare:

(1) Predetermined times with normalized times for various processing operations in the two crab plants studied.

(2) Standard times for the various processing operations studied shall also be compared.

(3) Production yields in both plants due to the differences in processing techniques used.

(4) Recommendations shall be made for further improvements in job layout and methods for utilization of equipment.

(5) Propose an incentive payment system for processing crab, based on standard output rates and yield.

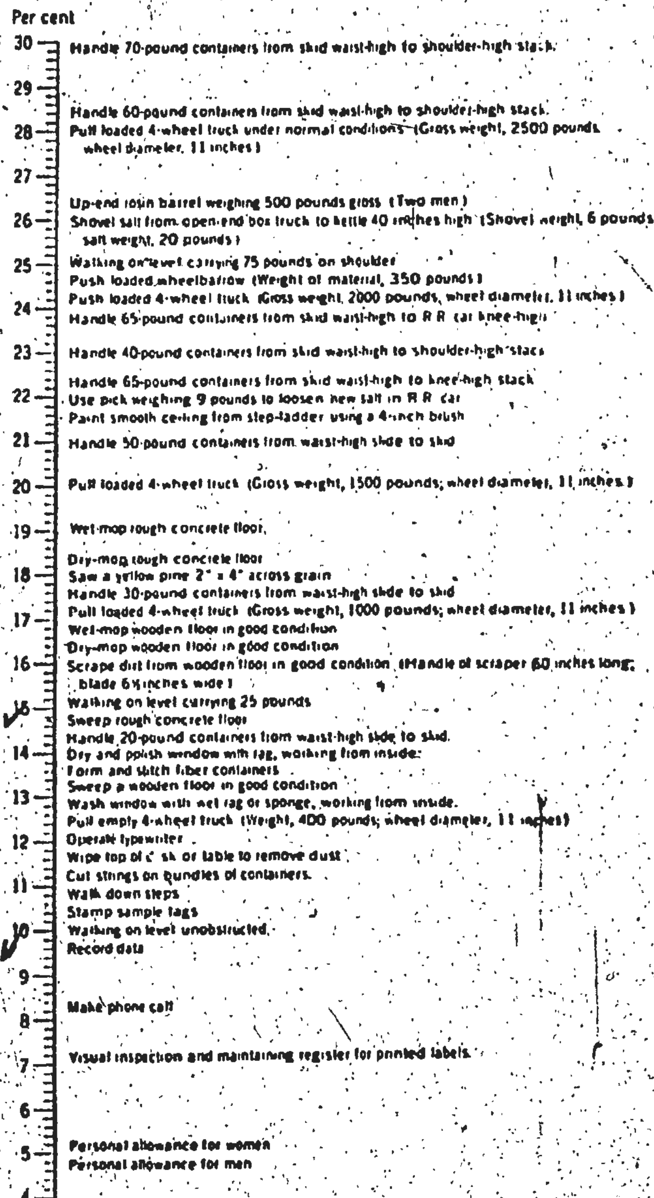


Figure 3:1 Personal and Fatigue allowance charge for a particular plant operation.

(Taken from: Barnes, 1968)

4:00 PROCEDURE:

4:10 GENERAL:

When the project was formulated, management of each plant was contacted and their assurance of assistance and co-operation was provided. The inplant production staff was also consulted in the plants and it was through these peoples' efforts that the workers on the floor of the plants became aware of the tests and their significance.

With the use of motion and still photographic equipment all the operations in the two plants were recorded on film for later consideration. The Methods, Time, Measurement study of the various operations in the plants was done from the motion pictures taken at the plants. Performance ratings were conducted while the various operations were performed.

4:20 SPECIFIC INPLANT PROCEDURES FOLLOWED:

Figure 2:13 is a operational chart for the Ship Cove plant. A list of these operations is as follows:

(1) Holding of live crab.

(2) Butchering, degilling and washing of live crab.

(3) Cooking crab sections - (Continuous Method).

(4) Cooling crab sections - (Batch Method).

(5) Divide cooked and cooled sections into: (a) Tips and small legs, (b) Claw legs with claws, (c) Shoulder, large legs and knuckles.

(6) (1) Shuck meat from knuckles and shoulders of the section; then (2) break the large legs from the shucked shoulder shell and finally (3) place the large legs and all shucked knuckle and shoulder shells into separate pans.

(7) Shuck claw and claw leg.

(8) Slit large crab legs, one side only.

(9) Remove leg meat from slit legs.

(10) Roll legs tips to remove meat.

(11) Roll small legs to remove meat.

(12) Weigh output from each shucker.

(13) Black light inspection of broken meat.

(14) Washing and brine dipping of broken meat.

(15) Weigh whole legs and shoulder meat for packing.

(16) Packing of 5 lb. of 'Combination Pack' (40% whole leg meat, 60% broken meat) for freezing.

(17) Freezing of fresh crab meat.

(18) Packing of frozen crab meat.

(19) Cold storage of frozen crab.

From Figure 2:12, for the Valleyfield plant, the list of the operations is as follows:

(1) Holding of live crab.

(2) Butchering, degilling and washing of live crab.

(3) Cooking crab sections - (Batch Method).

(4) Cooling crab sections - (Batch Method).

(5) Weigh cooked sections for the shuckers.

(6) Shuck shoulders, legs, knuckles, claw and claw legs.

Remove tips and small legs.

(7) Roll combined tips and small legs to remove meat.

(8) Weigh output of each individual shucker.

(9) Black light inspection of broken meat.

(10) Washing and brine dipping of broken meat.

(11) Weigh whole legs and shoulder meat for packing.

(12) Freezing or canning of fresh crab meat.

(13) Packaging of finished crab product.

(14) Cold storage of frozen crab or dry storage of canned crab meat.

The operations at the two plants can be presented on flow process chart which shows the flow of materials and men through a given process. This can present more detailed information then can the operation process chart. The information can be shown on the charts using the following symbols:

(1) ○ - denotes an operation.

(2) ⇨ - denotes transportation or movement.

(3) ◇ - denotes an inspection.

(4) D - denotes a delay.

(5) ▽ - denotes a permanent storage.

Figures 4:1 and 4:2 are flow process charts for Ship Cove and Valleyfield plants respectively.

4:21 <u>SHIP COVE</u>:

The operations which were studied both by Methods, Time, Measurement, (M.T.M.) analysis and by Time Study are:

(2) Butchering, degilling and washing of live crab.

(5) Divide cooked and cooled sections into (a) Tips and small legs, (b) Claw legs with claws, (c) Shoulder, large legs and knuckles.

(6) (1) Shuck meat from knuckles and shoulders of the section; then (2) Break the large legs from the shucked shoulder shell and finally (3) Place the large legs and all shucked knuckle and shoulder shells into separate pans.

(7) Shuck claw and claw leg.

(8) Slit large crab legs one side only.

(9) Remove leg meat from slit legs.

(10) Roll leg tips to remove meat.

(11) Roll small legs to remove meat.

(16) Packaging of 5 lbs. of "Combination Pack" (40% whole leg meat, 60% broken meat) for freezing.

Motion pictures were taken of these operations and later analyzed by the M.T.M. method. To obtain the necessary data for calculating the normal and standard outputs and times for the various operations it was necessary that the actual amounts of work done in a period of time be known. To determine this work done, amounts of whole crab or crab parts (as the particular job required) were weighed and provided to the person being rated and the actual time to do this quantity of work was recorded by the use of stop watch. Several times during the work period, performance rating of the worker was taken.

To calculate the yields of desirable product during these activities the worker's output was also weighed. The yields of continuous cooking was investigated by weighing sections into and out of the unit and calculating the yields.

4:22 VALLEYFIELD:

The operations which were studied both by Methods, Time, Measurement (M.T.M.) analysis and by Time Study are:

(6) Shucking of shoulders, large legs, knuckles, claws and claw legs. Removal of tips and small legs.

(7) Rolling combined tips and small legs to remove meat from shell -(yield test conducted only).

(3) Cooking Batch Method -(yield tests conducted only).

As noted earlier there are differences between the operations of the Valleyfield and Ship Cove plants. The major difference in work methods between the two, however, lies in the methods of shucking of the crab sections. At Valleyfield, the same person is required to shuck all the various parts of the crab sections with the exception of the tips and the small legs. The shuckers total daily output is recorded and a bonus is paid on the workers individual performance. At the Ship Cove plant, the section is broken into components and only the shoulders and claw legs with claws are shucked by traditional manual methods. The leg meat is extracted manually, but only after the leg shell has been cut by the slitting machine. The tips and small legs are rolled to extract the meat by the same method as used at Valleyfield.

Motion and still pictures were taken of the operations at Valleyfield and the M.T.M. analysis was done later. During the inplant tests, performance ratings were taken for the operations studied. The same procedure for testing was followed here as was done at Ship Cove with the actual times recorded for the completion of a known amount of work.

The yield of the batch cooker was also tested and compared to that of the continuous cooker at Ship Cove.

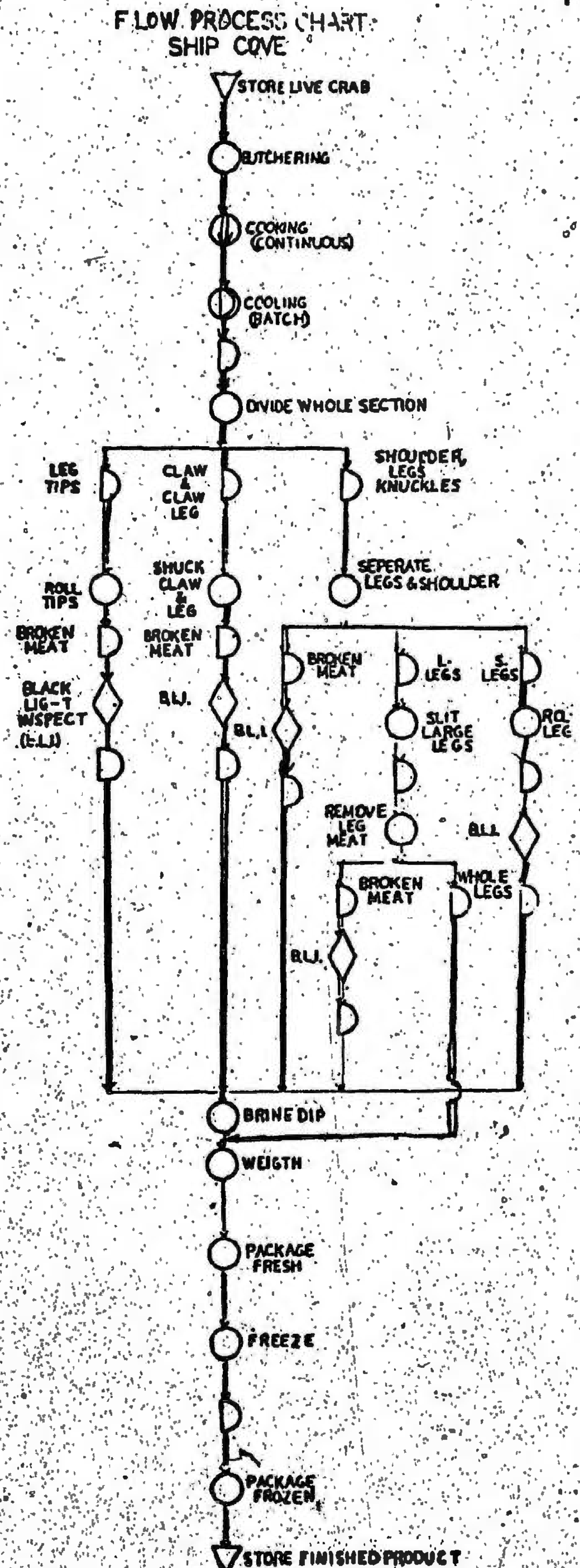

FLOW PROCESS CHART
SHIP COVE
STORE LIVE CRAB
BUTCHERING
COOKING (CONTINUOUS)
COOLING (BATCH)
DIVIDE WHOLE SECTION
LEG TIPS
CLAW & CLAW LEG
SHOULDER, LEGS KNUCKLES
ROLL TIPS
SHUCK CLAW & LEG
SEPERATE LEGS & SHOULDER
BROKEN MEAT
BROKEN MEAT
BROKEN MEAT
L. LEGS
S. LEGS
BLACK LIG-T INSPECT (B.L.I.)
B.L.I.
B.L.I.
SLIT LARGE LEGS
ROL LEG
REMOVE LEG MEAT
B.L.I.
BROKEN MEAT
WHOLE LEGS
B.L.I.
BRINE DIP
WEIGTH
PACKAGE FRESH
FREEZE
PACKAGE FROZEN
STORE FINISHED PRODUCT

FIGURE 4:21

FLOW PROCESS CHART
VALLEYFIELD

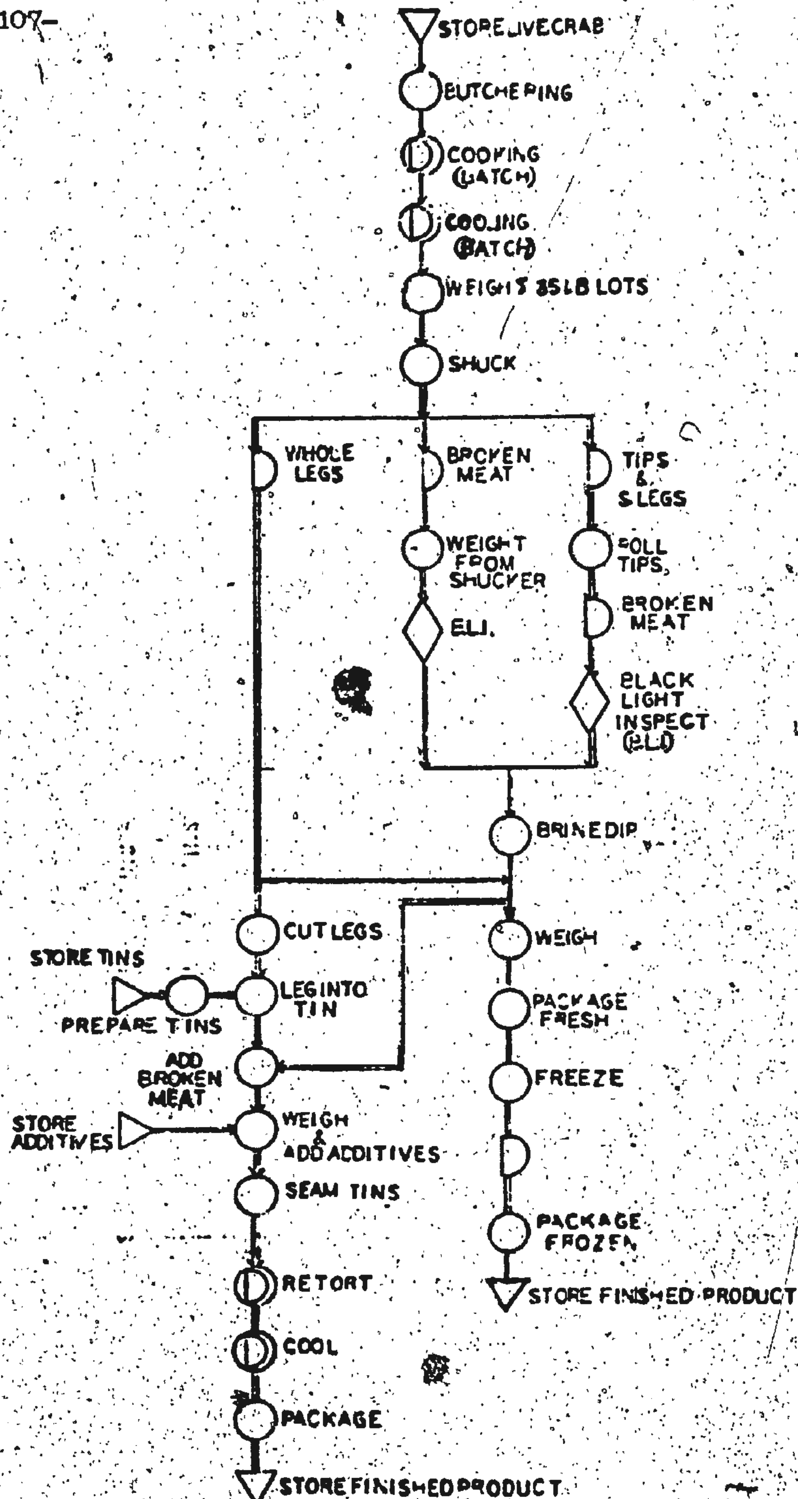


FIGURE: 4:2

GENERAL NOTE ON TEST RESULTS CONTAINED IN CHAPTER 5

At the Ship Cove and Valleyfield plants the raw material used for testing purposes was judged by the particular staff to be representative of actual plant operations.

A worker's performance ie. his speed of movement can be rated by comparing his effort to a standard. Rating, however, is a matter of judgement on the part of the time study analyst. There is no way to establish a time standard for an operation without the judgement of the analyst entering into the process. Mr. Surinda Sarna, an Engineering Graduate Student at Memorial University, did the performance ratings in both plants. His work was supervised by Professor Pesi Amaria of Memorial University. Both gentlemen have had considerable experience in work study analysis.

Both Time Study and M.T.M. techniques level a worker's performance to achieve a standard which can be adopted for the work layout under consideration. Using these systems, the same work results should occur if there were no differences in the skill and effort of the operators.

By using raw material in these tests which is indicative of actual in-plant situations and employing leveling techniques, then the results obtained can be considered reasonable for the various work layouts used.

5:00 RESULTS:

5:10 SHIP COVE - OCEAN HARVESTERS LTD.:

5:11 INTRODUCTION:

Section 4:21 lists the various operations which were analyzed at this plant using M.T.M. and Time Study techniques. The data collected during that analysis is now presented.

5:12 TIME STUDY RESULTS; Ship Cove:

5:121 BUTCHERING, DEGILLING AND WASHING OF LIVE CRAB; (Operation No. 2, Ship Cove):

Figure 2:14 shows a portion of the butchering operation at the plant. The work was performed on a specially constructed table which incorporated the following features:

(1) An input belt which brought the live crab to the operations.

(2) Cleaning wheels which had nylon bristles in a wooden core and revolved at approximately 1700 RPM.

(3) An anvil as shown in Figure 2:14 on which the animals were broken.

(4) A discharge conveyor which transported the processed sections to the cooker.

DATA FROM OPERATION

(a) Weight of whole live crab = 80 lbs. (test sample).

(b) Actual time to butcher test sample = 7 min. - 45 sec.

= 7.8 min.

5:00 RESULTS:

5:10 SHIP COVE - OCEAN HARVESTERS LTD.:

5:11 INTRODUCTION:

Section 4:21 lists the various operations which were analyzed at this plant using M.T.M. and Time Study techniques. The data collected during that analysis is now presented.

5:12 TIME STUDY RESULTS; Ship Cove:

5:121 BUTCHERING, DEGILLING AND WASHING OF LIVE CRAB; (Operation No. 2, Ship Cove):

Figure 2:14 shows a portion of the butchering operation at the plant. The work was performed on a specially constructed table which incorporated the following features:

(1) An input belt which brought the live crab to the operations.

(2) Cleaning wheels which had nylon bristles in a wooden core and revolved at approximately 1700 RPM.

(3) An anvil as shown in Figure 2:14 on which the animals were broken.

(4) A discharge conveyor which transported the processed sections to the cooker.

DATA FROM OPERATION

(a) Weight of whole live crab = 80 lbs. (test sample).

(b) Actual time to butcher test sample = 7 min. - 45 sec.
= 7.8 min.

(c) Average observed performance rating = 118.1.

(d) Weight of crab section obtained from test sample of live crab = 53 lbs.

CALCULATIONS

(1) Normal time $= \frac{\text{Actual time x observed rating}}{\text{Normal rating}}$

$$= \frac{7.8 \times 118.1}{100}$$

= 9.2 minutes, for 80 lb. test sample.

(2) Normal output (live crab) in pounds per hour

$$= \frac{\text{Sample weight x 60}}{\text{Normal time}}$$

$$= \frac{80 \times 60}{9.2}$$

= 521 lbs. (live crab)/hr.

(3) Normal output (butchered sections) pounds per hour

$$= \frac{\text{Output x 60}}{\text{Normal time}}$$

$$= \frac{53 \times 60}{9.2}$$

= 345 lbs. (butchered sections)/hr.

For the calculations of standard times, output allowances must be considered. Sections 3:32 to 3:34. inclusive discussed allowances for particular jobs. For this particular operation, a total of 13.5 was used, (Barnes, 1968).

(4) Standard time = Normal time x $\frac{100}{100 - \text{percentage allowance}}$

$$= 9.21 \times \frac{100}{100 - 13.5}$$

$$= \frac{9.21 \times 100}{86.5}$$

= 10.6 minutes, for 80 lb. test sample.

(5) Standard output (live crab) in pounds per hour.

$$= \frac{\text{Sample weight} \times 60}{\text{Standard time}}$$

$$= \frac{80 \times 60}{10.6}$$

= 452 lbs. (live crab)/hr.

(6) Standard output (butchered sections) pound per hour.

$$= \frac{\text{Sample weight} \times 60}{\text{Standard time}}$$

$$= \frac{53 \times 60}{10.6}$$

= 300 lbs. (butchered sections)/hr.

The yield of the operation is important.

(7) Yield of sections as a percentage of whole live weight.

$$= \frac{\text{Output (butchered sections)}}{\text{Input (live whole crab)}} \times 100\%$$

$$= \frac{53}{80}$$

= 66.3% of live crab.

SUMMARY OF RESULTS: Butchering, degilling and washing of live crab (Operation No. 2, Ship Cove).

Normalized results	Standardized results	Yield Output weight to input test sample weight of live crab
1. Time = 9.2 min. (test sample).	1. Time = 10.6 min. (test sample).	
2. Output live crab = 521 lbs/hr.	2. Live crab = 452 lbs/hr.	66.3%
3. Output butchered raw sections = 345 lbs/hr.	3. Butchered sections = 300 lbs/hr.	

5:122 COOKING CRAB SECTIONS (CONTINUOUS METHOD); (Operation No. 3, Ship Cove):

Figure 2:17 shows the continuous cooker used at Ship Cove. This unit was insulated to reduce heat loss from the cooking water. It was equipped with both a direct steam injection system and a continuous steam coil which was used after the cooking water had been brought up to the desired temperature of 212 degrees F. by using the direct steam.

DATA FROM OPERATION

(a) Weight of uncooked sections

= 53 lbs. (test sample)

(b) Cooking time

= 9 min. - 32 sec.

= 9.53 min.

(c) Weight of cooked sections

= 46.5 lbs.

(d) Percentage yield

$$= \frac{46.5}{53} \times 100\%$$

= 87.74%

NOTES: (1) The belt speed in the cooker is adjusted to provide a cooking time of seven minutes. However, during a production operation the belt is filled with sections and some are forced to float in the cooking water carried along by the movement of the water as the belt travels through the cooker. This can cause delays with the sections moving through the cooker especially if there is a strong boiling action in the cooker. This explains the cooking time of 9.53 min. for this experiment. Sections in the sample were tagged and the average of their times to move through the cooker was used.

(2) There is a loss of material in the continuous cooker. If the section floats itself or is forced off the belt as explained above, some sections may be trapped in the eddy effect of the boiling water. These sections remain in the cooker for extended periods of time and become spoiled by over cooking. This problem is solved by the batch cooker as the sections are enclosed in wire cage boxes and cannot escape into the cooker itself.

5:123 <u>DIVIDE COOKED SECTIONS INTO (A) TIPS AND SMALL LEGS, (B) CLAW LEGS WITH CLAWS AND (C) SHOULDER, LARGE LEGS AND KNUCKLES; (Operation No. 5, Ship Cove)</u>:

Figure 2:17 shows this operation in progress. After the sections were cooked and cooled, they were divided into their various portions. These pieces were then placed in tote pans for distribution to the areas in the plants where the actual extraction techniques were used.

DATA FROM OPERATION

(a) Weight of cooked and cooled sections

= 20 lbs. (test sample)

(b) Actual time to divide test sample

= 4 min. - 13 sec.

= 4.2 min.

(c) Average performance observed rating factor

= 113

The calculations of the normal times and outputs were performed in the same manner as for the butchering operation. For the establishment of standards, the allowance percentage was lowered because this job was considered easier than the butchering of the animals. The calculations for the standard time and output was also similar to those done in section 5:121. For this reason, the actual computation shall not be presented here, but rather a summary of the results obtained.

NOTE: The allowances for this operation was increased to 13%; (Barnes, 1968) The method of extracting the meat from the shoulder requires the knocking of the shoulder shell against the side of the meat holding pan.

SUMMARY OF RESULTS: Divide cooked sections into (a) Tips and small legs, (b) Claw legs with claws and (b) Shoulder, large legs and knuckles; (Operation No. 5, Ship Cove):

Normalized results	Standardized results
1. Time = 4.7 min. (test sample)	1. Time = 5.3 min. (test sample).
2. Output crab section in shell = 252 lbs./hr.	2. Output crab section portions = 227 lbs./hr.

5:124 SHUCK MEAT FROM KNUCKLES AND SHOULDERS OF THE SECTION; (2) BREAK THE LARGE LEGS FROM THE SHUCKED SHOULDER SHELL AND (3) PLACE THE LARGE LEGS AND ALL SHUCKED SHELLS INTO SEPARATE PANS; (Operation No. 6, Ship Cove):

Figure 2:19 shows this operation in progress at the Ship Cove plant. This type of shucking was done by a number of workers who worked on only this type of crab section. These practices enabled the workers to improve their techniques for the job.

DATA FROM OPERATION

(a) Weight of sections complete (shoulder, knuckles, all legs and claw)

= 20 lbs. (test sample)

(b) Actual time to shuck and divide test sample

= 19 min. - 31 sec.

= 19.50 sec.

(c) Average observed performance rating factor

= 107.5

(d) Weight of meat from shoulder and knuckles

= 3.0 lbs.

(e) Weight of small legs on section

= 0 lbs. - 10 oz.

(f) Weight of large legs on section

= 8 lbs. - 3.25 oz.

Again since the calculations of the normalized and standardized times and output were the same as those done previously, only the summaries shall be presented. The percentage allowance taken for this operation was 13% (Barnes, 1968).

SUMMARY OF RESULTS: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder shell and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6, Ship Cove):

Normalized results	Standardized results	Yield: output weight of section components to input test sample weight of whole section
1. Time = 20.9 min. (test sample).	1. Time = 24.1 min. (test sample).	1. Meat from shoulders and knuckles = 15% of test sample.
2. Output section in shell = 57.3 lbs./hr.	2 Output sections in shell = 50 lbs /hr.	2. Large legs in shell = 41 % of test sample.
3 Output of meat from shoulder and knuckle = 8.6 lbs./hr.	3. Output meat from shoulder and knuckle = 7.5 lbs./hr.	3. Small legs in shell = 3.1% of test sample.
4. Output small legs = 1.9 lbs./hr.	4. Output small legs = 1.7 lbs./hr.	4. Empty shoulder shell = 28.6% of test sample.
		5. Waste, knuckles and tendons = 12.3% of test sample.
		Yield
		1. Total weight of meat to section weight = 33.9 %.
		2. Total weight of meat to live crab weight = 19.7%

SUMMARY OF RESULTS: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder shell and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6, Ship Cove):

Normalized results	Standardized results
5. Output large legs = 20.4 lbs./hr.	5. Output large legs = 20.4 lbs./hr.

5:125 <u>DESHELLING OF SHOULDER SHELLS AFTER THE MANUAL SHUCKING WAS PERFORMED</u>:

Appendix A contains detailed descriptive literature on the Baadar 694 bone separating machine. This unit was originally designed for the removal of bones from demersal fish species, but it was used at Ship Cove for the separation of crab meat from the shoulder portion of the crab section.

The product obtained from this machine using a drum containing 3 m.m. holes was of a fine paste like nature. It was packed separately as a minced crab meat. A lower price was obtained by the plant for this product, but the process did increase the overall yield of crab meat.

<u>DATA FROM OPERATION</u>

(a) Weight of shoulder shells

= 5 lbs. - 11.5 oz. (test sample)

= 5.72 lbs.

(b) Weight of meat obtained from meat separator

= 3 lbs. - 3.5 oz.

= 3.22 lbs.

(c) Yield of meat from test sample

$$= \frac{3.22}{5.72} \times 100\%$$

$$= 56.3\%$$

5:126 SHUCK CLAW AND CLAW LEG:

Figure 2:18 shows the shucking of the claw leg and claw at Ship Cove. The meat in this portion of the crab was usually very fibrous and adds body to the broken meat product. At the Ship Cove plant there were workers who shucked only this type of crab part. This practice like that of section 5:024 improves the particular worker's technique to obtain the best method for the meat extraction.

The allowance for this section was considered the same as for section 5:024; 13%. (Barnes, 1968)

DATA FROM OPERATION

(a) Weight of claw legs with claws
= 10 lbs. (test sample)

(b) Average observed performance rating
= 100

(c) Weight of meat from claw and claw leg
= 4.17 lbs.

(d) Actual time to shuck test sample
= 33 min. - 0 sec.

SUMMARY OF RESULTS: Shuck claw and claw leg; (Operation No. 7, Ship Cove)

Normalized results	Standardized results	Yield Output weight of meat to weight of input test sample
1. Time = 33 min. (test sample)	1. Time = 37.9 min. (test sample)	41.7%
2. Output in shell = 18.18 lbs./hr.	2. Output sections in shell = 15.8 lbs./hr.	1. Total meat from claw and claw leg = 17.4% of whole sections.
3. Output of meat from claw and claw leg = 7.58 lbs./hr.	3. Output of meat from claw and claw leg = 6.60 lbs./hr.	2. Total meat from claw and claw leg = 10.1% of live crab.

5:127 SLIT LARGE CRAB LEGS, ONE SIDE ONLY; (Operation No. 8, Ship Cove):

Figure 2:23 and 2:24 show pictures of the slitting machines and in operation. As mentioned previously the machines which were actually at the plant were prototypes, but the final assembly is shown in Figure 2:22. This new model had many refinements with regard to the types of materials used in the construction, but the basic operation of the units had not been changed.

The crab leg was passed under a guide which pressed the shell into a rotating knife as the crab leg was lightly pushed through the machine by the operator.

The allowance for this operation taken as 12% because the operator must be careful to fit the leg on the guide, but as the operator becomes experienced the fitting time was reduced. (Barnes, 1968)

DATA FROM OPERATION

TEST NUMBER ONE

(a) Weight of crab legs in shell

= 8 lbs. - 9 oz.

= 8.56 lbs. (test sample)

(b) Actual time to slit test sample

= 8 min - 51 sec.

= 8.85 min.

(c) Average observed performance rating factor

= 123.6

SUMMARY OF RESULTS: Slit large crab legs, one side only; (Operation No. 8, Ship Cove):

Test No. 1

Normalized results	Standardized results
1. Time = 10.94 min. (test sample.	1. Time = 12.43 min.
2. Output legs in shell = 46.96 lbs./hr.	2. Output legs in shell = 41.32 lbs./hr.

TEST NUMBER TWO

(a) Actual weight of legs in shell

= 4 lbs. - 3.5 oz.

= 4.22 lbs. (test sample)

(b) Actual time to slit test sample

= 5 min. - 15 sec.

= 5.25 min.

(c) Average observed performance rating factor

= 121.7

SUMMARY OF RESULTS: Slit large crab legs, one side only; (Operation No. 8, Ship Cove):

Test No. 2

Normalized results	Standardized results
1. Time = 6.39 min. (test sample).	1. Time = 7.26 min.
2. Output legs in shell = 39.62 lbs./hr.	2. Output legs in shell = 34.88 lbs./hr.

5:128 REMOVE LEG MEAT FROM SLIT LEGS; (Operation No. 9, Ship Cove):

Figure 2:25 shows the removal of the meat from the slit leg. The shell of the leg was soft after the cooking process and when it was slit it was possible to open the leg shell completely and remove the meat. The technique which was used to remove the meat was to hold the leg between the thumbs of both hands and the shell was forced open slightly to allow the insertion of a thumb further into the leg and thus spread the shell open. When the shell was opened and held by one hand, the second hand reached to the exposed meat and removed it from the shell.

The allowance for the removal of the meat was the same as for the slitting of the leg; 12%. (Barnes, 1968)

DATA FROM OPERATION

(a) Weight of legs in shell

= 8 lbs. - 9 oz.

= 8.56 lbs. (test sample)

(b) Actual time to remove meat from test sample

= 33 min. - 35 sec.

= 33.58 min.

(c) Average observed performance rating factor

= 102.5

(d) Weight of whole legs from test sample

= 4 lbs. - 9.5 oz.

= 4.59 lbs.

(e) Weight of broken meat from test sample

= 9.5 oz.

= 0.59 lbs.

SUMMARY OF RESULTS: Remove leg meat from slit legs;
(Operation No. 9, Ship Cove)

SUMMARY OF RESULTS: Remove leg meat from slit legs; (Operation No. 9, Ship Cove)

Normalized results	Standardized results	Yield Output weight to weight of input test sample weight
1. Time = 34.42 min. (test sample).	1. Time = 39.11 min. (test sample).	1. Whole legs = 53.62% of test sample.
2. Output of slit legs in shell = 9.03 lbs./hr.	2. Output of broken and whole legs in shell = 7.95 lbs./hr.	2. Broken legs 6.89% of test sample.
3. Output of whole unbroken leg meat from slit legs = 8.00 lbs./hr.		3. Total meat = 60.51% of test sample.
4. Output of broken leg meat from slit legs = 1.02 lbs./hr.		4. Whole legs = 88.55% of all meat removed from test sample.

1. Total meat (broken & whole from legs = 15.4% of whole sections.

2. Total meat (broken & whole) from legs = 8.9% of live crab.

5:129 ROLL LEGS TIPS TO REMOVE MEAT; (Operation No. 10, Ship Cove):

Section 2:28 of this report described in some detail the operation of the tip rolling machine which was used for the extraction of meat from both the tips and the small legs of the crab.

The allowance for this operation was taken to be 11.5%. (Barnes, 1968)

DATA FROM OPERATION

(a) Weight of crab tips in shell
= 2 lbs. (test sample)

(b) Actual time to roll test sample
= 6 min. - 9 sec.
= 6.15 min.

(c) Average observed performance rating factor
= 119.37

(d) Weight of meat obtained
= 0 lbs. - 12.5 oz.
= 0.78 lbs.

SUMMARY OF RESULTS: Roll legs tips to remove meat; (Operation No. 10, Ship Cove):

SUMMARY OR RESULTS: Roll legs tips to remove meat; (Operation No. 10, Ship Cove):

Normalized results	Standardized results	Yield Output weight to weight of input test sample weight.
1. Time = 7.34 min. for test sample.	1. Time = 8.29 min. for test sample.	1. 39.06% meat from test sample.
2. Output of tips in shell = 16.35 lbs./hr.	2. Output of tips in shell = 14.47 lbs./hr.	1. Meat from leg tips = 5.2% of whole sections.
3. Output of meat from tips = 6.37 lbs./hr.	3. Output of meat from the tips = 5.65 lbs./hr.	2. Meat from leg tips = 3.05% of live crab.

5:1210 ROLL SMALL LEGS TO REMOVE MEAT; (Operation 11, Ship Cove):

The small legs of the crab section cannot be economically shucked manually or on the slitting machine because of their small size. However, they do contain valuable meat and it must be removed from the shell for the increased viability of the total operation. The size of the small leg was such that it would fit conveniently into the rollers of the tip rolling machine and for this reason meat extraction takes place using the tip rolling machine.

The allowance for small legs was the same as for tips 11.5%. (Barnes, 1968)

DATA FROM OPERATION

(a) Weight of small crab legs in shell (test sample)

= 2.0 lbs.

(b) Actual time to roll test sample

= 8 min. - 4 sec.

= 8.07 min.

(c) Average performance or observed rating factor

= 110.8

(d) Weight of meat obtained

= 0 lbs. - 14.25 oz.

= 0.89 lbs.

SUMMARY OF RESULTS: Roll small legs to remove meat; (Operation No. 11, Ship Cove):

Normalized results	Standardized results	Yield Output weight to weight of input test sample weight
1. Time = 8.94 min. for test sample.	1. Time = 10.10 min. for test sample.	1. 44.53% meat from test sample.
2. Output of small legs in shell = 13.42 lbs./hr.	2. Output of small legs in shell = 11.88 lbs./hr.	1. Meat from small leg = 0.79% of whole sections.
3. Output of meat from small legs = 5.97 lbs./hr.	3. Output of meat from small legs = 5.29 lbs./hr.	2. Meat from small leg = 0.46% of live crab.

5:1211 PACKAGING OF FRESH CRAB MEAT FOR FREEZING; (Operation No. 16, Ship Cove):

Section 2:216 outlined in detail the method of packaging the crab for freezing. Figure 5:7 shows the packing of the "Combination" (60% broken meat and 40% whole leg meat) pack at Ship Cove. The legs were laid on the bottom, sides and top of the carton with the broken meat sandwiched in between.

The allowance for this operation was 11.5%. (Barnes, 1968.)

DATA FROM OPERATION

(a) Weight of crab meat

= 5 lb.

(b) Actual time to pack carton

= 2 min. - 30 sec.
= 2.5 min.

(c) Average performance or observed rating factor

= 105.8

SUMMARY OF RESULTS: Packaging of fresh crab meat for freezing; (Operation No. 16, Ship Cove):

Normalized results	Standardized results
1. Time = 2.65 min./5 lb. unit.	1. Time = 2.99 min./5 lb. unit.
2. Output of finished product = 113 lbs./hr.	2. Output of finished product = 100.3 lbs./hr.

5:130 DATA ON THE AVERAGE SIZES OF LIVE CRAB AND CRAB SECTION PORTIONS PROCESSED AT SHIP COVE AND VALLEYFIELD:

5:131 INTRODUCTION:

Chapter two of this report discussed some problems which can occur when poor quality crabs are processed. The purchase of: undersized crab (carapace width less than 3 3/4 inches), "soft shell" crab, damaged crab and weak or dead crab will reduce the overall output yield of the plant. Damaged crab refers to the crabs which have lost one or more body parts. Crabs have been caught with one or more of their legs or a claw missing. These crabs experienced an accident during their lives which resulted in these injuries, but the animals adjusted and survived.

The detail presented in section 5:132 is typical of the average size of crab which were processed in the Valleyfield and Ship Cove plants.

The average weights of the various items and the section components was taken by weighing a random sample and dividing by the number of pieces in the sample.

It will be noted that the total of the average of the parts of the whole section is more than the average weight of the section itself. It is highly unlikely that these two figures would, if ever, be equal because of the mathematical law concerning the summation of averages. Due to this fact, it is not possible to express each average weight of section component as a percentage of the overall average weight of the section.

5:132 AVERAGE SIZE OF LIVE CRAB AND CRAB SECTION PORTIONS PROCESSED AT SHIP COVE AND VALLEYFIELD:

(1) Average carapace width of crab
= 4.75 inches.

(2) Average weight of live crab
= 1.582 pounds.

(3) Average weight of one raw whole section in the shell
= 0.483 pounds.

(4) Average weight of one cooked whole section in shell
= 0.46 pounds.

(5) Average weight of cooked and cooled whole section portions in shell.

(a) Claw and claw leg
= 0.150 pound.

(b) Shoulder, legs and knuckles
= 0.311 pounds.

(c) Leg tips
= 0.011 pounds/each.

(d) Large legs
= 0.044 pounds/each.

(e) Small legs

= 0.013 pounds/each.

5:140 **METHODS, TIME, MEASUREMENT (M.T.M.) ANALYSIS: Ship Cove:**

5:141 **INTRODUCTION:**

Figures 5:1, 5:2 and 5:3 are charts containing the required data to perform a M.T.M. analysis on a work situation. These charts present the Time, Measurements Units (M.T.U.) for the motions of M.T.M. analysis.

To use these charts the operator's motion being performed must be noted and the value obtained from the chart for the particular case situation.

5:142 **Example: Taken from: Shuck claw and claw leg (Operation No. 7, Ship Cove):**

The first motion of the operator's hands for the shucking of the claw leg with claw is reaching for the section in the holding pan.

Taken from M.T.M. analysis chart.

5:146 OPERATION DESCRIPTION: Shuck claw and claw leg. (Operation No. 7. Ship Cove)

No.	Description	LH	TMU	RH	Description
7:03			12.9	RC-10	Reach for section.

EXPLANATION:

(a) No. 7:03 — 7, The seventh operation on the Operational Chart for Ship Cove.

03, The third motion performed by the operator in the M.T.M. analysis.

(b) Description

(c) L.H. — Left Hand of the operator is idle at this point in time.

(d) T.M.U. 12.9 — From Reach chart, Case 'C' for a distance of 10 inches.

(d) Note, value of 12.9 T.M.U.

(e) R.H. — Short method of describing action of Right Hand.
RC-10 — RC - Reach motion; Case 'C' ; 10 inch distance.

(f) Description — Written description of action of Right Hand.
Reach for section

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<u>NOTE</u>: (1) The symbol [ ] around either of the motions of the hands indicates that the T.M.U. value for this particular motion is disregarded and the other is chosen. The decision as to which operations to be eliminated is made by the M.T.M. analyst and his decision is based on the complexity of the motions involved. If no [ ] symbol appears, then both values are taken. This occurs when difficult motions are required to be performed by both hands.

M.T.M. Analysis Chart

5:143 Sheet No. 1 of 6

Operation Description: Butchering, degilling and washing of live crab; (Operation No. 2, Ship Cove)

No.	Description	LH	TMU	RH	Description
2:01			9.1	ET	Eye travel to crab on conveyor belt.
2:02			7.3	EF	Eye focus on crab on conveyor belt.
2:03			17.0	RC-16	Reach for crab on belt.
2:04			7.3	G4A	Grasp crab on belt.
2:05			16.0	MA-16	Move crab toward left hand.
2:06			9.1	ET	Eye travel back to anvil.
2:07			7.3	EF	Eye focus on crab.
2:08	Reach for crab in R.H.	RB-8	7.2		
2:09	Grasp whole crab.	G-3	5.6	G-2	Regrasp whole crab.
2:10	Move crab to anvil.	MC-8	11.8	MC-8	Move crab to anvil.

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M.T.M. Analysis Chart

5:143 Sheet No. 2 of 6

Operation Description: Butchering, degilling and washing of live crab; (Operation No. 2, Ship Cove)

No.	Description	LH	TMU	RH	Description
2:11	Position crab over anvil.	P1SS	9.1	P1SS	Position crab over anvil.
2:12	Crab struck on anvil and broken as crab is moved downward on anvil.	MA-4	6.1	MA-4	Crab carapace struck on anvil and broken as crab is moved downward on anvil.
2:13	Move crab back over anvil.	MC-4	8.0	MC-4	Move crab back over anvil.
2:14	Position crab back over anvil.	P1SS	9.1	P1SS	Position crab over anvil.
2:15	Move crab down on anvil for final breaking of carapace from crab.	MA-4	6.1	MA-4	Move crab down on anvil for final breaking of carapace from crab.
2:16			7.6	EM	Eye movement to revolving brush.

M.T.M. Analysis Chart

5:143 Sheet No. 3 of 6

Operation Description: Butchering, degilling and washing of live crab; (Operation No. 2, Ship Cove)

No.	Description	LH	TMU	RH	Description
2:17			7.3	EF	Eye focus on revolving brush.
2:18	Move section to brush.	MA-6	8.1	MA-6	Move section to revolving brush.
2:19	Position crab section on revolving brush holding tightly.	P2SS	19.7	P2SS	Position crab section on revolving brush holding tightly.
2:20	Move section in on brush to improve cleaning.	MA-2	3.6	MA-2	Move section on brush to improve cleaning.
2:21	Move section down to offal flume underneath revolving brush.	MA-10	11.3	MA-10	Move section down to offal flume underneath revolving brush.
2:22	Strike section against edge of offal flume to remove entrails of crab.	P1SS	9.1	P1SS	Strike section against edge of offal flume to remove entrails of crab.

M.T.M. Analysis Chart

5:143

Operation Description: Butchering, degilling and washing of live crab; (Operation 2, Ship Cove)

No.	Description	LH	TMU	RH	Description
2:23	Raise section over edge of offal flume.	MB-4	4.3	MB-4	Raise section over edge of offal flume.
2:24	Move section down on edge of offal flume.	MA-4	6.1	MA-4	Move section down on edge of offal flume.
2:25	Strike section against edge of offal flume to remove entrails of crab.	P1SS	9.1	P1SS	Strike section against edge of offal flume to remove entrails of crab.
2:26	Move section back to revolving brush.	MA-10	11.3	MA-10	Move section back to revolving brush.
2:27	Position crab on brush holding tightly.	P2SS	19.7	P2SS	Position crab on brush holding tightly.
2:28	Move section from brush to discharge conveyor.	MB-10	8.6	MB-10	Move section from brush to discharge conveyor.

M.T.M. Analysis Chart

5:143 Sheet No. 5 of 6

Operation Description: Butchering, degilling and washing of live crab; (Operation No. 2, Ship Cove)

No.	Description	LH	TMU	RH	Description
2:29			9,6	EM	Eye movement to discharge conveyor.
2:30			7.3	EF	Eye focus on discharge of conveyor.
2:31	Release section on conveyor.	RL-1	2.0	RL-1	Release section on conveyor.

TOTAL = 280.8 T.M.U.
= 0.002808 Hr.
= 0.1685 Min.
= 10.11 Sec.

From section 5:13 the average weight of whole crab is 1.582 lbs.

M.T.M. Analysis Chart

5:143

Sheet No. 6 of 6

Operation Description: Butchering, degilling and washing of live crab: (Operation 2, Ship Cove)

No.	Description	LH	TMU	RH	Description

From section 5:13 the average weight of raw whole section in shell is 0.483.

Therefore,

(a) Output ~~in~~ pounds per hour of live crab using M.T.M. analysis,

= 1.582 lbs. divided by .002808 hr.

= 563.39 lbs./hr.

(b) Output in pounds per hour of whole section in shell using M.T.M. analysis,

= 0.483 lbs. divided by .002808 hr.

= 172 lbs./hr. (For one section, but for whole crab must multiply by 2)

= (172 lbs./hr.) x 2 = 344 lbs./hr. whole sections.

M.T.M. Analysis Chart

5:144

Sheet No. 1 of 7

Operation Description: Divide cooked and cooled sections into: (a) Tips and small legs, (b) Claw legs with claws and (c) Shoulder, large legs and knuckles: (Operation No. 5, Ship Cove)

No.	Description	LH	TMU	RH	Description
5:01			9.0		Eye travel to pan of whole crab sections.
5:02			7.3		Eye focus on pan.
5:03	Reach for whole crab sections.	RC-12	14.2		
5:04	Grasp whole section.	G4A	7.3		
5:05			9.0	ET	Eye travel from pan to work area in front of operator
5:06			7.3		Eye focus on work area.
5:07	Move whole section toward R.H.	MA-12	12.9	RA-6	Reach for section in L.H.

M.T.M. Analysis Chart

5:144 Sheet No. 2 of 7

Operation Description: Divide cooked and cooled sections into: (a) Tips and small legs, (b) Claw legs with claws and (c) Shoulder, large legs and knuckles; (Operation No. 5, Ship Cove)

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No.	Description	LH	TMU	RH	Description
5:08	Regrasp whole section.	G-2	5.6	G1A	Transfer grasp of whole section.
5:09	Move whole section to work area in front of operator.	MB-4	4.3		Move whole section to work area in front of operator.
5:10	Move whole section 90° to pull claw leg with claw from whole section.	T-90°	5.4	T-90°	Turn whole section 90° to pull claw leg with claw from whole section.
5:11			10.6	AP-2	Pull claw leg from section.
5:12			7.5	D	Disengage claw leg with claw from whole section.

<u>M.T.M. Analysis Chart</u>

5:144 Sheet No. 3 of 7

Operation Description: Divide cooked and cooled sections into: (a) Tips and small legs, (b) Claw legs with claws and (c) Shoulder, large legs and knuckles; (Operation No. 5, Ship Cove)

No.	Description	LH	TMU	RH	Description
5:13			7.3	MB-8	Move claw leg with claw to storage pan.
5:14			2.0	RL-1	Release claw leg with claw.
5:15			6.5	RA-8	Reach to take remaining portion of whole section.
5:16			9.1	G4B	Grasp first leg tip.
5:17	Turn section 45° to facilitate removal of tip - wrist movement.	T-45°	10.6	AP-2	Break tip away from leg.
5:18			4.0	D	Disengage first tip from leg.

M.T.M. Analysis Chart

5:144 Sheet No. 4 of 7

Operation Description: Divide cooked and cooled sections into: (a) Tips and small legs, (b) Claw legs with claws and (c) Shoulder, large legs and knuckles; (Operation No. 5, Ship Cove)

No.	Description	LH	TMU	RH	Description
5:19			7.3	RC-3	Move to grasp second leg tip.
5:20			9.1	G4B	Grasp second leg tip.
5:21	Turn section 45° to facilitate removal of tip - wrist movement.	T-45°	3.5	AP-2	Break tip from leg.
5:22			4.0	D	Disengage second tip from leg.
5:23			3.6	RB-3	Move to grasp third leg tip.
5:24			2.0	G1A	Grasp third leg tip.
5:25	Turn section 45° to facilitate removal of tip - wrist movement	T-45°	3.5	AP-2	Break tip from leg.

M.T.M. Analysis Chart

5:144

Sheet No. 5 of 7

Operation Description: Divide cooked and cooled sections into: (a) Tips and small legs, (b) Claw legs with claws and (c) Shoulder, large legs and knuckles; (Operation No. 5, Ship Cove)

No.	Description	LH	TMU	RH	Description
5:26			4.0	D	Disengage third tip from leg.
5:27			3.6	RB-3	Reach for fourth leg tip.
5:28			2.0	G1A	Grasp fourth leg tip.
5:29	Turn section 45° to facilitate removal of tip - wrist movement.	T-45°	10.6	AP-2	Break tip from leg.
5:30			4.0	D	Disengage fourth tip from leg.
5:31	Move remaining portion of whole section to separate storage pan.	MB-10	8.6	MB-8	Move tips to separate storage pan.

M.T.M. Analysis Chart

5:144 Sheet No. 6 of 7

Operation Description: Divide cooked and cooled sections into: (a) Tips and small legs, (b) Claw legs with claws and (c) Shoulder, large legs and knuckles; (Operation No. 5, Ship Cove)

No.	Description	LH	TMU	RH	Description
5:32	Release remaining portion of whole section.	RL-1	2.0	RL-1	Release tip.

TOTAL = 207.6 TMU
= 0.00207 TMU
= 0.125 Min.
= 7.47 Sec.

From section 5:13 the average weight of cooked whole section in shell is 0.46 lbs.

M.T.M. Analysis Chart

5:144 Sheet No. 7 of 7

Operation Description: Divide cooked and cooled sections into: (a) Tips and small legs, (b) Claw legs with claws and (c) Shoulders, large legs and knuckles; (Operation No. 5, Ship Cove)

No.	Description	LH	TMU	RH	Description

Therefore,

(a) Output in pounds per hour of cooked whole section in shell using M.T.M. analysis,

= 0.45 lbs. divided by .002076 hr.

= 221.56 lbs./hr.

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M.T.M. Analysis Chart

5:145 Sheet No. 1 of 12

Operation Description: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6, Ship Cove)

No.	Description	LH	TMU	RH	Description
6:01	Eye travel to pan of sections.	ET	8.0		
6:02	Eye focus on section in pan.	EF	7.3		
6:03	Reach for whole section.	RC-12	14.2		
6:04	Grasp whole section.	G4A	7.3		
6:05	Move section toward R.H.	MA-12	8.1	MB-6	Move to grasp section in L.H.
6:06			7.3	ET	Eye travel from storage pan to work area in front of worker.
6:07	Release section.	RL-1	5.6	G-3	Grasp section from L.H.

M.T.M. Analysis Chart

5:145 Sheet No. 2 of 12

Operation Description: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6, Ship Cove)

No.	Description	LH	TMU	RH	Description
6:08	Eye travel to section in front of worker.		8.0		
6:09	Eye focus on section in front of worker.		7.3		
6:10			4.3	MB-4	Move section to work area in front of worker.
6:11	Reach to section of knuckles.	RB-6	8.6		
6:12	Grasp knuckles to straighten.	G1A	2.0		
6:13	Release knuckles.	RL-1	2.0		

M.T.M. Analysis Chart

5:145

Sheet No. 3 of 12

Operation Description: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6; Ship Cove)

No.	Description	LH	TMU	RH	Description
6:14			9.7	MA-8	Move whole section against pan to remove meat from knuckles.
6;15			7.2	MB-8	
6:16	Reach for whole section.	RA-8	6.5		
6:17	Take section in L.H.	G-3	5.6		
6:18		MA-8	11.8	RE-12	Move hand down on shoulder to break soft shell around meat.
6:19			8.1	RA-12	Reach to grasp soft shell.
6:20			3.5	G1B	
6:21			3.6	MB-3	Move to break shoulder shell cover.

M.T.M. Analysis Chart

5:145 Sheet No. 4 of 12

Operation Description: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder shell and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6, Ship Cove)

No.	Description	LH	TMU	RH	Description
6:22			10.6	AP-2	Apply pressure to shoulder shell cover.
6:23			7.5	D	Disengage cover.
6:24			10.0	MB-12	Move shoulder shell cover to shucked storage pan.
6:25			2.0	RL-1	Release shoulder shell cover.
6:26			4.8	ET	Eye travel to whole section.
6:27			7.3	EF	Eye focus on whole section.
6:28	Release whole section.	RL-1	5.6	G-3	Grasp whole section.
6:29			7.2	MB-8	Move shoulder down against pan edge to knock out meat from shell.

M.T.M. Analysis Chart

5:145

Sheet No. 5 of 12

Operation Description: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder shell and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6, Ship Cove)

No.	Description	LH	TMU	RH	Description
6:30			9.7	MA-8	
6:31			8.6	MB-10	
6:32			11.3	MA-10	
6:33			8.6	MB-10	
6:34			11.3	MA-10	
6:35			8.6	MB-10	
6:36			11.3	MA-10	
6:37			8.6	MB-10	
6:38			11.3	MA-10	
6:39	Reach for whole section	RA-8	7.9		

M.T.M. Analysis Chart

5:145 Sheet No. 6 of 12

Operation Description: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder shell and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6, Ship Cove)

No.	Description	LH	TMU	RH	Description
6:40	Grasp section.	G-3	5.6	G-2	Both hands are now holding section.
6:41			2.9		Eye movement on work area.
6:42			7.3		Eye focus on whole section.
6:43			9.1	G-2	Re grasp knuckles of section.
6:44	Left hand is holding remainder of section.				
6:45			13.5	MC-10	Move breaking knuckles from section.
6:46			4.0	D	Disengage knuckles.

M.T.M. Analysis Chart

5:145 Sheet No. 7 of 12

Operation Description: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder shell and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6, Ship Cove)

No.	Description	LH	TMU	RH	Description
6:47			2.9	ET	Eye travel to offal shute.
6:48			2.0	RL-1	Release knuckles in offal shute.
6:49			2.9	ET	Eye travel back to whole section.
6:50			7.3	EF	Eye focus on remaining parts.
6:51			7.3	RA-10	Reach back to whole section to grasp small leg.
6:52			7.3	G4A	Grasp small leg.
6:53			4.3	MB-4	Move small leg from whole section.

M.T.M. Analysis Chart

5:145 Sheet No. 8 of 12

Operation Description: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder shell and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6, Ship Cove)

No.	Description	LH	TMU	RH	Description
6:54			4.0	D	Disengage small leg.
6:55	Reach to remove small portion of shoulder shell on small leg.	RA-4	6.1		
6:56	Grasp shoulder portion from small leg.	GA	2.0		
6:57	Move shoulder piece.	MB-10	8.6		
6:58	Release shoulder portion.	RL-1	2.0		
6:59			9.7	MA-8	Move to small leg storage pan.

M.T.M. Analysis Chart

5:145

Sheet No. 9 of 12

Operation Description: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder shell and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6, Ship Cove)

No.	Description	LH	TMU	RH	Description
6:60			9.5	ET	Eye travel on small leg holding pan.
6:61			7.3	EF	Eye focus to small leg holding pan.
6:62			2.0	RL-1	Release small leg.
6:63			12.9	RC-10	Reach back for large legs.
6:64			7.3	G4A	Grasp one large leg.
6:65			4.3	MB-4	Move to break first large leg off section.
6:66			4.0	D	Disengage large leg from section.

M.T.M. Analysis Chart

5:145 Sheet No. 10 of 12

Operation Description: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder shell and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6, Ship Cove)

No.	Description	LH	TMU	RH	Description
6:67			4.9	RA-4	Reach for second large leg.
6:68			2.0	G1A	Grasp second large leg.
6:69			4.3	MB-4	Move to break second large leg.
6:70			4.0	D	Disengage second large leg.
6:71			4.9	RA-4	Reach for third large leg.
6:72			2.0	G1A	Grasp third large leg.
6:73	Grasp shoulder section.	G-3			
6:74			4.0	D	Disengage third leg from shoulder.
6:75	Move toward shucked shoulder pan.	MB-2	2.9		

M.T.M. Analysis Chart

5:145 Sheet No. 11 of 12

Operation Description: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder shell and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6, Ship Cove)

No.	Description	LH	TMU	RH	Description
6:76		MB-4	4.3	MB-4	Move large legs towards holding pan.
6:77			9.5	ET	Eye travel to holding pans.
6:78	Eye focus changed here.		7.3	EF	Eye focus on holding pans.
6:79	Release shoulders.	RL-1	2.0	RL-1	Release legs.

TOTAL = 506.4 TMU
= .005064 Hr.
= 0.304 Min.
= 18.23 Sec.

M.T.M. Analysis Chart

5:145 Sheet No. 12 of 12

Operation Description: (1) Shuck meat from knuckles and shoulders of the section; (2) break the large legs from the shucked shoulder shell and (3) place the large legs and all shucked shells into separate pans; (Operation No. 6, Ship Cove)

No.	Description	LH	TMU	RH	Description

From section 5:13 the average weight of the whole section in shell less the tips and small legs is 0.311 lbs.

Therefore,

(a) Output in pounds per hour for this portion of whole section in shell using M.T.M. analysis
= 0.311 lbs. divided by 0.005064 hr.
= 61.41 lbs./hr.

M.T.M. Analysis Chart

5:146 — Sheet No. 1 of 9

Operation Description: Shuck claw and claw leg; (Operation No. 7, Ship Cove)

No.	Description	LH	TMU	RH	Description
7:01			9.5	ET	Eye travel to pan of sections.
7:02			7.1	EF	Eye focus on pan of sections.
7:03			12.9	RC-10	Reach for section.
7:04			7.3	G4A	Grasp section.
7:05			8.6	MB-10	Move section to work area in front of operator.
7:06			5.4	T-90°	Turn section 90° to shake shoulder meat on upper portion of claw leg.
7:07			4.3	MB-4	Move section upward for shaking procedure.
7:08			11.3	MA-10	Move section down on pan to jar meat loose.

M.T.M. Analysis Chart

5:146 Sheet No. 2 of 9

Operation Description: Shuck claw and claw leg; (Operation No. 7, Ship Cove)

No.	Description	LH	TMU	RH	Description
7:09	Reach for section in R.H.	RA6	8.1	MA-6	Move section towards left hand.
7:10	Grasp movable pincer of claw.	G-3	5.6		R.H. holding section.
7:11	Move to break movable pincer.	MB-3	3.6		
7:12	Disengage movable pincer from claw.	D-2	7.5		
7:13	Move pincer towards offal shute.	MB-6	5.7		
7:14	Release pincer.	RL-1	2.0		
7:15	Move to grasp remaining portion of section.	MB-6	5.7	MB-2	Move remaining portion of section towards L.H.
7:16	Grasp section from R.H.	G-3	5.6	RL-1	Release section.

M.T.M. Analysis Chart

5:146 Sheet No. 3 of 9

Operation Description: Shuck claw and claw leg; (Operation No. 7, Ship Cove)

No.	Description	LH	TMU	RH	Description
7:17	Move section to anvil.	MA-4	6.1	RB-4	Reach for mallet.
7:18	Position section on anvil	P1SS	9.1	G1A	Pick up mallet.
7:19			13.5	MC-10	Move mallet over section.
7:20			8.1	MA-6	Move mallet down on section to break stationary pincer.
7:21			5.7	MB-6	Move mallet for second break of shell.
7:22			5.7	MB-6	Put mallet to side.
7:23	Reach for broken piece of claw shell.	RA-6	5.7	RL-1	Release mallet.
7:24	Grasp broken piece of shell.	G1A	7.3	RA-10	Reach for whole section.

M.T.M. Analysis Chart

5:146

Sheet No. 4 of 9

Operation Description: Shuck claw and claw leg; (Operation No. 7, Ship Cove)

No.	Description	LH	TMU	RH	Description
7:25	Move shell to break away from claw shell.	MB-8	10.6	G1A	Grasp whole section.
7:26	Disengage broken shell from whole claw shell.	D-1	4.0		
7:27			5.7	MB-6	Move claw to shake meat through opening in shell.
7:28			5.4	T-90^{o}	Turn section to point broken claw at pan.
7:29			8.1	MA-6	Move hand down on side of pan to jar claw meat loose.
7:30	Reach for section.	RA-4	4.9	MA-2	Move section toward L.H.
7:31	Grasp claw shell of section.	G1A	2.0		

M.T.M. Analysis Chart

5:146

Sheet No. 5 of 9

Operation Description: Shuck claw and claw leg; (Operation No. 7, Ship Cove)

No.	Description	LH	TMU	RH	Description
7:32	Move to break empty claw shell from section.	MB-4	4.3		
7:33	Break empty claw shell from section at knuckle joint.	D-1	4.0		
7:34			5.6	G-2	Reposition section in R.H. to facilitate shucking of claw knuckle.
7:35			5.7	MB-6	Move section over shucking pan to shuck knuckle.
7:36			8.1	MA-6	Move section down so that hand strikes edge of pan to jar meat loose.

M.T.M. Analysis Chart

5:146

Sheet No. 6 of 9

Operation Description: Shuck claw and claw leg; (Operation No. 7, Ship Cove)

No.	Description	LH	TMU	RH	Description
7:37	–		5.7	MB-6	Second movement needed here to loosen meat from shell.
7:38			8.1	MA-6	
7:39	Reach for claw knuckle of section.	RA-6	7.0	MA-2	Move section towards L.H.
7:40	Grasp claw knuckle of section.	G1A	2.0		
7:41	Move to break claw knuckle from section.	MB-3	5.7		
7:42	Disengage claw knuckle from section.	D-1	4.0		
7:43			6.1	MA-4	Move to position claw leg on anvil.

M.T.M. Analysis Chart

5:146 Sheet No. 7 of 9.

Operation Description: Shuck claw and claw leg; (Operation No. 7, Ship Cove)

No.	Description	LH	TMU	RH	Description
7:44			9.1	P1SS	Position claw leg on anvil.
7:45	Reach to claw leg on anvil.	RA-4	6.1		
7:46	Grasp claw leg on anvil.	G1A	8.6	RB-10	Reach for mallet.
7:47			2.0	G1A	Grasp mallet.
7:48			8.6	MB-10	Move mallet over claw leg.
7:49			8.1	MA-6	Move mallet down on claw leg.
7:50			5.7	MB-6	Move mallet for second break.
7:51			8.1	MA-6	Put mallet down.
7:52	Reach for broken shell of claw leg.	RA-6	7.0	RL-1	Release mallet.
7:53	Grasp broken shell of claw leg.	G1A	4.5	RA-3	Reach to grasp claw leg.

M.T.M. Analysis Chart

5:146 Sheet No. 8 of 9

Operation Description: Shuck claw and claw leg; (Operation No. 7, Ship Cove)

No.	Description	LH	TMU	RH	Description
7:54			2.0	G1A	Grasp claw leg.
7:55	Move to break broken piece of shell from claw leg.	MB-4	6.9		
7:56			5.6	G-2	Regrasp leg in R.H. to position properly for shucking.
7:57			8.1	MA-6	Move R.H. down against pan to shuck claw leg.
7:58			10.0	MB-12	Move empty claw leg shell to offal shute.
7:59			2.0	RL-1	Release shell in shute.

M.T.M. Analysis Chart

5:146 Sheet No. 9 of 9

Operation Description: Shuck claw and claw leg; (Operation No. 7, Ship Cove)

No.	Description	LH	TMU	RH	Description

TOTAL = 383.4 T.M.U.
= 0.003834 Hr.
= 0.23 Min.
= 13.8 Sec.

From section 5:13 the average weight of claw leg with claw in shell is 0.15 lbs.

Therefore,

(a) Output per hour of claw leg with claw in shell using M.T.M. analysis
= 0.15 lbs. divided by 0.003834 hr.
≐ 39.12 lbs./hr.

M.T.M. Analysis Chart

5:147 Sheet No. 1 of 4

Operation Description: Slit large crab legs, one side only; (Operation No. 8, Ship Cove)

No.	Description	LH	TMU	RH	Description
8:01	Eye travel to legs in storage pan.	ET	9.5		
8:02	Eye focus on legs in pan.	EF	2.3		
8:03	Reach for leg.	RC-10	12.9		
8:04	Grasp leg.	G4A	7.3		
8:05	Eye travel from pan to slitter.	ET	7.6		
8:06	Eye focus on slitter.	EF	7.3		
8:07	Move leg to slitting machine	MC-10	13.5		
8:08	Position leg on slitter.	P1SS	9.1		

M.T.M. Analysis Chart

5:147 Sheet No. 2 of 4

Operation Description: Slit large crab legs, one side only; (Operation No. 8, Ship Cove)

No.	Description	LH	TMU	RH	Description
8:09			7.0	RA-6	Reach to leg on slitter.
8:10			2.0	G1A	Grasp leg to pull through slitter.
8:11	Force leg to move through slitter.	AP-2	10.6	AP-2	
8:12		MA-4	6.1	MA-4	Move leg through slitter.
8:13			9.1	P1SS	Move the slit leg to the back pack of the hand as more legs are slit before released.

NOTE: The operator does not release the slit leg until she has 5 legs in her right hand. Therefore, the total of the above can be multiplied by five.

M.T.M. Analysis Chart

5:147

Operation Description: Slit large crab legs, one side only; (Operation No. 8, Ship Cove)

No.	Description	LH	TMU	RH	Description

Total above = 109.3 T.M.U.

For the five sequences = 5 x 109.3

= 546.5 T.M.U.

Release of slit legs = 2.0 T.M.U.

TOTAL = 548.5 T.M.U.

= .005485 Hr.

= 0.329 Min.

= 19.75 Sec.

M.T.M. Analysis Chart

5:147

Sheet No. 4 of 4

Operation Description: Slit large legs, one side only; (Operation No. 8, Ship Cove)

No.	Description	LH	TMU	RH	Description

From section 5:13 the average weight of one large leg in shell is 0.044 lbs. Therefore,

(a) Output in pounds per hour of slit large legs in shell using M.T.M. analysis,

= 0.044 lbs. divided by 0.005485 hr.

= 40.15 lbs./hr.

M.T.M. Analysis Chart

5:148 Sheet NO. 1 of 4

Operation Description: Remove leg meat from slit legs; (Operation No. 9, Ship Cove)

No.	Description	LH	TMU	RH	Description
9:01	Eye travel to leg in storage pan.	ET	7.6		
9:02	Eye focus on leg in pan.	EF	7.3		
9:03			10.1	RC-6	Reach in pan for leg.
9:04			9.1	G4B	Grasp leg.
9:05	Reach for leg in R.H.	RA-1	8.1	MA-6	Move leg to work position in front of operators body.
9:06	Eye focus on work area	EF	7.3		
9:07		G-3	5.6	RL-1	
9:08			3.5	RA-2	Reach for leg to manipulate to correct position for opening of shell.

<u>M.T.M. Analysis Chart</u>

5:148

Sheet No. 2 of 4

Operation Description: <u>Remove leg meat from slit legs; (Operation No. 9, Ship Cove)</u>

No.	Description	LH	TMU	RH	Description
9:09	L.H. holding leg.		2.0	G1A	
9:10	Turn leg 180° to facilitate opening of shell.	T-180°	9.4	T-180°	Turn leg 180° to facilitate opening of shell.
9:11			10.6	AP-2	Apply pressure to open shell.
9:12			1.7	MB-3/4	
9:13	Reach for meat in shell.	RB-2	2.7		
9:14	Hook grasp	G-5			
9:15	Move L.H. to remove meat.	MB-3	3.6		
9:16			5.6	G-2	Regrasp shell in R.H.
9:17	Move L.H. to remove meat.	MB-6	5.6		Hold shell.

M.T.M. Analysis Chart

5:148

Operation Description: Remove leg meat from slit legs; (Operation No. 9, Ship Cove)

No.	Description	LH	TMU	RH	Description
9:18			8.6	MB-10	Move meat to storage pan.
9:19	Move empty shell to offal shute.	MB-8	7.2	RL-1	Release meat in pan.
9:20	Release empty shell	RL-1	2.0		

TOTAL = 125.2 T.M.U.
= 0.001252 Hr.
= 0.075 Min.
= 4.5 Sec.

From section 5:13 the average weight of one large leg in shell is 0.044 lbs.

M.T.M. Analysis Chart

5:148

Sheet No. 4 of 4

Operation Description: Remove leg meat from slit legs; (Operation No. 9, Ship Cove)

No.	Description	LH	TMU	RH	Description

Therefore,

(a) Output in pounds per hour for the removal of meat from slit large legs in shell using the M.T.M. analysis,

= 0.044 lbs. divided by 0.001252 hr.

= 35.14 lbs./hr.

M.T.M. Analysis Chart

5:149

Sheet No. 1 of 3

Operation Description: Roll leg tips to remove meat; (Operation No. 10, Ship Cove)

No.	Description	LH	TMU	RH	Description
10:01		ET	5.7		Eye travel to storage pan of tips.
10:02		EF	2.3		Eye focus on tips in storage pan.
10:03	Reach for tips in storage pan.	RA-6	2.0		
10:04	Grasp tips in storage pan.	G4B	9.1		
10:05	Move towards R.H.	MA-6	8.1		
10:06			5.7	RA-6	Reach for tip in L.H.
10:07			2.0	G1A	Grasp tip in L.H.
10:08			8.1	MA-6	Move tip towards roller.

M.T.M. Analysis Chart

5:149 Sheet No. 2 of 3

Operation Description: Roll leg tips to remove meat; (Operation No. 10, Ship Cove)

No.	Description	LH	TMU	RH	Description
10:09			5.4	T-90°	Turn tip 90° to line up for roller.
10:10			9.1	P2SS	Position tip on roller.
10:11			10.6	AP-2	Apply pressure to force tip into roller.
10:12			2.9	MB-2	Move tip into roller.
10:13			3.6	MB-3	Move tip meat to storage pan.
10:14			2.0	RL-1	Release meat in pan.

TOTAL T.M.U. = 86.6 T.M.U.
= 0.000866 Hr.
= 0.052 Min.
= 3.12 Sec.

M.T.M. Analysis Chart

5:149 Sheet No. 3 of 3

Operation Description: Roll leg tips to remove meat; (Operation No. 10, Ship Cove)

No.	Description	LH	TMU	RH	Description

From section 5:13 the average weight of a leg tip in shell is 0.011 lbs.

Therefore,

(a) Output in pounds per hour of leg tips in shell using M.T.M. analysis,

= 0.011 lbs. divided by 0.000866 hr.

= 12.70 lbs./hr.

M.T.M. Analysis Chart

5:150

Operation Description: Roll small legs to remove meat; (Operation No. 11, Ship Cove)

No.	Description	LH	TMU	RH	Description
11:01	Eye travel to legs in storage pan.	ET	5.7		
11:02	Eye focus on legs in storage pan.	EF	7.3		
11:03	Reach for legs in storage pan.	RC-10	12.9		
11:04	Grasp leg from storage pan.	G4B	9.1		
11:05	Move leg toward R.H.	MA-6	8.1		
11:06			7.0	RA-6	Reach for leg in R.H.
11:07			2.0	G1A	Grasp small leg from L.H.
11:08			8.1	MA-6	Move small leg towards roller.

M.T.M. Analysis Chart

5:150 Sheet No. 2 of 3

Operation Description: Roll small legs to remove meat; (Operation No. 11, Ship Cove)

No.	Description	LH	TMU	RH	Description
11:09			5.4	T-90°	Turn small leg 90° to line up for rollers.
11:10			19.7	P2SS	Position small leg on roller.
11:11			10.6	AP-2	Apply pressure to force leg into roller.
11:12			2.9	MB-2	Move small leg into roller.
11:13			3.6	MB-3	Move leg meat to storage pan.
11:14			2.0	RL-1	Release meat in pan.

TOTAL T.M.U. = 104.4 T.M.U.
= 0.001044 Hr.
= 0.063 Min.
= 3.76 Sec.

M.T.M. Analysis Chart

5:150

Operation Description: Roll small legs to remove meat; (Operation No. 11, Ship Cove)

No.	Description	LH	TMU	RH	Description

From section 5:13 the average weight of a small leg in shell is 0.013 lbs.

Therefore,

(a) Output in pounds per hour of small legs in shell using M.T.M. analysis,

= 0.013 lbs. divided by 0.001044 hr.

= 12.45 lbs./hr.

M.T.M. Analysis Chart

5:151 Sheet No. 1 of 10

Operatinn Description: Packing of 5 lb. of Combination Pack (40% whole leg meat, 60% broken meat) for freezing; (Operation No. 16, Ship Cove)

No.	Description	LH	TMU	RH	Description
16:01	Eye travel to pan of crab meat.	ET	9.5		
16:02	Eye focus on pan.	EF	7.3		
16:03	Reach for a quantity of whole legs.	RA-10	8.7		
16:04	Grasp number of legs.	G4A	9.1		
16:05	Move legs to packing cartons.	MB-6	5.7		
16:06	Eye travel to packing area in front of the worker.	ET	9.5		
16:07	Eye focus on packing carton.	EF	7.3		

M.T.M. Analysis Chart

5:151 Sheet No. 2 of 10

Operation Description: Packing of 5 lb. of Combination Pack (40% whole leg meat, 60% broken meat) for freezing; (Operation No. 16, Ship Cove)

No.	Description	LH	TMU	RH	Description
16:08	Left hand hold rest of the legs.		6.1	RA-4	Reach for legs in L.H.
16:09			2.0	G1A	Grasp one leg from L.H.
16:10			5.7	MB-6	Move leg to position in pan.
16:11			9.1	P1SS	Position leg in bottom of pan.
16:12			2.0	RL-1	Release.

NOTE NO. 1 The last five operations (No. 16:08 - 16:12) are repeated approximately ten times as there are ten legs in the left hand. Therefore, the total T.M.U. for these motions is = 10 x 24.9
= 249 T.M.U.

M.T.M. Analysis Chart

5:151

Operation Description: Packing of 5 lb. of Combination Pack (40% whole leg meat, 60% broken meat) for freezing; (Operation No. 16, Ship Cove)

No.	Description	LH	TMU	RH	Description

NOTE NO. 2 The first seven operations (No. 16:01 - 16:07) above have to be repeated five times to get the balance of legs for the bottom and part of the sides of the carton. Therefore, the total T.M.U. for these operations is = 5 x 57.1

= 285.5 T.M.U.

NOTE NO. 3 Therefore, total T.M.U. to put legs on bottom and sides of carton is

= 285.5 + 5 (249)

= 1530.5 T.M.U.

NOTE NO. 4 After the leg meat is placed on the bottom and sides of the carton, the salad or broken meat must be placed in the center of the carton.

M.T.M. Analysis Chart

5:151 Sheet No. 4 of 10

Operation Description: Packing of 5 lb. of Combination Pack (40% whole leg meat, 60% broken meat) for freezing; (Operation No. 16, Ship Cove)

No.	Description	LH	TMU	RH	Description
16:13	Eye travel to pan of crab meat.	ET	9.5		
16:14	Eye focus on pan.	EF	7.3		
16:15	Reach for salad meat.	RA-10	7.3		
16:16	Grasp quantity of salad meat.	G1A	2.0		
16:17	Eye travel to work area.	ET	9.5		
16:18	Eye focus on work area.	EF	7.3		
16:19	Move meat to pan.	MB-6	5.7		
16:20	Position salad meat in pan.	P1SS	9.1	RA-4	Reach to shape salad into pan.
16:21	Move crab meat into shape of carton.	MC-1	3.4	MC-1	Move crab into shape of carton.

M.T.M. Analysis Chart

5:151

Operation Description: Packing of 5 lb. of Combination Pack (40% whole leg meat, 60% broken meat) for freezing; (Operation No. 16, Ship Cove)

No.	Description	LH	TMU	RH	Description

NOTE NO. 5 The last 8 operations above (No. 16:14 - 16:21) are repeated approximately five times until all salad meat (3 Pounds) is in place in the carton. Therefore, the total T.M.U. of the operations is = 5 (61.1)

= 305.5 T.M.U.

NOTE NO. 6 After the salad meat is placed in the carton, the top layer of legs must be placed over the salad or broken meat. There shall be less time required for this work then was required to place the legs on the bottom and sides of the carton.

M.T.M. Analysis Chart

5:151 Sheet No. 6 of 10

Operation Description: Packing of 5 lb. of Combination Pack (40% whole leg meat, 60% broken meat) for freezing; (Operation No. 16, Ship Cove)

No.	Description	LH	TMU	RH	Description
16:22	Eye travel to pan of crab legs.	ET	9.5		
16:23	Eye focus on pan of crab legs.	EF	7.3		
16:24	Reach for number of legs.	RA-10	8.7		
16:25	Grasp legs.	G1A	2.0		
16:26	Move legs to packing carton.	MB-6	5.7		
16:27	Eye travel to work area in front of worker.	ET	9.5		

M.T.M. Analysis Chart

5:151 Sheet No. 7 of 10

Operation Description: Packing of 5 lb. of Combination Pack (40% whole leg meat, 60% broken meat) for freezing; (Operation No. 16, Ship Cove)

No.	Description	LH	TMU	RH	Description
16:28	Eye focus on packing carton.	EF	7.3		
16:29			6.1	RA-4	Reach for legs in L.H.
16:30			2.0	G1A	Grasp one leg from L.H.
16:31			5.7	MB-6	Move leg towards top of packing carton.
16:32			9.1	P1SS	Position leg on top of salad meat.
16:33			2.0	RL-1	Release leg.

M.T.M. Analysis Chart

5:151 Sheet No. 8 of 10

Operation Description: Packaging of 5 lb. of Combination Pack (40% whole leg meat, 60% broken meat) for freezing; (Operation No. 16, Ship Cove)

No.	Description	LH	TMU	RH	Description

NOTE NO. 7 The five above operations (No. 16:29 - 16:33) will be repeated approximately ten times as there will be approximately 10 legs in the left hand. Therefore, the total T.M.U. for these operations is = 10 x 24.9

= 249 T.M.U.

NOTE NO. 8 The operations (No. 16:22 - 16:28) directly above are repeated approximately three times to get all the legs to cover salad meat. Therefore, total T.M.U. for these operations is = 3 x 50.0

= 150.0

NOTE NO. 9 The total T.M.U. required to place the whole legs on top of salad meat is

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M.T.M. Analysis Chart

5:151 Sheet No. 9 of 10

Operation Description: Packing of 5 lb. of Combination Pack (40% whole leg meat, 60% broken meat) for freezing; (Operation No. 16, Ship Cove)

No.	Description	LH	TMU	RH	Description

= 3 x 249 + 150.0

= 897.0 T.M.U.

NOTE NO. 10 The Grand Total T.M.U. for packing the 5 lb. of combination (40% whole leg meat, 60% broken meat)

= 1530.5 T.M.U.

= 305.5 T.M.U.

= 897.0 T.M.U.

2733.0 T.M.U.

= 0.02733 Hr.

= 1.64 Min.

= 98.39 Sec.

M.T.M. Analysis Chart

5:151

Sheet No. 10 of 10

Operation Description: Packing of 5 lb. of Combination Pack (40% whole leg meat, 60% broken meat) for freezing; (Operation No. 16, Ship Cove)

No.	Description	LH	TMU	RH	Description

The weight of the product packed is 5.0 lbs.

Therefore,

(a) Output of finish product "Combination Pack" in pounds per hour using M.T.M. analysis,

= 5.0 lbs. divided by 0.02733 Hr.

= 182.95 lbs./hr.

5:20 VALLEYFIELD - BEOTHIC FISH PROCESSORS:

5:21 INTRODUCTION:

Section 4:22 lists the various operations which were studied using M.T.M and Time Study techniques at the Valleyfield plant. The test data which was collected at the plant is now presented.

5:22 TIME STUDY RESULTS; VALLEYFIELD:

5:221 SHUCK (A) SHOULDERS, LARGE LEGS, KNUCKLES, CLAW AND CLAW LEGS, (B) REMOVE TIPS AND SMALL LEGS; (Operation No. 6, Valleyfield):

Figure 2:18 shows pictures at the Valleyfield plant of women shucking the whole section. Eash person is provided with pans containing 35 pounds of whole sections. They were required to shuck all the portions with the exception of the tips and small legs which were broken off in the operation to be taken later to a tip rolling assembly for meat extraction. As the workers shucked the section, the broken salad meat was kept separate from the whole unbroken legs.

The meat is extracted by the workers from the shoulders, the knuckles, the claw and claw leg and the three large legs of each section.

DATA FROM OPERATION

(a) Weight of cooked and cooled sections

= 10 lbs. (test sample)

(b) Actual time to shake sections

= 25 min. - 33 sec.
= 25.55 min.

(c) Average observed performance rating

= 111.4

(d) Weight of broken meat extracted from test sample

= 2.0 lbs. - 12 oz.
= 2.75 lbs.

(e) Weight of whole leg meat extracted from test sample

= 1 lb. - 6 oz.
= 1.375 lbs.

(f) Weight of tips and small legs in shell from test sample

= 1 lb. - 6 oz.
= 1.375 lbs.

As the calculations for the normalized and standardized results are the same as those done in section 5:121 for the Ship Cove plant, they shall not be presented here. Rather, the summary of the results themselves is given in table form.

The allowances for this operation shall be 14.4% (Barnes, 1968).

SUMMARY OF RESULTS: SHUCK (A) SHOULDERS, LARGE LEGS, KNUCKLES CLAW AND CLAW LEGS,

(B) REMOVE TIPS AND SMALL LEGS; (Operation No. 6, Valleyfield)

Test No. 1

Normalized results	Standardized results	Yield Output weight to input test sample weight
1. Time = 28.46 min. (test sample)	1. Time = 33.29 min. (test sample)	1. Broken meat = 27.5% of whole sections.
2. Output whole section = 21.08 lbs./hr.	2. Output whole sections = 18.02 lbs./hr.	2. Whole leg meat = 13.75% of whole sections.
3. Output of broken meat = 5.79 lbs./hr.	3. Output of broken meat = 4.96 lbs./hr.	3. Tips and small legs (in shell) = 13.75% of whole sections.
4. Output of whole leg meat = 2.89 lbs./hr.	4. Output of whole leg meat = 2.48 lbs./hr.	
		1. Total meat from whole sections (excluding leg tips and small legs) = 23.9% of live crab.

DATA FROM OPERATION

TEST NO. 2

(a) Weight of cooked and cooled sections

= 10 lbs. - 2 oz.
= 10.125 lbs. (test sample)

(b) Actual time to shake sections

= 27 min. - 13 sec.
= 27.22 min.

(c) Average observed performance rating

= 102.5

(d) Weight of broken meat extracted from test sample

= 3 lbs. - 4 oz.
= 3.25 lbs.

(e) Weight of whole leg meat extracted from test sample

= 1 lb. - 2 oz.
= 1.125 lbs.

(f) Weight of tips and small legs in shell from test sample

= 1 lb. - 2 oz.
= 1.125 lbs.

SUMMARY OF RESULTS: SHUCK (A) SHOULDERS, LARGE LEGS, KNUCKLES CLAW AND CLAW LEGS,
(B) REMOVE TIPS AND SMALL LEGS; (Operation No. 6, Valleyfield)

Test No. 2

Normalized results	Standardized results	Yield Output weight to input test sample weight
1. Time = 27.90 min. (test sample).	1. Time = 32.63 min. (test sample).	1. Broken meat = 32.1% of whole sections.
2. Output whole sections = 21.77 lbs./hr.	2. Output whole sections = 18.62 lbs./hr.	2. Whole leg meat = 11.11% of whole sections.
3. Output of broken meat = 6.99 lbs./hr.	3. Output of broken meat = 5.98 lbs./hr.	3. Tips and small legs (in shell) = 11.11% of whole sections.
4. Output of whole leg meat = 2.42 lbs./hr.	4. Output of whole leg meat = 2.07 lbs./hr.	1. Total meat from whole sections (excluding leg tips & small legs) = 25.1% of live crab.

DATA FROM OPERATION

TEST NO. 3

(a) Weight of cooked and cooled sections

= 10 lbs. - 5 oz. (test sample)
= 10.31 lbs.

(b) Actual time to shake sections

= 21 min. - 54 sec.
= 21.9 min.

(c) Average observed performance rating

= 123.3

(d) Weight of broken meat extracted from test sample

= 3 lb. - 2 oz.
= 3.125 lbs.

(e) Weight of whole legs extracted from test sample

= 1 lb. 6 oz.
= 1.375 lbs.

(f) Weight of tips and small legs in shell from test sample

= 1 lb. - 10 oz.
= 1.625 lbs.

SUMMARY OF RESULTS: SHUCK (A) SHOULDERS, LARGE LEGS, KNUCKLES CLAW AND CLAW LEGS.

(B) REMOVE TIPS AND SMALL LEGS; (Operation No. 6, Valleyfield)

Test No. 3

Normalized results	Standardized results	Yield Output weight to input weight of test sample
1. Time = 27 min. (test sample).	1. Time = 31.58 min. (tested sample).	1. Broken meat = 30.30% of whole sections.
2. Output whole section = 22.92 lbs./hr.	2. Sections = 19.59 lbs./hr.	2. Whole leg meat = 13.33% of whole sections.
3. Output of broken meat = 6.94 lbs./hr.	3. Output of broken meat = 5.94 lbs./hr.	3. Tips and small legs in shell 15.76% of whole sections
4. Output of whole leg meat = 3.06 lbs./hr.	4. Output of whole leg meat = 2.61 lbs./hr.	1. Total meat from whole sections (excluding leg tips and small legs) = 25.2% of live crab.

Summary of three test results:

Test 1: <u>Standard output</u>: 18.02 lbs./hr. whole sections.
Total meat from whole sections (excluding leg, tips and small legs) = 23.9%.

Test 2: <u>Standard output</u>: 18.62 lbs./hr. whole sections.
Total meat from whole sections (excluding leg tips and small legs) = 25.1%

Test 3: <u>Standard output</u>: 19.59 lbs./hr. whole sections.
Total meat from whole sections (excluding leg tips and small legs) = 25.2%

5:222 <u>COOKING CRAB SECTION - (BATCH METHOD); (Operation No. 3, Valleyfield)</u>:

One of the main differences in the processing techniques used by both is the method of cooking. The Valleyfield plant uses the batch cooking process and the Ship Cove plant uses a continuous cooker. Section 2:24 of this report outlined in detail the differences in the two cooking methods used.

DATA FROM OPERATION

(a) Weight of raw sections in shell plus cooking basket

= 347.5 lbs.

(b) Weight of cooking basket empty

= 100 lbs.

(c) Weight of raw sections in shell

= 247.5 lbs.

(d) Weight of cooked and cooled sections in shell plus cooking basket

= 336 lbs.

(e) Weight of cooked and cooled sections in shell

= 236 lbs.

SUMMARY OF RESULTS: <u>Cooking crab section - (Batch Method); (Operation No. 3, Valleyfield)</u>:

(1) Loss of weight in cooking

= 247.5 lbs. - 236 lbs.
= 11.5 lbs.

(2) Loss of weight as percentage of raw sections

$$= \frac{11.5}{247.5} \times 100\%$$

$$= 4.6\% \text{ or approximately } 5\%$$

(3) Percentage yield of cooked and cooled sections to raw sections

$$= \frac{236}{247.5} \times 100\%$$

$$= 95.40\%$$

5:223 <u>ROLL COMBINED TIPS AND SMALL LEGS TO REMOVE MEAT; (Operation No. 7, Valleyfield)</u>:

At the Ship Cove plant the small legs and the tips were separated for individual rolling on the machine. At Valleyfield during the study, the tip and small legs were not being separated, but rather rolled as one unit.

The percentage allowance taken for this operation was 11.5% which was the same value used for the Ship Cove computations.

<u>DATA FROM OPERATION</u>

<u>TEST NO. 4</u>

(a) Weight of tips and small legs in shell (test sample)

= 4 lbs.

(b) Actual time to roll test sample

= 7 min. - 41 sec.
= 7.68 min.

(c) Average observed performance rating factor

= 114.3

(d) Weight of meat obtained

= 1 lb. - 8 oz.
= 1.5 lbs.

SUMMARY OF RESULTS: ROLL COMBINED TIPS AND SMALL LEGS TO REMOVE MEAT; (Operation No. 7, Valleyfield)

Test No. 4

Normalized results	Standardized results	Yield Output weight to imput weight of test sample
1. Time = 8.78 min. (test sample).	1. Time = 9.92 min. (test sample)	1. 37.5% meat output of test sample.
2. Output tips and small legs in shell = 27.33 lbs./hr.	2. Output tips and small legs in shell = 24.19 lbs./hr.	1. Meat from leg tips & small legs = 2.4% of live crab.
3. Output of meat from tips and small leg = 10.25 lbs./hr.	3. Output of meat from tips and small legs = 9.07 lbs./hr.	

5:224 FREEZING OR CANNING OF FRESH CRAB MEAT; (Operation No. 12, Valleyfield):

The Valleyfield plant has the capability to produce canned as well as frozen crab products. This feature in the plant allows operational flexibility as change from a frozen to a canned product can be made quickly in the plant without much disruption of production. Both operations can be conducted simultaneously or separately according to the discretion of the plant management.

The following is a list of the operations which are used on the canning line at Valleyfield.

Operation No.	Description	No. of workers required
1	Cut whole legs to desired length to fit the round can.	1
2	Bring prepared cans to work area. NOTE: When the cans are taken from their holding cartons, they must be spray washed with hot water to remove dust or foreign material and then fitted with a parchment liner. The parchment liner ensures that the crab meat will not come in contact with the metal of the can which can cause blueing of the crab meat.	1
3	Place layer of cut leg portions in bottom of cans.	1
4	Place broken meat in can over leg portions.	1
5	Place layer of cut leg portion on top of broken cans.	2
6	Weigh can adding or substracting meat as required. NOTE: Usually only one girl	1

Operation No.	Description	No. of workers required
	does the weighing of the cans, but if a build up occurs, a worker, from operation number five does weighing also.	
7	Arrange legs on top of cans after weighing.	2
8	Add necessary additives.	1
	NOTE: The types of additives used and their function was discussed in section 2:28	
9	Fold parchment liner down over crab meat.	1
10	Place cans on conveyor belt which takes cans to the seaming machine.	1
	NOTE: The worker who folds the paper also places the cans on the conveyor after a number of cans have been prepared.	
11	Seaming machine - capacity 45 cans per minute.	
		12 Total

Operation No.	Description	No. of workers required
12	Can washing prior to re- torting.	NOTE: See notes in this table for utilization of workers on line.
13	Retorting - temperature of 230° F. for 90 min. for the type of can used.	
14	Cooling.	
15	Labelling and final pack- aging. NOTE: This operation is not performed continuously as the cans are filled and retorted, but, rather done later when broken time occurs in other operations and the worker can do the work to fill the work day.	

Figure 2:9 shows the floor plan of the Valleyfield plant. The canning of the crab is done in the area of the plant where the fresh crab meat is prepared. After the cans are filled, they move by roller conveyor to the seaming machine and finally on to the retorts and cooking tanks.

DATA FROM OPERATION

TEST NO. 5

Since the canning operation is a group dependent operation, performance ratings were done on each worker in the group and the overall average used in the calculation of normal and standard times. The allowance percentage for this operation was taken as 12% (Barnes, 1968).

SUMMARY OF RESULTS: Freezing or canning of fresh crab meat; (Operation No. 12, Valleyfield):

NOTE: Canning results.

Normalized results	Standardized results
1. Time = 9.99 min. (test sample).	1. Time = 11.36 min. (test sample).
2. Output = 600 cans/hr. for 12 operators.	2. Output = 528 cans/hr. for 12 operators.
3. Output = 50 cans/hr./ operator.	3. Output = 44 cans/hr./ operator.

5:230 METHODS, TIME, MEASUREMENT (M.T.M.) ANALYSIS; (Valleyfield):

5:231 INTRODUCTION:

One operation was studied using M.T.M. techniques for the Valleyfield plant. This was the shucking of the whole section which was done by completely manual means with the exception of the tips and small legs. The meat from these portions was removed by means of a rolling unit.

M.T.M. Analysis Chart

5:232 Sheet No. 1 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:01			7.6	ET	Eye travel to pan of sections.
6:02			7.3	EF	Eye focus on pan of sections.
6:03			11.5	RC-8	Reach to pan for whole sections.
6:04			7.3	G4A	Grasp whole section.
6:05	Reach for section in R.H.	RA-8	7.2	MB-8	Move section to work area center of operator.
6:06	Grasp section in R.H.	G-3	5.6	RL-1	Release section.
6:07	Turn section in R.H. to grasp tips.	T-45°	4.9	RA-4	Reach back for tip.
6:08			9.1	G4B	Grasp one tip.
6:C9	Turn to facilitate breaking of tips.	T-360°	10.6	AP-2	

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M.T.M. Analysis Chart

5:232 Sheet No 2 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:10			2.9	MB-2	Move section.
6:11			4.0	D	Disengage tip from section.
6:12			4.3	MB-4	Move tip away from section.
6:13	Release whole section.	RL-1	2.0		
6:14	Reach for tips in R.H.	RA-3	4.5		
6:15	Take tip from R.H.	G1A	2.0		
6:16		AP-2	10.6		
6:17	Move tip to pan.	MB-8	7.2		
6:18	Release tip.	RL-1	2.0		
6:19	Reach for whole section.	RB-8	7.2	RB-8	Reach for whole section.
6:20		G1A	2.0	G1A	

M.T.M. Analysis Chart

5:232 Sheet No. 3 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small leg; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:21	Move section.	MB-4	4.3	MB-4	Move section.
6:22			2.0	RL-1	Release section to L.H.
6:23			4.5	RA-3	Reach for sectioh again.
6:24		MB-4	5.6	G-2	
6:25	Position hands on section to break legs.	RL-1	2.0		
6:26		G1A	2.0		
6:27			10.6	AP-2	Break off first leg.
6:28			4	D	Disengage leg.
6:29			7.2	MB-8	Move leg away from section.
6:30			9.7	MA-8	Move hand with leg against pan side.

M.T.M. Analysis Chart

5:232 Sheet No. 4 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:31			5.7	MB-6	Move up from box.
6:32			8.1	MA-6	Move hand with leg down on box.
6:33			4.3	MB-4	Move leg back to top of table.
6:34			2.0	RL-1	
6:35			5.7	RA-6	Reach for whole section.
6:36		G-2	5.6	G-3	Grasp tip.
6:37		MB-3	10.6	AP-2	Break tips.
6:38			4.0	D	Disengage tips from section.
6:39	Turn to help remove tips.	T-45°	4.3	MB-4	Move section as tips are broken.

M.T.M. Analysis Chart

5:232 Sheet No. 5 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs, remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:40			2.0	RL-1	Release tips.
6:41			6.5	RA-8	Reach back for whole section.
6:42	Release whole section.	RL-1	5.6	G-3	Transfer grasp on section.
6:43			8.1	MA-6	Strike whole section on side of shucking pan.
6:44			5.7	MB-6	Raise whole section from side of shucking pan.
6:45			8.1	MA-6	
6:46		RA-6	5.7	MB-6	
6:47	Transfere grasp on section.	G-3	5.6	RL-1	Release section.

M.T.M. Analysis Chart

5:232 Sheet No. 6 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs: (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:48	Move up for R.H. grasp.	MB-4	4.9	RA-4	Reach for section
6:49		G-5	5.6	G-3	
6:50	Move L.H. to pan of meat.	MB-8	7.2		
6:51		RL-1	2.0		
6:52	Reach for section.	RA-8	6.5		
6:53		G-3	5.6	RL-1	
6:54			4.5	RA-3	Reach for knuckles.
6:55		$T-150^{\circ}$	8.1	G1A	Grasp all knuckles.
6:56			10.6	AP-2	Break knuckles.
6:57			4.0	D	Disengage knuckles.

M.T.M. Analysis Chart

5:232 Sheet No. 7 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:58			5.7	MB-6	Move knuckles to shute.
6:59	Move section to anvil on shucking table.	MC-10	13.5	RL-1	Release knuckles.
6:60					Reach for mallet.
6:61	Position crab on anvil.	P1SS	9.1	RB-4	
6:62			2.0	G1A	Grasp mallet.
6:63			7.2	MB-8	Move mallet over crab.
6:64			9.7	MA-8	Move mallet down on section.
6:65			7.2	MB-8	Moving of mallet down on section a number of times to break the soft shell covering the shoulder meat.

M.T.M. Analysis Chart

5:232 Sheet No. 8 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:66			7.2	MB-8	
6:67			9.7	MA-8	
6:68			7.2	MB-8	
6:69			9.7	MA-8	
6:70			5.7	MB-6	
6:71			8.1	MA-6	
6:72			5.7	MB-6	
6:73	Move section from anvil.	MB-6	8.9	RL-1	Release mallet.
6:74			5.7	RA-6	Reach for section.
6:75	Release section.	RL-1	5.6	G-3	Transfer grasp.
6:76			5.4	T-90°	Turn crab to strike pan to knock out shoulder meat.

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M.T.M. Analysis Chart

5:232 Sheet No. 9 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:77	Reach to take shoulder portion of section.	RA-6	5.7	MB-4	
6:78		G1A	2.0		
6:79	Apply pressure to shoulder portion of section.	AP-2	10.6		
6:80		RL-1	2.0		
6:81			5.7	MB-6	
6:82			8.1	MA-6	
6:83			2.9	MB-2	
6:84			3.6	MA-2	
6:85			2.9	MB-2	

M.T.M. Analysis Chart

5:232 Sheet No. 10 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:86			3.6	MA-2	
6:87			2.9	MB-2	
6:88			3.6	MA-2	
6:89			2.3	MB-1	
6:90			2.5	MA-1	
6:91	Reach to remove piece of shell in meat.	RC-6	10.1	MB-1	
6:92	Grasp piece of shell.	G4C	12.9	MA-1	
6:93	Move shell to offal flume.	MB-10	8.6	MB-8	
6:94	Release piece of shell.	RL-1	9.7	MA-8	

M.T.M. Analysis Chart

5:232 Sheet No. 11 of 27

Operation Description: Shuck shoulder, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:95			5.7	MB-6	Shaking of shoulder meat.
6:96			8.1	MA-6	
6:97			2.9	MB-2	
6:98		RL-1	3.6	MA-2	
6:99			2.3	MB-2	
6:100			3.6	MA-2	
6:101			2.3	MB-2	
6:102			3.6	MA-2	
6:103			2.3	MB-2	
6:104			3.6	MA-2	

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M.T.M. Analysis Chart

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Sheet No. 12 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips [illegible]

No.	Description	LH	TMU	RH	Description
6:105	Reach for second piece of shell in meat.	RC-10	12.9	MB-8	
6:106	Grasp shell fragment.	G4C	12.9		
6:107	Move shell fragment.	MB-6	5.7		
6:108	Hit shell fragment on side of pan to remove meat.	MA-6	8.1		
6:109		MB-8	7.2		
6:110		MA-8	9.7		
6:111	Release piece of shoulder shell.	RL-1	2.0		

M.T.M. Analysis Chart

5:232 Sheet No. 13 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:112	Reach for remaining section in R.H.	RA-6	5.7		
6:113	Take crab section.	G1A	2.0	RL-1	
6:114			4.9	RA-4	Reach to L.H. for section.
6:115			2.0	G1A	Grasp section.
6:116			10.6	AP-2	
6:117		MB-3	5.7		
6:118			2.0	RL-1	Release section.
6:119			2.3	RA-2	Reach for piece of shell on table.
6:120			2.0	G1A	

M.T.M. Analysis Chart

5:232 [illegible]

[illegible]

and small legs: (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:121			10.6	AP-2	
6:122			5.7	MB-6	
6:123			2.0	RL-1	Release piece of shoulder.
6:124			5.7	RA-6	Reach for first leg.
6:125			2.0	G1A	Pick up leg.
6:126	Left hand holding remaining crab section.		8.1	MA-6	Move leg from shoulder.
6:127			4.0	D	
6:128			5.7	MB-6	Shucking of leg.
6:129			8.1	MA-6	
6:130			5.7	MB-6	

M.T.M. Analysis Chart

5:232 Sheet No. 15 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:131			8.1	MA-6	
6:132			5.7	MB-6	
6:133			8.1	MA-6	
6:134			5.7	MB-6	
6:135			8.1	MA-6	
6:135	Reach to leg meat moving from shell.	RA-6	5.7	MB-6	
6:136	Grasp leg.	G4A	7.3	MB-2	
6:137	Move leg to pan.	MC-8	11.8		Holding shell as meat removed by left hand.
6:138	Release leg meat in pan.	RL-1	11.8	MC-8	

M.T.M. Analysis Chart

5:232

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:139	Reach for second leg.	RB-8	7.2	RB-8	Reach for mallet.
6:140			5.7	ET	Eye travel to anvil.
6:141			7.3	EF	Eye focus on anvil.
6:142	Grasp leg in shell.	G1A	2.0	G1A	Grasp mallet.
6:143	Move leg to anvil.	MC-6	10.3	MB-8	Move mallet over leg.
6:144			9.7	MA-8	Move mallet down on leg.
6:145			7.2	MB-8	Move mallet up from leg.
6:146			2.0	RL-1	Release mallet to table down on swing.
6:147	Move leg from anvil.	MB-4	4.3	RA-2	Reach for leg.
6:148	Move towards R.H.	MB-2	2.9		

M.T.M. Analysis Chart

5:232 Sheet No. 17 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:149			2.0	G1A	Grasp leg L.H.
6:150			10.6	AP-2	Apply pressure to leg.
6:151			2.9	MB-2	Move leg for shucking.
6:152			2.0	RL-1	Leg dropped accidently.
6:153			3.5	RA-2	Reach for leg again.
6:154			2.0	G1A	Grasping of the leg to get it in position for shucking.
6:155			5.7	MB-6	Shuck leg.
6:156			8.1	MA-6	
6:157			4.3	MB-4	
6:158			6.1	MA-4	Move hand down on edge of pan to jar the leg meat free.

M.T.M Analysis Chart

5:232 — Sheet No. 18 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:159			4.3	MB-4	
6:160			6.1	MA-4	
6:161			4.3	MB-4	
6:162			6.1	MA-4	
6:163	Reach for piece of broken meat from leg shell move to pan and release.	RC-4	6.4		
6:164		G4A	7.3		
6:165		MC-8	11.8	MB-6	
6:166			8.1	MA-6	Continue to shuck remainder of leg.

M.T.M. Analysis Chart

5:232 Sheet No. 19 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:167		RL-1	5.7	MB-6	
6:168			8.1	MA-6	
6:169			8.6	MB-10	Move shell to shute.
6:170			2.0	RL-1	Release shell.
6:171			5.6	ET	Eye travel to mallet.
6:172			7.3	EF	Eye focus on mallet.
6:173	Reach for another leg.	RB-10	8.6	RB-10	Reach for mallet.
6:174	Grasp leg.	G1A	2.0	G1A	Grasp mallet.
6:175	Move leg to anvil.	MC-4	8.0	MB-6	Move mallet over leg.
6:176	Position leg on anvil.	P1SS	9.1	MA-6	Move mallet over leg.
6:177			5.7	MB-6	Move mallet down on leg to break shell.

M.T.M. Analysis Chart

5:232

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:178			8.1	MA-6	
6:179			2.0	RL-1	Release mallet on table.
6:180	Move leg from anvil.	MB-6	4.5	RA-3	Reach for third leg.
6:181				G-5	Hook grasp - full contact not made.
6:182			3.5	RA-2	Reach again for third leg.
6:183	Release leg.	RL-1	5.6	G-3	Transfer grasp from L.H.
6:184			5.7	MB-6	Move third leg for shucking.
6:185			8.1	MA-6	
6:186			4.3	MB-4	
6:187			6.1	MA-4	

M.T.M. Analysis Chart

5:232

Sheet No. 21 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:188			4.3	MB-4	
6:189			6.1	MA-4	
6:190			5.7	MB-6	
6:191			8.1	MA-6	
6:192			5.7	MB-6	
6:193			8.1	MA-6	
6:194			5.7	MB-6	
6:195			8.1	MA-6	Leg difficult to shuck, move back to anvil.
6:196	Reach for leg in L.H.	RA-4	5.7	MB-6	
6:197	Grasp leg.	G-3	5.6	RL-1	Release leg.

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M.T.M. Analysis Chart

5:232 Sheet No. 22 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:198	Position leg on anvil.	P1SS	9.1	RB-6	Reach for mallet.
6:199			2.0	G1A	Grasp mallet.
6:200			5.7	MB-6	Move mallet over leg.
6:201			8.1	MA-6	
6:202			5.7	MB-6	
6:203			8.1	MA-6	
6:204			5.7	MB-6	
6:205			8.1	MA-6	
6:206			2.0	RL-1	Release mallet.
6:207	Move leg towards L.H.	MB-4	5.7	RA-6	Reach for leg in L.H.

M.T.M. Analysis Chart

5:232 Sheet No. 23 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:208	Release leg.	RL-1	5.6	G-3	Transfer grasp from L.H.
6:209			5.7	MB-6	
6:210			8.1	MA-6	
6:211	Eye travel to leg meat in pan.	ET	3.8		
6:212	Eye focus on leg meat in pan.	EF	7.3		
6:213	Reach for meat in pan.	RC-6	10.1		
6:214	Grasp leg meat in pan.	G4A	7.3		
6:215	Move meat to exact position with other legs in the pan.	MC-8	11.8		

5:232

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs. (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:216	Release leg meat in pan.	RL-1	2.0		
6:217			4.0	ET	Eye travel to offal shute.
6:218			7.3	EF	Eye focus on offal shute.
6:219			11.8	MC-8	Move leg shell to offal shute.
6:220			2.0	RL-1	Release leg shell.
6:221	Reach for claw and claw leg.	RB-10	8.6	RB-8	Reach for claw and claw leg.
6:222	Grasp claw and claw leg.	MB-8	2.0	G1A	Grasp claw and claw leg.
6:223		MB-8	7.2	MB-8	
6:224			10.6	AP-2	Apply pressure to break shell.

M.T.M. Analysis Chart

5:232 Sheet No. 25 of 27

Operation Description: Shuck shoulders, legs, knuckles, claws and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:225	Move claw and claw leg.	MC-8	11.8	RL-1	Release claw and claw leg.
6:226	Position claw and claw leg on anvil.	P1SS	9.1	RB-6	Reach for mallet.
6:227			2.0	G1A	Pick up mallet.
6:228			5.7	MB-6	Move mallet over claw and claw leg.
6:229			8.1	MA-6	
6:230			7.2	MB-8	
6:231			8.1	MA-6	
6:232			2.0	RL-1	Release mallet.
6:233	Move claw and claw leg from anvil.	MA-10	11.3		

M.T.M. Analysis Chart

5:232 Sheet No. 26 of 27

Operation Description: Shuck shoulders, legs, knuckles, claws and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description
6:234	Shake claw and claw leg.	MB-6	5.7		
6:235		MA-6	8.1		
6:236	MB-4	MB-4	4.3		
6:237		MA-4	6.1		
6:238	Move claw shell to offal shute.	MC-8	11.8		
6:239	Release claw and claw leg in shute.	RL-1	2.0		

TOTAL = 1445.5 T.M.U.
= 0.0145 Hr.
= 0.867 Min.
= 52.04 Sec.

M.T.M Analysis Chart

5:232 Sheet No. 27 of 27

Operation Description: Shuck shoulders, legs, knuckles, claw and claw legs and remove tips and small legs; (Operation No. 6, Valleyfield)

No.	Description	LH	TMU	RH	Description

From section 5:13 the average weight of cooked and cooled sections in shell is 0.46 lbs.

Therefore,

(a) Output in pounds per hour of whole section using M.T.M. analysis,

= 0.46 divided by 0.0145 hr.

= 31.72 lbs./hr.

5:30 COMPARISON OF RESULTS OBTAINED BY USING TIME STUDY AND METHODS, TIME, MEASUREMENT (M.T.M.) ANALYSIS:

5:31 INTRODUCTION:

Time Study and Methods, Time, Measurement (M.T.M.) techniques were used for the analysis of the same operation at the Ship Cove and Valleyfield plant. There are, however, particular advantages of each system and the actual work situation will dictate where each should be used.

The Time Study method is a very quick means of arriving at the time standards for the working conditions as they exist under the production operation. But, it is dependent upon the performance rating and its establishment in practice. Also, the Time Study requires the use of stop watches which are usually disliked by the operators in the plant.

The M.T.M. techniques can be done before the actual production commences in the plant and by the detailed study of motion pictures, the methods of performing the work can be improved and changed without disrupting the inplant operations.

5:32 COMPARISON AND DISCUSSION OF RESULTS:

Table No. 5:1 presents a comparison of the normal outputs of the various operations at the Ship Cove and Valleyfield plants using Time Study and Method, Time, Measurement (M.T.M.) techniques.

In all of these cases the M.T.M. results are different from those obtained by the Time Study technique. There are reasons to explain these differences in the two results.

(a) There could be error in the performance rating which was arrived at for the various operations.

(b) The operator may not have been performing the correct method for doing the job resulting in unnecessary motions.

(c) To arrive at the output for the M.T.M. analysis, the average weight of the various elements of the crab had to be used. Possibly slight errors could result due to size of sample taken or missing claws, legs, tips, etc. could affect the average result.

(d) The operator may have developed a high degree of skill which the M.T.M. could not reflect. The performance rating would take into account such factors as the effort and the speed of the operator would be considered as the ratings are made.

(e) As M.T.M. analysis is done from motion picture study, it may be difficult to recognize all the motions involved in the operation. A case in point is the removal of the meat from the slit legs. The operators were required to perform many small manipulations of the crab leg and their hands to extract the meat. In operations such as these, some movements could be overlooked and delays not recognized.

An M.T.M. analysis can not be used for any yield establishment of any operation. This is because actual inputs and outputs are not measured for the study, but rather the methods are determined from motion picture and a predetermined value of time is prescribed for each motion in the whole operation. Time Study would provide the necessary data as inputs and outputs are determined for any operation under consideration.

It will be noted from table 5:1 using the normal output time study analysis that the quantity of crab meat per worker is higher in the Valleyfield plant then at the Ship Cove plant.

At Valleyfield the shucker is required to shuck the whole crab section with the exception of the small legs and the leg tips. Using test No. 1 results page 257 of this report the total poundage output of broken meat and whole legs is 8.68 pounds per hour per person involved in the shucking operation. If the poundage of crab meat per hour is added for the Ship Cove plant (Operation Nos. 6,7,8 & 9) a total of 25.20 pounds per hour is obtained. However, the total number of workers involved to produce this much crab meat is five (Operation No. 5 must also be included) which gives a 5.04 pounds per hour per person involved in the shucking operation.

5:40 INCENTIVE SYSTEMS AND HOW THEY COULD BE EMPLOYED IN THE SNOW CRAB PROCESSING:

5:41 INTRODUCTION:

Any incentive system which is established in a production operation should have desirable effects upon the employer and upon his employees.

In the Snow Crab processing industry there are a number of factors which affect the overall productivity of the operation. These are:

(a) Rate of output.

(b) Yield of finished product.

(c) Quality of finished product.

(d) Quality of raw material.

(e) Environmental conditions in plant.

(f) Mechanization of operation.

(g) Work layout and plant layout.

(h) Attitude of supervisory staff.

(i) Worker turnover.

(j) Quality control.

Thus, any incentive system must be linked to these requirements and provide benefits to the employer and his employees.

5:42 ESTABLISHING OF INCENTIVE SYSTEM:

There are two basic kinds of wage incentives based on labor standards. One system pays the operator in direct proportion to any performance above a normal or 100% pace. The other pays bonus according to some sort of sliding scale other than in a direct proportion.

The latter of the two above was used in early incentive system installation, but today most have been converted to the direct proportion approach. The direct proprotional system is simple to apply and operate. The worker's reward is tied directly to his amount of output. Also, the worker enjoys the full benefit of any extra effort which he may perform at his job and he can easily calculate his particular earnings.

Thus, for a crab processing plant, a direct proportional system can be implemented which would incorporate a standard rate of output at a standard yield for a given quality of work produced. The necessary standards must be established by work measurement techniques such that they are fair and equable to both the employer and the employee.

The incentive system can be established by setting a reward (usually in terms of money) for any unit increase in output above the standard rate. Coupled with this increase in output rate must be the fact that yield standards are maintained. Rewards are paid for increases in yields above the standard minimum. The quality of the output is related to a required level dictated by market demands. The quality of the operators work would be related to the amount of shell fragments in the broken meat or in the amount of unnecessary broken leg meat produced.

After the motions are established the time study is performed by qualified rating personnel and the normal outputs calculated. Having determined these normal values and the decisions made regarding personal and other allowances, the standard outputs can be obtained.

Included in the analysis work done during the plant studies must be the gathering of yield data on various operator's work.

Figure 5:4 shows the relationship which would be found to exist if an operators speed and skill is plotted against his output yields. This figure is indicative of the results which would occur for the shucking of the whole crab section, but other studies (Amaria, Research Report No. 3, 1974) have shown that similar results occur whenever speed and skill are plotted against yield. Generally, as the workers pace of doing the job increases his output yield drops off.

With an incentive system each person is guaranteed his hourly rate of pay. However, incentives are only paid for work done over the standards decided by Time Measurement techniques. In most job situations new employees are allowed time to achieve these standards for the particular job for which he was hired. If he can not achieve these goals within a reasonable period of time, he will be replaced. Once the workers do achieve the standards, the incentive is provided to increase the workers output, but without sacrificing the output yield. It should be remembered that the effort which an employee chooses to exert at a given time or a particular day is entirely a personal matter for him, but he must maintain the minimum standards which were established.

Therefore, incentive systems based upon proper work measurement techniques and practice:

(1) Encourage the developement of improved methods for performing the work.

(2) Shows the employee the standards which he must achieve in order to receive bonus. It encourages him not to waste time or motions.

(3) Encourages the worker to work to increase his skill at his job and improve his techniques.

5:43 <u>EXAMPLE OF INCENTIVE SYSTEM; FOR SHUCKING OF SHOULDERS, LARGE LEGS, KNUCKLES, CLAWS AND CLAW LEGS AND REMOVAL OF TIPS AND SMALL LEGS:</u>

<u>STEP NO. 1</u>

Various workers performing this work must be studied and their performance ratings established and their output yields calculated. From this raw data on the workers, graphs such as shown in Figure 5:4 should be constructed. It will be noted that only workers who have achieved a 100% rating or higher can be used for this incentive study.

<u>STEP NO. 2</u>

The relationship between labor and material must be

<u>Note</u>: The details provided here are used for example purposes only and are not meant to be based on actual case study. However, following the format as described in section 5:42 above all the details for an incentive system for the various jobs in a crab plant can be established.

The standard output of all meat is taken for this example to be 10 lbs./hr., however, for a correct incentive system, this would be established by Methods Study techniques. The yields of crab meat in this example are used for explanation purposes, but for an incentive system establishment yield data would be gathered for the actual inplant operating conditions.

established. The cost of the raw live crab to the plant is fixed and is known. For the purposes of this example a cost of 16 cents per pound shall be assumed. It shall also be assumed that a standard output of all meat (broken plus whole legs) for this operation is 10 lbs./hr and that the hourly pay for this operation is $3.00/hr.

(a) Thus the average cost of shucking meat per pound for a operator working at 100% output

$$= \frac{300}{10}$$

$$= 30 \text{ cents/lb.}$$

If the operator works at 130% rating he shall produce 13 lbs. of meat per hour.

Thus, the average cost of shucking meat per pound for a worker working 130%

$$= \frac{300}{13}$$

$$= 23 \text{ cents/lb.}$$

Similarly the costs of meat per pound can be calculated for all other performance ratings.

(b) Since the cost of raw live crab is known to be 16 cents per pound, then the cost of meat for various yields can be calculated.

For a 18% yield the meat cost

$$= \frac{16¢}{18} \times 100$$

$= 88.9$ cents/lb. - meat.

For a 24% yield the meat cost

$$= \frac{16 \text{ cents}}{24} \times 100$$

$= 66.7$ cents/lb. - meat.

In a similar manner the costs of meat for various yields can be calculated.

Table 5:2 shows the cost of crab meat extracted from the whole crab section in relationship to the percentage output yield and performance rating.

The objective of the incentive system is to have the operators for the particular operation work in the lower right hand portion of this table. The closer the worker comes to this area, the lower will be the cost per pound of the meat which he produces.

Table 5:3 shows the savings per pound of meat extracted and per hour for the different values of performance rating and percentage of output yields.

Example, calculations for Table 5:3:

Rating = 120

Yield = 20%

(a) Per pound saving

$$= (\$1.14 - \$1.05) + (\$1.10 - \$1.05)$$

$$= \$0.09 + \$0.05$$

$$= \$0.14$$

(b) Per hour saving

= Output (lbs.)/hr. x saving per pound.
= 12.0 x 0.13
= $1.56/hr.

When the table of savings is known to the management of the company, a decision has to be made as to the amount of increase in pay which the worker shall receive. To make this decision, the following items must be considered.

(1) The cost of setting the incentive system in the plant. Time Study, etc.

(2) The cost of maintaining the incentive system.

(3) Other company overheads which are reduced by the volume throughput in the plant.

(4) Extra profit will be realized by the company because yields and throughput are increased.

(5) Overall company policy toward employee relations.

(6) Labour negotiations with employee's representatives about the amount of incentive.

It shall be assumed for the purpose of this example that it is decided that 50% of the hourly savings shall be given to the workers as a bonus.

Table No. 5:4 shows the hourly rates to pay for the various performance ratings and percentage output yields.

Using table 5;4 an operators hourly pay for various performance standards can be calculated. The following steps must be used:

(1) Find the operators output of meat in pounds per hour.

(2) Find the operators yield of meat from cooked whole sections.

(3) Compare the output and yield obtained for the standards established for the job.

(4) If the operators output and yield is above the standard he is paid a bonus. From table 5;4 his wages per hour can be found for the various performance ratings and yield.

(5) Using this rate for daily pay can be calculated.

For example if an operator performs at 18% yield and a performance rating of 120, his hourly pay would be $3.30 per hour.

Table No. 5:1

COMPARISON OF NORMAL OUTPUTS OF VARIOUS OPERATIONS AT SHIP COVE AND VALLEYFIELD PLANTS USING TIME STUDY AND METHODS, TIME, MEASUREMENT TECHNIQUES:

Operation No.	Description	Normal output Time Study analysis	Normal output (M.T.M.) analysis
2 (Ship Cove)	Butchering, degilling and washing of live crab.	(a) 521 lbs./hr. live crab.	(a) 563.39 lbs./hr. live crab.
		(b) 345 lbs./hr raw whole sections.	(b) 344 lbs./hr. raw whole sections.
5 (Ship Cove)	Divide cooked and cooled sections into (a) Tips and small legs, (b) claw legs with claws, (c) shoulder, large legs and knuckles.	(a) 252 lbs./hr. cooked and cooled whole sections.	(a) 221.56 lbs./hr. cooked and cooled whole sections.

Table No. 5:1

COMPARISON OF NORMAL OUTPUTS OF VARIOUS OPERATIONS AT SHIP COVE AND VALLEYFIELD PLANTS USING TIME STUDY AND METHODS, TIME, MEASUREMENT TECHNIQUES:

Operation No.	Description	Normal output Time Study analysis	Normal output (M.T.M.) analysis
6 (Ship Cove)	Shuck meat from (a) knuckles and shoulders, (b) Remove large legs and (c) place shoulder and small legs into seperate pans.	(a) 57.3 lbs./hr. section in shell. (b) 8.6 lbs./hr. broken meat from shoulder and knuckles. (c) 1.9 lbs./hr. small legs in shell. (d) 20.4 lbs./hr. large leg in shell.	(a) 61.41 lbs./hr. section in shell.
7 (Ship Cove)	Shuck claw and claw leg.	(a) 18.18 lbs./hr. claw and claw legs in shell.	(a) 39.12 lbs./hr. claw and claw leg in shell.

Table No. 5:1

COMPARISON OF NORMAL OUTPUTS OF VARIOUS OPERATIONS AT SHIP COVE AND VALLEYFIELD PLANTS USING THE TIME STUDY AND METHODS, TIME, MEASUREMENT TECHNIQUES:

Operation No.	Description	Normal output Time Study analysis	Normal output. (M.T.M.) analysis
		(b) 7.58 lbs./hr. broken meat from claw and claw leg.	
8 (Ship Cove)	Slit large crab legs, one side only.	(a) 46.96 lbs./hr. large legs in shell. (test No. 1)	(a) 40.15 lbs./hr. large legs in shell.
		(b) 39.62 lbs./hr. large legs in shell. (test No. 2)	
9 (Ship Cove)	Remove leg meat from slit leg.	(a) 9.03 lbs./hr. legs in shell.	(a) 35.14 lbs./hr. legs in shell.
		(b) 8.00 lbs./hr. whole unbroken leg meat from slit leg.	

Table No. 5:1

COMPARISON OF NORMAL OUTPUTS OF VARIOUS OPERATIONS AT SHIP COVE AND VALLEYFIELD PLANTS USING THE TIME STUDY AND METHODS, TIME, MEASUREMENT TECHNIQUES:

Operation No.	Description	Normal output Time Study analysis	Normal output (M.T.M.) analysis
		(b) Meat from slit legs.	
		(c) 1.02 lbs./hr. broken leg meat from slit leg.	
10 (Ship Cove)	Roll leg tips to remove meat.	(a) 16.35 lbs./hr. leg tips in shell.	(a) 12.70 lbs./hr. leg tips in shell.
		(b) 6.37 lbs./hr. meat from leg tips.	
11 (Ship Cove)	Roll legs to remove meat.	(a) 13.42 lbs./hr. small legs in shell.	(a) 12.45 lbs./hr. small legs in shell.
		(b) 5.97 lbs./hr. meat from small legs.	

Table No. 5:1

COMPARISON OF NORMAL OUTPUTS OF VARIOUS OPERATIONS AT SHIP COVE AND VALLEYFIELD PLANTS USING THE TIME STUDY AND METHODS, TIME, MEASUREMENT TECHNIQUES:-

Operation No.	Description	Normal output Time Study analysis	Normal output (M.T.M.) analysis
16 (Ship Cove)	Packaging of 5 lb. "Combination Pack" crab meat.	113 lbs./hr.	182.95 lbs./hr.
6 (Valleyfield)	Shuck (A) Shoulders, large legs, knuckles, claw and claw legs (B) Remove tips and small legs.	Test No. 1 (a) 21.08 lbs./hr. whole section in shell. (b) 5.79 lbs./hr. broken meat. (c) 2.89 lbs./hr. whole leg meat. Test No. 2 (a) 21.77 lbs./hr. whole section in shell.	(a) 31.72 lbs./hr. whole section in shell.

Table No. 5:1

COMPARISON OF NORMAL OUTPUTS OF VARIOUS OPERATIONS AT SHIP COVE AND VALLEYFIELD PLANTS USING THE TIME STUDY AND METHODS, TIME, MEASUREMENT TECHNIQUES:

Operation No.	Description	Normal output Time Study analysis	Normal output (M.T.M.) analysis
		(b) 6.99 lbs./hr. broken meat.	
		(c) 2.42 lbs./hr. whole leg meat.	
		Test No. 3	
		(a) 22.92 lbs./hr. section in shell.	
		(b) 6.94 lbs./hr. broken meat.	
		(c) 3.06 lbs./hr. whole leg meat.	
3 (Ship Cove)	Cooking (Continuous)	Yield: 87.74%	
3 (Valleyfield)	Cooking (Batch)	Yield: 94.5%	

NOTE: For this table assume (1) Basic pay $3.00/hr.; (2) Raw live crab cost $0.16/lb.

Table No. 5:2

Rating \ Yield	18%	20%	22%	24%
100	30.0 + 89 = $1.19	30 + 80 = $1.10	30 + 72 = $1.02	30 + 66 = $0.96
110	27 + 89 = $1.16	27 + 80 = $1.07	27 + 72 = $0.99	27 + 66 = $0.93
120	25 + 89 = $1.14	25 + 80 $1.05	25 + 72 = $0.97	25 + 66 = $0.91
130	23 + 89 = $1.12	23 + 80 = $1.03	23 + 72 $0.95	23 + 66 = $0.89

(Cost of crab meat extracted from whole crab section in relationship to percentage output yield and performance rating.)

NOTE: For this table assume: (1) Basic pay $3.00/hr.
(2) Raw live crab cost $0.16/lb. The yields chosen are for example - see note page 249 A.

Table No. 5:3

Yield / Rating	18%		20%		22%		24%	
	Per/lb.	Per/hr.	Per/lb.	per/hr.	per/lb.	per/hr.	per/lb	per/hr.
100	0	0	$0.09	$0.90	$0.17	$1.70	$0.23	$2.30
110	$0.03	$0.33	$0.12	$1.32	$0.20	$2.20	$0.26	$2.86
120	$0.05	$0.60	$0.13	$1.56	$0.26	$3.12	$0.28	$3.36
130	$0.07	$0.91	$0.16	$2.08	$0.24	$3.12	$0.30	$3.90

(Savings per pound of meat extracted and per hour for the different values of performance rating and percentage yield for the shucking of whole crab section.)

NOTE: For this table assume: (1) Basic pay $3.00/hr.
(2) One half of hourly saving to be paid worker.

Table No. 5:4

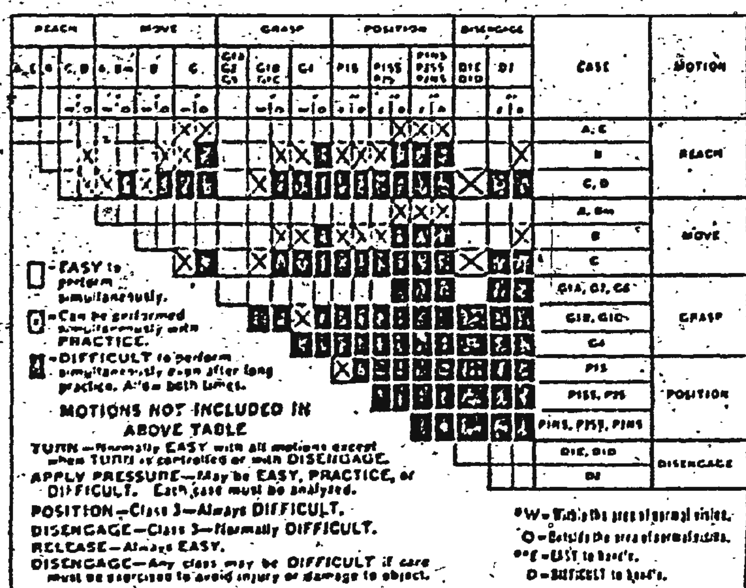
Yield / Rating	18%	20%	22%	24%
	Per hour	Per hour	Per hour	Per hour
100	$3.00	$3.45	$3.85	$4.15
110	$3.16	$3.66	$4.10	$4.43
120	$3.30	$3.78	$4.56	$4.68
130	$3.46	$4.04	$4.56	$4.95

(Proposed pay schedule for incentive system for shucking of whole crab sections.)

Body, Leg, and Foot Motions

DESCRIPTION	SYMBOL	DISTANCE	TIME TMU
Foot Motion—Hinged at Ankle.	FM	Up to 4"	8.5
With heavy pressure.	FMP		19.1
Leg or Foreleg Motion.	LM —	Up to 6"	7.1
		Each add'l. inch	1.2
Sidestep—Case 1—Complete when leading leg contacts floor.	SS-C1	Less than 12"	Use REACH or MOVE Time
		12"	17.0
		Each add'l. inch	.6
Case 2—Lagging leg must contact floor before next motion can be made.	SS-C2	12"	34.1
		Each add'l. inch	1.1
Bend, Stoop, or Kneel on One Knee.	B,S,KOK		29.0
Arise.	AB,AS,AKOK		31.9
Kneel on Floor—Both Knees.	KBK		69.4
Arise.	AKBK		76.7
Sit.	SIT		34.7
Stand from Sitting Position.	STD		43.4
Turn Body 45 to 90 degrees— Case 1—Complete when leading leg contacts floor.	TBC1		18.6
Case 2—Lagging leg must contact floor before next motion can be made.	TBC2		37.2
Walk.	W-FT.	Per Foot	5.3
Walk.	W-P	Per Pace	15.0

Simultaneous Motions



(Taken from: Barnes, 1968)

METHODS-TIME MEASUREMENT APPLICATION DATA IN TMU

1 TMU = .00001 hour
= .0006 minute
= .036 second

Do not attempt to use this chart or apply Methods-Time Measurement in any way unless you understand the proper application of the data. This statement is included as a word of caution to prevent difficulties resulting from misapplication of the data.

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Figure 5:1 Methods, Time, Measurement (M.T.M.) application data in T.M.U. for: (a) Body, leg and foot motions. (b) Simultaneous motions.

Move—M

Distance Moved Inches	Time TMU A	Time TMU D	Time TMU C	Time TMU Hand in Motion B
¾ or less	2.0	2.0	2.0	1.7
1	2.5	2.9	3.4	2.3
2	3.6	4.6	5.2	2.9
3	4.9	6.7	6.7	3.6
4	6.1	6.9	8.0	4.3
5	7.3	8.0	9.2	5.0
6	8.1	8.9	10.3	5.7
7	8.9	9.7	11.1	6.5
8	9.7	10.6	11.8	7.2
9	10.5	11.5	12.7	7.9
10	11.3	12.2	13.5	8.6
12	12.9	13.4	15.2	10.0
14	14.4	14.6	16.9	11.4
16	16.0	15.8	18.7	12.8
18	17.6	17.0	20.4	14.2
20	19.2	18.2	22.1	15.6
22	20.8	19.4	23.8	17.0
24	22.4	20.6	25.5	18.4
26	24.0	21.8	27.3	19.8
28	25.5	23.1	29.0	21.2
30	27.1	24.3	30.7	22.7

Wt. Allowance: Wt. (lb.) Up to	Factor	Constant TMU
2.5	0	0
7.5	1.06	2.2
12.5	1.11	3.9
17.5	1.17	5.6
22.5	1.22	7.4
27.5	1.28	9.1
32.5	1.33	10.8
37.5	1.39	12.5
42.5	1.44	14.3
47.5	1.50	16.0

CASE AND DESCRIPTION
A Move object to other hand or against stop.
B Move object to approximate or indefinite location.
C Move object to exact location.

Position *—P

CLASS OF FIT		Symmetry	Easy To Handle	Difficult To Handle
1—Loose	No pressure required	S	5.6	11.2
		SS	9.1	14.7
		NS	10.4	16.0
2—Close	Light pressure required	S	16.2	21.8
		SS	19.7	25.3
		NS	21.0	26.6
3—Exact	Heavy pressure required.	S	43.0	48.6
		SS	46.5	52.1
		NS	47.8	53.4

Turn and Apply Pressure—T and AP

Weight	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
Small— 0 to 2 Pounds	2.8	3.5	4.1	4.8	5.4	6.1	6.8	7.4	8.1	8.7	9.4
Medium—2.1 to 10 Pounds	4.4	5.5	6.5	7.5	8.5	9.6	10.6	11.6	12.7	13.7	14.8
Large— 10.1 to 35 Pounds	8.4	10.5	12.3	14.4	16.2	18.3	20.4	22.2	24.3	26.1	28.2

(Time TMU for Degrees Turned)

APPLY PRESSURE CASE 1—16.2 TMU. APPLY PRESSURE CASE 2—10.6 TMU

Figure 5:2 Methods, Time Measurement (M.T.M.) application data in T.M.U. for:
(a) Grasp - G
(b) Reach - R
(c) Eye travel time & eye focus - ET - EF
(d) Release - RL
(e) Disengage - D

(Taken from: Barnes, 1968)

Reach—R

(Tables courtesy MTM Association)

Distance Moved Inches	Time TMU A	Time TMU B	Time TMU C or D	Time TMU E	Hand in Motion A	Hand in Motion B
¾ or less	2.0	2.0	2.0	2.0	1.6	1.6
1	2.5	2.5	3.6	2.4	2.3	2.3
2	4.0	4.0	5.9	3.8	3.5	2.7
3	5.3	5.3	7.3	5.3	4.5	3.6
4	6.1	6.4	8.4	6.8	4.9	4.3
5	6.5	7.8	9.4	7.4	5.3	5.0
6	7.0	8.6	10.1	8.0	5.7	5.7
7	7.4	9.3	10.8	8.7	6.1	6.5
8	7.9	10.1	11.5	9.3	6.5	7.2
9	8.3	10.8	12.2	9.9	6.9	7.9
10	8.7	11.5	12.9	10.5	7.3	8.6
12	9.6	12.9	14.2	11.8	8.1	10.1
14	10.5	14.4	15.6	13.0	8.9	11.5
16	11.4	15.8	17.0	14.2	9.7	12.9
18	12.3	17.2	18.4	15.5	10.5	14.4
20	13.1	18.6	19.8	16.7	11.3	15.8
22	14.0	20.1	21.2	18.0	12.1	17.3
24	14.9	21.5	22.5	19.2	12.9	18.8
26	15.8	22.9	23.9	20.4	13.7	20.2
28	16.7	24.4	25.3	21.7	14.5	21.7
30	17.5	25.8	26.7	22.9	15.3	23.2

CASE AND DESCRIPTION
A Reach to object in fixed location, or to object in other hand or on which other hand rests.
B Reach to single object in location which may vary slightly from cycle to cycle.
C Reach to object jumbled with other objects in a group so that search and select occur.
D Reach to a very small object or where accurate grasp is required.
E Reach to indefinite location to get hand in position for body balance or next motion or out of way.

Grasp—C

Case	Time TMU	DESCRIPTION
1A	2.0	Pick Up Grasp—Small, medium or large object by itself, easily grasped.
1B	3.5	Very small object or object lying close against a flat surface.
1C1	7.3	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter larger than ½".
1C2	8.7	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter ¼" to ½".
1C3	10.8	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter less than ¼".
2	5.6	Regrasp.
3	5.6	Transfer Grasp.
4A	7.3	Object jumbled with other objects so search and select occur. Larger than 1" x 1" x 1".
4B	9.1	Object jumbled with other objects so search and select occur. ¼" x ¼" x ⅛" to 1" x 1" x 1".
4C	12.9	Object jumbled with other objects so search and select occur. Smaller than ¼" x ¼" x ⅛".
5	0	Contact, sliding or hook grasp.

Eye Travel Time and Eye Focus—ET and EF

Eye Travel Time $= 15.2 \times \frac{T}{D}$ TMU, with a maximum value of 20 TMU.

where T = the distance between points from and to which the eye travels.
D = the perpendicular distance from the eye to the line of travel T.

Eye Focus Time = 7.3 TMU.

Release—RL

Case	Time TMU	DESCRIPTION
1	2.0	Normal release performed by opening fingers as independent motion.
2	0	Contact Release.

Disengage—D

CLASS OF FIT	Easy to Handle	Difficult to Handle
1—Loose—Very slight effort, blends with subsequent move.	4.0	5.7
2—Close — Normal effort, slight recoil.	7.5	11.8
3—Tight — Considerable effort, hand recoils markedly	22.9	34.7

Figure 5:3 Methods, Time Measurement (M.T.M.) application data in T.M.U. for: (a) Move - M
(b) Position - P
(c) Turn & apply pressure - T & AP

(Taken from: Barnes, 1968)

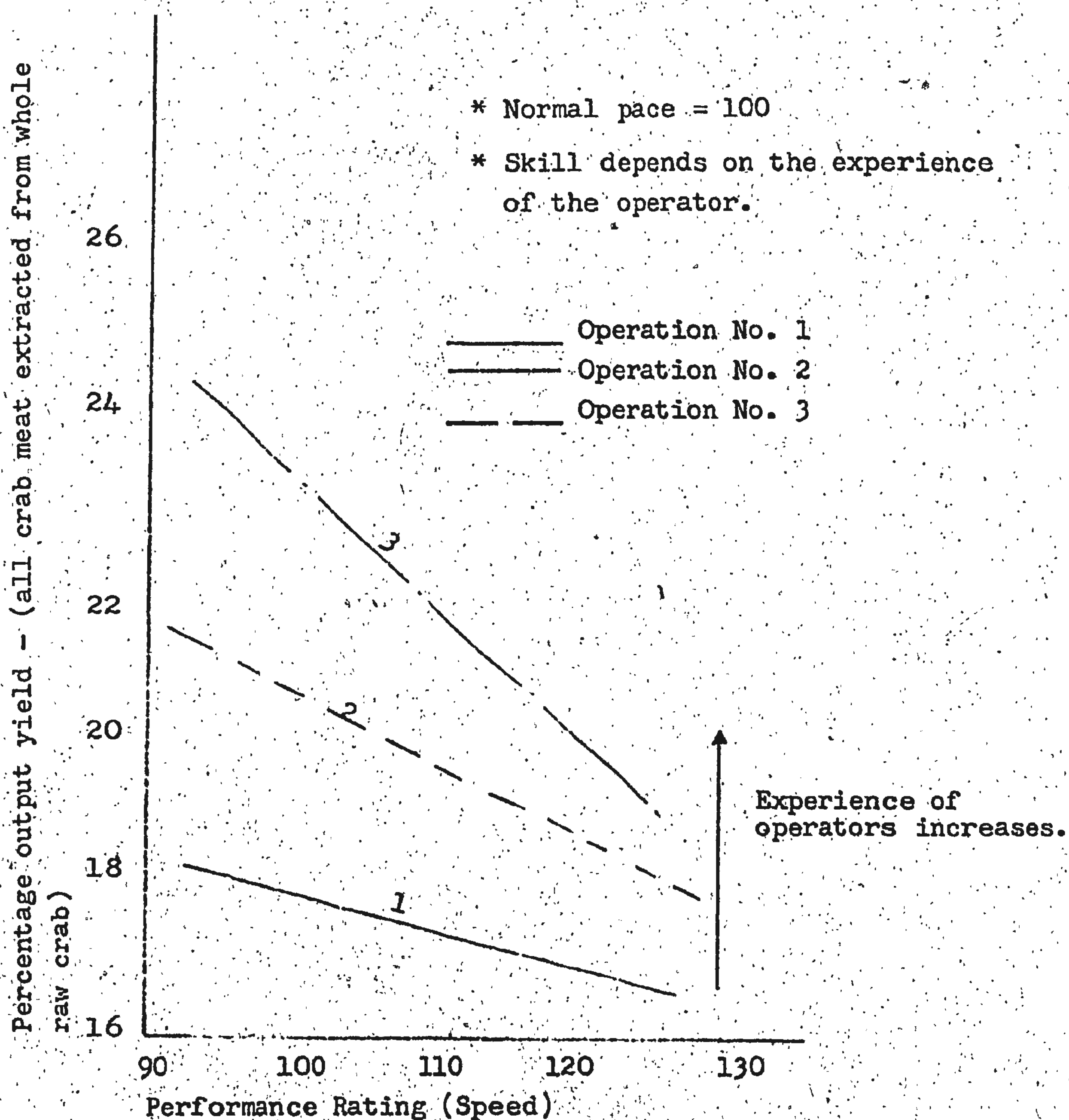


Figure 5:4 Effect of speed and skill on percentage of output yield for shucking of shoulders, large legs, knuckles, claws and claw legs. Removal of tips and small legs.

6:00 DISCUSSION, RECOMMENDATIONS AND OBSERVATIONS:

6:10 DISCUSSION:

This report has presented the various procedures and methods which must be used when a detailed and complete work measurement program is to be undertaken in a Snow Crab processing plant. To completely understand the various operations in the plant and to analyze their interaction on one another such techniques are required. Each operation system is dependent either directly or indirectly upon other operations in the system or on outside forces. For example, the overall output yield is dependent upon the extraction processes used in the plant, but it is also related to the quality of raw material which is purchased for the plant. A systems approach to the problems associated with production of crab will require the complete dissertion of each facet of the total operation into the various elements. Work Measurement analysis can be used to understand some of the interrelations which are in the processing plant.

Figure 6:1 is a systems dynamic model of Snow Crab processing.

It will be noted that the model is built up of various components or systems which are all linked to one another to make up the total model.

Work Measurement techniques will show the plant management what the normal and standard outputs should be for each operation in their plants. If these values are not suitable to the management then corrective changes can be made in the method of doing the task to improve the output performance of the workers involved. When his output is known it can be compared to standards which are set using the proper methods of performing the task.

6:20 RECOMMENDATIONS AND OBSERVATIONS:

The following are recommendations which the author would make for improvements in the operations at Ship Cove and Valleyfield plants.

(A) A wage incentive system can be instituted in a plant with worth-while results, but can be only considered fair to the worker and employee when based on standards established by complete Work Measurement analysis of the various operations at the plant.

(B) Time Study techniques provide more flexibility for the actual inplant situation than do the Methods, Time Measurement (M.T.M.) approach. For this reason it should be relied upon for the most comprehensive results for normal and standard times and outputs. M.T.M. analysis, however, should be considered when the methods of performing the task are to be improved. The motion picture study allows for more concentrated thought by the analyst on the work performed and the methods used.

(C) The Ship Cove plant employed the practice of separating the whole crab section into component parts and requiring separate groups of people to work on only one type of component. This practice should allow for the increased efficiency of the workers as their motions become automatic after repeative performance of the same task.

However, as in most repeative work the possibility always exists for job monotony and boredom. The Ship Cove worker is required to work on one separate position of the crab section and the likelihood of job monotony could be increased. The supervisory staff would detect this from a workers attitude and performance and take corrective measures. Further study would be required to understand the extent of this occurrence.

The Valleyfield shuckers on the other hand are required to perform the whole shucking sequence. This practice requires that they increase their techniques as each portion of the section requires that different motions be used. If the work load is too large the worker reacts psychologically in a negative manner. Tests should be conducted to ascertain the correct weight of sections or section components which should be presented to the worker.

Section 5:32 of this report provided comparison of the results in Table 5:1. It would appear that the Valleyfield procedure for shucking of the whole section (except tips and small legs) produces better results regarding the cost of the finished product. Further study is recommended in this matter to compare both techniques. The Ship Cove plant by using slitting machines was able to produce more unbroken legs than could be achieved by the manual operation at Valleyfield. This fact must be remembered in doing a cost benefit analysis of both methods.

(D) Slitting machines have advantages to complete manual shucking and should be considered by the Valleyfield plant. The advantages are:

1. Increases the amount of whole unbroken leg meat which is the most valuable portion of all crab meat.

2. Reduces the physical load on the operators as they are not required to knock their hands against the edge of hand surface to jar the meat loose in the leg.

3. The overall yield of all the meat from the leg is increased. The meat can be completely removed from the shell when it is cut and opened up.

4. There is no loss of red pigment from the exterior of the leg meat. It can be removed from the slit leg without the meat having to be scraped by the shell.

It is recommended that more work be undertaken for the automation of the slitting machine such that the legs can be fed to the machine without care having to be taken by the operator to ensure that the shell centers the cutting blade properly. Also, the meat extraction from the slit legs should be improved so that the meat can be removed by the machine when the shell has been slit.

NOTE: Appendix B contains a paper by Mr. Sid A. Hann of the College of Fisheries, St. John's, Newfoundland on a third technique which could be used for the removal of crab legs. This employs the use of a rolling unit similar to that used for the leg tips. There would be an advantage in using this idea in the plant if extra capacity exists on the tip rolling unit and it can be modified to take the leg. But, there are some disadvantages associated with this technique.

1. The output yield can be lower than the slitting machines as some meat could be lost when the leg is clipped to make an opening for the meat to be extracted through. Also, if the operator is not experienced, the whole leg can be passed inadvertently through the rollers and the meat is pressed out and lost. (This was observed at the Ship Cove plant during trial tests)

2. Some of the red pigment on the surface of the crab leg is removed when the meat is pushed out of the shell.

3. The leg must be forced into the revolving rollers which requires the operator to exert greater effort than that required for slitting the leg.

(E) Further comparison work must be conducted to do more tests on both techniques to obtain data and to determine the advantages of each. Most of the operators are required to stand in the one position at the work tables during the full work period except for the personal allowance times of 10 minutes in the mornings and in the afternoon shifts. This almost continuous standing is very tiring. Study should be made of the situation as it could be improved if some sort of seat rest could be provided. A full seat is not required, just a support on which a person could rest occasionally during the work period.

(F) The mechanical extraction of the meat from the shoulder portion of the section could be the next step towards the eventual full mechanization of the meat extraction. The equipment which would eventually be used must produce a product of a nature similar to that now achieved by the manual method. The Ship Cove plant is experienced with the use of a Baadar 694 for the complete extraction of the meat from the shoulder portions. These tests proved unsuccessful because the fibers of the product produced were too short to gain market acceptability. A unit which would employ the use of a vibrating rubber roller assembly may have potential. The sections would be pulled through the rollers with the meat being removed by the vibrating and rolling action of the assembly.

6:30 CONCLUSION:

The work which has been done at the Valleyfield and Ship Cove plants have shown that work measurement practices can be used in the Snow Crab processing industry. More work is required to gather more exhaustive data on the various operations in the plants. Using this, a fair and equable incentive system for wage payment can be instituted and in so doing, conceivably increase the productivity of the plant concerned.

The M.T.M. results of the various operations in both plants are different from those obtained by Time Study. Section 5:30 of this report provided reasons for such differences.

The fact that the crab meat output per person shucking at the Valleyfield plant is higher than at the Ship Cove plant is a fact which requires more study and consideration. At the time the material was gathered for this report the Ship Cove plant had not been in operation a full year, but Valleyfield had been working for a number of years. The skill of the Valleyfield workers is greater than the Ship Cove workers and could explain this difference in throughput.

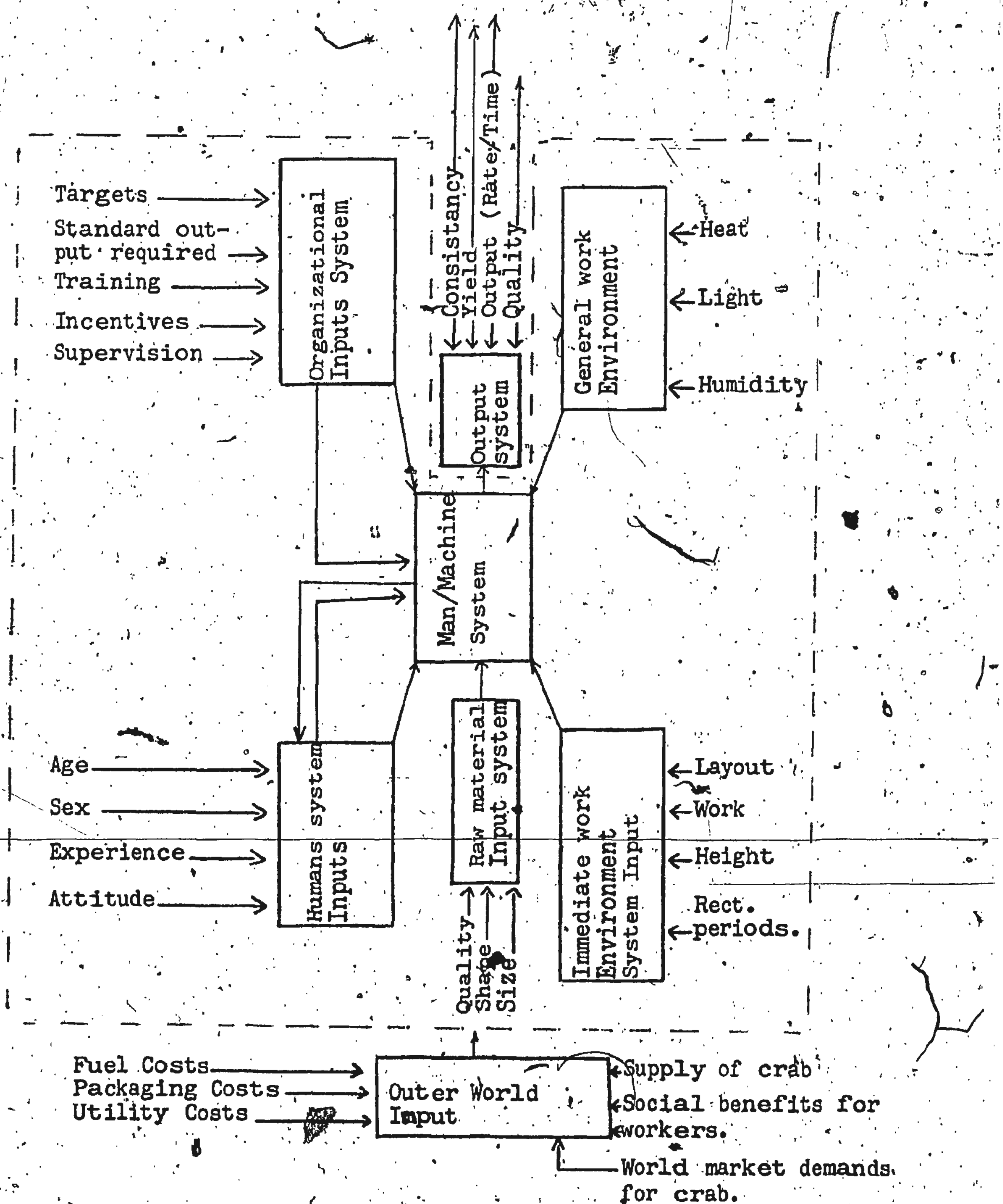
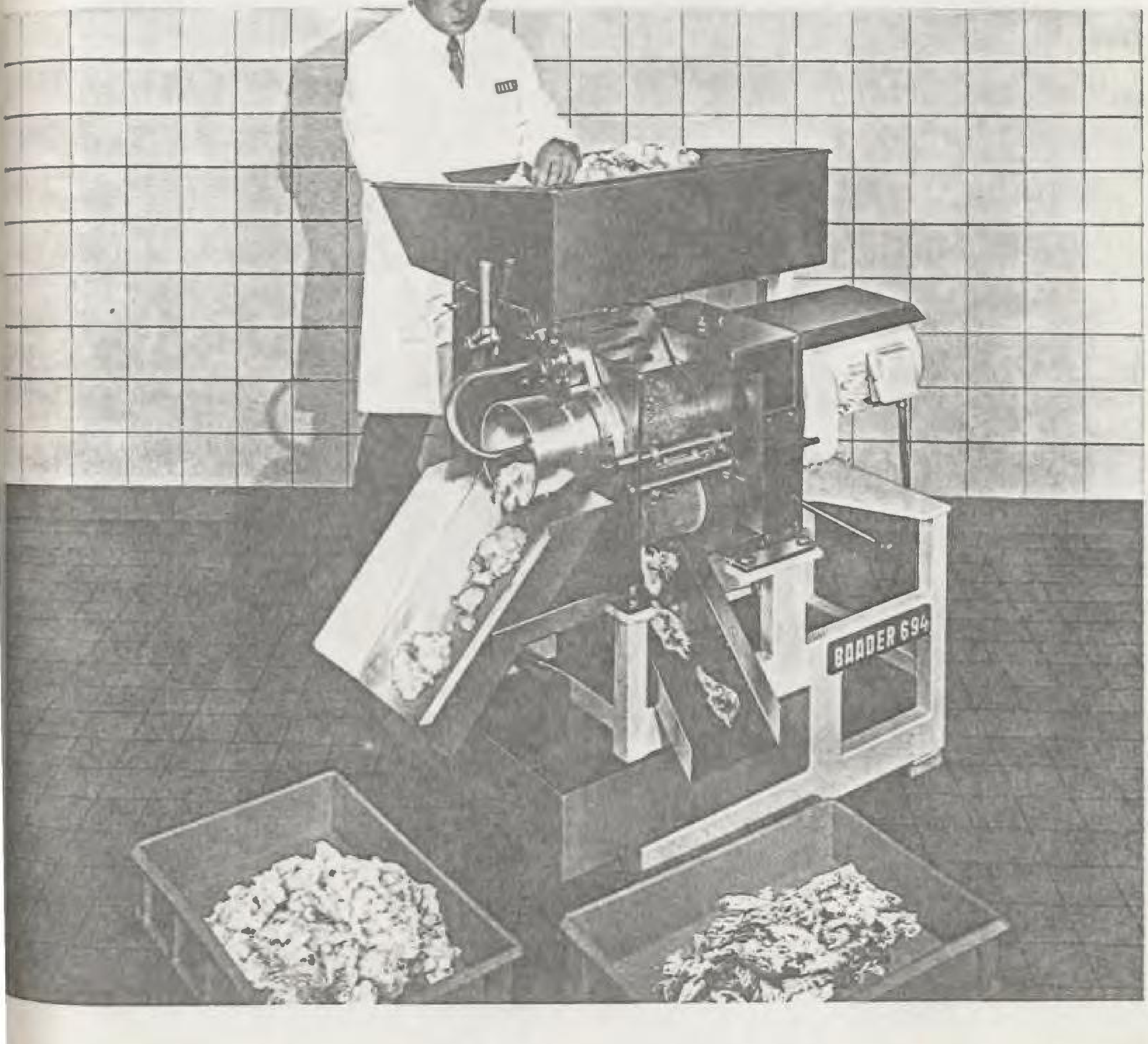


Figure 6:1 (A systems Dynamic Model of Crab Processing)

APPENDIX A

Bone Separator



NORDISCHER MASCHINENBAU RUD. BAADER

BAADER 694

General

The maximum possible yield of bone-free meat is an essential prerequisite for profitable production in the industrial processing of fish.

There is a problem: to obtain bone-free fillets it is necessary for the so-called pin bones to be cut out. On the one hand this cut should be made as carefully as possible and without any excessive losses of fish meat, on the other hand it is essential to obtain maximum productivity with this intensive method of processing.

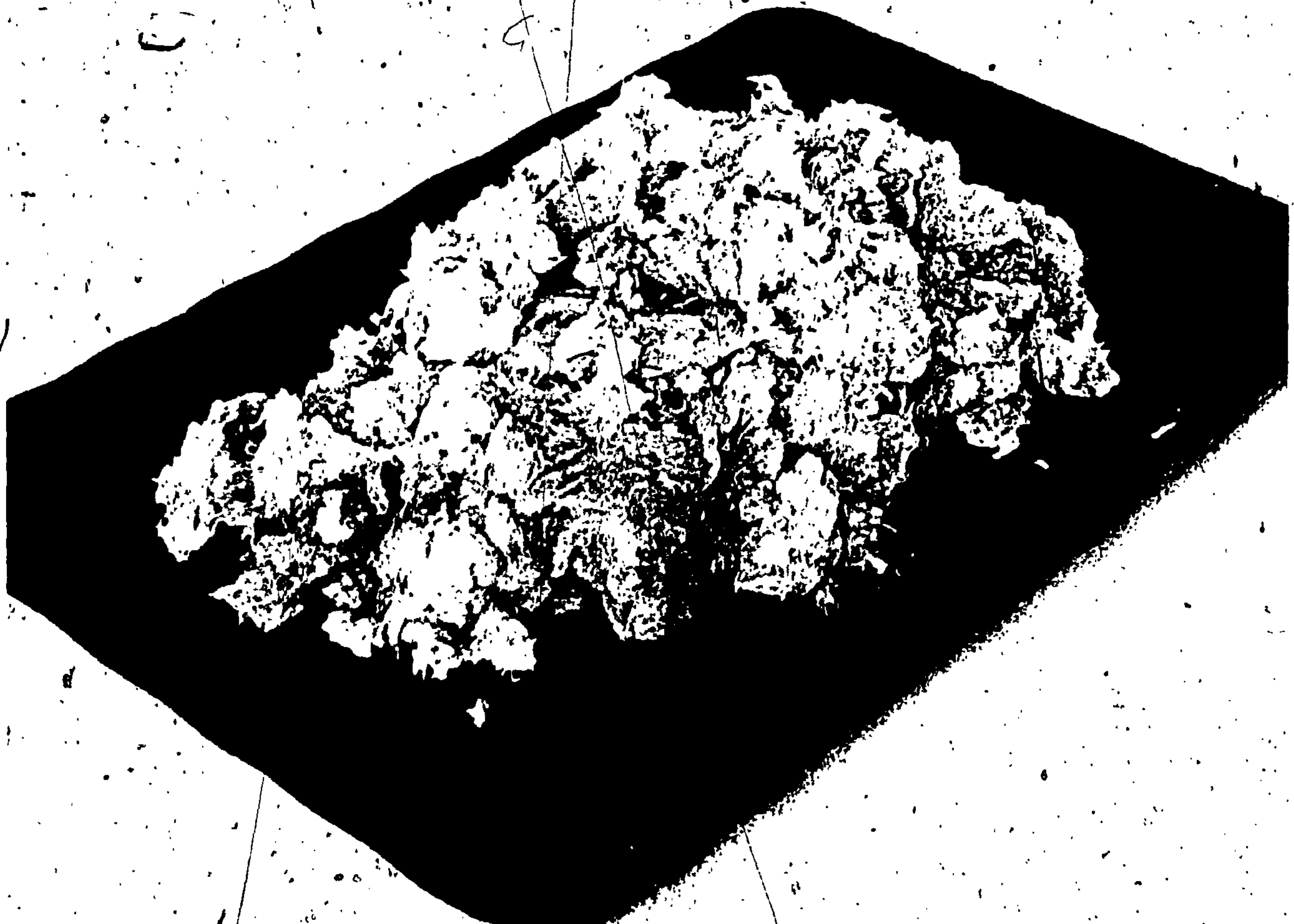
We were able to solve this problem with our BAADER 694 bone separator. This machine is capable of yielding a high proportion of high quality, bone-free meat, even from waste. The pin bone strips can now be removed with a generous cut, more reliably, faster and therefore with relatively lower wages cost, since the meat thus separated is not lost from the overall productive output.

The bone separator separates the raw fish meat from bones, fins and skin. The material is neither chopped, rubbed nor ground in the separator. It is merely exposed to a brief extrusion process. The result is an end product of bone-free fish meat whose fibre structure is retained and which can be further processed in many different ways.

The excellent separation between meat and solids is a particular feature of the BAADER 694. The bones are almost completely freed of any adhering meat. When processing pin bone V-cuts without skin it is possible to obtain a meat yield of 90–95%.

Method of operation

The bone separator operates continuously. The meat pieces are fed into the machine through a fill-



Perfect boneless fish meat after separating of bones ing hopper. A conveyor belt of strong, elastic material conveys the processing meat to a perforated drum. The meat is extruded through the perforations into the interior chamber of the drum while bones and other solid particles remain on the external drum shell from which they are removed by a stripper. The bone-free meat is delivered on the side by means of a screw conveyor incorporated in the perforated drum. The extrusion pressure can be adopted by a simple lever adjustment to suit the characteristics of the raw material. This ensures optimum separation of meat and bones while ensuring a high yield of useful meat.

Construction characteristics

All parts in contact with the fish, for example hopper, housing, perforated drum, screw conveyor and discharge chute, are made of stainless steel. The perforated drum rotates in stainless ball bearings. It can be easily removed form its locating mechanism by brief rotation in the opposite direction to enable it to be withdrawn from the machine. Furthermore, the smooth surfaces of the housing walls facilitate cleaning the machine. The side wall can be easily removed by detaching two screws. This provides easy access to the extrusion band and all cylinders which can thus be removed. All parts can thus be cleaned daily and sterilised with chemical detergents in order to meet hygienic requirements.

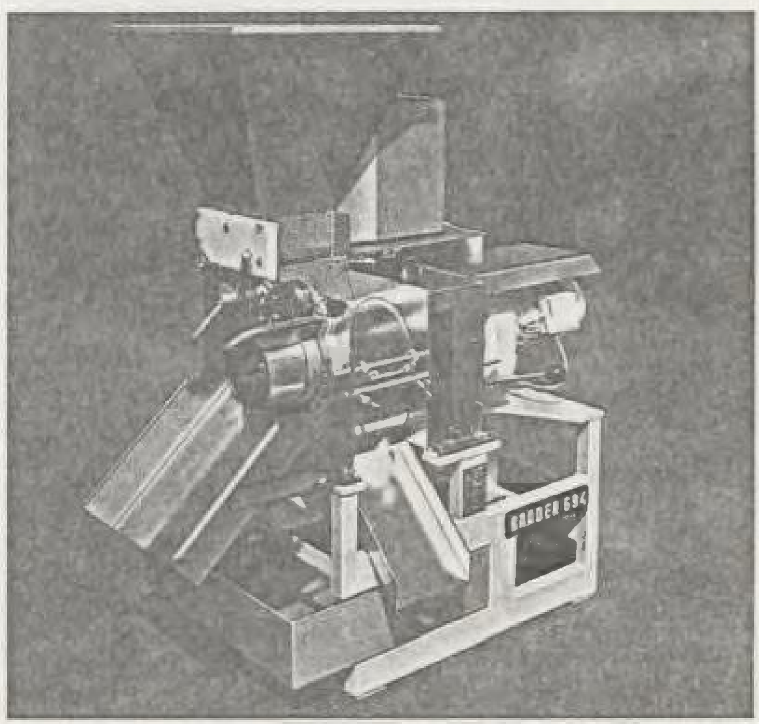
The standard version of the machine includes the bone separator with a perforated drum having a perforation diameter of 5 mm. Other perforation diameters are available on request.

Fish meat with skin and bones before separating the bones

Remaining particles of skin and bones

Special outfit

The BAADER 694 can be completed with an infeed hopper to facilitate servicing. The hopper receives the raw material in charges or over a conveyor belt. A driven stirring arrangement takes care of the uniform flow of the raw material onto the pressure belt. With a few manipulations the machine can be adjusted from manual infeed to automatical operation.



APPENDIX B

BULLETIN NUMBER ONE

SPECIALIZED AND SEMI-MECHANIZED SNOW CRAB PROCESSING

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PUBLISHED BY
DEPARTMENT OF FOOD TECHNOLOGY
COLLEGE OF FISHERIES

Presently, in Newfoundland, most Snow Crab processing operations are using manual methods of crab meat extraction. In the meat extraction area of the process, cooked crab sections are generally weighed to individual shuckers who in turn, hand shuck the meat excluding tips.

<u>A complete cooked crab section consists of:</u>

(a) Three main legs
(b) Shoulder
(c) Claw
(d) Claw leg
(e) Knuckles
(f) Tips
(g) Small leg

All section parts have to be handled differently in the shucking process.

Training a worker to effectively extract meat from a complete crab section in a short period, is no easy task. There are approximately twenty consecutive steps to follow in the shucking procedure which require much practice before a shucker becomes proficient.

In 1974, the author was involved in the training of supervisors and workers of four new snow crab operations in Newfoundland. During the meat extraction phase of the training programme, good yields, and production were obtained from the majority of workers after a very short time, when compared to past training methods. This was achieved by breaking down the crab section as follows:

(a) Shoulder and leg portion (approx. 2/3 cooked section)
(b) Claw Portion (approx. 1/3 cooked section)

See illustration:-

Complete Crab Section

(a) Shoulder & Leg Portion

(b) Claw Portion

Trainees were given only one portion of the cooked section either (a) or (b) and were switched to the second portion only when they fully grasped the techniques of shucking the first.

During the setting up of a Snow Crab operation for Jason Enterprises Ltd. in Bareneed, Conception Bay, in the fall of 1974, I experimented with the roll extrusion of crab legs in their tip rolling machine with encouraging results.

Past experience with the rolling of crab legs has not been favourable, the biggest problems being the speed of the rollers and the quality of the rolling machine itself. Periodically, jamming as legs were fed through, broken and damaged leg meat could not be avoided.

<u>The following recommendations are suggested for the rolling of Snow Crab legs.</u>

1. Rolling machine should be a sturdy, heavy duty model capable of withstanding considerable pressure. The roller in question was manufactured by Charlottetown Metals, Prince Edward Island, and was a chain drive model with a reduction gear connected to the 2 hp motor. This particular model stood up well during the two months it was in use, with single legs and tips being

fed into the rollers. It is difficult to say what affect the stress of two legs rolling at once, and varying leg sizes will have on this model over a prolonged period.

2. Rolling crab legs with a fast roller speed damaged the meat considerably. Good results were obtained by reducing the roller speed to 62 r.p.m. It is possible that different combinations of speed, roller diameter and changes in roller structure -- and/or composition may produce further improvements in performance.

3. The majority of legs prior to rolling require chipping, workers using small knives to remove the shell bend in the large end of the leg to facilitate meat removal. A chipping technique has been developed using a cracking rather than a cutting action which causes little or no damage to the meat during the chipping process. (See Illustration). Presently, feeding single legs into the rollers under commercial conditions approximately one back up chipper is needed. Experiments being conducted on a technique of snapping legs from the section will decrease the need for chipping.

NOTE:- Chippers should position legs "in shell" in such a way in the pan or a feed trough or belt as to facilitate quick pick up by roller operators.

4. Jason Enterprises rolling machine was rented by the College of Fisheries during a two week vocational programme in Snow Crab Processing in February, 1975. Experiments conducted with the roller utilizing good principles of motion study have shown both hands may be put into action, rolling two legs at once, in the rolling machine.

With single leg feeding, under commercial conditions, in excess of 200 lbs. leg meat per day per operator was common, even though operators spent much of their time transporting legs to and from the rolling machine. Meat production based on recent studies using the two hand feeding method showed leg meat production of one, to one and one quarter pounds per person per operating minute was possible, with optimum yields and maximum percentages of whole leg meat. No allowances were given for rest periods, breaks, fatigue, etc. when calculating projections.

MAXIMUM OUTPUT PROJECTIONS:-

Leg meat rolled per minute, per person	..... 1.25 lbs.
Leg meat rolled per hour per person	..... 75 lbs.
Leg meat rolled per day (8 hrs.) per person	..... 600 lbs.

Snow crab used in the College experiments were a poor, small grade of production crab, 30-36 legs "in shell" per pound.

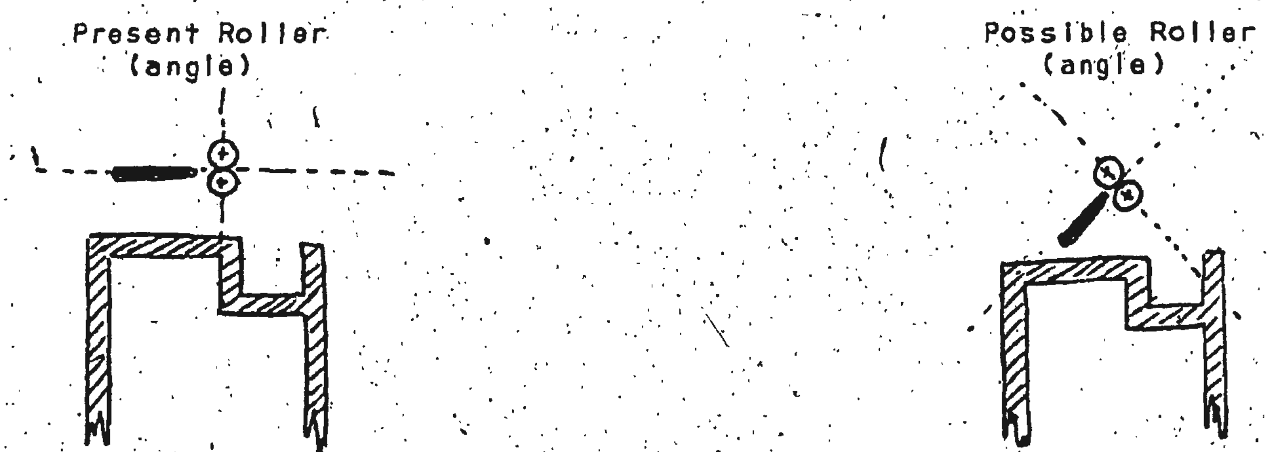
5. Gap between the rotating stainless steel rollers when adjusted tight gave best results. Loose adjustment on rollers increasing roller gap causing damaged leg meat.

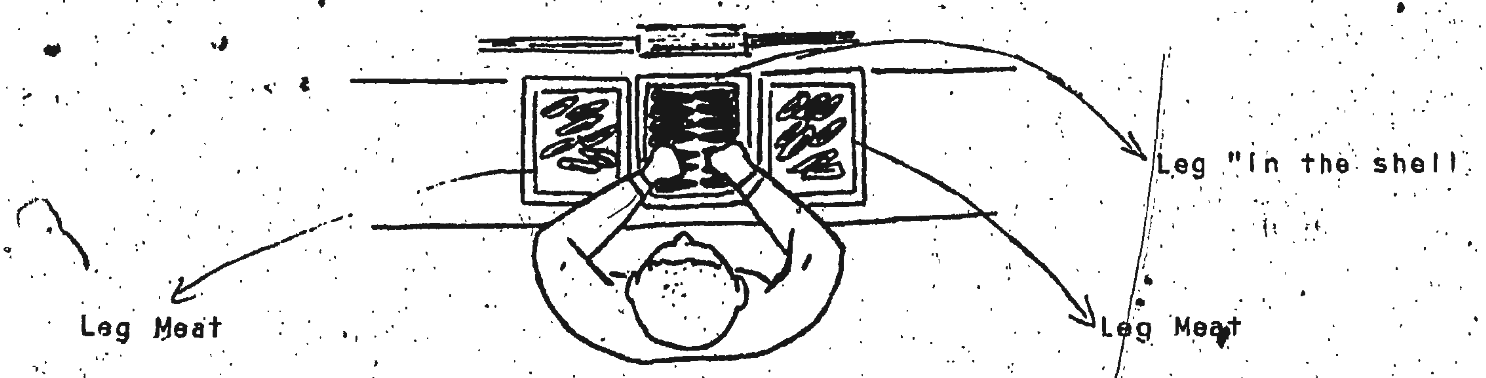
6. Roller operators should adopt a technique of quickly but lightly pulling the meat from the shell as legs pass between the rollers. Leg tendons left in the leg meat often cause the leg to be pulled between the rollers. A piece of leg meat accidentally lost in the roller may be easily recovered (damaged meat falls out of and directly under the rollers.) Varying hand pressures applied on the legs during the initial insertion between the rollers may have a tendency to tire some workers over long periods. Therefore, it is suggested chipper and

6. roller people could rotate their jobs during the day. Possibly, under an incentive set-up these workers could operate as a team. Workers here, as in other parts of the process, would be more comfortable if provided with special stools as they could carry out their work function in half standing, sitting position.

Presently, parallel horizontal rollers are positioned perpendicular to the table. A leg rolling machine with rollers positioned at an angle such that legs have to be fed up rather than straight in (horizontal to table) could possible omit the need for lifting meat away from the roller. Varying sizes of rollers should also be experimented with. (See illustration.)

SNOW CRAB
TIP AND LEG ROLLER





POSITION OF LEG SHUCKING PANS
(Two Hand Feeding)

THE ADVANTAGES OF USING A SPECIALIZED AND SEMI MECHANIZED PROCESSING SYSTEMS ARE AS FOLLOWS:-

1. THE SHUCKERS WORK IS MADE EASIER:-

Crab meat extraction is the most important part of the process, and the hardest and most demanding on the worker. Shuckers suffering from sore and swollen hands from the pounding of crab legs is common place. Using this system, the most important part of the crab, the leg, will be all mechanically rolled.

2. IMPROVED MEAT YIELDS:-

Based on observations close to 100% leg meat recovery is possible using leg rollers. It is practically impossible to state a real yield improvement that rollers may give over manual meat extraction, without extensive in-plant research. The Snow Crab Industry is very complex, and meat yields vary from plant to plant and process to process and above all, on the nature of the crab being processed. Poor shucking technique is a major problem, contributing to reduced yields. It is common in all plants to find legs which are difficult to shuck often discarded.

3. PERCENTAGES OF WHOLE LEG MEAT ARE INCREASED:-

Generally, there are great fluctuations experienced in percentages of broken crab leg meat in most Newfoundland Snow Crab Operations. These fluctuations are dependent upon many factors. A piece of leg meat in good condition in the shell, may be rolled in perfect condition. Leg meat stuck fast to tendons or to the shell, etc. prior to shucking, will be broken immaterial of what system is used to remove the meat.

A. DAMAGE CAUSED DIRECTLY TO LEG MEAT IN THE MANUAL SHUCKING PROCESS ARE AS FOLLOWS:-

(a) Poor shucking technique

1. Careless cracking of shell (large end)
2. Loosening leg meat in shell with mallet

~~(b) Impact of the leg meat with shucked meat pan on jarring.~~

(c) Constant hand pressure often applied to loosen meat in the shell.

B. INDIRECT CAUSES OF BROKEN LEG MEAT ARE AS FOLLOWS:-

1. * Nature of production crab (biological factors).
2. Meat extraction method
3. Type of cook (salt vs. fresh water)

4. Time between cooking and cooling
5. Effectiveness of the cooling
6. Quality of crab (organoleptic)
7. Excessive over cooking
8. Cooked section holding methods, etc.

*Leg meat sticking to leg tendons in varying degrees is frequently experienced with poor grade production snow crab. This seems to be a natural occurance.

Increased whole leg meat production means, naturally, a higher percentage of more valuable finished packs. Excessive handling of leg meat throughout the process is also a major cause of broken leg meat. It is suggested that to cut down on this loss, perforated pans (cheap plastic types) may be used to handle legs without the frequent switching from pan to pan throughout the whole process. Leg meat would remain in the same pan from the rolling to the packaging.

4. DECREASE IN LABOUR COST:-

Leg meat production is based on the following breakdown:-

	Yields	
Live animal	100%	......
Cooked section	60%	......
Leg meat	10%	......
Total shucked meat ...	26%	......

YIELD BREAKDOWN
(10,000 LBS. SNOW CRAB)

Live Snow Crab	10,000 lbs.
Cooked Sections	6,000 lbs.
Leg Meat	1,000 lbs.
Total Shucked Meat	2,600 lbs.

A comparison with the regular process is roughly outlined below using an assumed figure of 40 lbs. shucked meat per eight hour working day per person in all hand operations.

Using a figure of 2,600 lbs. of meat from 10,000 lbs. of live crab, broken down into 1,000 lbs. leg meat and 1,600 lbs. of other meat.

MANUAL PROCESS	NEW PROCESS: Semi-Mechanized & specialized	NEW PROCESS: Manual Process specialized
2,600 lbs. shucked meat at (40 lbs/worker/day)	1,000 lbs. leg meat. 13 workers are required	1,600 lbs. (other meat) 40 workers are required
A total of 65 workers are required.	A total of 53 workers are required.	

Thus saving of $211.20 per eight hour day for twelve workers based on above projections $2.20 per hour basic wage on a 10,000 lb. daily throughput.

A conservative breakdown of direct and indirect labour involved in the removal of 1,000 lbs. of leg meat under the new process is as follows:-

(a)	Cooked section breakdown	2
(b)	Leg chippers	6
(c)	Leg rollers (based on 384 lbs. each/day)	3
(d)	Chippor and roller helper (transporting legs etc.)	1
(e)	Blending Crab Meat	1
	TOTAL	13

COMMENTS:-

Good supervision in a specialized and semi-mechanized snow crab process can easily bring out the best in optimum meat yields from specialized workers. Shell -- a big problem within the industry is most effectively controlled at the shucker level. When workers are specialized, only a limited number of mistakes can be made and these can be detected and corrected with good supervision.

Final projections made at the end of this report are quite conservative and rolled leg production could far exceed figures stated here with practice and especially if large, top grade production type Snow Crab are being processed. Further improvement of methods and machinery may prove even more efficient.

In future, experimenting with the rolling of shoulder meat may prove fruitful. The marketing of crab cocktail claws (crevisse) or slit crab legs in shell, etc. could further specialize this whole operation.

One of the major complaints from crab fishermen over the past few years have been the limited amounts of crab they are able to sell at times. Hopefully, with the semi-mechanized process plants will not have to reduce their present work force, but will be able to increase their throughput of snow crab and consequently reduce unit cost and proceed to give them a competitive edge in the marketplace.

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