A STUDY OF SOME FACTORS AFFECTING NORMAL OUTPUT RATE AND PERCENTAGE YIELD OF FILLETING COD

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by

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ABSTRACT

The purpose of this study was to investigate some factors affecting the normal output rate and percentage yield of filleting cod. The man-machine relationships chosen for inclusion in the study included the effect of overall fish length upon the normal output rate and yield of filleting, the effect of the experience of the filleter upon each of the aforementioned factors, the effect of work table layout upon filleting rate and the effect of cutting time upon percentage yield.

The aforementioned study was carried out at a small fish processing plant utilizing five filleters randomly selected from the work force. These filleters were asked to fillet boxes of gut-in codfish, of various size categories, the performance rating and weight of the fillets produced being recorded. From these results the normal input, output and percentage yield was calculated.

An analysis of the results of this study showed:

1. A linear relationship between input, as pounds per hour, and length, input rate increased as the length increased.
2. A linear relationship between input, as fish per hour, and length, the time required to fillet a fish increased as the length increased.
3. A linear relationship between output and length, the quantity of fillet produced increased as the length increased.
4. Little or no relationship between percentage yield and length.

5. The indication of a correlation between speed and yield for two of the four filleters used in the study.
6. A reduction in (a) unproductive activities (33 percent reduction in time taken for the get fish motion, 19 percent for the place fillet motions), and (b) the number of eye fixiations (22 percent reduction in time) by conversion from a group to an individual work place filleting table. However, the aforementioned conversion would introduce certain non- productive miscellaneous activities (get box of fish, get fillet pan, place empty fish box, place pan of fillets) into the filleting cycle, said activities taking up to 30 - 36 seconds between the filleting of each box of fish (4 to 18 percent, depending on the size of the fish, of the total cycle time per box of fish filleted).

ACKNOWLEDGEMENTS

I herein acknowledge the following persons: Dr. P.J. Amaria, Associate Professor, Engineering Department, Memorial University (my project leader); the Manager of the fish plant used in the study; the filleters selected for inclusion in the study, and Max Manuel, Demonstrator, Department of Food Technology, College of Fisheries - for their assistance during the course of this study.

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CHAPTER 1 - INTRODUCTION

1.10 FRESH AND FROZEN FISHING INDUSTRY IN NEWFOUNDLAND

1.11 Origin of the Fresh and Frozen Fish Processing Industry

The first important experiments into the marketing of fresh-frozen fish were conducted in 1937 (Perlin, 1972). The industry received enormous impetus during the second world war with the help of a large investment by government for the purpose of providing food for embattled Britian. Within five years, the annual output of frozen fillets rose from three million to thirty million pounds, and as processing plants increased, the need of an economic source of supply led to the rapid growth of a trawler fleet.

1.12 Reliance Upon a Single Species, Cod

Table 1.10, in conjunction with Table 1.11, shows that since 1954 the percentage of codfish making up the total catch of groundfish has shown a steady decline from a high of 75 - 80 percent to a low of 33 percent in 1973. The reverse is true of plaice and greysole (previously looked upon as trash fish) having increased from 14 to 38 percent.

It should be noted that there were no substantial catches of plaice until 1962 and yellowtail suddenly sprang into

TABLE 1.10 - SEAFISH LANDINGS FOR THE PERIOD 1954 - 1971

Variable (Unit)	1954	1956	1958	1960	1962	1964	1966	1968	1970	1971
1. Cod, gutted head-on (xooo lb.)	441,435 (83%)	398,251 (79%)	300,085 (80%)	406,335 (82%)	374,552 (77%)	369,601 (75%)	344,540 (61%)	370,915 (61%)	281,441 (46%)	256,715 (48%)
2. Plaice and Greysole	12,478 (2%)	22,656 (4%)	26,914 (7%)	43,414 (9%)	37,789 (8%)	69,527 (14%)	113,339 (20%)	135,953 (22%)	204,739 (34%)	190,140 (36%)
3. Redfish (xooo lb.)	19,754	2[illegible],744	25,469	19,016 (7%)	35,815 (7%)	41,674 (8%)	76,375 (14%)	76,443 (11%)	91,716 (15%)	59,923 (11%)
4. Turbot (xooo lb.)	1,191	1,726	2,099	1,256	1,312	3,585	29,859	26,887	24,789	21,479
5. Haddock (xooo lb.)	42,817	62,264	30,760	25,620	38,883	10,241	3,821	2,382	3,803	2,954

Source - Statistics Canada Publication Number 24 - 202, Fisheries Statistics, Newfoundland, 1955 - 1972, Economics Branch, Federal Fisheries, St. John's, 1973

TABLE 1.11 - NEWFOUNDLAND FISHERIES STATISTICS 1970 - 1973

Year	Total Catch (Millions Pounds)	Value (Millions Dollars)	Groundfish Landings (Millions Pounds)	Landings by Specie, (Millions Pounds) Cod	Flounder	Redfish	Turbot	Registered Plants Filleting & Freezing
1970	982	34.9	612	281.0 (46%)	204.7	91.6 (15%)	24.8 (4%)	340
1971	855	35.3	533	232.1 (48%)	188.2 (35%)	57.8 (11%)	23.8 (4%)	50 [1]
1972	650	34.6	471	210.0 (45%)	181.0 (40%)	56.3 (12%)	19.8 (4%)	54
1973	643	45.0	503	167.0 (33%)	192.0 (38%)	122.0 (24%)	16.7 (3%)	67 [2]

1 - Enactment of new fish inspection regulations in May, 1971 requiring that all filleting plants producing fresh and frozen fish for sale to freezing plants for further processing would have to meet registration requirements.

2 - Additional feeder plants from which fresh fish was filleted and the fillets transported to other registered plants.

Source: Department of the Environment (Fisheries and Marine Service), Newfoundland Region, Annual Reports prominence after the haddock fishery almost disappeared in 1965. At present, flounder represents 85 to 95 percent of the production in Newfoundland's larger year round plants (Grand Bank, Fortune, Burin, and Marystown) and over 50 percent in the smaller seasonal plants (approximately 8,000 plant workers depend on this particular resource for earnings).

The catch of redfish has remained relatively constant, at approximately 12 percent over the aforementioned period, however, it rose to 24 percent in 1973. This rise was the result of a good year class of fish in 1956, in the Gulf of St. Lawrence area, the only year from 1946 to 1966 in which any substantial number of redfish survived. It is estimated that that year class will have yielded 31 billion pounds before it runs out in 1975. There was a good survival in 1966, but only one-eighth as many as in 1956. This crop will not be ready for harvest for at least another year (estimated to be good for only 397 million pounds). Any decline in redfish will undoubtedly seriously affect such plants as Burgeo, Ramea, and Gaultois, where 90 to 95 percent of the production is from redfish. The National Sea Products plant in St. John's also depends on redfish to a large extent. In fact, the plant may have to close, or redirect its fishing effort to the procurement of increased landings of cod, (also applies to the aforementioned plants) if a substantial decline in redfish should occur. (Daily News, February 1974)

Quotas for American plaice for 1973 and 1974 were 132 million pounds of which Canada's was 105 million pounds (80 percent) in 1973 and 92 million pounds (70 percent) in 1974. Quotas for yellowtail for the same period were 110 million pounds (Canada's share, 71 million pounds - 81 percent) respectively. By the end of September, 1973, quotas had reached 70 percent for plaice and 54 percent for yellowtail and were expected to reach 100 percent by December (sum of above equals 183 million pounds for 1973.) Table 1.11, shows actual catch of 192 million pounds).

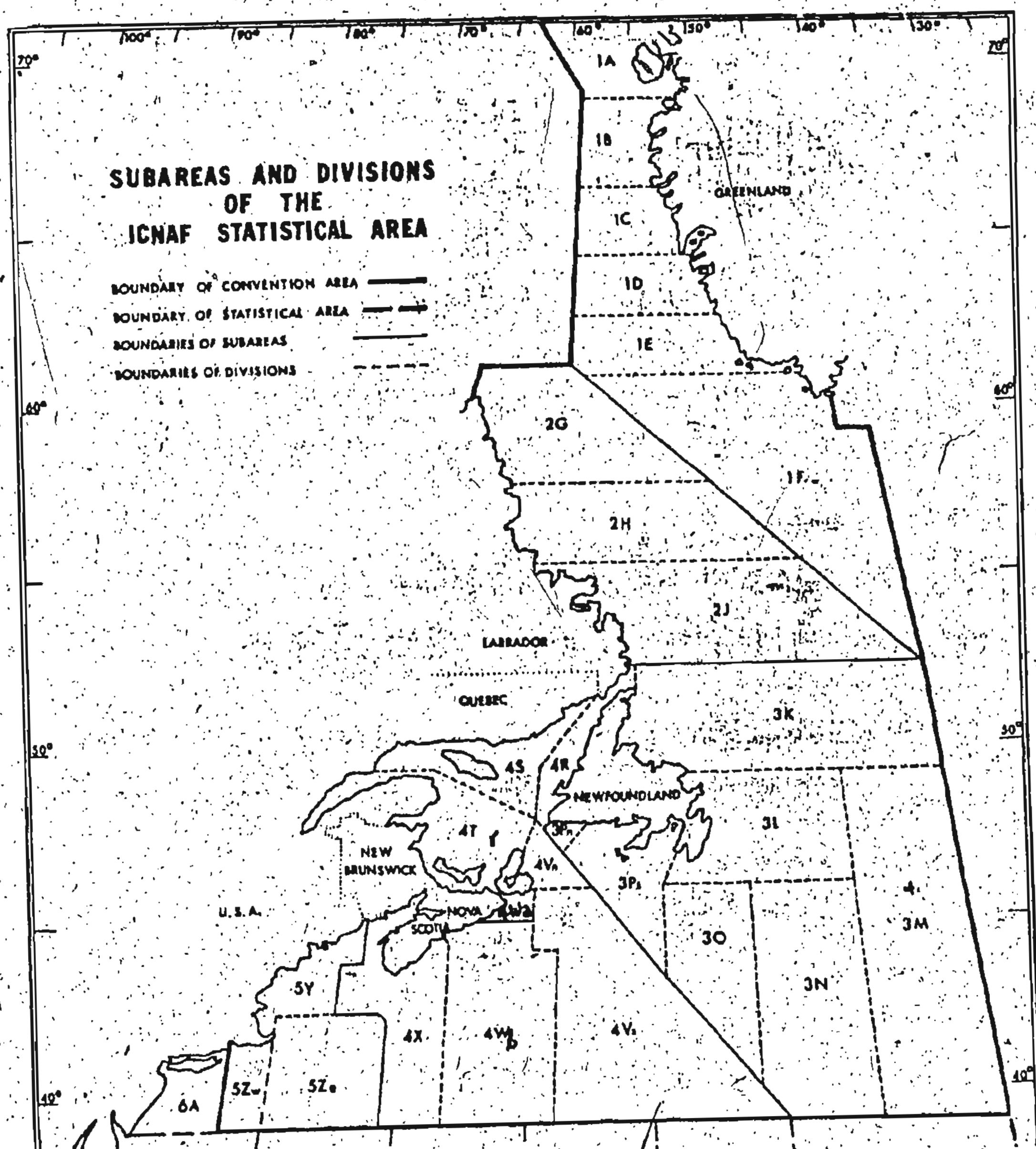
The Newfoundland Fishing Industry have asked that fishing in waters off the east coast (ICNAF sub-area 3) be restricted to trawlers based in Newfoundland. What they fear is that when redfish activity peters out in the Gulf of St. Lawrence trawlers engaged there will turn to flounder. Since flounder is on a firm catch quota that can't be revised upward, increased fishing would merely shorten the season for everyone, leaving the plants short of raw material for probably several months of the year.

With the possibility of the redfish activity petering out in the Gulf of St. Lawrence, and flounder on a firm catch quota that can't be revised upward, it would appear as if the future of the industry lies in the development of the cod fishery.

Figure 1.10, gives sub-areas and divisions of the ICNAF statistical area. Locations in which Canada's landings of cod could be increased are as follows: -

1. Sub-Area 2 - Canada's share fell from 100 percent of the total in 1950 to 1 percent of the total in 1972 (the Newfoundland inshore Labrador fishery which in 1938 produced 171 million pounds, produced only 4 million pounds in 1972 - 10 million pounds in 1973).

FIGURE 1.10 - SUBAREAS AND DIVISIONS OF THE ICNAF STATISTICAL AREA



2. Southern Grand Banks - Canada's share of the 1972 ICNAF quota of 221 million pounds was only 26 million pounds (11 percent)
3. Northern Half of the Grand Banks to the Hamilton Inlet Bank off Labrador - 1972 ICNAF quota of 1.3 billion pounds.

Data derived from tagging programs show that cod which come to the shore in summer may be found in great pre-spawning and spawning concentrations during the Winter and Spring in deep water at the edges of the continental shelves and banks. The international trawler fishery concentrates upon those concentrations. In recent years, above 70% of the total landed volume of cod taken by Europeans has been taken in the period January to March. The result is the decimation of the larger commercial size fish that ordinarily would have moved towards the shore in June and July. The consequence has been the destruction of the inshore fishery on the Labrador coast and along much of the North East coast.

1.13 Productivity of the Frozen Fish Industry in Newfoundland

The following are the conclusions of the Inbucon Report[1] which dealt with the productivity of the frozen fish industry in Newfoundland (Inbucon Services Limited, 1968):

1. Productivity in the Industry is low, the productivity index of the plants ranging from 39 to 82. It is significant to note that in those plants handling a multiplicity of specie and

1 Memorial University Library, Newfoundland Section

pack the productivity is lower than those plants which concentrate on fewer specie and pack. These differences are not necessarily reflected in profitability, or lack of it.

2. The greatest factor contributing to the low productivity of the labour itself is that of the underlying social structure and environment.

3. The basic measurements needed to identify and isolate the various factors contributing to labour productivity, control of yield and effective work organization and planning are, with one exception, missing or are not used. In one case steps are being taken to correct this (Fishery Products) and in at least two others, (Booth Fisheries and Burgeo Fisheries Limited), plans for this exist but have been deferred.

4. In general, the basic methods and techniques employed compare favourable with those in Nova Scotia, England and Europe. The main differences are matters of detail. The two new plants, Atlantic Fish Processors at Marystown and Ross Steers in St. John's, compare favourably with similar plants in Nova Scotia.

5. There is a danger for new plants to be "over engineered" in that the degree of automation, mechanical handling, etc., being introduced is not commensurate with the operating flexibility required, the skills presently available to service and maintain the equipment, and the type of labour available to effectively use the equipment.

6. For better control of productivity and product yeild individual cutting as opposed to the current practice of group cutting can yield significant benefits. One Company (Fishery Products Limited), has, during the course of this assignment, introduced on a limited basis two units, one with 20 work stations at Trepassey and one with 14 work stations at Burin.
7. The individuals holding supervisory positions lack the necessary technical background. Out of 79 supervisory positions analyzed, 61 are filled by men under 45 years of age. Of this 61, 33 have received formal education beyond Grade 8 and only 3 have post high school training, this non-related to the Industry.
8. For the average plant processing mixed species and producing mixed packs wherein raw material is processed and flows continuously from operation to operation until packed, continuous flow process is not the most suitable considering the specie, pack mix and operating flexibility required (Marystown is a prime example of an over-engineered plant).

The author speculates that productivity should have increased since the publishing of the Inbucon Report as a result of the following:

1. The installation of incentive schemes in most fish plants.
2. The conducting of management training courses by the College of Fisheries in conjunction with the Commerce Department of Memorial University.
3. The insistance of the American buyer for a high quality product.

1.20 EXISTING INCENTIVE PLANS

1.21 A Plan Based Upon Performance Rating

Prior to 1968 filleters employed in fish processing plants were paid an hourly wage, usually the minimum wage, irrespective of performance and quality of fillets produced. In 1966, Fishery Products Limited engaged the services of Associated Industrial Consultants of Toronto to develop an incentive program for its fish processing plants. This program, based upon performance rating, and including such factors as fish size, speed, yield, and quality of workmanship, was inaugurated at Trepassey and Burin in November, 1968. Since the program has expanded to include plants located at Catalina (1973) and Twillingate (1974).

In these aforementioned plants, filleters fillet fish at individual work stations - similar to Figure 1.11. Each filleter receives fish in seventy five-pound lots, which are filleted, the fillets being placed in numbered pans which are weighed, the weight recorded and a random sample of the fillets inspected for quality. Four quality checks are carried out on each filleter per day. Tolerances on yield are based upon the performance of the best filleters in a plant. The aforementioned type of table will be evaluated by the author in the "results and discussion section" of this report.

FIGURE 1.11 - INDIVIDUAL WORK STATION-INCENTIVE FISH FILLETING TABLE

Figure 1.12 shows a floor plan of the Fishery Products Fish Processing Plant in Burin. This plant has a straight line layout, the type used in the majority of fish processing plants. All employees at this plant are on an incentive scheme, even the foremen; their bonus being based upon the performance of the workers whom they supervise. Recently, a co-worker of the author visited this plant and described the operation as a beehive of activity.

1.22 A Plan Based Upon Predetermined Motion Times

The next Company to inaugurate an incentive program (Spring, 1970) was Atlantic Fish Processors of Marystown; work standards being based upon predetermined motion times (MTM) as established by the Stevenson Kellogg Co. of Toronto. A part of the initial work included the selection and training of three employees (two of which are still employed with the Company) in the use of MTM-1 tables.

MTM analyses any manual operation or method into the basic motions required to perform it and assigns to each motion a predetermined time standard. The standard time is determined by the nature of the motion and the conditions under which it is made. Behind MTM tables of standard motion element times are literally thousands of time studies and high speed motion pictures of operations, each of which has been analysed and leveled with great care by the engineers associated with the Methods Engineering Council. This has attributed much to their over-all accuracy.

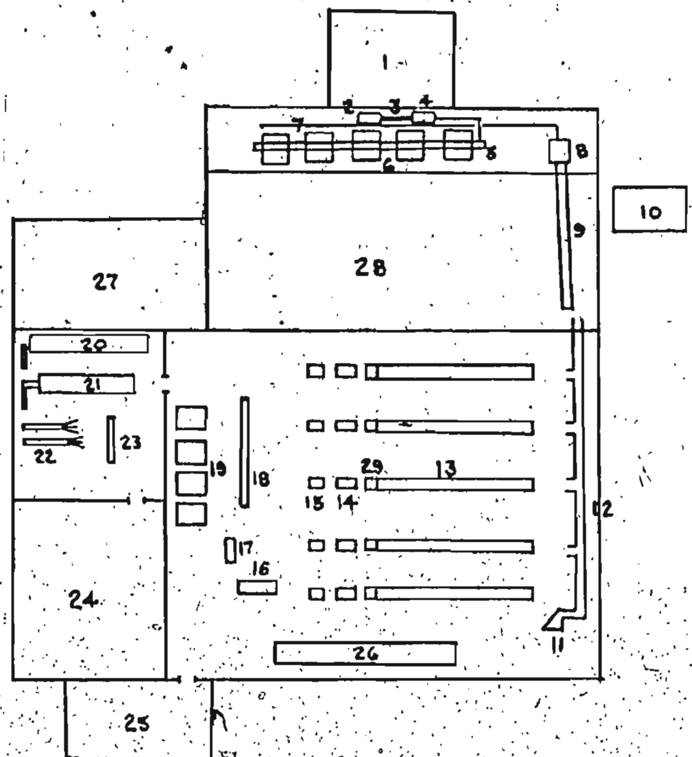


FIGURE 1.12 FLOOR PLAN OF FISHERY PRODUCTS FISH PROCESSING PLANT IN BURIN

Legend

1. Unloading area at dock
2. Vacuum Unloader
3. Conveyor
4. Weigh Scales
5. Conveyor transporting fish to tanks
6. Fish held in water in tanks
7. Water flume
8. Conveyor
9. Conveyor
10. Ice Plant
11. Weigh Scales (Fish weighed out into 75# lots)
12. Conveyor taking boxes of fish to filleting lines
13. Individual station incentive tables - 72 cutters
14. Trimming tables - 24 trimmers
15. Skinning machines
16. Individual station packing line (1 pound packs)
17. Wrapping machine
18. Packing table - 30 packers
19. Plate freezers
20. Breading, battering, frying and freezing tunnel area
21. IQF freezing line (stainless steel belt)
22. Electronic frozen fillet salter
23. Packing line
24. Cold storage room
25. Dry storage area (packing materials)
26. Offices
27. Frozen offal storage area
28. Offal Freezing area (vertical plate freezers)
29. Weigh scales

Basic elements originally recognized by MTM include "reach", "grasp", "move", "turn", "position", and "disengage": others include eye movements, application of pressure, and cranking motions.

To establish a time standard using tabulated MTM data, the methods engineer breaks the activities into standard motions. This he does by observing an operator who is doing the job or by visualizing the motions which should be used. If the method he records is ineffective, he corrects the motion pattern before proceeding. An operation analysis must be very thorough, so the MTU selections may be appropriately made from those tabulated.

When an acceptable method has been recorded, he determines the time required for each motion from previously established standards.

The industrial uses of MTM analysis of any manual operation or method are:

1. Work Measurement
2. Developing effective methods in advance of production.
3. Improving existing methods
4. Establishing time standards
5. Developing time formulas and standard data
6. Estimating
7. Guiding product design.
8. Selecting effective equipment
9. Training supervisors to become methods conscious.

10. Settling grievances
11. Operator training
12. Research, particularly in connection with methods.
13. Developing effective tool design.

Some of the disadvantages of the use of the MTM tabulated data to establish work standards are:

1. The skill of and the effort expended by the operator are not taken into consideration.
2. Variations in the work pattern from piece to piece, unable to be detected by the human eye, may not be taken into consideration.
3. The percentage yield and quality of the finished product cannot be determined.
4. A great deal of time is required for the collection and analysis of data - may entail the taking and analysis of motion picture film.
5. The work pattern of the operator being studied is continually interrupted for the taking of measurements and rearranging of equipment.
6. The work must be carried out under the supervision of a person trained by the MTM Association or an institution or consulting firm recognized by it.

At Marystown, the performance of a new filleter is determined by having him fillet two hundred pounds of fish at a mockup of the plant's filleting tables. Based upon this test, his maximum attainable earnings are computed - dependent upon his placement (by mutual agreement) at the group filleting tables.

The size of the fish being filleted by the filleters in Marystown is determined daily by two checkers, whose only job function is to count the number of fish in a random sample of a predetermined weight.

Figure 1.13 shows a layout of the fish plant at Marystown. This plant is the one described as over-engineered in the Inbucon Report (Inbucon Associates Ltd., 1968). Group filleting tables are used at Marystown; again a type not favoured by the Inbucon Report. This type of table will be evaluated by the author in the "results and discussion" section of this report. Figure 1.14 shows a group filleting table.

1.23 Seasonal Plants

Small seasonal plants, unable to afford the services of a consulting firm, have attempted to institute incentive schemes, based either upon past performance or the opinion of production personnel. These include:

1. Wages based upon a rate, dependent upon yield, for each pound of fillet produced.
2. Wages based upon an hourly rate plus a bonus for each pound of fillet produced.

Developing standards for these plants is one of the objectives of this report.

1.30 DESCRIPTION OF THE COD FILLETING PROCESS

1.31 Description of a Group Filleting Table

Figure 1.14 (page 18) shows a group filleting table similar to the one used in this study. The species of fish being filleted

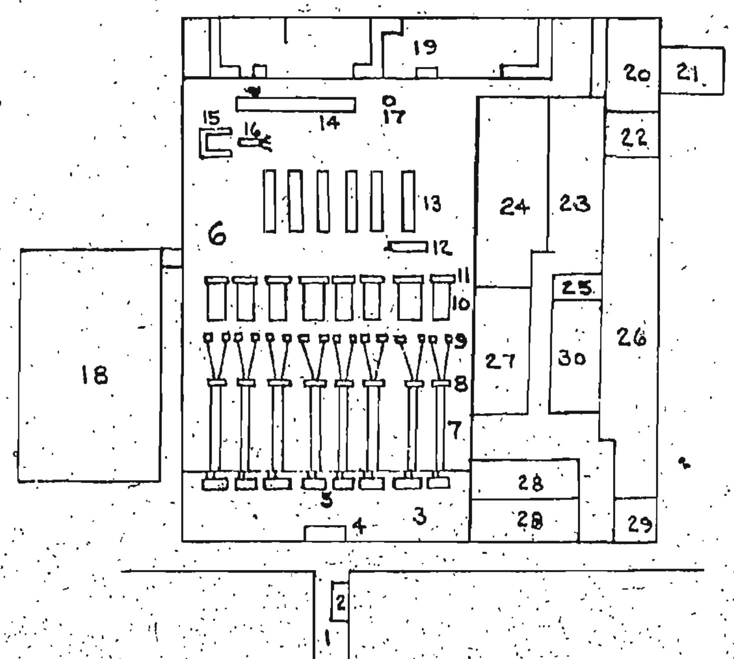


FIGURE 1.13 - FLOOR PLAN OF ATLANTIC FISH PROCESSORS LTD. FISH PROCESSING PLANT IN MARYSTOWN

Legend

1. Wharf
2. Unloading & Receiving room
3. Holding room (fish held in plastic boxes)
4. Weigh scales (500 lbs./box)
5. Hoppers
6. Processing room
7. Filleting lines (group tables) 80 cutters
8. Weighing - fillets
9. Skinning machines
10. Trimming lines
11. Weighing area
12. TPP machine
13. Packing lines
14. Plate freezers
15. IQF Fillets area
16. Automatic Weight sorter
17. Hand washing area
18. Cold storage building
19. Offices, lockers
20. Compressor room
21. Generator room
22. Boiler room
23. Meal storage area
24. Dry storage area
25. Electric shop
26. Reduction plant
27. Stock room
28. Ice bins
29. Carpenter shop
30. Machine shop

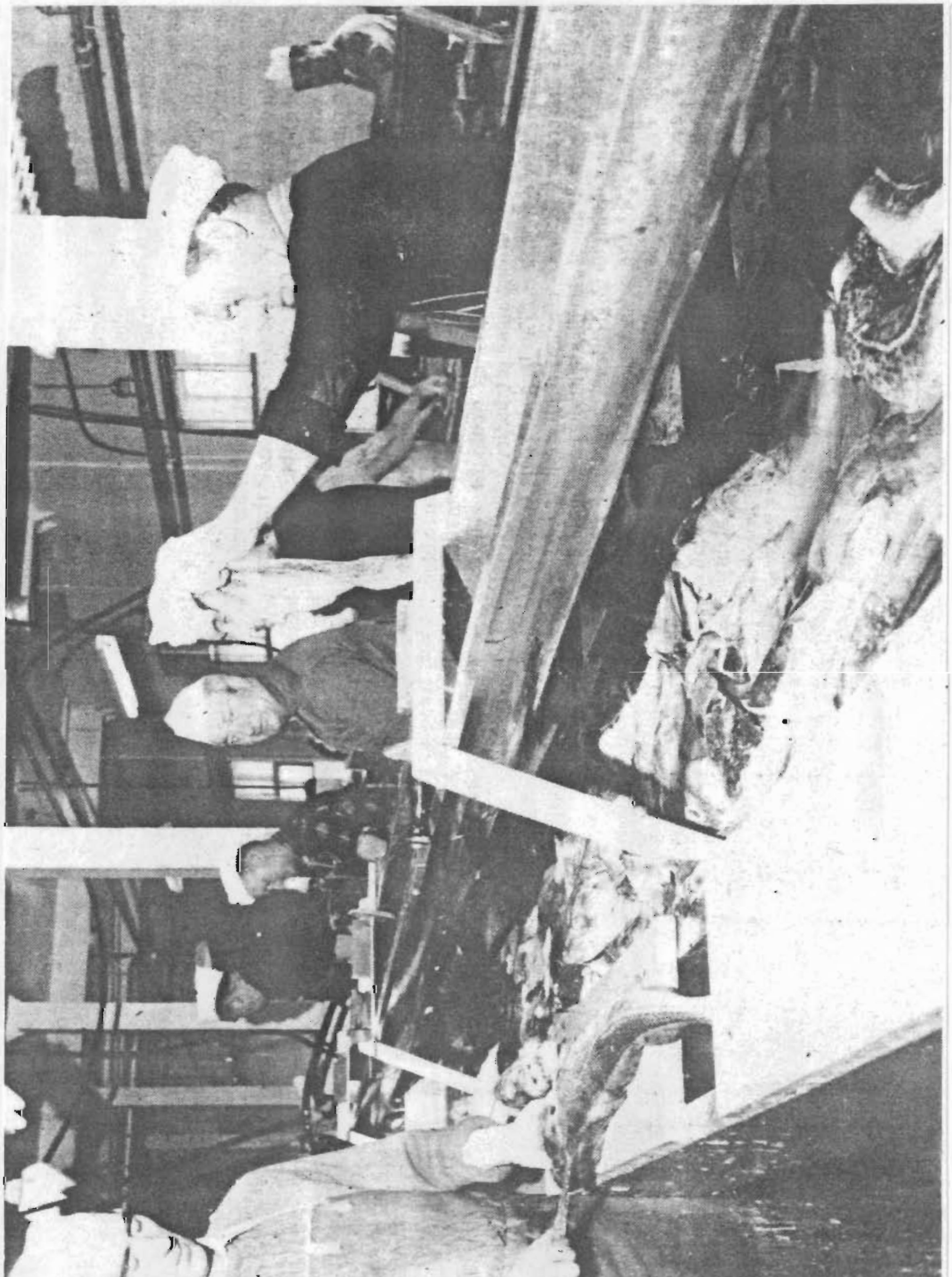


FIGURE 1.14 - GROUP FISH FILLETING TABLE

is codfish. The fish are held in a water flume located between the lines of filleters. The fillets are placed in a water flume located in front of and above the filleting surface.

The advantages of a group filleting table are as follows:

1. The water in the flume removes the surface slime from the fish enabling the filleter to get a firmer hold on the fish during the filleting process.
2. It reduces the bacterial load on the fillets - fillets conveyed to the skinning machine in a water flume.
3. The get fish and place fillet finger, hand and arm movements (lower body members) are in a vertical plane, thereby minimizing trunk and leg movements (High body members).
4. The capital cost of equipment is low - some plants build their own tables.

The disadvantages of this type of table are:

1. The non-rotation of the fish in the water flume - tendency for the filleter to reach for the top most fish.
2. Inability of management to continuously monitor pounds of fish filleted per hour, percentage yield of skin on fillets and quality (freedom from filleting defects) of the fillets produced by each filleter.
3. Low productivity where incentive pay is based upon the performance of the group.

Referring to Figure 1.14 the filleter on the left has completed the first cut on the second side (head on the left) of the fish. Note (1) the position of his body with respect to the cutting surface (at about a 45 degree angle), and (2) the position of the fish on the cutting surface (to his right). The filleter on the right has completed cutting the fillet from the fish and is about to place it in the fillet chute; note the distance his hand has moved.

1.32 Description of an Individual Work Place Filleting Table

Figure 1.11 (page 11) shows an individual work place filleting table. Boxes, containing 75 pounds of fish travel down the filleting line on a roller conveyor (extreme left in the picture); work stations projecting at a 90 degree angle to this conveyor. The species of fish being filleted is flounder. The fish are held in a plastic box located in front of and to the right of the filleter (filleter in the forefront - to the left for the filleters in the rear). The fillets are placed in a plastic pan located next to the box containing the fish.

The following are the advantages of an individual work place incentive table over a group table layout:

1. Continual monitoring of the pounds of fish filleted per hour, pounds of fillet produced per hour, percentage yield of skin-on fillets, and quality (freedom from filleting defects - fins, belly bones, black nape) of fillets produced by each filleter - corrective action can be taken before the situation gets out of control.
2. Immediate feedback to trainees of the results of their actions - first principle of learning.
3. The development of a competitive attitude between operators.

4. Less supervision required -a glance at the filleting report determining a worker's performance during the foreman's absence.
5. Payment for work accomplished based upon an individual's performance rather than that of a group.

The disadvantages of this type of table are:

1. Higher cost of equipment - boxes, pans, weigh scales, individual work places, conveyors.
2. Higher labour costs - weigh in fish, weigh out fillets, compute incentive pay, hand wash boxes and pans.
3. Higher overhead costs - increased plant area required, extra maintenance.
4. The inclusion of extra miscellaneous motions into the filleting operation - get box of fish, get fillet pan, place empty fish box, place pan of fillets.
5. The possibility of increased bacterial populations on the fillets - limited use of water.

1.33 Basic Motions

The following are the basic motions involved in the filleting of cod fish, see figures 1.11 and 1.14.

1. Reach for fish contained in a trough (group table) or box (individual table), transport to table, and orient on filleting surface - left hand.

2. Fillet first side (head on filleters right) - right hand.
3. Trim filleting defects plus those incurred in handling and storage, off the fillet - right hand.
4. Place first fillet into trough (group table) or fillet pan (individual table) - left hand.
5. Turn fish through 180 degrees - both hands.
6. Fillet second side - right hand.
7. Trim second fillet - right hand.
8. Place second fillet (left hand) - skeleton is placed into the offall chute simultaneously with this motion - right hand.

1.34 Miscellaneous Operations

Miscellaneous operations in fish filleting include the following:

1. Obtain box containing 75 pounds of fish (individual table only) - both hands.
2. Obtain empty fillet pan (individual table only) - either hand.
3. Sharpen knife by rubbing it on a steel - right hand.
4. Place pan of fillets on a conveyor belt (individual table) - both hands.
5. Place empty fish box on a conveyor (individual table only) - both hands.

1.35 Detailed Description of the Filleting Operations for a Maximum yield cut

The following is a detailed description of the filleting operations for a maximum yield cut (see Figure 1.15, page 24).

Operation 2A - Remove the first fillet (first cut) - Using the left hand to hold the fish firmly against the filleting surface, a V-cut is made directly behind the gill cover area of the head of the fish. The full length of the blade of the knife is utilized in making this cut. If the cut should be made by moving the knife at right angles to the lateral line (straight cut), a loss of yield would result.

Operation 2B - Remove the first fillet (second cut) - Holding the fish firmly with the left hand the blade of the knife is turned so that it is parallel to the filleting surface and at an angle to the back of the fish, then the edge of the blade is inserted into the flesh near the head and moved through the flesh until it reaches the break in the lateral line. Care must be exercised to keep the blade near the backbone of the fish or a loss in yield will result.

Operation 2C - Remove the first fillet (third cut) - The tip of the blade of the knife is pushed through the flesh, emerging from the other side near the anus of the fish. If the tip is not moved parallel to the filleting surface, but at a slight downward angle, it could pass under the fins as it emerges from the other side, leaving fins attached to the fillet. These should be removed from the fillet.

Figure 1.15 MTM Analysis of Cod Filleting
Sheet 1 of 13.

Operation 1A - Get Fish and Transport to Table - head on the right and gut away from the filleter (left hand).

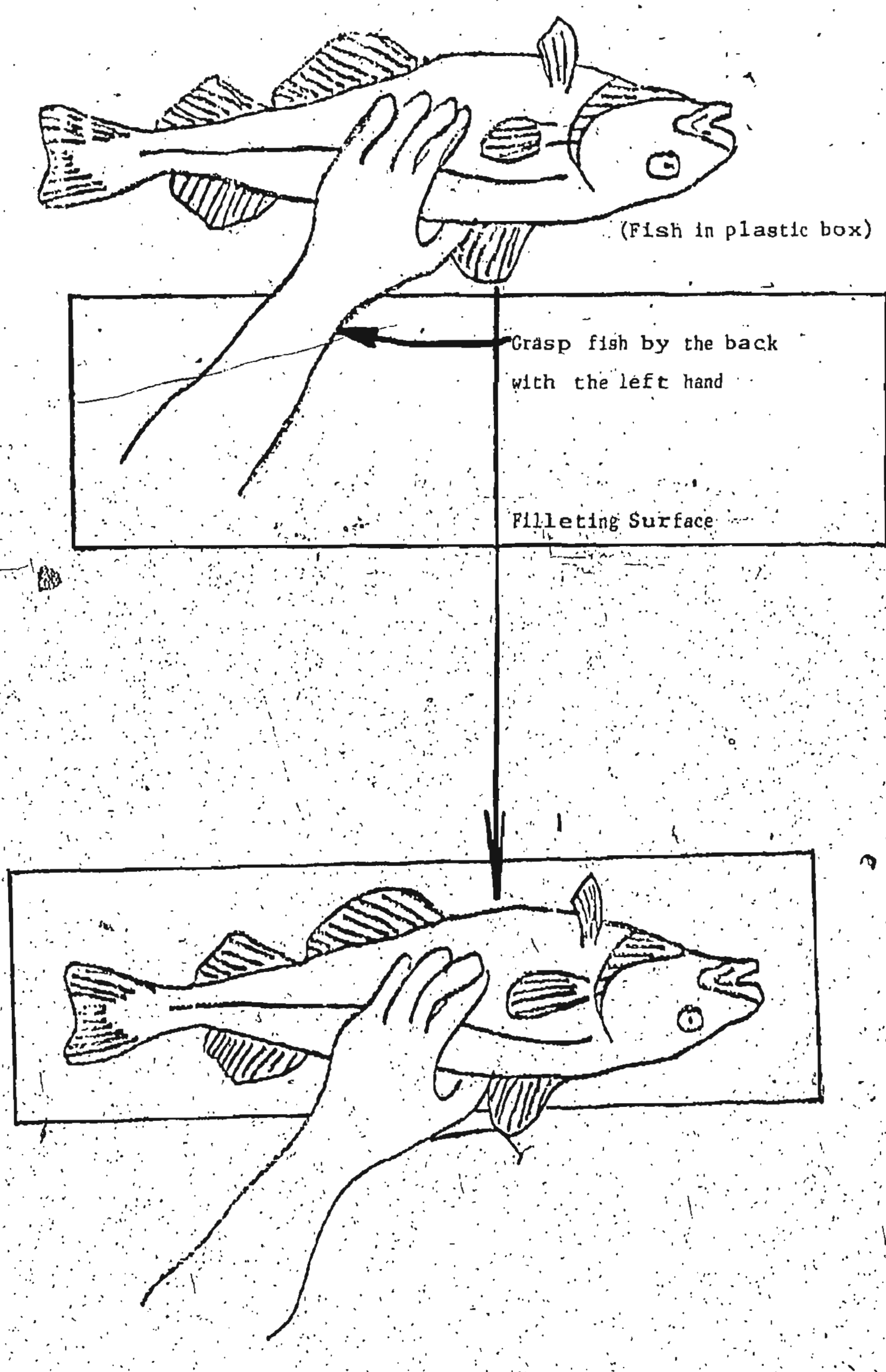


Figure 1.15 Continued
Sheet 2 of 13.

Operation 1B - Get Fish and Transport to Table - head on the right and gut toward filleter (left hand)

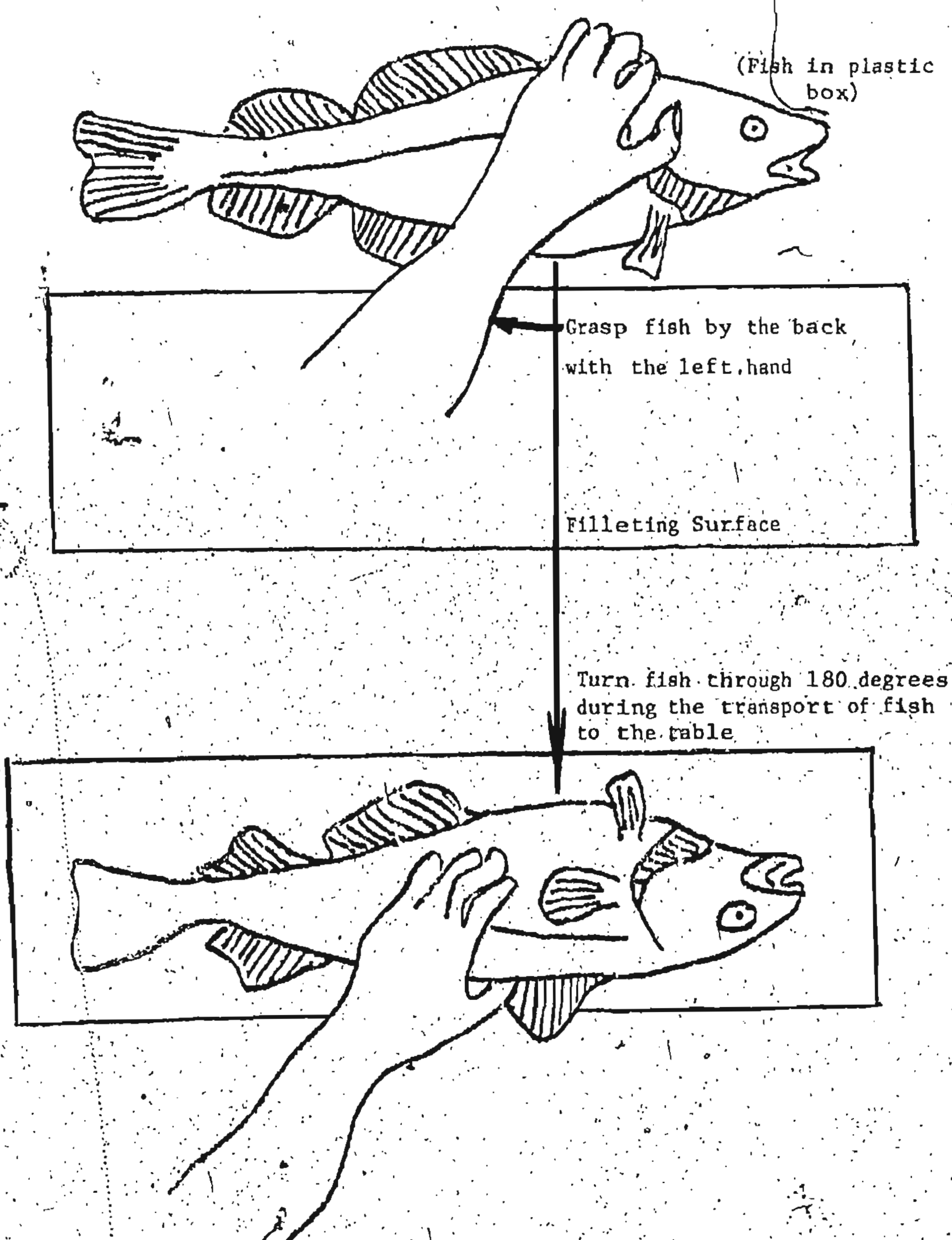


Figure 1.15 Continued
Sheet 3 of 13

Operation 1C - Get Fish and Transport to Table - heat on the left and gut toward filleter (left hand).

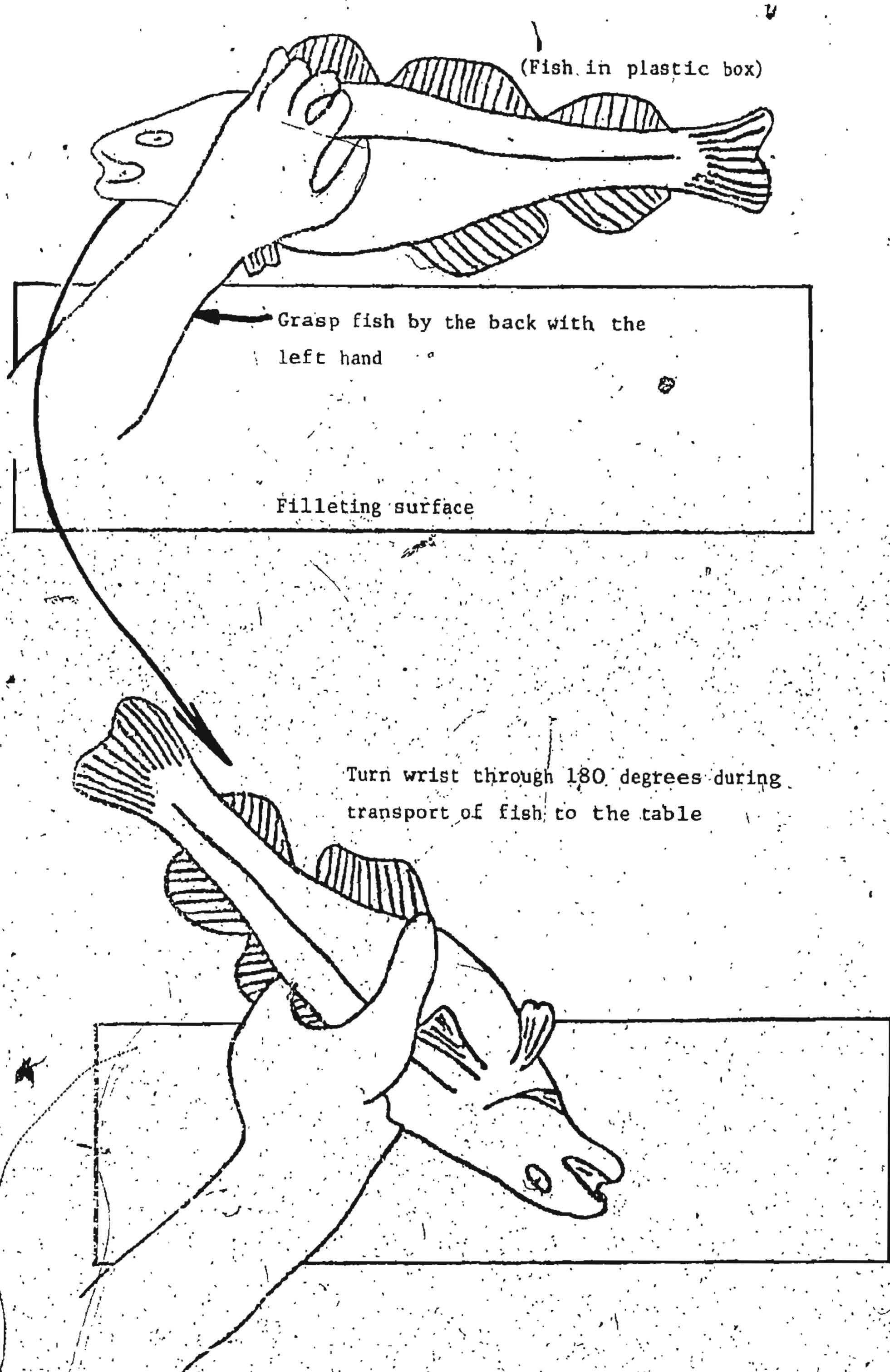


Figure 1.15 Continued
Sheet 4 of 13

Operation 1D - Get Fish and Transport to Table - head on left and gut toward filleter (left hand).

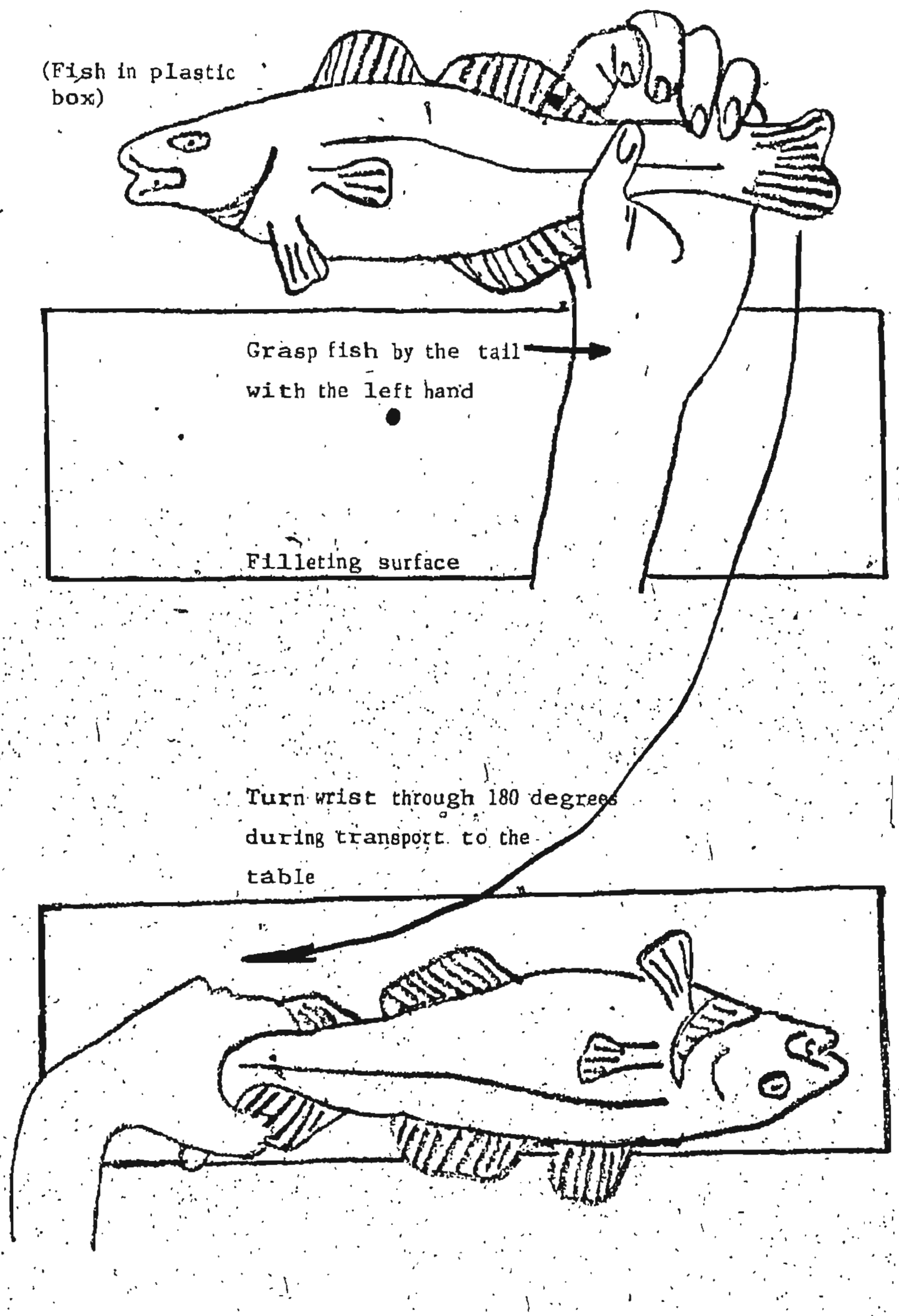


Figure 1.15 Continued
Sheet 5 of 13

Operation 1E - Get Fish and Transport to Table - head on left and gut away from the filleter (left hand).

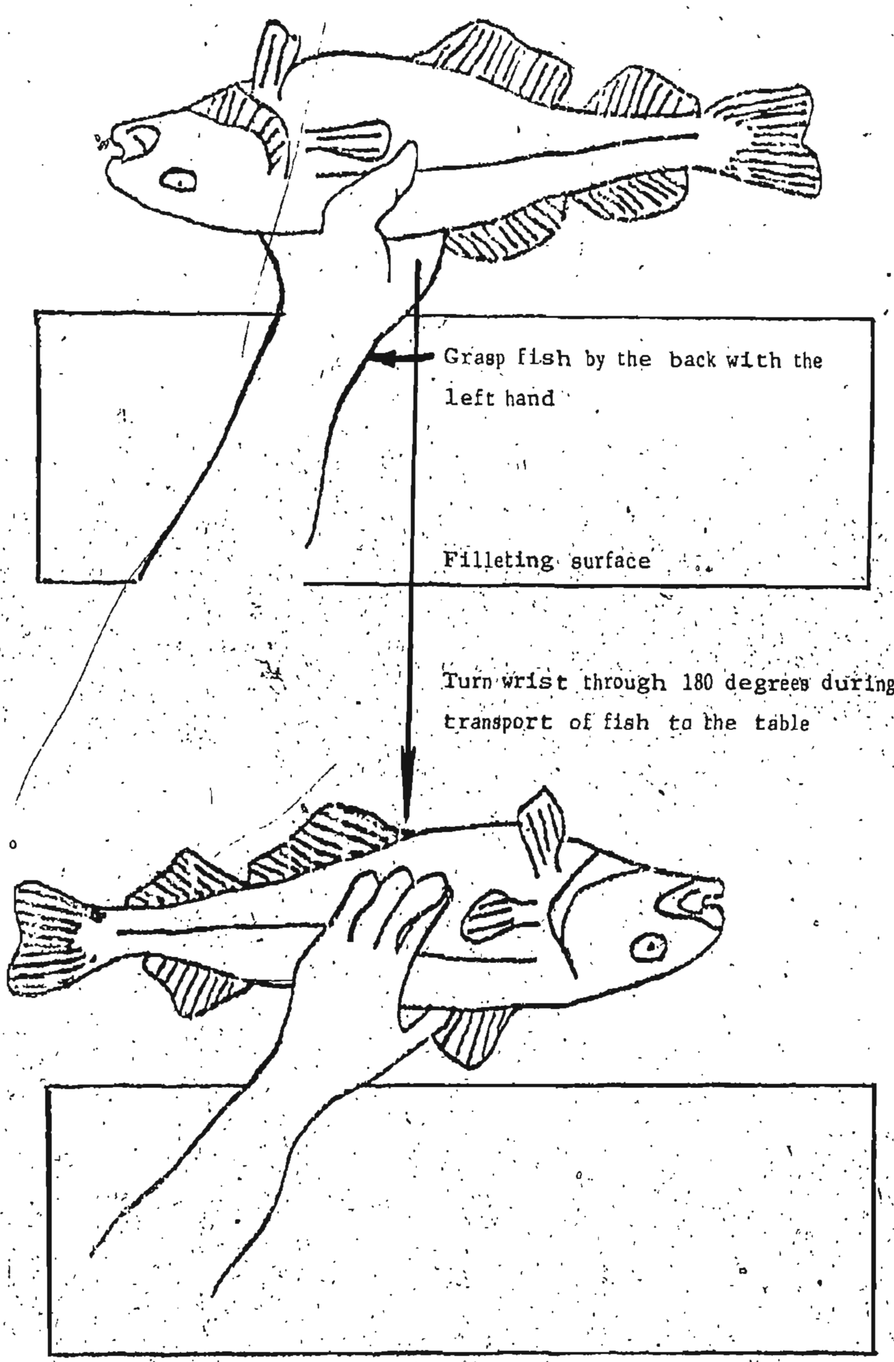
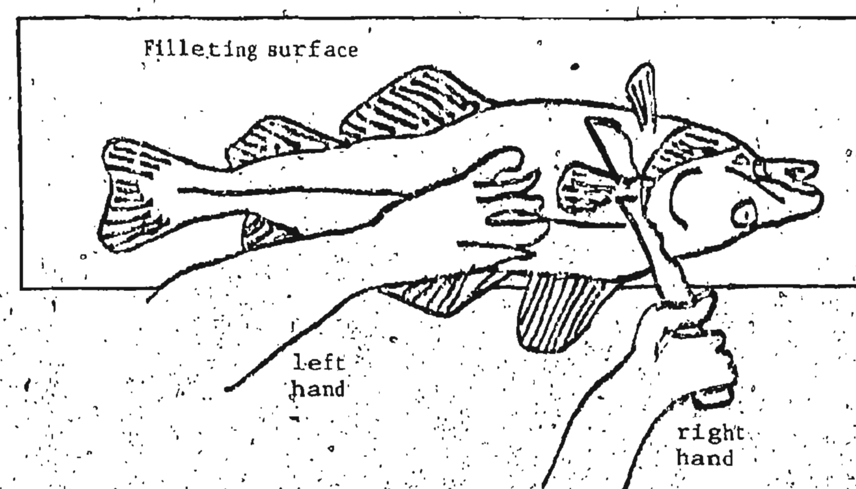


Figure 1.15 MTM Analysis of Cod Filleting
Sheet 6 of 13

Operation 2A - Remove the First Fillet, First Cut - V-cut behind gill cover (right hand).



Operation 2B - Remove the first fillet, second cut - Insert tip of blade of the knife into the flesh near the head and move it along to the break in the lateral line (right hand).

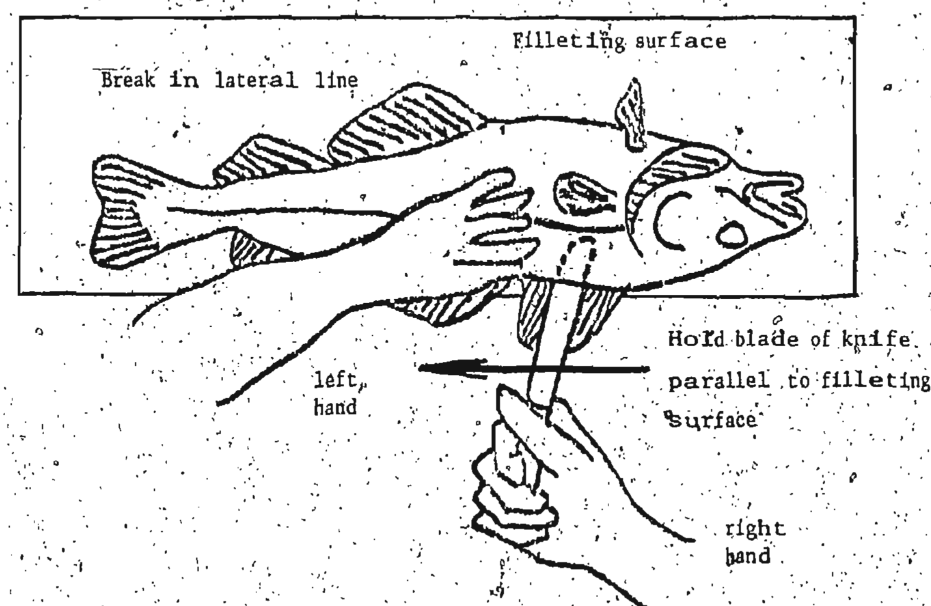
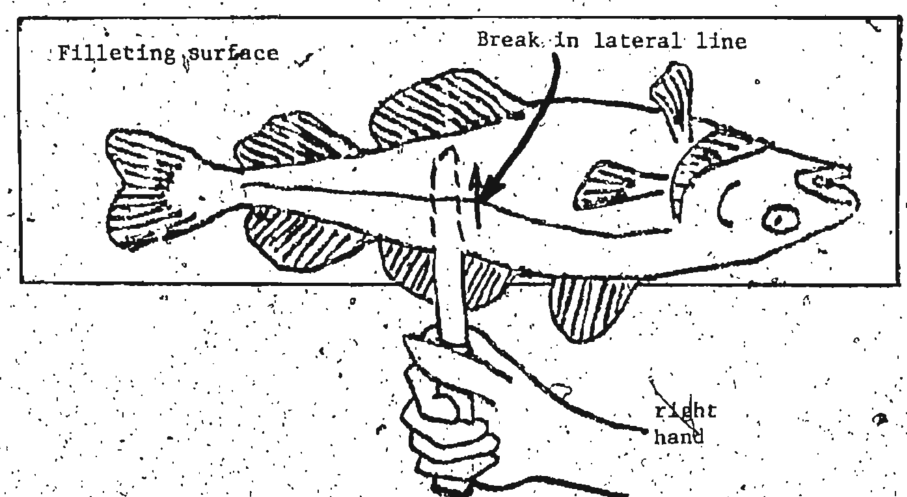


Figure 1.15 Continued
Sheet 7 of 13

Operation 2C - Remove the First Fillet, third cut - Push the tip of the blade through the flesh until it comes out the other side (right hand).



Operation 2D - Remove the First Fillet, fourth cut - move the blade towards the tail (right hand).

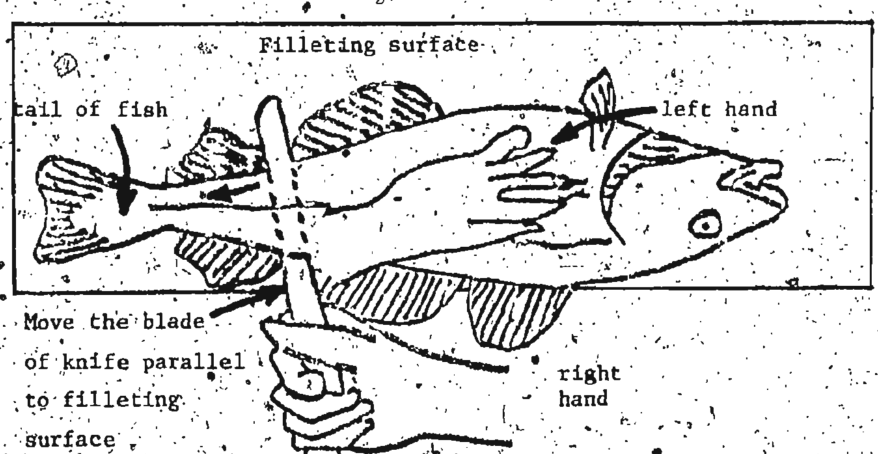
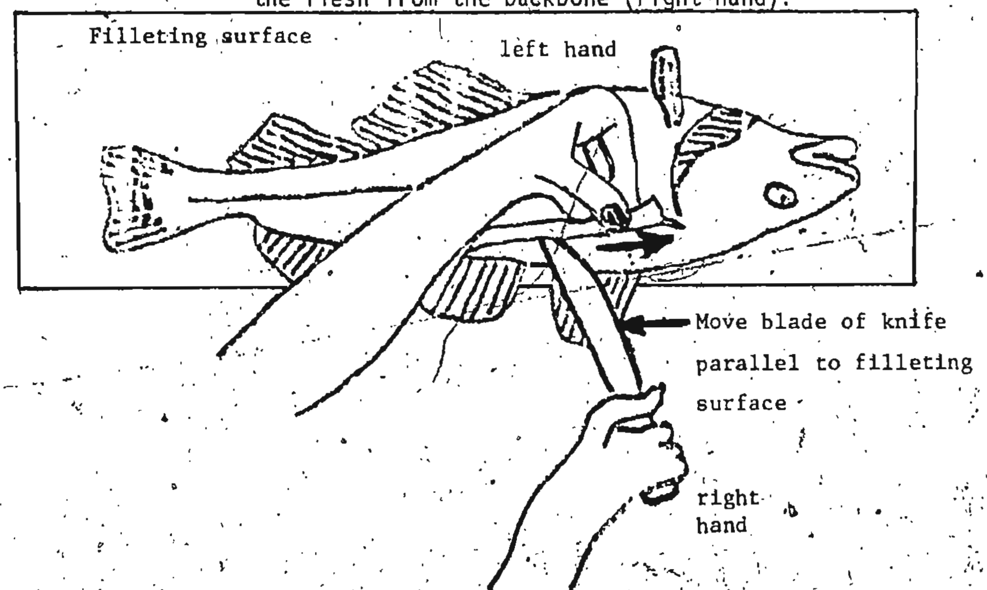


Figure 1.15 Continued
Sheet 8 of 13

Operation 2E - Remove the First Fillet, fifth cut - lift edge of fillet (left hand) insert tip of knife and releasing the flesh from the backbone (right hand).



Operation 2F - Remove the First Fillet, sixth cut - lift edge of fillet higher (left hand), insert tip of knife and release the flesh from rib cage (right hand).

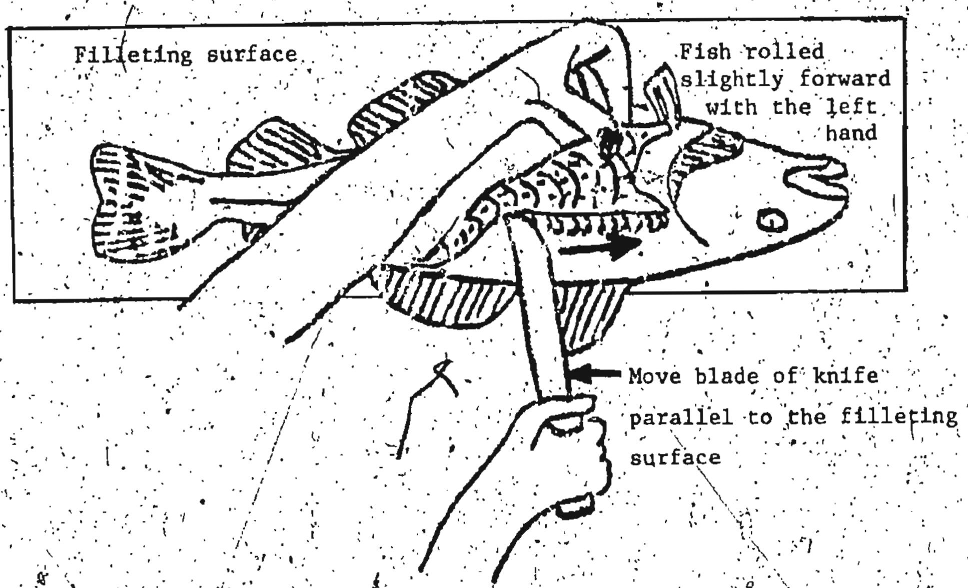
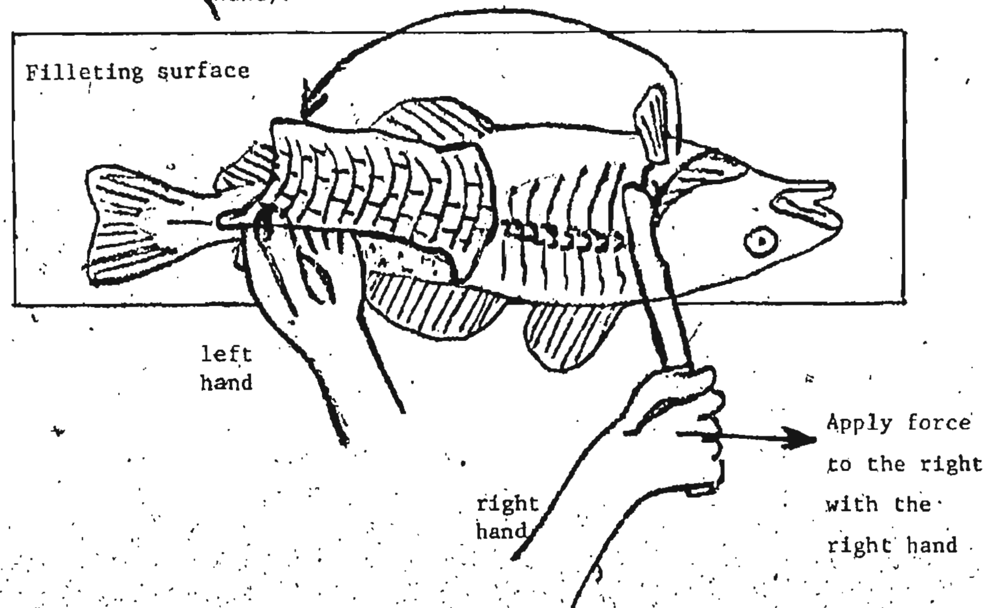


Figure 1.15 Continued
Sheet 9 of 13

Operation 2G - Remove the First Fillet, seventh cut - move blade of knife to head and position blade behind the gill cover (right hand) then tear fillet loose from rib cage (left hand).



Operation 2H - Remove the First Fillet, eight cut - cut fillet from the fish (right hand).

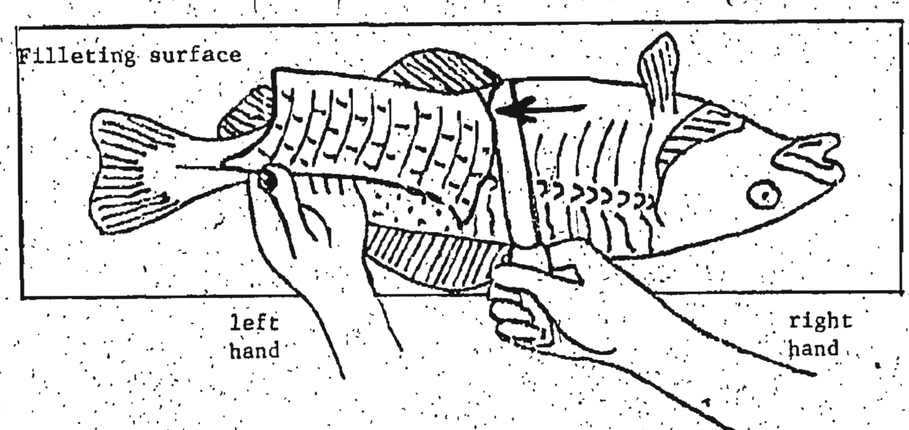
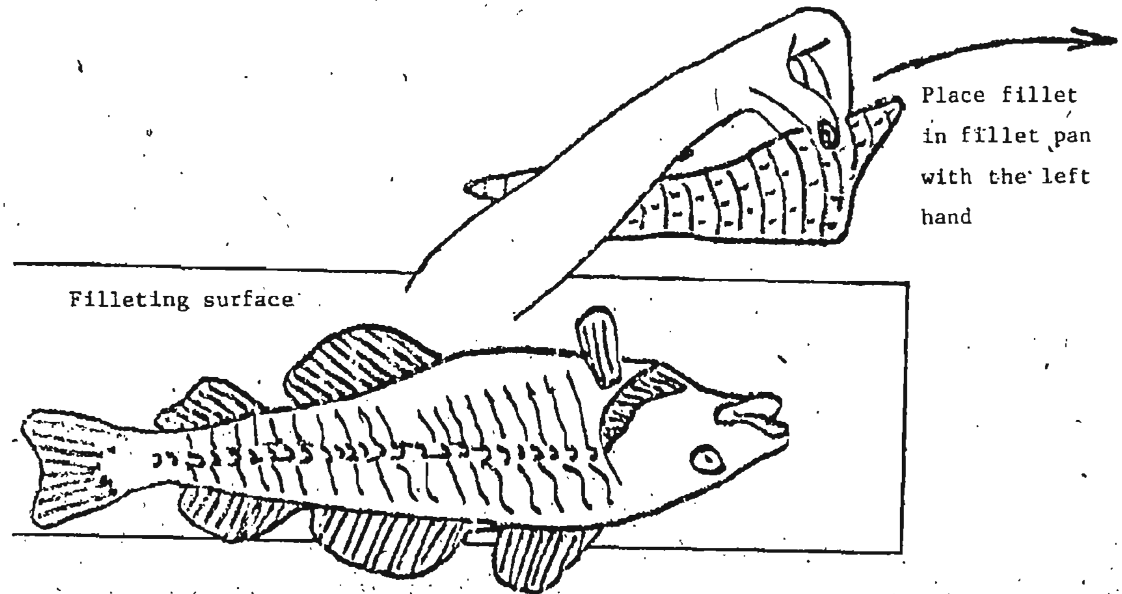


Figure 1.15 Continued
Sheet 10 of 13

Operation 3 - Place First Fillet in Fillet Pan (Left Hand).



Operation 4 - Turn the Fish through 180 Degrees (Both Hands) - Method A

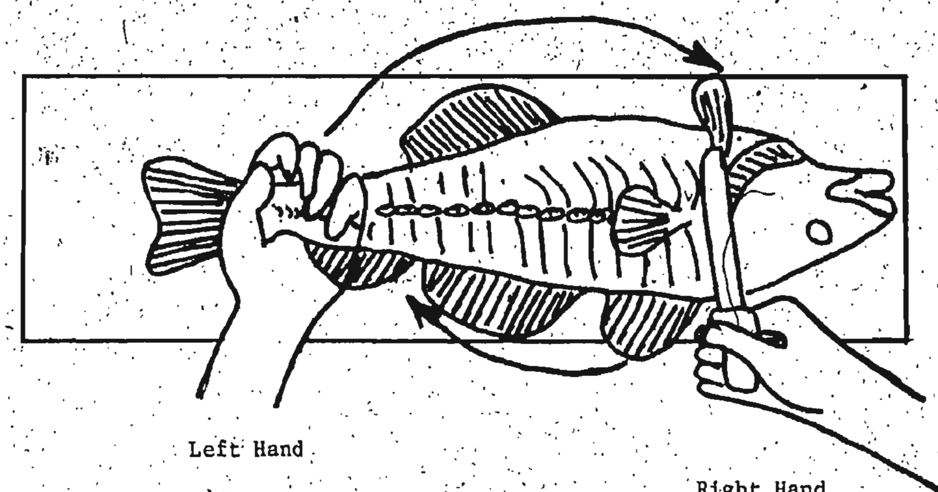
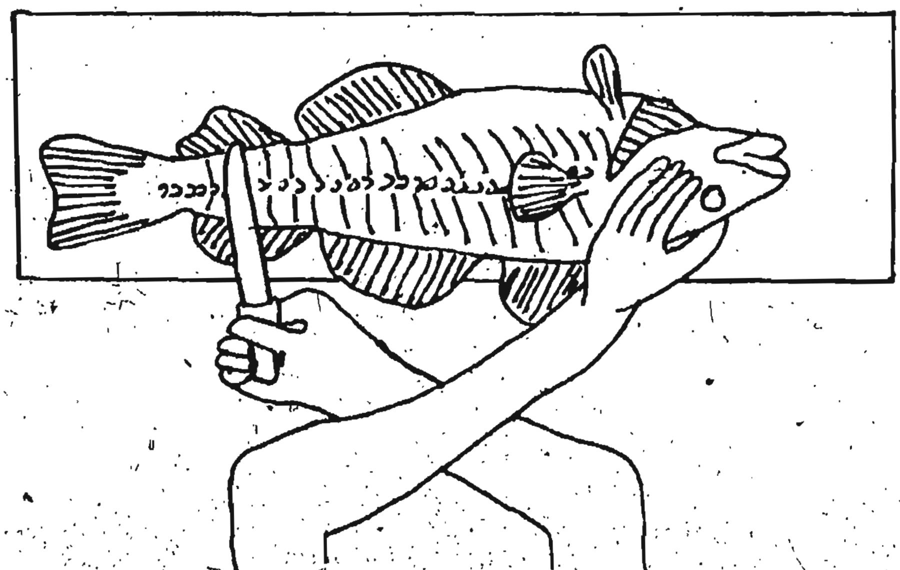


Figure 1.15 Continued
Sheet 11 of 13

Operation 4 (Cont.) - Turn the fish through 180 degrees (both hands) - Method B (Method used in the study)



Operation 4 (Cont.) - Turn the fish through 180 degrees - Method C (Utilizing only the blade of the knife)

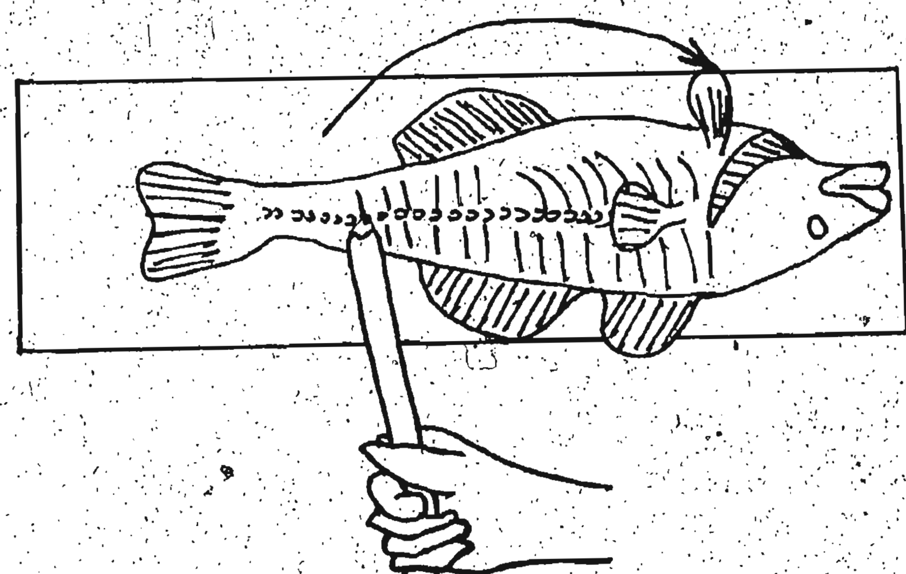
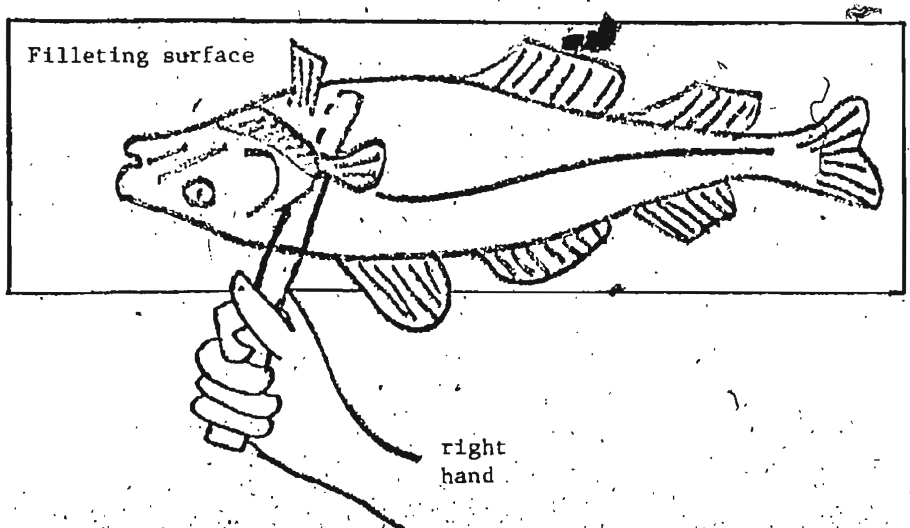


Figure 1.15 Continued
Sheet 12 of 13

Operation 5A - Remove the second fillet, First Cut - slash cut behind the gill cover (right hand)



Operation 5B - Remove the second fillet, Second Cut - Insert the tip of the knife near the tail and move the blade toward the head (right hand).

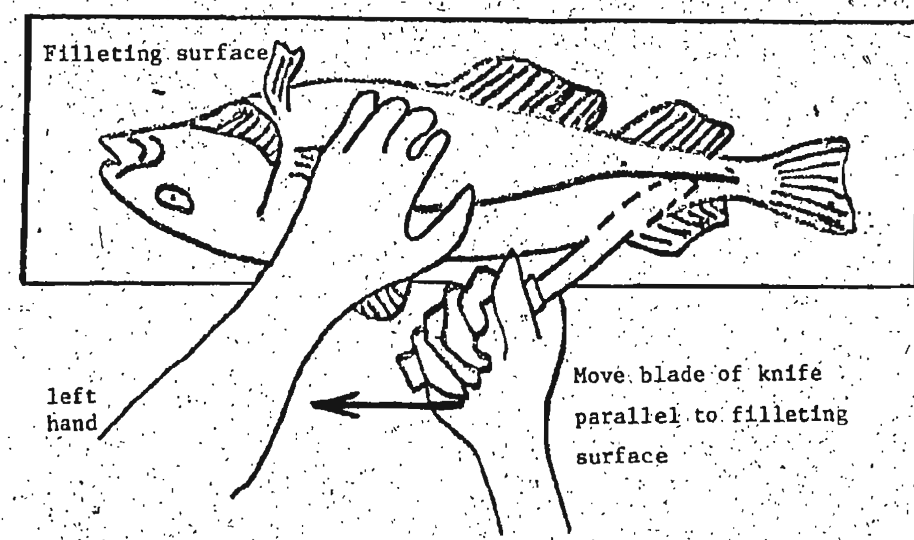
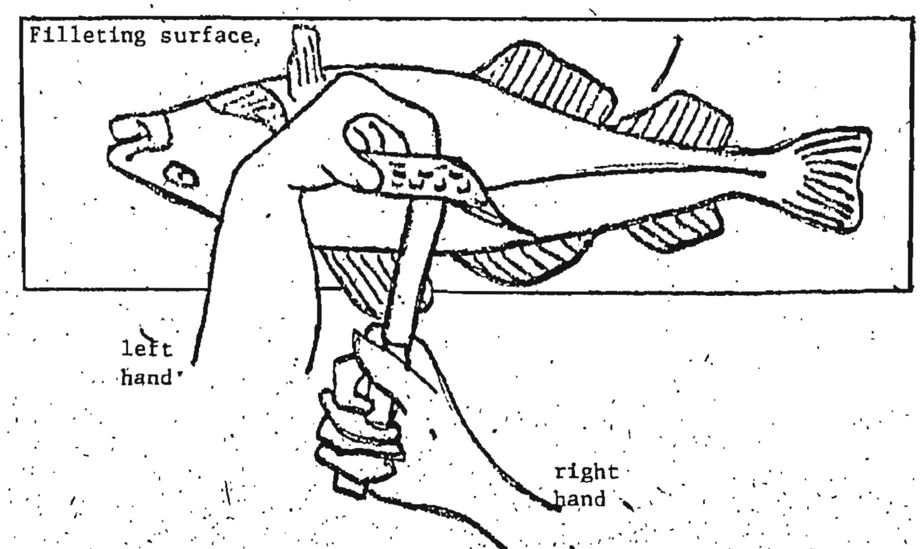


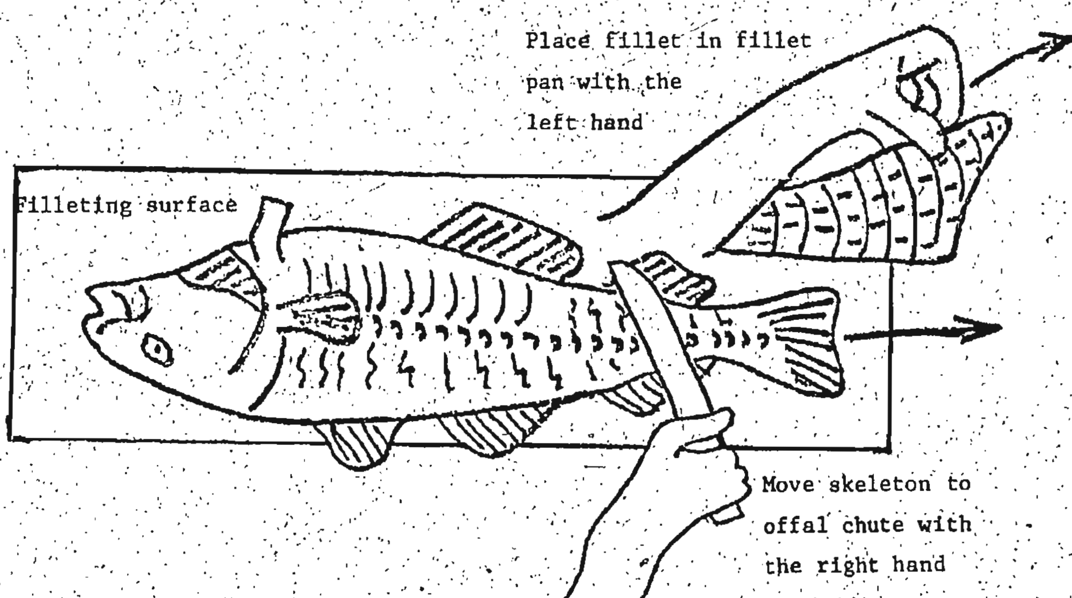
Figure 1.15 Continued
Sheet 13 of 13

Operation 5C - Remove the second fillet, Third Cut - Lift the edge of the fillet (left hand), insert the tip of the knife and cut the fillet from the backbone.



NOTE - The remaining operations are similiar to 2F, 2G, and 2H.

Operation 6 - Place the second fillet (left hand) and discard the skeleton into the offal chute.



Operation 2D - Remove the first fillet (fourth cut) - The blade of the knife is moved through the flesh to the tail, care being exercised to keep the blade as close to the backbone as possible so as to avoid a loss of yield. If the blade is not parallel to the filleting surface, but is held at a slight downward angle, pieces of backbone may be removed with the flesh. These do not constitute a serious quality problem.

Operation 2E - Remove the first fillet (fifth cut) - The edge of the fillet is grasped with the left hand and rolled back. The tip of the blade of the knife is inserted and moved toward the head, releasing the flesh from the backbone. When performing this cut, care should be exercised to ensure that the blade is kept close to the backbone. Operation 2E may have to be repeated when filleting large fish.

Operation 2F - Remove the first fillet (sixth cut) - The edge of the fillet is raised, rolling the fish slightly forward. Failure to roll the fish sufficiently forward can result in a loss of yield when performing this cut. The tip of the blade of the knife is inserted and moved toward the head, releasing the flesh from the backbone.

Operation 2G - Remove the first fillet (seventh cut) - The blade of the knife is placed under the gill cover, force being exerted to the right as the left hand, moving to the left, releases the flesh from the belly cavity of the fish.

The filleting operations for removing the second fillet are similar to those for removing the first fillet.

1.36 Method Used in England

Enclosed are magazine photographs (see Appendix "A") describing the method used (in England) to fillet head-off cod. The steps in this operation are as follows:

1. The head is cut off and the lugs or shoulders removed.
2. The knife is run from the tail to the head end along the top of the backbone, aiming for the centre round bone.
3. A cut is made over the top of the round centre bone from the tail to the head end, stopping half-way up the fish at the rib bones.
4. The fish is turned on to its belly and the cut is continued to the head end.
5. The knife is reversed and the fillet is separated from the bone by a cut from the head end to the tail.
6. The flap is trimmed off.
7. The fish is turned over and a cut is made on top of the bone from the head to the tail, aiming for the round centre bone.
8. The knife is continued over the top of the centre bone at the tail section and the flesh is cut away.
9. The fish is turned on to its belly and the fillet is separated from the rib bone by a cut from the head end.
10. The flap is trimmed away from the fillet.

The author has seen a film, a short segment of which showed the aforementioned method used to fillet cod in England. He is of the opinion that it places no constraints upon the filleting of codfish. In fact, it could reduce the load to be transported in the get fish and turn fish filleting motions. However, the fish would have to be headed manually, or by machine. This additional cost might offset any benefits gained during the filleting operation.

1.37 Cod Filleting Machinery

The following information on Baader processing machinery has been taken directly from an article by J. Drews (Drews 1974).

Rising costs and a shortage of labour on one hand and the increase in price for the raw material and the scarcity of some popular fish species on the other hand have led to the development of more specialized processing machinery.

A fish processing machine has to perform the cuts in a way to avoid any unnecessary loss of valuable meat in order to achieve a high product yield. To select a suitable combination of processing machines for a particular processing line, the following details must be considered:

1. Type of fish
2. Smallest and largest fish to be processed
3. Average size of fish
4. Desired capacity per hour.
5. Type of end product

Each machine has certain features, depending upon its design and operating system, which bring advantages for one operation and disadvantages for another operation. The following are some factors to be considered when selecting the white fish processing machinery shown in Table 1.12:

TABLE 1.12 - WHITE FISH HEADING AND FILLETING MACHINERY

Manufacturer	Machine Type	Operations	Fish Length Inches	Speed - Fish Per Minute	Operators	Filleters Replaced [3]	Remarks
Arenco[1]	KMSHV - 35	Heading	14 - 26	30	1		V-cut
	KMSHV - 100	Heading	up to 30	40	1 - 2		Straight cut
	KMSFV - 35	Filleting	16 - 25	20 - 35	1	5 - 9	
Baader[2]	187	Filleting	12 - 22	25 - 40	1	6 - 10	Separate heading machine 417
	188	Filleting	14 - 28	27	1	6	Separate heading machine 417, 413 or 160
	189	Filleting	16 - 33	up to 34	1	up to 9	Separate heading machine 410 or 161
	99	Filleting	20 - 47	up to 25	3	3	Separate heading machine 412 or 419
	338	Filleting	16 - 28	40	1		Heading and gutting included
	160	Heading & Gutting	14 - 28	40	1		Straight cut
	161	Heading & Gutting	20 - 33	28	1		Straight cut

(continued on next page)

(continued) TABLE 1.12

Manufacturer	Machine Type	Operations	Fish Length Inches	Speed - Fish Per Minute	Operators	Filleters Replaced [3]	Remarks
	410	Heading	17 - 33	34	1		V-cut
	412	Heading	20 - 47	25	1		V-cut
	413	Heading	12 - 28	40	1		V-cut
	417	Heading	12 - 28	40	1		V-cut
	419	Heading	20 - 43	25	1		V-cut

1 - K. Myklebust Marine Ltd. (Distributor), 67 Glen Forest Drive, Clayton Park, Halifax, N.S.

2 - J. Canning (Distributor), Osborne St., St. John's, Newfoundland.

3 - Based upon normal performance.

* - require heading machines

1. Both the 188 and 189 filleting machines need a separate heading machine and with it an extra operator.
2. The speed of the 338 filleting machine is 40 fish per minute whereas the 188 and 189 are slower with 27 and 30.
3. The system of the 338 enabling the higher speed and the inclusion of the heading operation does not allow for optimum in meat recovery (the 188 and 189 are much better).
4. For operation in a factory trawler where both space and labour are scarce and expensive, the 338 proves to be the more economical solution.
5. For a shore plant, the higher yield (about 3 percent for 21.7 inch fish) of the 188 and 189 brings more savings than the additional expense for the separate heading machine.
6. The 189, besides giving a 3 percent gain in yield, handled a wider range of sizes (up to 33 inches) and has an adjustable speed (up to 34 fish per minute). However, it requires a far bigger investment than the 188.
7. The 160 heading machine would be specified only if ungutted fish had to be processed.
8. The 423 machine, with a straight cut, does not recover as much flesh from the heads as the V-cut heading machines 413, 417, and 410, do. (410 is the most sophisticated model giving the highest yield).

The following is a statement by the Fisheries Association of Newfoundland and Labrador (renamed the Fish Trades Association) pertaining to the use of filleting machines in fish processing establishments:

"One of our competitive Countries is in the fortunate position that it can use filleting machines on the cod it processes and thus has cutting costs at least half as high as ours. This one aspect gives this particular Country a cost advantage in the market place, as their market too is the United States. Operators in Newfoundland have all looked very closely at machines, but cost and other factors have precluded any wide use." (Daily News, 1972).

At present, only small inshore trap cod (uneconomical to hand fillet) are machine cut. A complete conversion to machine filleting would create a major unemployment problem, however, a continual rise in wage demands, coupled with decreasing market prices, could force many processors in this direction. Examples of automation in the fishing industry are as follows:

1. Loss of forty jobs with the replacement, at Port aux Choix, of the hand peeling of shrimp by mechanical peelers.
2. The purchase of Baader splitting machines by the Canadian Salt Fish Corporation.

The offering, by the College of Fisheries, of machinery maintenance courses, conducted by regionally based Baader maintenance personnel, could be another reason which might favour conversion to machine filleting.

1.40 OPERATING DEMANDS ON FISH FILLETING

1.41 Filleting Skills

The so-called repetitive semi-skilled tasks in industry can be performed by most people, but few can attain the standards of speed and quality demanded of, and attained by, experienced workers. Seymour (1954) in a detailed study of industrial tasks showed that the speed skills depend more on mastering the perceptual requirements of the task than on merely performing the movements involved. He concludes that experienced workers differ from learners, not so much in the movements they make, nor in the speed of those movements, as in the manner in which they use their senses to derive information from the task for controlling the movements. Other experiments conducted by Seymour (1974b) on the acquisition of industrial skills, indicate that the learning of the sequence of activities in an industrial task usually involved much less difficulty than acquiring the perceptual skills.

A much greater degree of sensory and affector co-ordination is required in filleting for the fillet side No. 1 (head on the right side) and fillet side No. 2 (head on the left side) operations than for the other operations such as, obtain fish, place fillets, turn fish and place head and bone (Amaria, 1974a).

The effort expended by a filleter when filleting a fish is partially dependent upon the ease with which his filleting knife moves through the fish flesh (posture, method, quality of fish, etc. also affect). Knife sharpening is a skill, one which does not come easily to most potential filleters. The use of a dull knife can result in decreased yield and poor fillet appearance. Some plants have a full-time employee on staff whose only job function is to sharpen knives.

It takes approximately 30 minutes to sharpen a knife on a whetstone, thereafter a periodic 10 to 20 second rub on a steel being sufficient to restore the cutting edge. The author has observed filleters steeling knives for 2 - 3 minutes, between, and while filleting boxes of fish. A conscientious filleter spends many extra hours molding the shape of the blade of his knife to his particular specifications.

The following are some relationships which exist between skill and age (Edholm, 1967):

1. Aging results in a slowing of performance (decision taking, identification of information, sight, hearing).
2. Older workers find it harder to understand new and unfamiliar instructions (verbal instruction may be inadequate.)

When performing simple tasks, little difference has been found between young and old workers; the speed of the young being compensated by the accuracy of the old. Amaria (1974,b) has suggested that the skill required for filleting a fish normally depends upon the experience of the operator; the average percentage yield of filleting increasing with the skill of the operator. He also observed that better than average workmanship would be obtained for performance ratings below 110-112, and poor workmanship for performance ratings between 110 and 127.

1.42 Positioning Fish on the Cutting Surface

As with knife sharpening, the selection of codfish from a disoriented pile, followed by reorientation during transport to the filleting surface, involves manual dexterity in the use of the wrist and forearm. Any physical handicaps in this area could lead to reduced speed and the expenditure of extra effort, when filleting.

Filleters require that fish be properly positioned on the cutting surface - to their right and near the edge of the cutting board (Figure 1.14 - page 18). It has been observed that it is difficult to fillet a fish if it is positioned directly in front of the body (because of the knife and hand movements involved).

1.43 Cutting Surface Height

When designing filleting tables, little or no allowance is made for the adjustment of the height of the filleting surface. When in a standing position and working with one's hands, the optimum height of the working area should be 2 to 4 inches below the height of the elbow (Grandjean, 1971). This 2 to 4 inches may, however, not be true for fish filleting.

For maximum recovery of edible fish flesh, some cutting motions require that the blade of the knife be moved parallel to the cutting surface (see Section 3.32, page 85). This requirement puts an added strain upon filleters whose elbow heights are well above the allowable limits. This added strain could result in decreased outputs and reduced yields (filleters building extra rest pauses into their work patterns).

1.44 Paced and Unpaced Operations

It has been shown that when experienced workers in industry, engaged on repetitive method studied tasks, are free to work at their own natural pace, their performance displays a highly consistent pattern, the principle feature of which is the absence of any trend in operation times throughout the work period (Dudley, 1955, 1958). This finding was in marked contrast to that of another investigator (Siddall, 1954) who found a markedly unstable pattern of motion times. Siddall's Study, however, was of workers on a conveyor belt, that is, paced workers.

Even in apparently unpaced operations, that is, those in which the speed of working is not determined or influenced by a machine, or belt, or other worker, research has shown that there are a number of factors - quite apart from any question of incentive payment - which have a significant effect on working pace. With the individual incentive table, where work is presented in batches (boxes of fish), the size of the batch and the anticipated availability of further batches, are both important. With group tables, where there is a continuous progressing of work, interruptions, both unexpected and anticipated, influence the time to perform an operation.

Whereas it was found earlier (Dudley, 1955) that the distribution of operation cycle or element time of trained and experienced operatives on repetitive work is positively skewed when workers are free to work at their own pace, there is a marked tendency for paced performance to yield a much more nearly normal distribution of operation times (Dudley, 1961).

With the introduction of incentive programs into fish plants, with their continuous monitoring of speed, quality and yield, filleters have had to convert from a self paced to an incentive paced system; this conversion placing more stress upon older employees. Older workers find paced work increasingly burdensome but will work effectively at his or her own pace (Edholm, 1967).

1.50 Purpose of the Project

The purpose of this project was to develop norms for filleting gut-in codfish; at the same time collecting sufficient data to observe the effect of:

1. Speed on the yield of filleting

2. Skill on the yield of filleting
3. Size of fish on the yield of filleting
4. Speed on the quality of workmanship of filleting
5. Size of fish on normal output rate.

CHAPTER 2 - OBJECTIVES

2.10 Man-Machine Relationship

Figure 1.16 shows the man-machine relationship and the factors which affect that relationship. Interest in man-machine relationship and details of human performance began, on the one hand, with physiological studies of muscular work (Frederick W. Taylor, U.S.A. 1881), and on the other hand, with close examination of the details of work in the industrial setting by engineers (Frank B. Gilbreth, U.S.A., early 1900's) and, later psychologists.

Time and motion study and work study techniques have proved to be powerful tools and are used extensively in a large number of industrial companies by specialized personnel. Their functions vary greatly but frequently include planning new operations, studying the work layout and organizing it in the most efficient manner, determining the time required for a work cycle in repetitive tasks, and the rest pauses or fatigue allowances required.

Accounts of the biological aspects, that is, the physiological, psychological, anatomical, and engineering features (Figure 1.16 items C, E and F) and their effect upon the man-machine relationship have been reported by O.G. Edholm (1967) and E. Grandjean (1971). These biological aspects are a part of the study of ergonomics (customs, habits, or laws of work).

Work study techniques are new to the Newfoundland fishing industry. The need for such studies have been pointed out in the Inbucon Report (page 7). The application of the aforementioned techniques first began

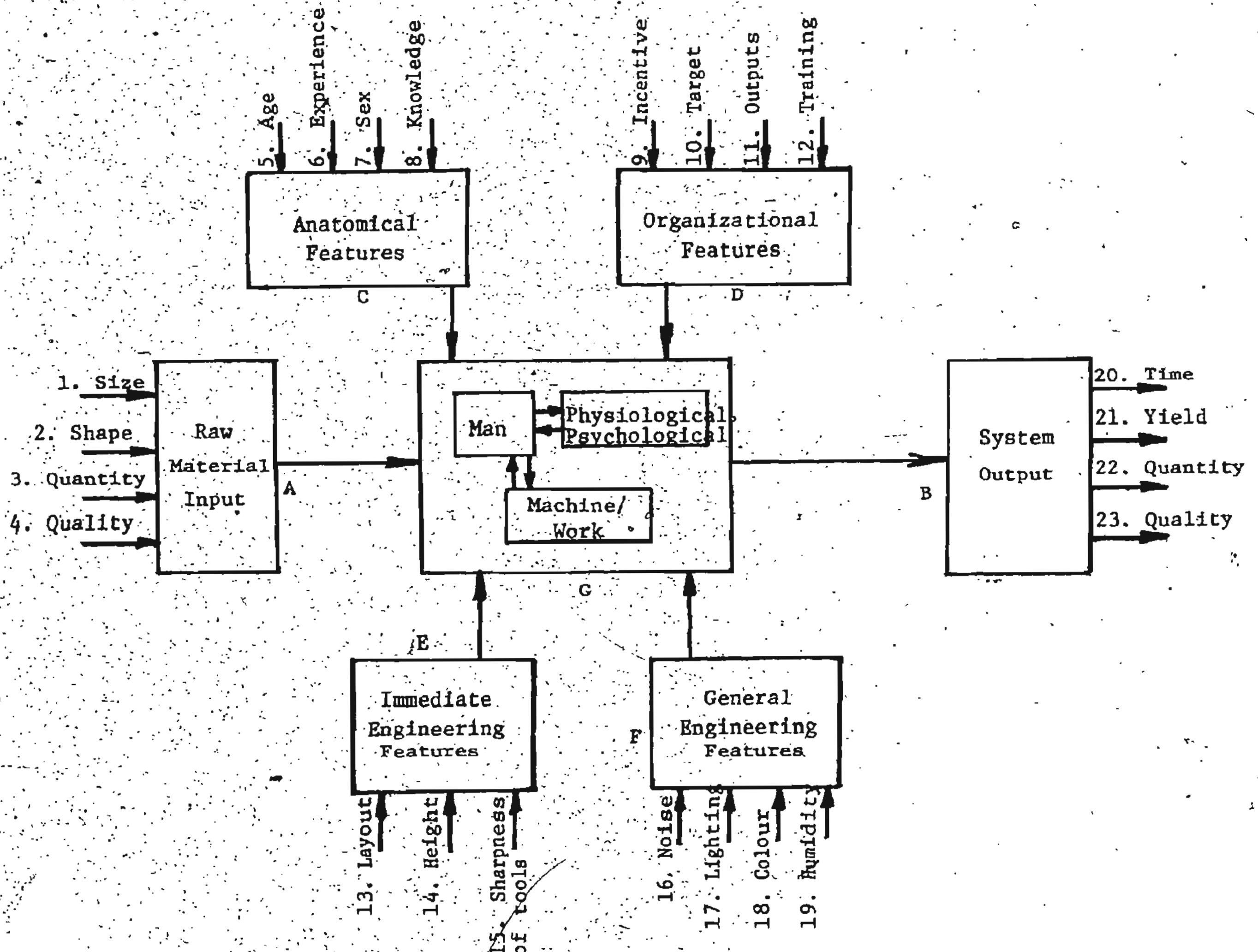


FIGURE 1.16 - DIAGRAM OF THE MAN-MACHINE RELATIONSHIP

in 1968 at the Fishery Products Plants located at Trepassey and Burin (page 10). At present Atlantic Fish Processors, Marystown and National Sea Products, St. John's, also make use of work study techniques.

2.20 OBJECTIVES OF THE STUDY

2.21 Man—Machine Relationships to be Included in This Study

To date, the primary purpose of the application of work study techniques to the fishing industry has been to establish work standards, not to determine effect of input and output variables upon the man-machine relationship. Incentive schemes, based upon individual work stations, produce voluminous quantities of data whose only use, at present, is for the computation of incentive pay.

Referring to Figure 1.16, the purpose of this study was to determine:

1. The effect of overall fish length in inches upon:
   (a) Input of gut in fish per hour;
   (b) Output of skin-on fillets per hour;
   (c) Percentage yield of skin-on fillets.
2. The effect of experience upon:
   (a) Input of gut in fish per hour;
   (b) Output of skin-on fillets per hour;
   (c) Percentage yield of skin-on fillets.
3. The effect of filleting table design upon the time, in seconds, to fillet a codfish.
4. The effect of cutting time, in seconds, upon the percentage yield of skin-on fillets.

2.22 Effect of Size Upon Input, Output Quantities and Percentage Yield

Some fish processing plants have had to either offer to purchase at a reduced price, or refuse to purchase altogether, fish below a certain size limit (14 inches overall length), because of the extra processing costs involved. In contrast, a higher price is paid for large gill net fish. The effect of overall fish length, in inches, upon input quantity, in pounds of gut-in fish per hour, output quantity, in pounds of skin-on fillets per hour, and percentage yield, will be discussed in this report.

2.23 Effect of Experience Upon Input, Output and Percentage Yield

When a repetitive task is performed, the time taken for each repetition, commonly called the cycle time, diminishes at first fairly rapidly, and then less and less until a constant cycle time is reached. In some tasks it may continue for a very long time before a constant speed is reached.

The effect of experience upon input, output, and percentage yield (units the same as in section 2.22) will be discussed in this report.

2.24 Effect of Filleting Table Layout Upon Cutting Rate

Codfish filleting contains many manipulative motions (such as get fish, turn fish, place fillet, place offal) which do not result in productive work, but are essential to the overall operation (see page 21). A reduction in the time required to perform each of the aforementioned motions would not only result in an increase in output per filleter, but would increase wages in plants which pay a bonus for each pound of fillet produced.

This report will study group and individual incentive tables to determine the effect of design (reduction of non-productive motions) upon normalized cutting rate, in pounds of round fish per hour.

2.25 Effect of Cutting Time Upon Yield

As skill is acquired, movements become smoother and less hesitant; this applies not only to manual operations but also to eye movements. The number of times the eyes are focussed on a particular object diminishes with successive repetitions. The experienced worker is very consistent in reproducing almost exactly similar patterns of movement in very similar time.

The first stage in training an operator in industry is to provide preliminary training exercises in difficult elements of the task; difficult because of perceptual problems or of motor skills, or to provide feed back of results. After this preliminary training is completed, the actual task must be learned in detail and practised in parts. It is then built up into a complete performance when each bit has been mastered and carried out to the level of proficiency of an experienced worker.

This report will examine the effect of skill, as determined by the rating of the filleter, upon the percentage yield of skin on fillets.

CHAPTER 3 - MATERIALS AND METHODS

3.10 Time - Motion Study of a Group Filleting Table

3.11 Description of Group Filleting Table Used in the Study

Figure 1.17 shows a diagram of the group filleting table used in this study. The fish are held in a water flume located between the lines of filleters. The fillets are placed in a water flume located in front of and above the filleting surface. Hand motion distances for the get fish and place fillet motions are 26 to 32 and 22 inches respectively.

3.12 Evaluation of Filleters

According to Barnes (1968), by far the most widely used system of rating in the United States is that of rating a single factor - operator speed, pace, or tempo. This system is called "performance rating." The rating factor may be expressed in percentage, in points per hour, or in other units. In this study the percentage system, with normal performance equal to 100 percent, (walking 3 miles per hour equals 100 percent) was used.

In the summer of 1972, the fish plant used in this study was visited and the performance of each filleter evaluated. The skill of the filleters was determined using the definitions expressed by Lowry, Maynard and Stegemerten (1940). The performance rating and skill of each filleter is shown in Table 1.13.

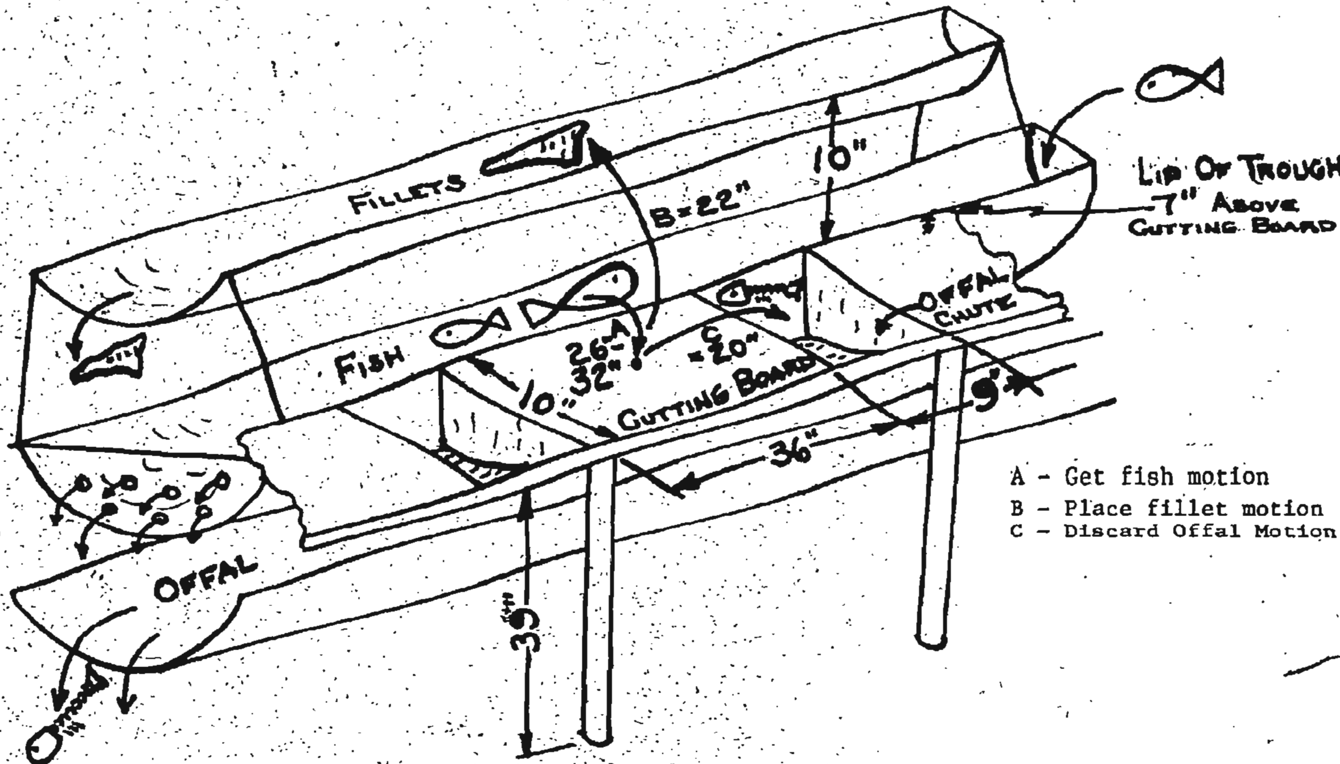


FIGURE 1.17 - DIAGRAM OF THE GROUP FILLETING TABLE USED IN THE STUDY

TABLE 1.13 - EVALUATION OF SPEED, SKILL OF THE FILLETERS AT THE FISH PLANT USED IN THIS STUDY-GROUP TABLE

Filleter	Rating	Skill
1 *	105	Excellent
2	100	Good
3	90	Average
4	115	Good
5	90	Average
6	105	Good
7	100	Good
8	95	Good
9 *	100	Good

* chosen for the study

3.13 Selection of Filleters to be Used in the Study

The criteria used to select filleters for the study of a group filleting table was as follows (Broom, 1962):

1. They should be co-operative and regularly do good work.
2. They should work at a rate close to the normal pace (less chance of errors in judgement).
3. They should exhibit good skill and effort.

Based upon these criteria two filleters, one with 25 years experience, and the other with 8 years experience, were selected (see Table 1.13.)

3.14 Determination of Elemental Motion Times

The precise moment at which a stopwatch was started and stopped when determining times for the basic filleting motions (see page 21) is shown in Table 1.14. These motion times were not all determined sequentially, nor were the same number of observations recorded for each motion (more for motions containing a large number of therbligs). The average performance rating of each filleter and not the speed with which he performed each of the basic motions, was recorded.

3.15 Determination of Fish Characteristics

The individual weights, in pounds, and lengths in inches of a random sample of the fish contained in the pounds in the holding room were determined. The average weight and length of the sample population was recorded.

TABLE 1.14 - MOMENT A STOPWATCH WAS STARTED AND STOPPED IN GROUP FILLETING STUDY

Motion	Start Stopwatch	Stop Stopwatch
get fish	fingers touch fish in trough	knife enters fish to begin to cut first fillet
cut first fillet	knife enters fish to begin to cut first fillet	first fillet is fully released from the backbone
place first fillet	first fillet is fully released from the backbone	hand returns and touches fish to begin turn motion
turn fish	hand returns from placing first fillet and touches the fish	knife enters fish to begin the second cut
cut second fillet	knife enters fish to begin the second cut	second fillet is fully released from the backbone
place second fillet	second fillet is fully released from the backbone	fingers touch fish in the trough to begin get fish motion

NOTE: the discard skeleton motion takes place simultaneously with the place second fillet motion

3.16 Determination of Normal Elemental Motion Times

The normal elemental motion times, in seconds, were determined using the following formula:

$$\text{Normal time in seconds} = \frac{\text{actual time in seconds} \times \text{performance rating}}{100}$$

The standard deviation and the coefficient of variation, for each set of observations, was also determined. The advantages of calculating the coefficient of variation are:

1. It measures the spread of the data in relative terms.
2. It is independent of the units in which the variate is measured.

3.17 Determination of Normal Filleting Rates for a Group Table

The normal filleting rates, in pounds per hour and fish per hour, for each of the mean sizes, in inches, of fish filleted in the study, were determined using the following formulae:

1. $$\text{Fish per hour} = 3600 \text{ seconds per hour} \times \frac{1}{\text{normal time to fillet a fish in seconds}}$$

2. $$\text{Normal Filleting Rate in Pounds per hour} = \text{fish per hour} \times \text{mean weight per fish in pounds}$$

3.20 Determination, for an Individual Work Place Filleting Table, of the Relationship Between Overall Fish Length in Inches and Pounds of Gut-In Fish Filleted per Hour, Number of Fish Filleted per Hour, Output of Skin-On Fillets in Pounds per Hour and Percentage Yield in Pounds per Hour

3.21 Description of the Individual Work Place Filleting Table Used in the Study

Figure 1.18 shows the individual work place filleting table used in this study. A plastic fish box, containing 75 pounds of fish, is located in front of and to the left of the filleter. The fillets are placed in a plastic fillet pan located next to the fillet box. The hand motion distances for the get fish and place fillet motions are 10 to 22 inches and 8 to 20 inches respectively.

3.22 Selection of Filleters

In the late summer of 1974 the same fish plant was revisited, having converted, in 1973, from group tables to individual incentive tables. At this time, one filleting table was in operation, there being 5 or 6 filleters on each side of this table.

Five filleters were randomly selected from the aforementioned group (the results for one filleter were incomplete, because of a lost time accident; thus they have not be included in this report). The years of experience and skill, and effort of these filleters are shown in Table 1.15. Filleter A has been filleting fish for two summers. He possesses average skill and exerts a killing effort. Filleter B learned to fillet on his own. He has been filleting fish for three summers, a part of this time having

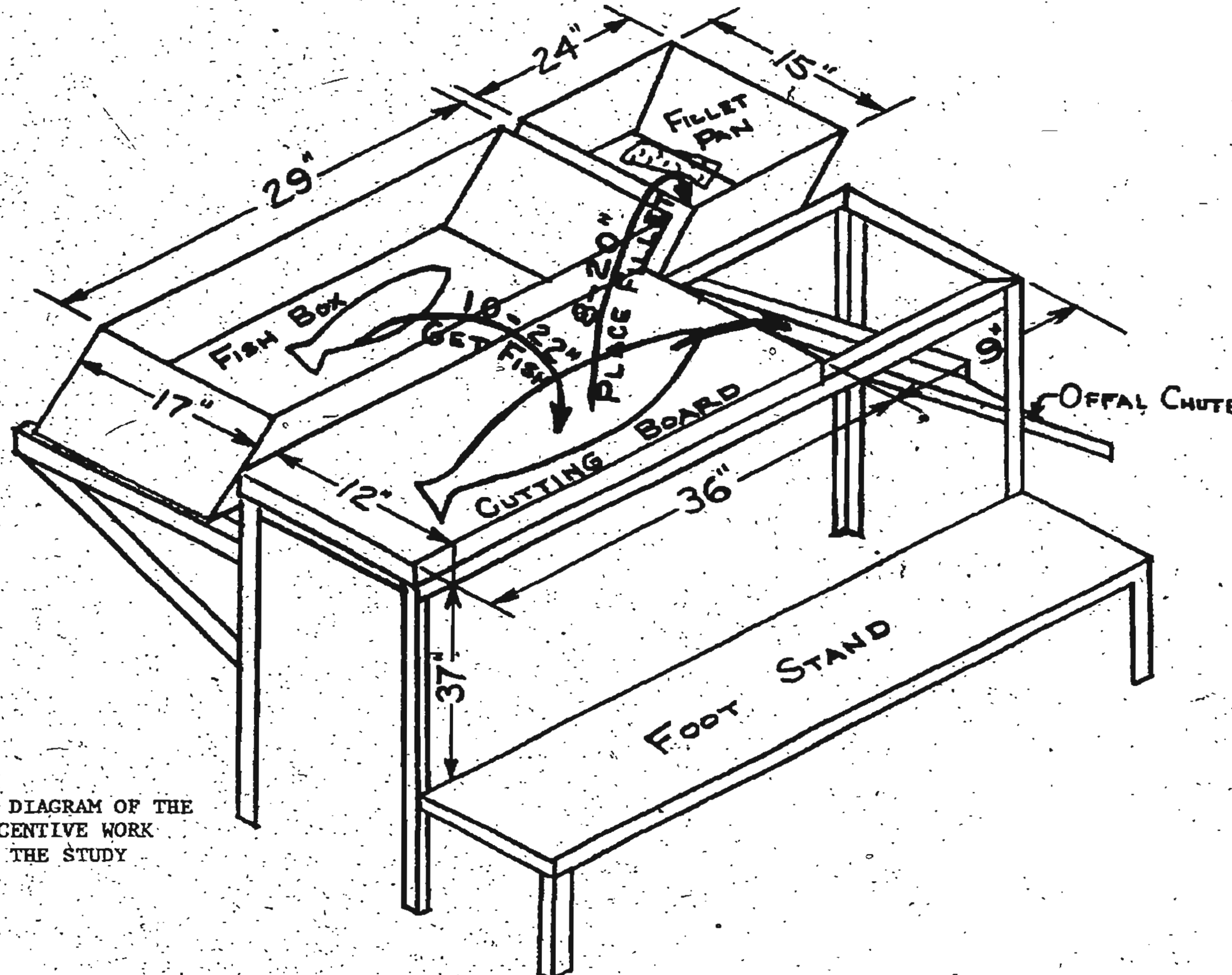


FIGURE 1.18 – DIAGRAM OF THE INDIVIDUAL INCENTIVE WORK PLACE USED IN THE STUDY

TABLE 1.15 - ELBOW HEIGHT, EXPERIENCE, SKILL AND EFFORT OF THE FILLETERS USED IN THE STUDY OF AN INDIVIDUAL INCENTIVE TABLE

Filleter	Elbow Height* (Inches)	Experience	Skill	Effort
A	6	2 Summers	Average	Killing
B	4½	3 Summers	Good	Good
C	8½	3 Summers	Excellent	Excellent
D	5	20 Summers	Very Good	Excellent

* Above the filleting surface

been spent with National Sea Products where his incentive pay was based upon percentage yield of skin-on fillets. Filleter C possesses excellent skill and exerts an excellent effort. One of his three summers' experience was spent working for Martin O'Brien, Tors Cove, where his incentive pay was based upon percentage yield of skin-on fillets. Filleter D, the most experienced filleter - twenty summers experience - possesses excellent skill and exerts an excellent effort.

3.23 <u>Fish Size Categories</u>

The size categories selected were the same as those used to grade salt fish; allowing approximately 17 percent for the head. These size categories are shown in Table 1.16.

3.24 <u>Quality of Fish Utilized</u>

Whenever possible, Grade 1 fish were selected for the study. The characteristics of this type of fish are shown in appendix B. Grade 1 fish have bright eyes, red gills, firm flesh, a bright sheen on the skin, and the gills possess a seaweedy to neutral odour.

3.25 <u>Information Given to Filleters</u>

The purpose of the study was explained to the foreman of the plant, who passed this information on to the filleters. The filleters were told that they should fillet for maximum yield, use only a nape cut (includes the belly flap), and they should remove

TABLE 1.16-Fish Size Categories Used In This Study

Size Category	Salt Fish Length (Headless) In Inches	Overall Fish Length In Inches[1]
Extra Large	25	30
Large	22 - 25	27 - 30
Medium	18 - 22	22 - 27
Small	12 - 18	14 - 22
Extra Small	12	14

1 - Allowing 17 percent of the total length for the head.

Source: Fish Inspection Regulations, Federal Department of the Environment.

any filleting defects (as described in the fish inspection regulations - see appendix C) from the fillets prior to placing them in the fillet pan.

3.26 Conducting the Study

Grade 1 fish, within the various size categories, used in the study, were selected from pounds in the holding room, weighed, and their individual lengths recorded. These fish were presented sequentially to each filleter. The fish were filleted, the fillets being placed in the fillet pan, at the same time the rating of the filleter being continuously recorded. The fillets were weighed and the weight recorded. Four test runs, in each size category, were conducted on each filleter.

It should be noted that the filleting of extra small category had to be excluded from the study, and the weight of small fish reduced from 75 to 50 pounds per box.

3.27 Determination of Normal Pounds of Gut-in Fish Filleted per Hour, Number of Fish Filleted per Hour, Pounds of Skin-on Fillets Produced per Hour and Percentage Yield of Skin-on Fillets

The normal pounds of gut-in fish filleted per hour, number of fish filleted per hour, pounds of skin-on fillets produced per hour and percentage yield of skin-on fillets were determined using the following formulae:

$$\text{Pounds of Gut-in Fish Filleted per Hour} = \frac{1}{\text{Time in Minutes to fillet a box containing 75 lbs. of fish}} \times \frac{\text{60 minutes}}{\text{Hour}} \times \text{75 pounds of fish per box} \times \frac{100}{\text{Performance Rating}}$$

$$\text{Number of Fish Filleted per Hour} = \frac{1}{\text{Time in Minutes to fillet a box containing 75 lbs. of fish}} \times \frac{\text{60 minutes}}{\text{Hour}} \times \text{Number of of fish per box} \times \frac{100}{\text{Performance Rating}}$$

$$\text{Pounds of Skin-on Fillets per Hour} = \frac{1}{\text{Time in minutes to fillet a box containing 75 lbs. of fish}} \times \frac{\text{60 minutes}}{\text{Hour}} \times \text{Weight in Pounds of Fillet per Pan} \times \frac{100}{\text{Performance Rating}}$$

$$\text{Percentage Yield of Skin-on Fillets} = \frac{\text{Pounds of Skin-on Fillets per Hour}}{\text{Pounds of Gut-in Fish Filleted per Hour}} \times 100$$

3.28 Determination of the Time in Seconds for Miscellaneous Activities (Get Box of Fish, Get Fillet Pan, Sharpen Knife, Place Empty Fish Box, Place Pan of Fillets)

The time taken by three filleters, two of whom had been selected for inclusion in the study of an individual work place filleting table, to perform the aforementioned activities, was determined. A stopwatch was started the moment the last fillet was placed in the fillet pan and stopped when the hand reached for the first fish to begin the filleting process.

3.30 DETERMINATION OF PREDETERMINED MOTION TIMES FOR FILLETING CODFISH

3.31 Determination of Elemental Motion Times

The researching, gathering and recording of the data required for an MTM analysis of fish filleting, for inclusion in this report, took a considerable amount of time. A thorough understanding of the background behind the development and method application of the tabulated MTM data (see appendix D) as described by Karger and Bayha (1966), had to be obtained. Repeated trips had to be made to the field to check and recheck data, especially when calculated values were out of line with actual elemental motion times as determined during the study of a group filleting table. (results on page 105)

Knife travel distances, as shown in Figure 1.15, Operations 2 and 5, were determined by having a filleter fillet fish of various sizes, during which time individual movements were measured with a steel tape accurate to 1/16 inch. It should be noted that the number and length of these motions are dependent upon the sharpness of the knife, plus the skill and effort of the filleter. The amount of force required to move the knife through the flesh was determined by applying force to a spring balance attached to the blade of the knife.

CHAPTER 4 - RESULTS AND DISCUSSION

4.10 Effect of Overall Fish Size Upon Input and Output, Quantities and Percentage Yield

4.11 Relationship Between Overall Fish Length in Inches and Pounds of of Gut-In Fish Filleted Per Hour

Figure 1.19 is a graph of filleting rate in pounds of gut-in fish per hour as a function of overall fish length in inches (see Tables 1.17 to 1.24 for data). The curves for all filleters slope upward indicating an increase in cutting rate with increasing overall fish length. The filleting rate of filleter A, using a straight cut on the majority of fish filleted, is 17 percent higher than that of filleters C and D, and 32 to 40 percent higher than that of filleter B (for fish having a length of over 22 inches). The curve for filleter B is similar to those for filleters C and D up to a fish length of 22 inches, deviating from them thereafter - the movements of filleter B, when filleting larger fish, are not as smooth and more hesitant than those of a more experienced filleter.

Table 1.25 shows that the coefficient of determination for all filleters lies very close to 1 (0.96) indicating that all points lie very close to an exact straight line. It also indicates that 96 percent of the total variation can be attributed to the variation of pounds of gut-in fish cut per hour with fish length.

Table 1.26 shows that there is no significant difference between filleters at $P < 0.05$ and $P < 0.01$.

FIGURE 1.19 - CUTTING RATE AS POUNDS OF GUT-IN FISH PER HOUR AS A FUNCTION OF OVERALL LENGTH IN INCHES

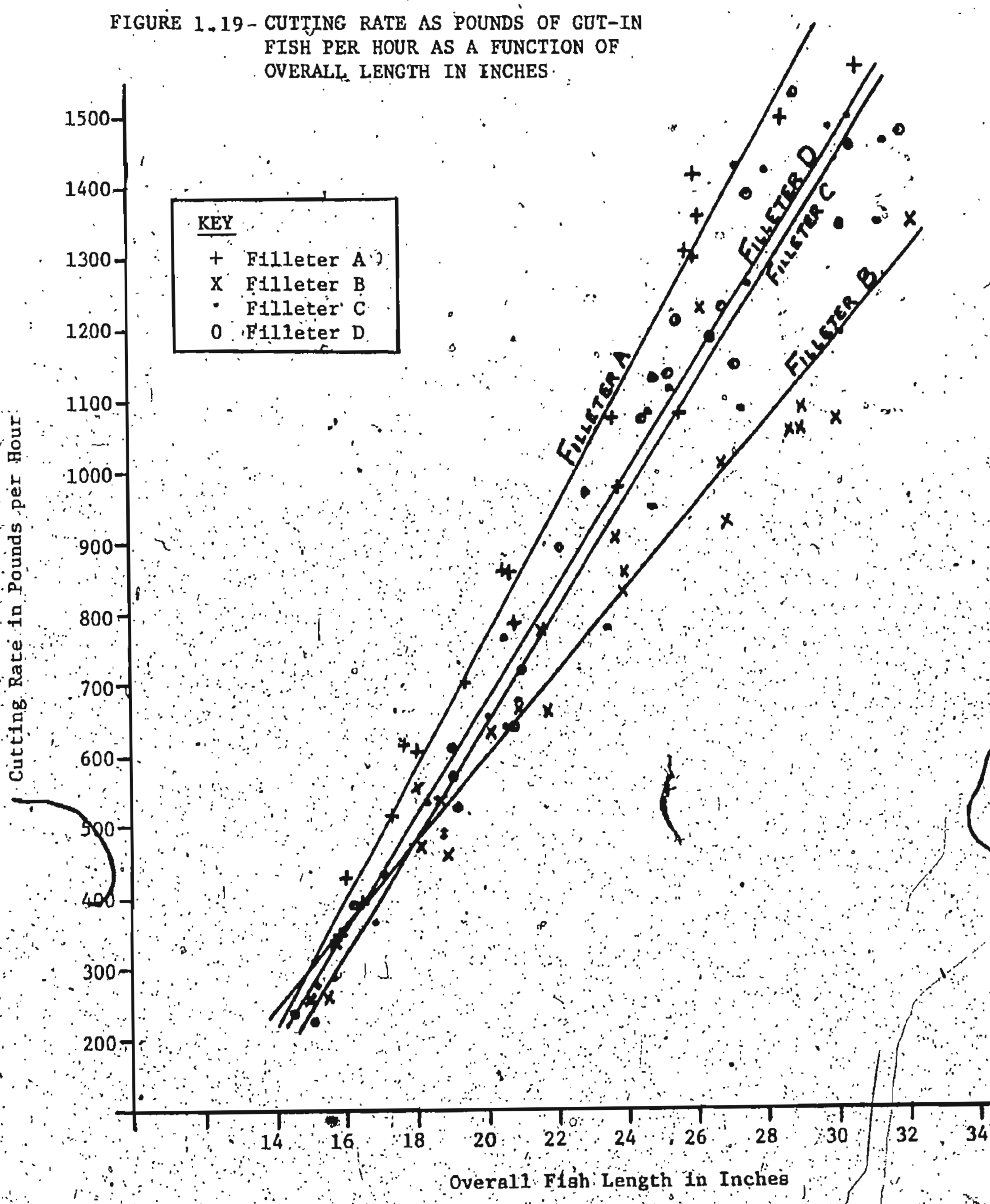


TABLE 1.17- Field Observations for Filleter A

Size Category	Test No.[a]	Mean Length (Inches)	Weight Fish (Pounds)	Number Fish	Rating	Cutting Time (Minutes)	Weight Fillets (Pounds)
x-Small + Small	1	14.5		53	120	8.2	24.1
	2	16.0	79	59	125	8.9	27.3
	3	15.8	50	38	125	7.0	17.4
	4	16.4	50	35	127.5	6.0	17.5
	5						
Mean Values -					124.4		
Small	1	19.3		29	110	5.5	26.7
	2	19.4	79	33	120	5.6	29.7
	3	17.3	76	45	125	7.1	27.4
	4	18.0	76	38	130	5.8	29.2
	5	17.7	75	40	135	5.4	25.9
Mean Values -					124.0		
Small + Medium	1	21.2		21	119	4.2	26.4
	2	20.7	80	26	118	4.8	29.4
	3	20.8	76	25	125	4.7	28.8
	4	20.5	77	26	130	4.1	29.1
	5	20.5	75.5	24	135	3.9	26.8
Mean Values -					124.6		
Medium	1	24.9		13	105	4.8	26.9
	2	23.7	80	18	115	3.9	30.9
	3	23.8	77	17	125	3.8	29.8
	4	26.1	74	13	130	2.5	27.6
	5	25.7	76	13	135	2.6	27.5
Mean Values -					122.0		
Medium + Large	1	26.5		11	110	2.8	24.9
	2	26.0	78	14	118	3.1	29.8
	3	25.6	78	14	125	3.5	27.8
	4	28.1	76	10	127.5	2.1	28.8
	5	26.1	74	12	135	2.3	26.9
Mean Values -					123.1		
Large	1	28.8			110	2.5	23.8
	2						
	3	28.5	78	10	123	2.6	29.9
	4	30.6	73	8	125	2.2	26.1
	5	28.8	76	10	135	2.0	26.7
Mean Values -					123.3		

TABLE 1.18-Field Observations for Filleter B

Size Category	Test No.	Mean Length	Weight Fish	Number Fish	Rating	Cutting Time	Weight Fillets
		(Inches)	(Pounds)			(Minutes)	(Pounds)
x-Small	1	14.7	-	65	115	12.0	27.3
	2	15.7	47	35	115	7.3	18.6
	3	15.0	50	46	118	10.0	18.3
	4	15.6	50	41	105	11.1	17.6
Mean Values -					113.3		
Small	1	18.3	-	29	115	6.5	27.4
	2	18.7	79	36	103	8.6	32.4
	3	18.9	75	34	120	8.2	28.5
	4	18.2	75	38	120	8.0	30.3
	5	18.1	77	39	118	7.0	29.6
Mean Values -					115.2		
Small + Medium	1	20.8	-	22	115	4.9	26.6
	2	21.0	75	23	108	6.3	31.3
	3	21.8	76	22	115	6.0	29.2
	4	20.7	74	26	120	5.9	28.1
	5	21.6	75	22	113	5.1	28.8
Mean Values -					114.2		
Medium	1	24.0	-	15	110	4.1	28.0
	2	23.7	81	18	100	5.4	32.2
	3	23.9	77	17	116	4.9	30.7
	4	24.0	77	17	117	4.6	31.1
	5	25.8	75	13	118	3.7	28.8
Mean Values -					112.6		
Medium + Large	1	24.8	-	14	113	3.9	25.1
	2	26.9	78	12	103	4.9	30.1
	3	26.8	75	12	108	4.1	29.4
	4	29.0	74	9	110	3.8	29.1
	5	26.2	79	13	115	3.7	30.8
Mean Values -					109.8		
Large	1	27.7	-	11	110	4.1	26.8
	2	29.7	76	9	110	3.2	28.4
	3	28.7	77	10	105	4.1	30.0
	4	30.0	74	9	112	3.7	27.6
	5	32.1	81	8	105	3.4	29.6
Mean Values -					108.4		

TABLE 1.19 Field Observations for Filleter G

Size Category	Test No.	Mean Length (Inches)	Weight Fish (Pounds)	Number Fish	Rating	Cutting Time (Minutes)	Weight Fillets (Pounds)
x-Small + Small	1	14.5	–	64	113	12.9	28.1
	2	16.44	50	34	120	6.9	20.6
	3	15.2	50	43	120	9.0	19.3
	4	15.7	50	38	118	8.7	19.6
Mean Values –					117.8		
Small	1	20.4	–	25	118	5.4	3.0
	2	18.3	75	34	120	7.0	31.7
	3	18.8	79	36	125	7.7	33.4
	4	18.8	75	33	130	7.2	30.1
	5	18.6	75	34	127	6.7	30.4
Mean Values –					124.0		
Small + Medium	1	21.1	–	23	118	5.4	28.5
	2	20.6	75	24	120	4.9	31.9
	3	20.6	74	26	125	5.6	30.9
	4	21.0	76	24	125	5.4	30.3
	5	20.1	76	27	125	5.6	30.1
Mean Values –					122.6		
Medium	1	24.7	–	15	118	3.7	30.0
	2	24.7	77	15	115	3.7	31.6
	3	23.5	73	18	125	4.4	30.8
	4	24.8	75	15	135	3.8	31.0
	5	27.3	77	14	125	3.4	29.9
Mean Values –					121.6		
Medium + Large	1	26.6	–	12	120	3.2	28.9
	2	27.2	75	11	120	2.6	30.1
	3	25.3	75	14	122	3.3	30.5
	4	27.5	78	12	125	3.0	31.0
	5	28.0	78	10	122	2.7	30.9
Mean Values –					121.8		
Large	1	29.0	–	10	115	2.9	30.9
	2	30.3	79	9	115	2.8	31.0
	3	31.1	75	8	120	2.8	30.8
	4	31.2	75	8	120	2.6	29.4
	5	29.8	76	9	120	2.5	29.3
Mean Values –					118.0		

TABLE 1.20 - Field Observations for Filleter D

Size Category	Test No.	Mean Length (Inches)	Weight Fish (Pounds)	Number Fish	Rating	Cutting Time (Minutes)	Weight Fillets (Pounds)
x-Small	1	14.5	-	64	125	13.2	26.6
+ Small	2	16.2	79	51	135	9.1	28.6
	3	14.5	50	49	130	9.8	18.8
	4	15.1	50	43	135	10.0	19.3
Mean Values -					131.3		
Small	1	19.8		24	120	6.1	26.1
	2	18.9	79	32	135	5.8	28.5
	3	17.0	75	46	132	7.9	30.6
	4	19.1	75	31	135	6.4	29.4
	5	19.0	75	32	132	6.1	29.7
Mean Values -					130.8		
Small	1	21.0	-	22	125	5.1	27.1
+ Medium	2	22.1	79	19	125	4.3	28.1
	3	21.0	75	24	130	4.8	30.4
	4	20.8	75	24	133	5.3	29.8
	5	22.9	77	18	122	3.9	30.3
Mean Values -					126.9		
Medium	1	24.9	-	13	113	4.4	26.5
	2	24.9	79	14	130	3.2	27.6
	3	24.6	77	16	125	3.5	30.4
	4	25.5	76	13	130	2.9	30.1
	5	26.5	76	12	125	3.1	29.8
Mean Values -					124.6		
Medium	1	26.0	-	12	125	3.3	26.0
+ Large	2	25.2	80	13	125	3.4	28.4
	3	27.1	78	11	120	3.4	29.6
	4	26.9	84	13	125	3.3	32.8
	5	27.5	79	11	122	2.8	30.1
Mean Values -					123.4		
Large	1	28.7	-	9	105	4.0	27.5
	2	28.8	84	10	125	2.6	28.1
	3	30.4	79	9	120	2.7	30.6
	4	30.1	77	9	118	2.9	29.4
	5	31.8	78	8	117	2.7	30.5
Mean Values -					117.0		

TABLE 1.21 Normalized Results of Filleting Study for Filleter A

Size Category	Test No.	Mean Length Inches	Fish per 100 pounds	Fish per Hour	Pounds Round Fish per Hour	Pounds Fillet per Hour	Percentage Yield
x-Small + Small	1	14.5	-	322	-	147	
	2	16.0	75	318	425	147	34.6
	3	16.4	70	273	390	136	35.0
	4	15.8	76	261	343	120	34.9
Mean Values -		15.7	74	294	386	138	34.8
Small	1	19.3	-	288	-	264	-
	2	19.4	42	293	701	265	37.6
	3	17.3	59	306	516	186	36.0
	4	18.0	50	302	603	232	38.5
	5	17.7	53	329	616	210	34.5
Mean Values -		18.3	51	304	609	231	36.7
Small + Medium	1	21.2	-	259	-	325	-
	2	20.7	33	278	856	314	36.7
	3	20.8	33	254	773	293	37.8
	4	20.5	34	290	860	325	37.8
	5	20.5	32	276	869	307	35.5
Mean Values -		20.7	33	271	840	313	37.0
Medium	1	24.9	-	156	-	323	-
	2	23.7	23	242	1075	415	38.6
	3	23.8	22	216	977	378	38.7
	4	26.1	18	238	1357	507	37.3
	5	25.7	17	224	1310	474	36.2
Mean Values -		24.8	20	215	1180	419	37.7
Medium + Large	1	26.5	-	216	-	487	-
	2	26.0	18	233	1300	496	38.1
	3	25.6	18	194	1080	384	35.6
	4	28.1	13	224	1703	644	37.8
	5	26.1	16	229	1414	513	36.3
Mean Values -		26.5	16	219	1374	505	37.0
Large	1	28.8	-	176	-	523	-
	2	28.5	13	192	1495	569	38.4
	3	30.6	11	172	1569	561	35.8
	4	28.8	13	222	1688	593	35.1
Mean Values -		29.2	12	191	1584	562	36.4

TABLE 1.22 Normalized Result of Filleting Study
for Filleter B

Size Category	Test No.	Mean Length Inches	Fish per 100 Pounds	Fish per Hour	Pounds Round Fish per Hour	Pounds Fillet per Hour	Percentage Yield
x-Small	1	14.7	-	283	-	118	-
+ Small	2	15.7	74	249	334	133	39.6
	3	15.0	92	234	254	93	36.5
	4	15.5	82	210	257	90	35.1
Mean Values -		15.2	83	244	282	109	37.1
Small	1	19.3	-	233	-	220	-
	2	18.7	46	245	537	220	41.0
	3	18.9	45	208	458	174	38.0
	4	18.2	51	238	469	189	40.4
	5	18.1	51	281	553	213	38.5
Mean Values -		18.6	48	241	504	203	39.5
Small	1	20.8	-	233	-	283	-
+ Medium	2	21.0	31	204	665	277	41.7
	3	21.8	29	191	661	254	38.5
	4	20.2	35	221	629	239	38.0
	5	21.6	29	227	777	297	38.3
Mean Values -		21.1	31	215	683	270	39.1
Medium	1	24.0	-	196	-	366	-
	2	23.7	22	201	906	359	39.7
	3	23.9	22	183	828	330	39.9
	4	24.0	22	190	858	347	40.4
	5	25.8	17	181	1046	402	38.0
Mean Values -		24.3	21	190	910	361	38.4
Medium	1	24.8	-	192	-	345	-
+ Large	2	26.9	15	143	927	358	38.6
	3	26.8	16	161	1008	396	39.3
	4	29.0	12	129	1058	402	38.0
	5	26.2	16	185	1128	439	38.9
Mean Values -		26.7	15	162	1030	388	38.7
Large	1	27.7	-	148	-	360	-
	2	29.0	12	135	1093	423	38.7
	3	28.7	13	138	1058	415	39.2
	4	30.0	12	130	1071	400	37.3
	5	32.1	10	133	1350	491	36.6
Mean Values		29.5	12	137	1143	418	38.0

TABLE 1.23-Normalized Results of Filleting Study for Filleter C

Size Category	Test No.	Mean Length Inches	Fish per 100 Pounds	Fish per Hour	Pounds Round Fish per Hour	Pounds Fillet per Hour	Percentage Yield
x-Small	1	14.5	-	263	-	116	-
+ Small	2	16.4	68	248	365	151	41.3
	3	15.2	86	238	277	107	38.5
	4	15.7	76	222	292	115	39.3
Mean Values	-	15.5	77	243	311	122	39.7
Small	1	20.4	-	234	-	281	-
	2	18.3	45	247	533	225	42.3
	3	18.8	46	223	490	208	42.3
	4	18.8	44	213	484	194	40.2
	5	18.6	45	243	537	216	40.5
Mean Values	-	19.0	45	231	511	225	41.3
Small	1	21.1	-	215	-	267	-
+ Medium	2	20.6	32	245	765	325	42.5
	3	20.6	35	225	640	267	41.7
	4	21.0	32	213	673	268	19.8
	5	20.1	36	233	654	255	39.9
Mean Values	-	20.7	34	226	683	276	41.0
Medium	1	24.7	-	205	-	410	-
	2	24.7	19	211	1081	444	41.1
	3	23.5	25	197	799	337	42.2
	4	24.8	20	189	947	392	41.3
	5	27.3	18	198	1087	413	38.9
Mean Values		25.0	21	200	979	399	40.9
Medium	1	26.6	-	187	-	449	-
+Large	2	27.2	15	209	1424	571	40.1
	3	25.3	19	210	1116	457	40.9
	4	27.5	15	194	1262	502	39.7
	5	28.0	13	182	1422	554	39.6
Mean Values	-	26.9	16	196	1306	507	40.1
Large	1	29.0	-	183	-	565	-
	2	30.3	11	171	1499	588	39.2
	3	31.1	11	144	1347	554	41.1
	4	31.3	11	156	1461	572	39.2
	5	29.8	12	178	1485	579	38.5
Mean Values	-	30.3	11	166	1448	572	39.5

TABLE 1.24 Normalized Results of Filleting Study for Filleter D

Size Category	Test No.	Mean Length Inches	Fish per 100 Pounds	Fish per Hour	Pounds Round Fish per Hour	Pounds Fillet per Hour	Percentage Yield
x-Small	1	14.5	-	232	-	96	-
+ Small	2	16.2	65	250	388	141	36.2
	3	14.5	98	230	235	88	37.5
	4	15.1	86	192	223	86	38.5
Mean Values	-	15.1	83	226	282	103	37.4
Small	1	19.8	-	195	-	213	-
	2	18.9	41	246	607	219	36.1
	3	17.0	61	265	432	176	40.8
	4	19.1	41	216	522	205	39.2
	5	19.0	43	242	568	221	39.6
Mean Values	-	18.8	47	233	532	207	38.9
Small	1	21.0	-	207	-	255	-
+ Medium	2	22.1	24	215	892	317	35.5
	3	21.0	32	230	719	291	40.5
	4	20.8	32	204	637	253	39.7
	5	22.9	24	227	966	380	39.5
Mean Values		21.6	28	217	804	299	38.8
Medium	1	24.9	-	157	-	321	-
	2	24.8	18	200	1128	394	35.0
	3	24.6	21	223	1071	423	39.4
	4	25.5	17	207	1210	479	39.6
	5	26.5	16	188	1185	474	39.5
Mean Values	-	25.3	18	195	1149	418	38.4
Medium	1	26.0	-	174	-	376	-
+ Large	2	25.2	16	184	1135	403	35.5
	3	27.1	14	162	1147	436	38.0
	4	28.8	15	190	1228	480	39.1
	5	27.5	14	193	1387	528	38.1
Mean Values	-	26.5	15	181	1224	445	37.7
Large	1	28.7	-	130	-	398	-
	2	28.8	12	182	1531	513	33.5
	3	30.4	11	166	1454	564	38.8
	4	30.1	12	157	1342	512	38.1
	5	31.8	10	151	1476	577	39.1
Mean Values	-	30.0	11	157	1451	513	37.4

TABLE 1.25 - REGRESSION EQUATIONS FOR EACH FILLETER FOR SKIN-ON FILLETS IN POUNDS PRODUCED PER HOUR, FISH CUT PER HOUR, PERCENTAGE YIELD OF SKIN-ON FILLETS AND POUNDS OF GUT-IN FISH CUT PER HOUR AS A FUNCTION OF OVERALL FISH LENGTH IN INCHES

Filleter	Variable X	Variable Y	Regression Equation	Slope of the line	Explained variation of Y / Total Variation of Y r^2 [2]	Correlation Coefficient r [1]
A	Overall fish length in inches	Pounds of gut-in fish cut per hour	$y = -1053.33 + 90.90x$	+ 1.85	0.96	0.98
B			$y = -587.97 + 59.25x$	+ 1.20	0.95	0.97
C			$y = -953.36 + 79.59x$	+ 1.62	0.96	0.98
D			$y = -922.56 + 79.71x$	+ 1.65	0.96	0.98
A	Overall fish length in inches	Fish cut per hour	$y = 448.64 - 8.84x$	- 0.18	0.75	0.87
B			$y = 385.04 - 8.25x$	- 0.16	0.83	0.91
C			$y = 328.03 - 5.13x$	- 0.10	0.82	0.91
D			$y = 318.90 - 5.12x$	- 0.10	0.60	0.77
A	Overall fish length in inches	Skin-on fillets produced per hour	$y = -355.07 + 31.81x$	+ 0.64	0.93	0.96
B			$y = -202.54 + 21.91x$	+ 0.44	0.93	0.96
C			$y = -358.39 + 30.95x$	+ 0.62	–	
D			$y = -328.63 + 28.85x$	+ 0.58	0.94	0.97
A	Overall fish length in inches	Percentage yield of skin-on fillets	$y = 36.91 + 0.0025x$	0.00	0.00	0.00
B			$y = 42.34 - 0.14x$	- 0.14	0.23	0.48
C			$y = 44.44 - 0.16x$	- 0.15	0.35	0.59
D			$y = 40.93 - 0.11x$	- 0.11	0.05	0.22

1 - If $r > 0.35$ then results are significant at $P < 0.05$

2 - Coefficient of Determination

TABLE 1.26 - Studentized Range Tests for Significance at $P < 0.05$ and $P < 0.01$ For the Results Shown in Figures 1.19, 1.21, 1.22 and 1.23

Filleter	Variable X	Variable Y	Y^2	$\bar{Y}$	n	S_1^2	q_2	C	V	Tabulated Values $q_{0.01}$	Tabulated Values $q_{0.05}$
A	Overall Fish	Pounds of	25745960	996.04	22	185992					
B	length in	Gut-in fish	16031935	779.35	23	193729	2.63	4	87	4.50	3.69
C	inches	cut per hour	22391958	897.39	23	175903					
D			23818183	934.04	23	170558					
A	Overall fish	Fish cut	1802771	249.39	28	2270					
B	length in	per hour	1175914	196.62	29	1957	6.71	4	111	4.50	3.69
C	inches		1293877	209.34	29	822					
D			1196519	200.52	29	1089					
			q = 1.91 when comparing B,C and D								
A	Overall fish	Skin on	4311868	362.07	28	23749					
B	length in	fillets in	2917107	297.69	29	12398	2.39	4	111	4.50	3.69
C	inches	pounds per	4435884	358.00	29	25683					
D		hour	3947143	338.59	29	22232					
			q = 0.82 when comparing A,C and D								
A	Overall fish	Percentage	25990	36.96	19	1.94					
B	length in	Yield of	30403	38.97	20	1.58	10.70	4	75	4.50	3.69
C	inches	skin-on	32915	40.55	20	1.53					
D		fillets	29306	38.23	20	3.95					

1. $S^2 = \dfrac{Y^2 - nY^2}{n-1}$

2. $q = \dfrac{\bar{Y}max - \bar{Y}min}{\sqrt{\dfrac{S^2mean}{n}}}$

3. Results are significant when q calculated is less than q tabulated.

Using the regressions equations for filleters C and D the normal input rates for fish with overall lengths of 19.1 and 24.8 inches were 583 and 1038 pounds per hour; the input rates as fish per hour being 226 and 197 respectively. The values for a group filleting table, (see Tables 1.37 and 1.38, pages 120 - 121) were (1) as pounds per hour - 544 (19.1 inch fish) and (2) as fish per hour - 260 and 167. A comparison of the above results show that for a group filleting table:

(1) The input rate, as pounds per hour, is 7 percent lower (for a 19.1 inch fish) than the value for an individual work place (percentage gut-in fish will adversely affect this figure);

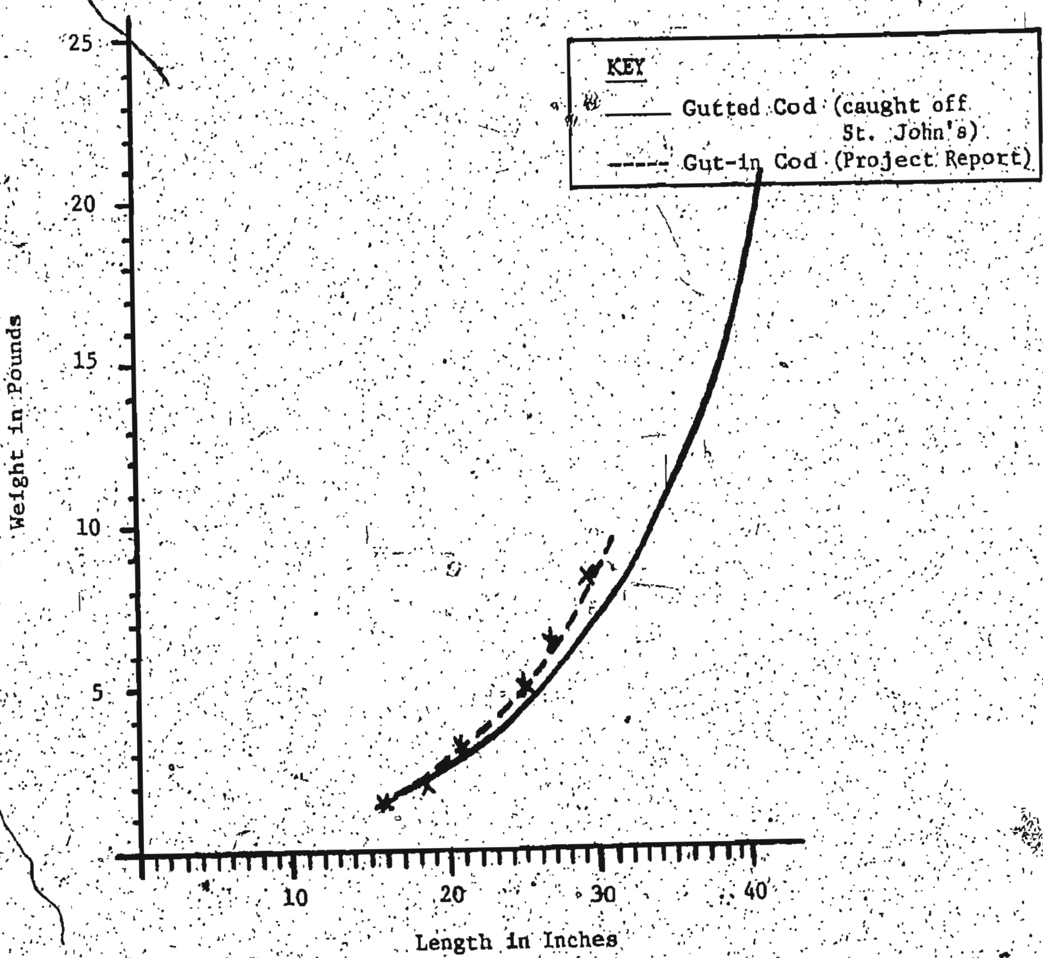
(2) The input rate as fish per hour, is 15 percent (19.1 inch fish) higher and 15 percent lower (24.8 inch fish) than the value for an individual work place.

It must also be remembered that there is a 30 - 36 second delay for miscellaneous activities (page 90)between the filleting of each box of fish at an individual work table.

Figure 1.20 shows a length - weight relation graph for gut-in and gutted cod. Knowing the mean length and number of fish filleted per hour one can predict the filleting rate as pounds of gut-in or gutted cod per hour.

Table 1.27 shows the variation in percentage gut-in cod over the months June, July, August 1975. Such variation would account for a lot of the point scatter in graphs of output versus fish length and percentage yield versus fish length.

Figure 1.20 - Length - Weight Relation for Gut-in and Gutted Cod



Source:- Data collected by the Author

TABLE 1.27 - VARIATION IN PERCENTAGE GUT-IN COD FOR THE MONTHS JUNE, JULY, AUGUST 1975 - AT THE PLANT USED FOR THIS STUDY

DATE	PERCENTAGE GUT
June 17	13
23	12
27	17
30	16
July 1	21
4	20
7	19
15	18
19	18
22	17
23	20
26	16
29	14
August 1	16
7	16
8	12
9	15
13	16
14	12
16	13
27	11

4.12 Relationship Between Overall Fish Length in Inches and Number Of Fish Filleted Per Hour

Figure 1.21 is a graph of number of gut-in fish filleted per hour as a function of overall fish length in inches (see Tables 1.17 to 1.24 for data). The curves for all filleters slope downward indicating a decrease in the number of fish filleted per hour with increasing fish length. The curve for filleter A, using a straight cut on the majority of fish filleted shows a 20 to 30 percent higher cutting rate for fish below 23 inches overall length than the curves for filleters C and D and 23 to 31 percent higher than that for filleter B for fish of 16 to 31 inches overall length.

Table 1.25 shows that:

1. The curves for filleters C and D are parallel.
2. The curves for filleters A and B are parallel and have a higher slope (-0.17) than the curves for filleters C and D (-0.10) indicating a higher degree of difficulty when filleting larger fish.
3. The coefficients of determination for filleters A,B and C are high (+0.75 to +0.83) indicating that all points lie close to an exact straight line; the value for filleter D, the most experienced operator, being only 0.60 indicating that only 60 percent of his total variation can be explained by the variation of fish per hour with overall length. This amount of unexplained variation is unusual, since factors such as the skill of the operator, quality of the fish, percentage gut-in fish, etc. which affect the number of fish cut per hour would also affect the pounds of gut-in fish cut per hour. This, however, is not the case - see section 4.11.

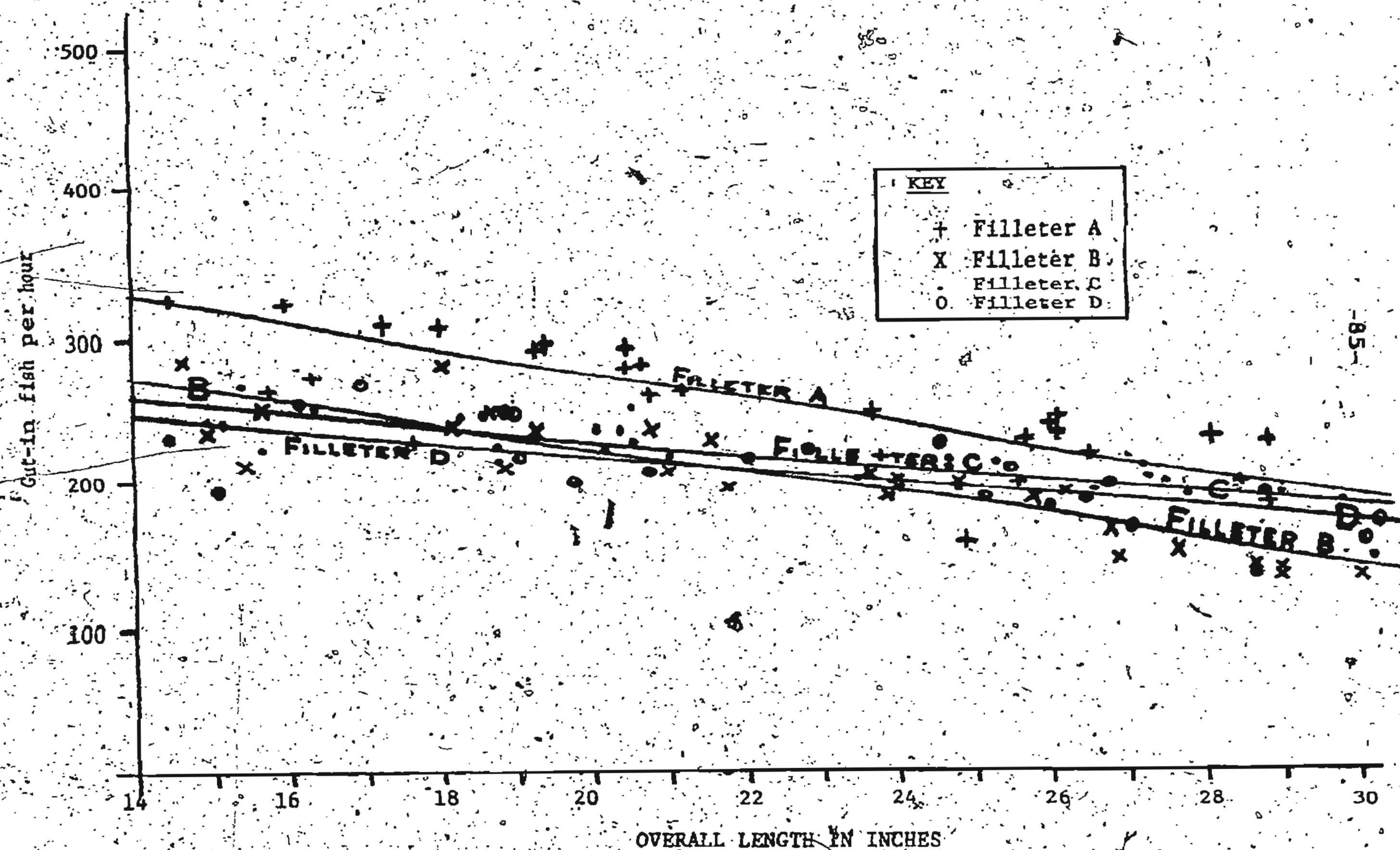


FIGURE 1.21 - NUMBER OF GUT-IN FISH FILLETED PER HOUR AS A FUNCTION OF OVERALL LENGTH IN INCHES

Table 1.26 shows that there is no significant difference between the regression curves for filleters B, C and D at $P < 0.05$ and $P < 0.01$ but are significantly different than that of filleter A.

4.13 Relationship Between Overall Fish Length in Inches and Pounds of Skin-on Fillets Produced per Hour

Figure 1.22 is a graph of pounds of skin-on fillets produced per hour as a function of overall fish length in inches (see Tables 1.17 to 1.24 for data). The curves for all filleters have a positive slope indicating an increase in fillet produced with increasing overall fish length. The output of fillets from filleter A, using a straight cut on the majority of fish filleted, is 5 to 7 percent higher than that for filleter C and 12 percent higher than that for filleter D. Although filleter D cut more pounds of fish per hour than filleter C (see figure 1.24), his percentage yield of skin on fillets was 2 percent lower than that of filleter C. The output from filleter B is similar to that for filleters C and D up to a fish length of 22 inches; deviating from them thereafter (less pounds of fish cut per hour despite an approximately 1 percent higher yield of skin-on fillets than filleter D). The movements of filleter B, when filleting larger fish, are not as smooth and more hesitant than those of a more experienced filleter.

The output from filleter B is the lowest, for the same reasons as outlined in section 4.11

Table 1.25 shows:

1. That the curves for filleters A, C and D are approximately parallel - same slope (+0.58 to +0.64).

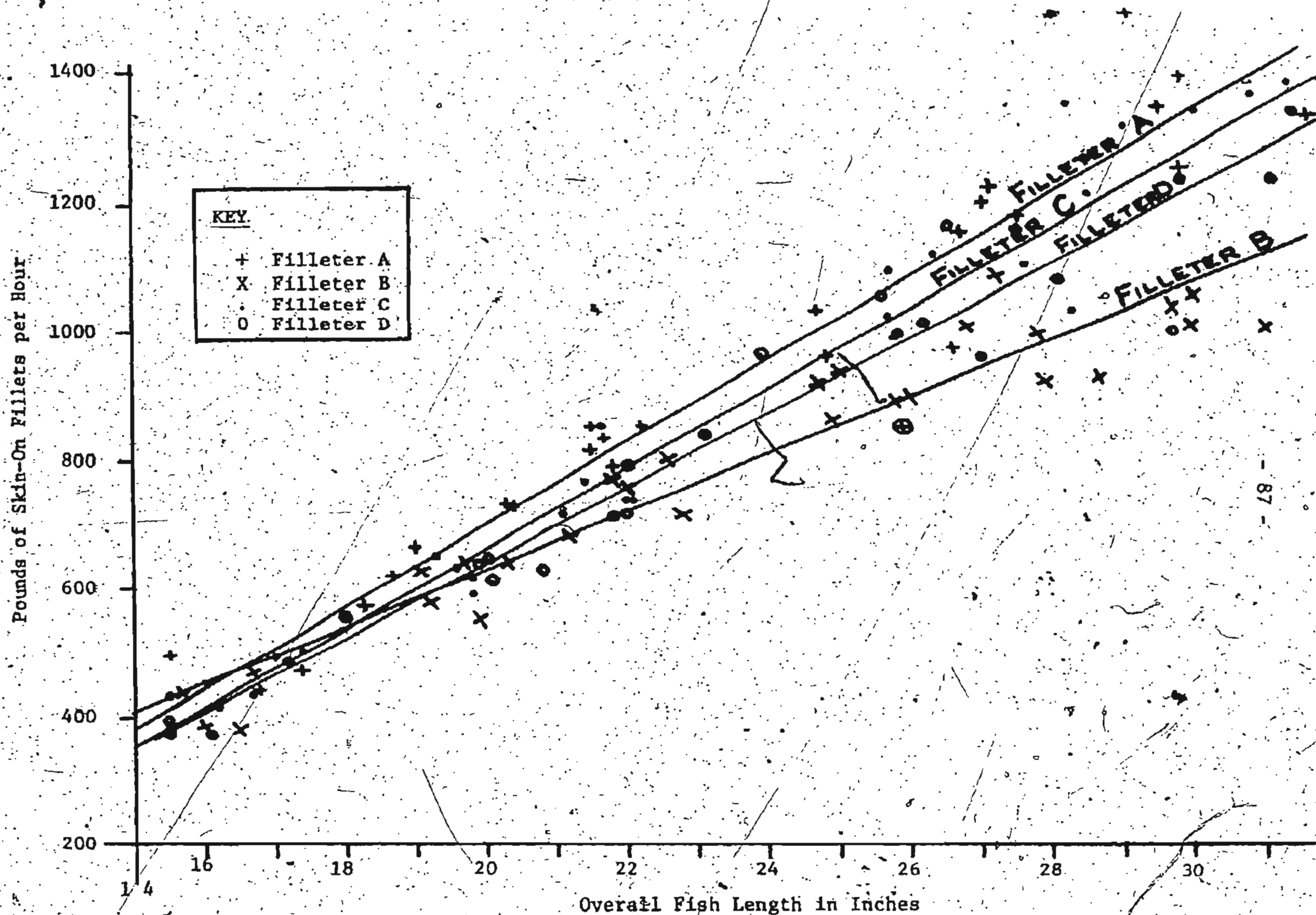


FIGURE 1.22 - POUNDS OF SKIN-ON FILLETS PRODUCED PER HOUR AS A FUNCTION OF OVERALL FISH LENGTH IN INCHES

2. That the coefficient of determination for all filleters lies very close to an exact straight line. It also indicates that 93 percent of the total variation can be attributed to the variation of pounds of skin-on fillets produced per hour with fish length.

Table 1.26 shows that there is a significant difference between filleters at $P < 0.05$ and $P < 0.01$. However, there is no significant difference between filleters A, C and D (filleter A has the highest cutting rate as pounds of gut-in fish per hour, but the lowest percentage yield).

4.14 Relationship Between Overall Fish Length in Inches and Percentage Yield of Skin-On Fillets

Figure 1.23 shows a graph of percentage yield of skin-on fillets as a function of overall fish length in inches (see Tables 1.17 to 1.24 for data). The curves for filleters B, C and D slope downward indicating a decrease in percentage yield as overall fish length increases from 17 to 31 inches. Below 17 inches there is a rapid decrease in percentage yield. The curves for filleters B and C show a higher percentage yield than that for the most experienced filleter, D (2.5 and approximately 1 percent) (see Tables 1.21 to 1.24). This is unusual since skill increases with experience. However, filleter D, although he was asked to cut for maximum yield, has continually worked in fish plants where yield was not taken into consideration when computing wages, whereas filleters C and D have worked for a short time in plants where incentive pay was based upon speed, yield, and quality of fillets produced. The curve for filleter A (using a straight cut) shows no change in percentage yield with fish length.

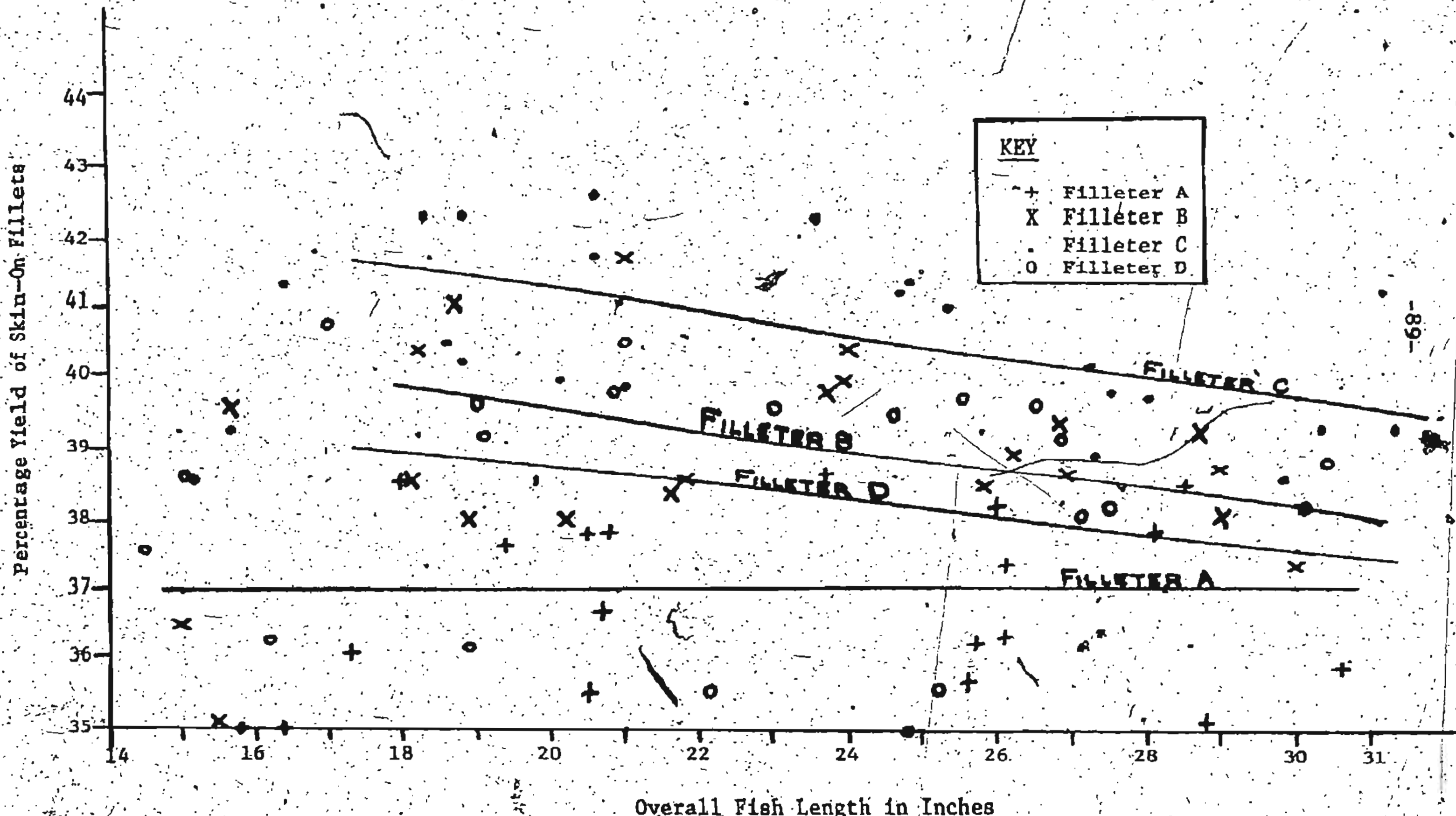


FIGURE 1.23 - PERCENTAGE YIELD OF SKIN-ON FILLETS AS A FUNCTION OF OVERALL FISH LENGTH IN INCHES

TABLE 1.28 - TIME TO PLACE PAN OF FILLETS, PLACE EMPTY FISH BOX, GET BOX OF FISH, GET EMPTY FILLET PAN AND STEEL KNIFE

	Filleter "D"	Filleter "F"	Filleter "E"
	33.5 seconds	26.0 (9.0) seconds	56.0 seconds
	23.0	31.0	89.0
	28.0	33.0 (15.0)	121.0
	23.0 (9.0)	25.0 (9.0)	204.0
	35.0 (12.0)	24.0 (9.0)	79.0
	28.0 (11.0)	29.0 (12.0)	64.0
	54.0	24.0 (9.0)	69.0
	42.0 (12.0)	31.0 (13.0)	60.0
	38.0 (16.0)	29.0 (9.0)	79.0
	44.0 (20.0)	36.0 (21.0)	
	58.0 (35.0)	31.0 (13.0)	
		27.0 (9.0)	
		34.0 (10.0)	
		31.0 (13.0)	
		35.0 (19.0)	
		33.0 (15.0)	
		35.0 (17.0)	
		28.0 (13.0)	
Mean Values	36.9 (16.4) seconds	30.1 (12.7) seconds	91.2 seconds

( ) Time to sharpen knife in seconds

Note:- This data was collected after the original study had been completed - filleters A, B and C not being working at the time.

TABLE 1.29 – Expected Normal Production Rates When Filleting Gut-in Codfish

Overall Length In Inches	Pounds of Gut-in Fish Per Hour[1]	Boxes of Fish Per Hour		Time per Box in Minutes		Boxes per Hour[2]		Fish per Box[3]		Fillet Per Hour[4]	
		75 lb. per box	100 lb. per box	75 lb. per box	100 lb. per box	76 lb. per box	100 lb. per box	75 lb. per box	100 lb. per box	75 lb. Fish per box	100 lb. Fish per box
16	336	4.48	3.36	13.4	17.9	4.0	3.0	54	72	105	105
18	496	6.61	4.96	9.1	12.1	5.6	4.4	35	47	147	154
20	655	8.73	6.55	6.9	9.2	7.2	5.6	25	34	189	196
22	815	10.86	8.15	5.5	7.4	8.8	6.8	19	26	231	238
24	974	12.98	9.74	4.6	6.2	10.2	7.9	15	21	268	277
26	1133	15.10	11.33	4.0	5.3	11.4	9.0	13	17	299	315
28	1293	17.2	12.9	3.5	4.6	12.7	10.2	10	14	333	357
30	1452	19.4	14.5	3.1	4.1	13.9	11.2	9	12	365	392

1 – Based upon mean calculated values using the regression equations for filleters C and D (see Table)

2 – Allowing 1 minute for miscellaneous activities (get box of fish, get empty fillet pan, place empty box, place pan of fillets, sharpen knife) between boxes of fish and a 5 percent P.D.F. (personal, delay, fatigue) allowance.

3 – Based upon the average regression curves for filleters C and D (see Table

4 – Based upon a 35 percent yield (maximum yield of filleter C minus 6 percent – method used by Fishery Products Ltd.).

Table 1.25 shows that:

1. The curves for filleters B,C and D are parallel - have the same slope (-0.11 to -0.15).
2. The slope of the curve for filleter A is 0.
3. Only a very small percentage (0 to 35) of the total variation can be explained by the variation of yield with length. Other factors such as the percentage gut in the fish (can vary between 12 and 22 percent of the total weight of the fish), quality of the fish, type of cutting method used, skill of the operator, etc, have a much greater effect upon the yield of skin-on fillets. Since the quality of the fish and type of cut were kept constant (except in the case of filleter A), and the percentage gut would have the same effect upon the results for each filleter, the differences in the percentage yield between filleters B, C and D can be mainly attributed to the skill of the operator.

4.15 <u>Expected Normal Production Rates When Filleting Gut-In Codfish</u>

Table 1.28 gives times for miscellaneous activities (get box of fish, get ~~empty fillet pan, place empty box,~~ place pan of fillets, sharpen knife) which interrupt the filleting process. These activities normally take 30 to 37 seconds to complete, but this figure may be increased to up to 204 seconds depending upon the ability of a filleter to maintain a sharp cutting edge on the blade of his knife.

Table 1.29 gives expected normal production rates when filleting gut-in codfish. These results are based upon mean calculated values using the regression equations for filleters C and D (filleter D being the most

TABLE 1.30-Rating Versus Percentage Yield of Skin-On Fillets for Small, Small + Medium and Medium Size Categories (Yield Appears to be Constant) for Filleters B, C and D

Filleter C		Filleter D		Filleter B		Filleter A	
Rating	Yield	Rating	Yield	Rating	Yield	Rating	Yield
120	42.3	135	36.1	103	41.0	120	37.6
125	42.3	132	40.8	120	38.0	125	36.0
130	40.2	135	39.2	120	40.4	130	38.5
127	40.0	132	39.6	118	38.5	118	36.7
120	42.5	125	35.5	108	41.7	125	37.8
125	41.7	130	40.5	115	38.5	130	37.8
125	39.8	132.5	39.7	120	38.0	115	38.6
125	39.9	122	39.5	113	38.3	125	38.7
115	41.1	130	35.0	100	39.7	130	373
125	42.2	125	39.4	115	39.9		
125	41.3	130	39.6	117	40.4		
125	38.9	125	39.5	118	38.4		

Filleter	Correlation Coefficient r	r^2_1	Significantly Different Than Zero	Significant at 95 percent Confidence Level
A	+0.019	3.6×10^{-4}	no	no
B	-0.53	0.28	yes at 10% level	yes
C	-0.40	0.16	yes at 20% level	no
D	0.00	0	no	no

Note: Tabulated Correlation Coefficient = 0.54

1 - Coefficient of Determination

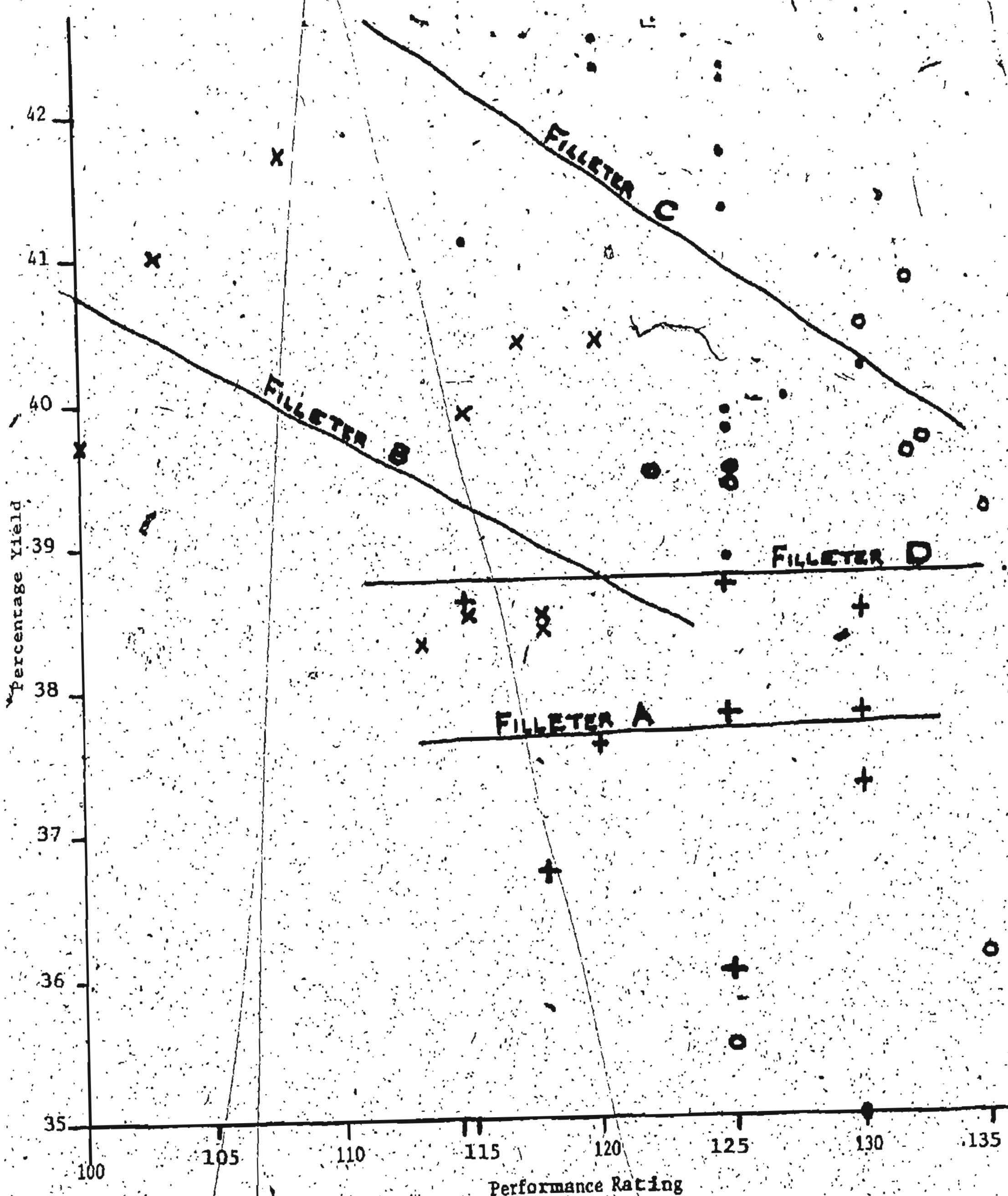


Figure 1.24 - Percentage Yield as a Function of Performance Rating

experienced filleter; filleter C giving the highest yield of skin-on fillets). Allowances of 1 minute for miscellaneous activities between boxes of fish and 5 percent of the working time for P.D.F allowances (personal, delay, fatigue) have been used in calculating these values. The quantity of fillet produced per hour is based upon a minimum expected yield of 35 percent. This value is approximately 6 percent below the maximum yield of filleter C (method used by Fishery Products Limited - see page32 to calculate minimum expected yield standards).

Referring to Table 1.29, and using a mean overall lenght of 22 inches, the expected normal production rates would be:

1. 8.8 boxes of 75 pounds of gut-in fish per hour; 6.8 for 100 pounds per box.
2. 231 pounds of skin-on fillets per hour; 238 when filleting boxes which contain 100 pounds of gut-in fish.

4.20 Factors Affecting Effort Expended when Filleting Gut-in Codfish

4.21 <u>Relationship Between Speed and Yield</u>

Table 1.30 gives performance rating and yield values for each filleter, the values being plotted in figure 1.24 . These values are for the small, small + medium, and medium size fish categories where the average percentage yield appears to be constant (see Tables 1.21 to 1.24

An analysis of the aforementioned results shows that the correlation coefficient for filleter B is significant at $P < 0.05$. The results for filleters A and D show no correlation between speed and yield. The coefficient of determination (r^2) shows that 0 percent for filleters A and D, 16% for filleter C and 28% for filleter B of the total variation in yield can be accounted for by the linear relationship with rating.

Work carried out by Amaria (1974b) has shown that when a filleter is asked to fillet fish at a faster rate his yield decreases. This is to be expected since filleting is a skill, proficiency increasing with the number of boxes of fish filleted. The author has seen many examples where young filleters working under an incentive scheme (based upon output - quality and yield not being taken into consideration) will try to match the speed of the more experienced workers. The net result of such actions is invariably a reduction in yield.

4.22 Relationship Between Speed and Overall Fish Length in Inches

Figure 1.25 is a graph of average performance rating versus overall fish length in inches (see Tables 1.17 to 1.20). This graph shows that, except for filleter A, rating decreases as fish size increases. The results for filleters B and C show a decrease in rating when filleting small fish.

The filleting of extra small fish requires the use of extra caution because the fish are very difficult to hold and there is the added danger of cutting one's fingers or hand. The reverse is true for large size fish, as they are awkward to hold and manipulate on the cutting surface. They also require the use of extra motions to remove the fillets.

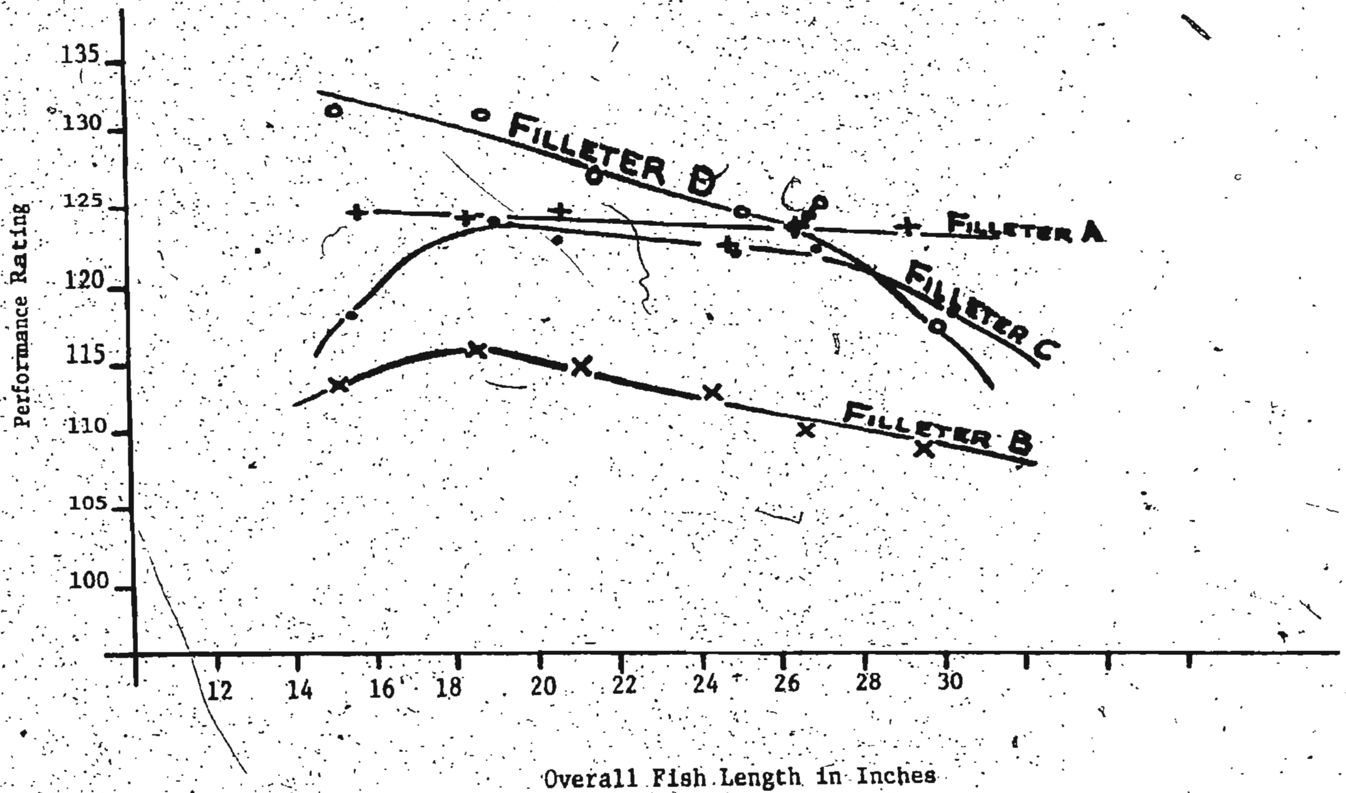


Figure 1.25-Average Rating As A Function of Overall Fish Length in Inches

4.30 Effect of Filleting Table Layout Upon Cutting Rate

4.31 Principles of Motion Economy

The following are the principles of motion economy:

1. The hands should begin and end their activity in a cycle at the same time and should work simultaneously with duplicate parts in opposite and symmetrical directions.
2. The hands should not have idle or hold time, but if necessary, the hands should not have idle or hold time occurring at the same time.
3. The operation method should have the fewest number of therbligs possible.
4. The hands should not do work which can be assigned to other body members through the use of jigs, vises, etc., as long as the hands have other work to perform.
5. The tools and parts should be pre-positioned in a definite location and so located that the hands travel the least distance and perform the fewest activities.
6. The work place should be arranged to permit smooth, continuous motions with a natural, rhythm.
7. The classification of body members (muscle groupings) used should be kept to the lowest feasible for the work. (Fingers are the lowest, progressing through wrist, elbow, full arm, and body.)
8. The motions of the hands should be arranged to take advantage of body-member momentum created through either previous or ballistic activity.
9. The number of eye fixations required in an operation method should be reduced to a minimum. (No eye fixations is the proper goal).

10. The work pattern should be performed within the work place areas which are considered normal (i.e., do not require the operator to use the trunk of his body).
11. The work place height should be arranged to permit the elbows of the operator to be above the table and allow the operator either to stand or sit while performing the work.
12. Handles, foot pedals, tools, etc., should be designed to permit the fewest number of muscle groupings to be used for activating the object.
13. Gravity should be used wherever possible to deliver parts to the operator and to remove or place aside parts.
14. When eye-hand co-ordination is required for grasping, positioning, assembling, etc., parts in a simultaneous, symmetrical hand pattern, the points at which a simultaneous activity takes place should be as close together as possible.
15. Reduce the total skills and amount of work involved, so that the operation may be made into an automatic or machine operation, if at all possible.

Reference shall be made to the aforementioned principles when discussing the engineering design of group and individual incentive tables.

4.32 Utilization of Body Members

Principle of Motion Economy number 2 states that the hands should not have idle or hold time, but if necessary, the hands should not have idle or hold time occurring at the same time. When filleting a fish, the right hand (holding the knife) is idle during the get fish, turn fish (small fish) and place first fillet motions. Referring to Tables 1.31 to 1.34 one sees that these motions constitute 31 to 34 percent of the total time taken to fillet a fish on a group filleting table. Figure, 1.18 shows get fish and place fillet distances of 10 - 22 inches and 8 - 20 inches for a 25 inch overall length fish; the corresponding distances for a group table being 26 - 32 inches and 20 inches (Figure 1.17). MTM-1 motion times based upon the mean values for the aforementioned distances and allowing 5 pounds for the weight of the fish and 1 pound for the weight of a fillet are 0.72 and 0.56 seconds for an individual work place and 1.0 and 0.69 seconds for a group table. These values represent a saving for the individual work station of 33 percent for the get fish motion and 19 percent for the place fillet motion over the corresponding times for a group table.

Principle of Motion Economy number 5 states that the parts should be pre-positioned in a definite location and so located that the hands travel the least distance and perform the fewest activities. Table 1.35 operation 1 (get fish, A to E (pages 105 to 107) shows that for a 25 inch fish (overall length) the get fish and transport to the filleting table motion time is a minimum when the fish is oriented in the fish box so that its head is on the right with the gut away from the filleter (3.60 seconds). This represents a saving of 11 percent over the average time (4.05 seconds) for all of the possible arrangements shown in Figure 1.15 (pages 24 - 36) - (see Table 1.36 for calculated MTM-1 motion times).

TABLE 1.31 - TIME-MOTION STUDY OF FILLETING ON A GROUP TABLE LAYOUT - NON-INCENTIVE (STUDY 1)

Motion	Actual Time, Seconds	Actual Mean Time Seconds
1. Get fish	2.3, 2.2, 1.8, 2.7, 2.1, 2.5, 1.8, 2.1, 2.8, 2.0, 2.3, 3.1, 2.5, 2.0, 2.3, 1.8, 2.3, 1.7, 2.5, 1.5, 1.9, 1.7, 1.8, 1.8, 3.0, 3.1, 2.2, 2.4, 1.6, 2.1, 2.4, 3.2, 1.5, 2.4, 2.3, 2.1, 2.7, 3.0, 3.1.	2.272
2. Cut first side (head on right)	4.5, 5.4, 5.5, 4.5, 4.5, 5.0, 3.7, 4.1, 4.7, 4.3, 4.5, 4.2, 5.6, 4.3, 4.9, 3.7, 3.5, 4.4, 4.9, 4.1, 3.9, 3.8, 3.5, 4.9, 4.5, 3.9, 5.1, 4.7, 4.0, 4.3, 4.0, 3.8, 3.5, 3.9, 4.3, 3.3, 4.4, 4.3, 4.7, 4.1, 5.1.	4.373
3. Place first fillet	1.1, 0.7, 1.1, 0.7, 1.1, 0.9, 1.0, 0.8, 0.6, 1.0, 1.0, 1.1, 1.0, 0.6, 1.0, 1.0, 1.2, 1.0, 0.8, 0.8, 1.1, 0.8, 0.7, 0.5, 0.9, 0.7, 1.1, 1.0.	0.904
4. Turn fish	1.0, 0.5, 0.5, 0.9, 0.5, 0.4, 0.4, 0.5, 0.5, 1.0.	0.620
5. Cut second side (head on left)	3.5, 3.1, 4.3, 3.3, 3.3, 5.7, 5.1, 5.1, 4.3, 3.3, 3.5, 3.7, 2.7, 4.3, 3.0, 4.7, 2.8, 3.1, 3.1, 2.9, 3.5, 2.8, 2.7, 4.4,4.3, 3.4, 3.1, 4.7, 3.2, 4.5, 3.6, 2.8, 4.1, 3.1, 2.9, 3.1, 3.1, 2.9, 2.7.	3.582
6. Place second fillet	0.3, 0.5, 1.0, 0.4, 0.5, 0.4, 0.4, 0.4, 0.5, 0.4, 0.4, 0.6, 0.5.	0.485

Legend:

Fish - Gut-in trap cod, excellent quality. $\overline{X}$ = 19.1 inches, R = 16 - 27 inches, $\overline{W}$ = 2.093 pounds per fish

Operator - Rating = 113
(Filleter 1) - Skill - Excellent
Effort - Excellent
Experience - 20 years.

TABLE 1.32 - TIME-MOTION STUDY OF FILLETING ON A GROUP TABLE - NON-INCENTIVE (STUDY 2)

Motion	Actual Time, Seconds	Actual Mean Time Seconds
1. Get fish	4.1, 3.0, 3.0, 3.3, 4.4, 2.8, 3.7, 3.5, 4.3, 4.8, 4.1, 3.9, 3.0, 4.1, 4.9, 3.5, 4.0, 5.2, 5.3, 3.5, 4.1, 5.1, 5.5.	4.048
2. Cut first side (head on right)	4.7, 7.1, 6.0, 5.9, 6.9, 8.0, 6.5, 5.9, 5.0, 6.3, 6.8, 7.4, 8.6, 6.3, 6.8, 7.7, 6.6, 4.9, 7.2, 7.3, 7.7.	6.648
3. Place first fillet	1.2, 1.5, 1.5, 1.4, 1.0, 1.1, 1.2, 2.0, 1.3, 1.2, 1.6, 1.0, 1.7, 1.3, 1.5, 1.3.	1.363
4. Turn fish	1.9, 2.5, 1.6, 2.0, 1.9, 2.0, 2.7, 1.5, 1.2, 2.1, 1.8, 2.5, 3.0, 1.7, 1.8, 1.5.	1.981
5. Cut second side (head on left)	6.3, 10.3, 5.7, 8.6, 6.8, 7.3, 6.1, 8.8, 7.1, 6.3, 7.0, 5.6, 5.5, 8.0, 6.7, 6.5, 6.3, 7.8, 6.4.	7.005
6. Place second fillet	0.7, 0.4, 0.5, 0.5, 0.5, 0.5, 0.5.	0.514

Data on fish and filleter:

Fish - Gut-in trap cod; soft texture. $\bar{X}$ = 24.8 inches, R = 16 - 29 inches,

Operator - Rating = 100
Skill - Good
Effort - Good
Experience - 7 - 8 years.

TABLE 1.33 – ANALYSIS OF THE RESULTS OF TABLE 1.31

(Mean length of fish = 19.1 inches)

Motion	Mean Time Seconds $\bar{X}$	Range R	Standard Deviation S	$\frac{S}{\bar{X}}$	Percent of Total Time	Normal Time Seconds
1. Get fish	2.272	1.5–3.1	0.48	0.21	18.6	2.567
2. Cut first side (head on right)	4.373	3.5–5.5	0.54	0.12	35.7	4.941
3. Place first fillet	0.904	0.5–1.2	0.19	0.21	7.4	1.022
4. Turn fish	0.620	0.5–1.0	0.24	0.39	5.1	0.701
5. Cut second side (head on left)	3.582	2.7–5.7	0.79	0.22	29.3	4.048
6. Place second fillet	0.485	0.3–1.0	0.17	0.35	4.0	0.548

Normalized Times

Time to fillet at 19 inch (overall length) fish = 13.827 seconds
Time spent in Productive Activities (2,5) = 8.989 seconds (65.0 percent)
Time spent in Non-Productive Activities (1,3,4,6) = 4.838 seconds (35.0 percent)
Time spent in Operations 1,3 and 6 = 4.137 seconds (29.9 percent)

Normalized Filleting Rate

Number of fish per hour = 260
Pounds of gut-in fish per hour = 544

TABLE 1.34 - ANALYSIS OF THE RESULTS OF TABLE 1.32

(Mean length of fish = 24.8inches)

Motion	Mean Time Seconds $\bar{X}$	Range R	Standard Deviation S	$\frac{S}{\bar{X}}$	Percent of Total Time	Normal Time Seconds
1. Get fish	4.048	2.8-5.5	0.80	0.20	18.8	4.048
2. Cut first side (head on right)	6.648	4.7-8.0	1.02	0.15	30.8	6.648
3. Place first fillet	1.363	1.0-2.0	0.26	0.19	6.3	1.363
4. Turn fish	1.981	1.2-3.0	0.48	0.24	9.2	1.981
5. Cut second fillet (head on left)	7.005	5.5-10.3	1.23	0.18	32.5	7.005
6. Place second fillet	0.514	0.4-0.7	0.09	0.18	2.4	0.514

Normalized Times

Time to fillet a 25 inch (overall length) fish = 21.559 seconds
Time spent in Productive Activities (2,5) = 13.653 seconds (63.3 percent)
Time spent in Non-Productive Activities (1,3,4,6) = 7.906 seconds (36.7 percent)
Time spent in motions 1,3,6 = 5.925 seconds (27.5 percent)

Normalized Filleting Rate

Number of fish per hour = 167

TABLE 1.35 MTM1 ANALYSIS Sheet No. 1 of 8

Operation Description: Cod Filleting (25 in.; gut-in and head on; maximum yield cut)

No.	Description	LH	TMU	RH	Description
	Operation 1 -- Get fish and transport to filleting table				
A.	**Head on right, gut away from filleter**				
A 1.01	Reach for fish	MR10C	12.9		Idle
A 1.02	Eye travel (45 degrees) and eye focus	ET and EF	20.2		
A 1.03	Grasp fish	G4A	7.3		
A 1.04	Apply pressure	AP1	16.2		
A 1.05	Move fish to table	M18B	17.0		
	Weight factor (5 lbs.)		0.9		
A 1.06	Release	RL1	2.0		
A 1.07	Reposition hand	R5E	7.4		
A 1.08	Regrasp fish	G2	5.6		
A 1.09	Apply pressure	AP2	10.6		
			100.1	TMU	
			3.60	seconds	
B.	**Head on right, gut toward filleter**				
B 1.01	Reach for fish	MR18C	18.4		Idle
B 1.02	Eye travel (45 degrees) and eye focus	ET and EF	20.2		
B 1.03	Grasp fish	G4A	7.3		
B 1.04	Apply pressure	AP2	16.2		
B 1.05	Move fish to table	M24B	20.6		
	Weight factor (5 lbs.)		1.1		

("B" continued on next page)

TABLE 1.35 MTM ANALYSIS Sheet No. 2 of 8

Operation Description: Cod Filleting (25 in.; gut-in and head on; maximum yield cut)

No.	Description	LH	TMU	RH	Description
B 1.06	Release	RL1	2.0		
B 1.07	Reposition hand	R5E	7.4		
B 1.08	Regrasp fish	G2	5.6		
B 1.09	Apply pressure	AP2	10.6		
			109.4	TMU	
			3.94	seconds	
C.	Head on left, gut toward filleter				
C 1.01	Reach for fish	MR22C	21.2		Idle
C 1.02	Eye travel (72 degrees) and eye focus	ET and EF	27.3		
C 1.03	Grasp fish	G4A	7.3		
C 1.04	Apply pressure	AP1	16.2		
C 1.05	Move Fish to table	M27B	22.5		
	Weight factor (5 lbs.)		1.2		
C 1.06	Release	RL1	2.0		
C 1.07	Reposition hand	R6E	8.0		
C 1.08	Regrasp fish	G2	5.6		
C 1.09	Apply pressure	AP2	10.6		
			121.9	TMU	
			4.39	seconds	
D.	Head on left, gut toward filleter, grasp by tail				
D 1.01	Reach for fish	MR13C	14.9		Idle
D 1.02	Eye travel (72 degrees) and eye focus	ET and EF	20.2		
D 1.03	Grasp fish	G4A	7.3		

("D" continued on next page)

TABLE 1.35 MTM1 ANALYSIS Sheet No. 3 of 8

Operation Description: Cod Filleting (25 in.; gut-in and head on; maximum yield cut)

No.	Description	LH	TMU	RH	Description
D 1.04	Apply pressure	AP1	16.2		Idle
D 1.05	Move fish to table	M30B	24.3		
	Weight factor (5 lbs.)		1.3		
D 1.06	Release	RL1	2.0		
D 1.07	Reposition hand	R12E	11.8		
D 1.08	Regrasp fish	G2	5.6		
D 1.09	Apply pressure	AP2	10.6		
			114.2	TMU	
			4.11	seconds	

E. <u>Head on left, gut away from filleter</u>

No.	Description	LH	TMU	RH	Description
E 1.01	Reach for fish	MR18C	18.4		Idle
E 1.02	Eye travel (72 degrees) and eye focus	ET and EF	27.3		
E 1.03	Grasp fish	G4A	7.3		
E 1.04	Apply pressure	AP1	16.2		
E 1.05	Move fish to table	M24B	20.6		
	Weight factor (5 lbs.)		1.1		
E 1.06	Release	RL1	2.0		
E 1.07	Reposition hand	R5E	7.4		
E 1.08	Regrasp fish	G2	5.6		
E 1.09	Apply pressure	AP2	10.6		
			116.5	TMU	
			4.19	seconds	

No.	Description	LH	TMU	RH	Description
	Operation 2 - Remove the first fillet				
2.01	Hold fish in position		10.6	AP2	Apply pressure with blade of knife.
2.02	Hold fish in position		8.9	M7A	Slash cut behind the gill cover.
2.03	Hold fish in position		6.8	T	Turn blade of knife 120 degrees to the right.
2.04	Hold fish in position		13.5	M10C	Cut along back of fish to break in the lateral line.
			3.9		Weight factor (7 pounds).
2.05	Hold fish in position		10.6	AP2	Apply pressure to tip of the blade of the knife.
2.06	Hold fish in position		8.0	M5B	Push knife through flesh.
			3.5		Weight factor (7 pounds).
2.07	Hold fish in position		8.0	M5B	Move blade of knife through tail portion of fish.
			4.8		Weight factor (10 pounds).
2.08	Hold fish in position		9.4	T	Turn blade of knife 180 degrees to the left.
2.09	Release hand	RL1			
	Reach to edge of fillet	R4A	29.9	M7A	Move knife to new location.
	Grasp edge of fillet	G2			
	Apply pressure	AP1			
2.10	Lift edge of fillet	M2B	4.6		
2.11	Lift edge of fillet	M2B	10.6	AP2	Apply pressure to blade of knife.
2.12	Lift edge of fillet	M2B	10.6	M8B	Release fish flesh from backbone with blade of knife.
			2.8		Weight factor (5 pounds).

(continued on next page)

TABLE 1.35 MTM1 ANALYSIS Sheet No. 5 of 8

No.	Description	LH	TMU	RH	Description
2.13	Lift edge of fillet	M2B	10.6	M8B	Move blade of knife to new location.
2.14	Lift edge of fillet	M2B	10.6	AP2	Apply pressure to blade of knife.
2.15	Lift edge of fillet	M2B	8.9	M6B	Release fish flesh from rib cage with blade of knife.
			2.7		Weight factor (5 pounds).
2.16	Lift edge of fillet	M2B	10.6	AP2	Apply pressure to head of the fish with the blade of the knife.
2.17	Tear fillet from rib cage of the fish	M15B	15.2		Apply pressure to head of the fish with the blade of the knife.
	Weight factor (3 pounds)		2.0		
			207.1 TMU		
			7.46 seconds		

<u>Operation 3</u> – Place first fillet

No.	Description	LH	TMU	RH	Description
3.01	Eye travel (24 degrees) and focus	ET and EF	6.8		Idle
3.02	Transfer fillet to pan	M20B	18.2		
	Weight factor (1 pound)		1.0		
3.03	Release fillet	RL1	2.0		
3.04	Return hand to table	M20A	19.2		
			47.6 TMU		
			1.70 seconds		

TABLE 1.35 MTM1 ANALYSIS Sheet No. 6 of 8

No.	Description	LH	TMU	RH	Description
5.07	Lift edge of fillet	M2B	4.6		
5.08	Lift edge of fillet	M2B	10.6	AP2	Apply pressure to blade of knife.
5.09	Lift edge of fillet	M2B	9.7	M7B	Release fish flesh from backbone with blade of knife.
			3.2		Weight factor (6 pounds).
5.10	Lift edge of fillet	M2B	9.7	M8A	Move knife to new location.
5.11	Lift edge of fillet	M2B	10.6	AP2	Apply pressure to blade of knife.
5.12	Lift edge of fillet	M2B	9.7	M7B	Release fish flesh from rib cage with blade of knife.
			3.2		Weight factor (6 pounds).
5.13	Life edge of fillet	M2B	10.6	AP2	Apply pressure to head of fish.
5.14	Tear fillet from rib cage.	M8B	10.6		Apply pressure to head of fish.
	Weight factor (3 pounds)		1.9		
5.15			9.4	T	Turn knife 180 degrees to the left.
5.16	Lift edge of fillet		8.9	M7A	Move knife to new location.
5.17	Lift edge of fillet		10.6	AP2	Apply pressure to blade of knife.
5.18	Lift edge of fillet		11.5	M9B	Release flesh from tail portion of fish.
			5.2		Weight factor (10 pounds).
			231.8 TMU		
			8.34 seconds		

TABLE 1.35 MTM1 ANALYSIS Sheet No. 7 of 8

No.	Description	LH	TMU	RH	Description
	Operation 4 - Turn fish				
4.01	Grasp head of fish	G1A	2.0		Idle
4.02	Apply pressure	AP1	16.2		
4.03			15.2	M15A	Move knife to tail of fish.
4.04	Turn fish	M27B	22.6		Assist in turning fish.
	Weight factor (5 pounds)		3.4		
			59.4 TMU		
			2.14 seconds		
	Operation 5 - Remove the second fillet				
5.01	Hold head of fish		10.6	AP2	Apply pressure with bade of knife.
5.02	Hold head of fish		8.9	M7A	Slash cut behind the gill cover.
5.03	Move hand to new location	M10A	21.9	M16A	Move blade of knife to tail of fish.
	Apply pressure	AP2			
5.04	Hold fish in position		10.6	AP2	Apply pressure with the blade of the knife.
5.05	Hold fish in position		15.8	M16B	Cut along back of the fish to the head.
			4.1		Weight factor (7 pounds)
5.06	Release hand	RL1			
	Reach to edge of fillet	R4A	29.9	M7A	Move knife to new location
	Grasp edge of fillet	G2			
	Apply pressure	AP1			

(continued on next page)

TABLE 1.35 MTM1 ANALYSIS Sheet No. 8 of 8

No.	Description	LH	TMU	RH	Description
	Operation 6 – Place second fillet				
6.01	Eye travel (24 degrees) and focus	ET and EF	6.8		
6.02	Transfer fillet to pan	M8B	10.6		
	Weight factor (1 pound)		1.0		
6.03	Release fillet	RL1	2.0		Transfer skeleton to offal shute.
			20.4 TMU		
			0.73 seconds		

TABLE 1.36. - ANALYSIS OF THE RESULTS OF MTM-1 EVALUATION OF COD FISH FILLETING (25 INCH OVERALL LENGTH, GUT-IN FISH)

Operation No.	Description	Time (Seconds)	Percent of Total time
1.	Get fish and transport to filleting table	4.05	16.6
2.	Remove the first fillet	7.46	30.5
3.	Place the first fillet in the fillet pan	1.70	7.0
4.	Turn the fish	2.14	8.8
5.	Remove the second fillet	8.34	34.2
6.	Place the second fillet	0.73	3.0
	Total	24.42 seconds	

Principle of Motion Economy number 9 states that the number of eye fixations required in an operation method should be reduced to a minimum (no eye fixations is the proper goal). Figure 1.26 gives eye travel angles of from 45 to 72 degrees, depending upon the orientation of the fish in the fish box, for the reach for fish motion at an individual work place, the value for transport the fish to the filleting surface and place first and second fillets motions being 24 degrees (Figure 1.27).

The corresponding eye travel angles for a group filleting table are (Figure 1.28):

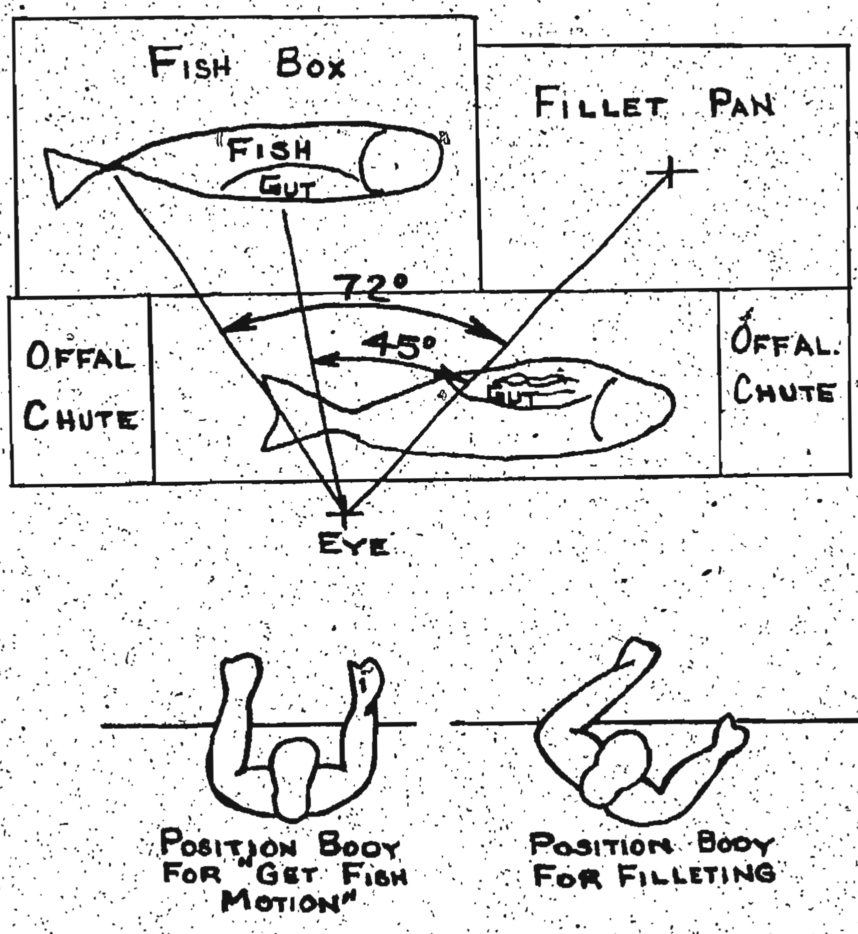
1. Reach for fish - 12 degrees.
2. Transport fish to filleting surface - 44 degrees.
3. Place first and second fillets - 56 degrees.

Using the formula TMU = 0.285 x degrees, the eye travel times for individual and group filleting tables are 1.34 and 1.72 seconds, the value for the individual table representing a saving of 22 percent. This saving could be further reduced by orienting the fish in the fish box - would also reduce eye focus for the reach for fish motion (0.26 seconds).

4.33 Time Spent in Miscellaneous Activities

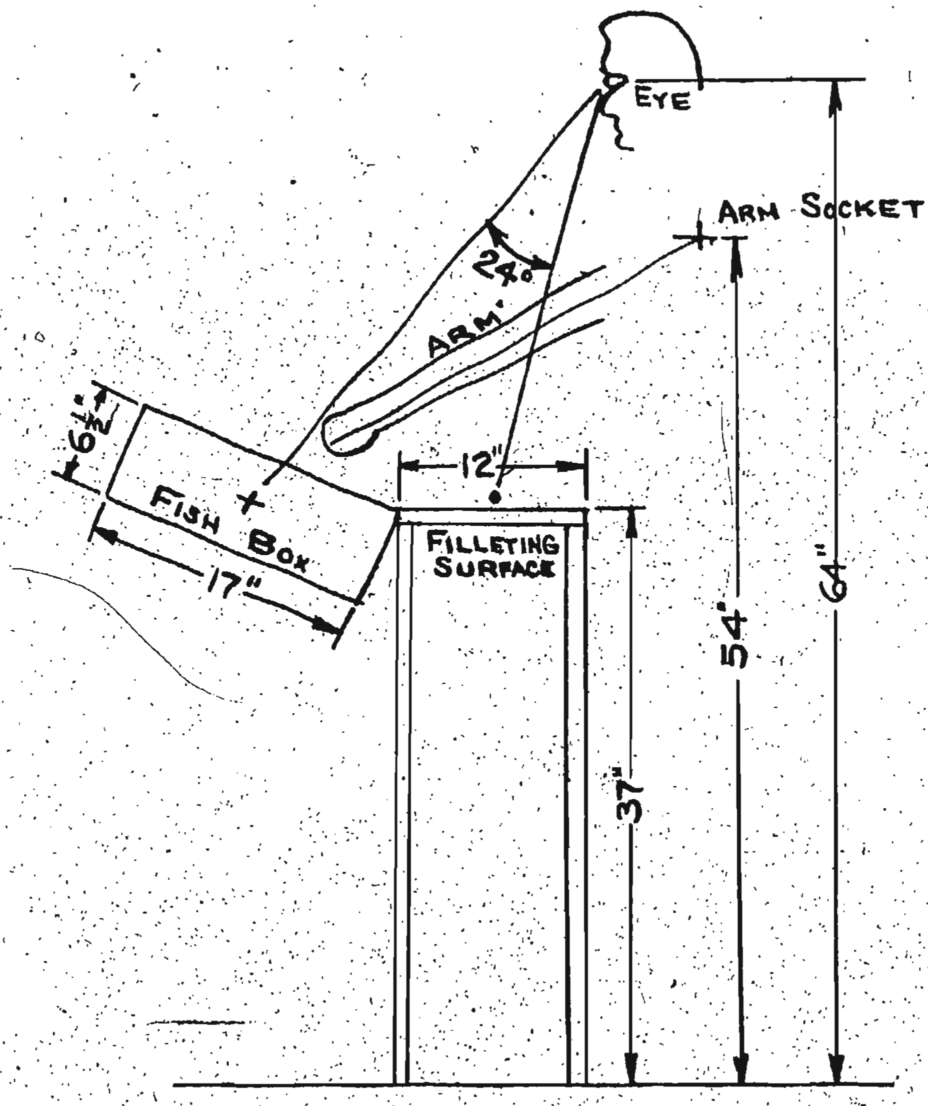
Table 1.41 shows that for an individual incentive table the time spent in miscellaneous activities - place pan of fillets, place empty fish box, get box of fish, get empty fillet pan and sharpen knife - is 30 -40 seconds. These operations (excluding sharpening knife) are usually performed at a normal rate by all filleters. Table 1.28 shows that if one allows 45 seconds (0.67 minute) for these activities, they can

FIGURE 1.26 - TOP VIEW OF THE INDIVIDUAL INCENTIVE WORK STATION USED IN THE STUDY - INCLUDES EYE TRAVEL (DEGREES) DISTANCES FOR THE GET FISH MOTION



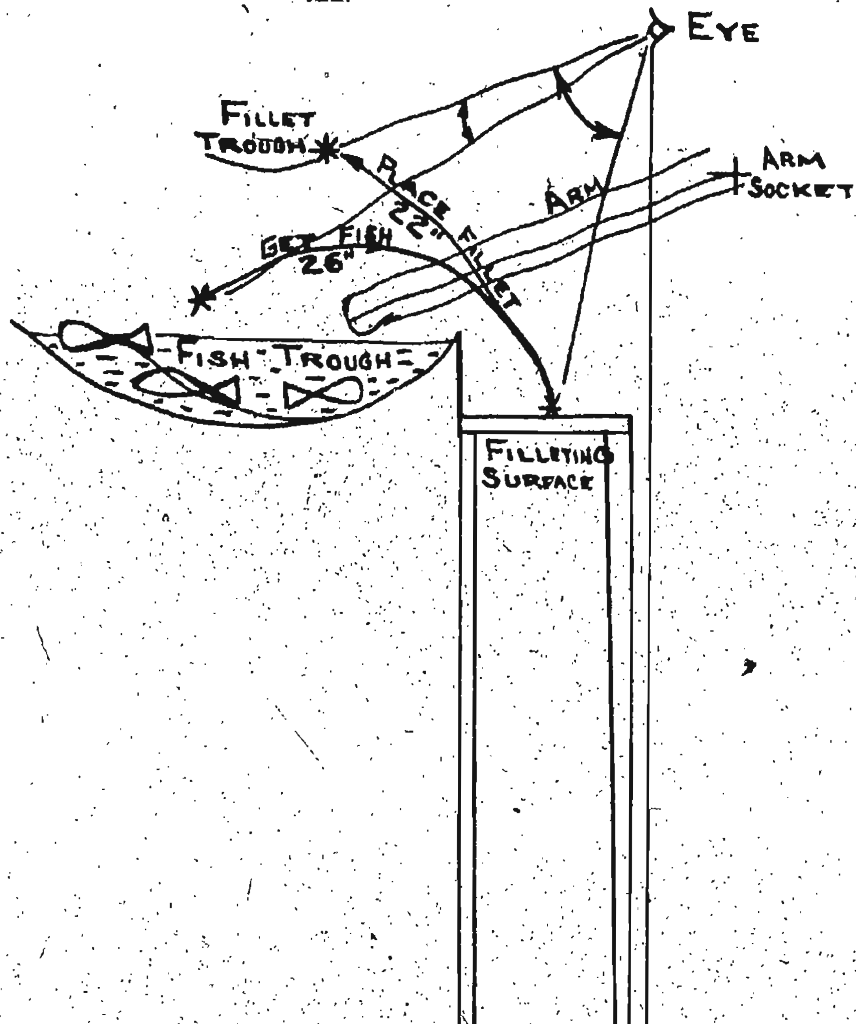
Scale: 1 inch = 10 inches

FIGURE 1.27 - SIDE VIEW OF THE INDIVIDUAL INCENTIVE STATION USED IN THE STUDY - INCLUDES EYE TRAVEL (DEGREES AND ARM REACH (INCHES) DISTANCES FOR A 69 INCH MAN



Scale: 1 inch = 10 inches

FIGURE 1.28 - SIDE VIEW OF THE GROUP FILLETING TABLE USED IN THE STUDY - INCLUDES EYE TRAVEL (DEGREES) AND ARM REACH (INCHES) DISTANCES FOR A 69 INCH MAN



Scale: 1 inch = 10 inches

Note: Trough not to scale

TABLE 1.37 - NORMALIZED PRODUCTION RATES AND COST OF FILLETING

Overall length Inches	Time per Box Minutes	Boxes per Eight Hours[1]	Percentage of Working Time-Miscellaneous Activities[2]	Labor Cost in Cents Per Pound of Round Fish filleted - No Bonus[3]
15.5	18.54	25	3.5	1.06
19.0	8.81	51	7.0	0.52
20.7	6.59	66	9.2	0.40
25.0	4.62	91	12.6	0.29
26.9	3.45	117	16.2	0.22
30.3	3.11	127	17.7	0.20

1 - Allowing 0.67 minutes for miscellaneous activities.

2 - Get box of fish, get fillet pan, place empty box, place pan of fillets, sharpen knife.

3 - $2.50 fixed rate per hour.

account for between 4 and 18 percent (depending upon the size of the fish) of the total working time.

4.34 Comparison of Group and Individual Work Station Fish Filleting Tables

A comparison, for codfish having an overall length of 25 inches, of the breakdown of the times required for the various filleting motions for group (Table 1.34 - measured values) and individual work station (Table 1.36 - calculated using MTM-1 tables) filleting tables shows only small differences in the tabulated values for the individual motions. In fact, the total time taken to fillet a cod on a group table appears to be 2.86 seconds less than at an individual work station. One would expect the times taken to remove the fillets and turn the fish to be independent of table design (elbow heights the same); the get fish and place fillet motions, being dependent upon distance of travel, having the greatest influence upon the tabulated values.

If no other factors were to be taken into consideration, there might be no benefit to installing an individual work station filleting table in a fish plant (especially when one considers the extra time required for miscellaneous activities - Table 1.41).

4.40 SETTING UP AN INCENTIVE PROGRAM FOR FILLETERS IN A FISH PLANT

4.41 Factors to be Considered When Setting Up An Incentive Scheme for Filleters in a Fish Plant

The main objective of every Company is to make a profit. A major factor affecting the cost of processing raw material in a fish plant is the labour cost of filleting, trimming and packaging. This cost is directly related to fish size - smaller fish incurring a higher processing labour cost than larger ones. A.A. Etchegary, Vice-President of Fishery Products Limited, is quoted in the January 12, 1976 issue of the St. John's Evening Telegram, as saying that the smaller size fish means increased costs in the labour industry. In the mid 1960's it took about 60 flounder to make up 100 pounds, whereas today it takes between 110 and 120 to make the same weight. Harris (1974) gives the following cost breakdown (for the year ending July 30, 1974) for filleting flounder: -

Cost of fish (30% yield)	40¢ per lb.
Cost of labour	18¢ per lb. (23%)
Fixed costs	11.5¢ per lb.
Materials	2.5¢ per lb.
Shipment and marketing	5.75¢ per lb.
Miscellaneous	0.25¢ per lb.
	78.0 ¢ per lb.

Because of a smaller number of fish required to make up 100 pounds, it would be expected that the labour cost per pound of cod fillet leaving a plant would be lower than that for flounder.

The major factors to be taken into consideration when establishing an incentive scheme for filleting cod are:

1. Size of the fish
2. Working pace of the filleter
3. Quality of raw material
4. Quality of workmanship
5. Conditions of the work environment

4.42 Proposed Procedure for Setting Up An Incentive Scheme for Filleting Fish

The following is a proposed procedure for setting up an incentive scheme in a fish plant:

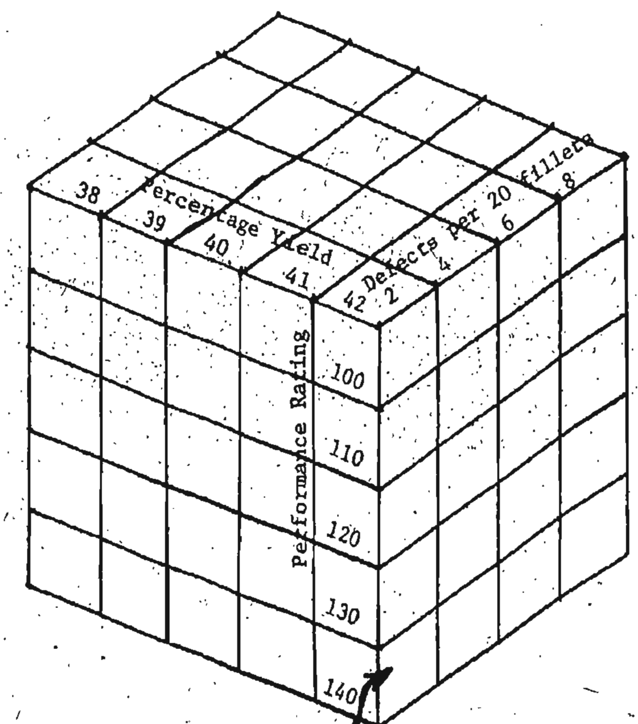
1. Establish relationship for and between size and output rate for the specie and range of quality of raw material being filleted.
2. Establish relationship between speed of cutting and yield for a number of operators in the plant.
3. Select speed - yield relationship curve for the average skilled operator.
4. Establish a matrix of speed versus yield as show in Figure 1.29.
5. Establish speed range of 100 - 140.[1]
6. Establish yield range based on the average skilled operator's speed - yield relationship.

(1) Since most workers in industry rarely work at the 100 performance rating, it is suggested that incentive pay only be given for performances above 110. Performances above 140 rarely occur in industry.

7. Observe yield values for 140 rating. This will be lowest yield the average operator gives when working at top of speed range - for example 39 percent for gut-in cod.
8. Observe yield value for normal rating of 100. This will be the yield which the average operator gives when working at the normal pace - for example 42 percent for gut-in cod.
9. Establish hourly base rate dependent upon job classification for particular type of operation - for example $3.00 per hour for filleting.
10. Establish proportion of incentive to be given for speed as against yield. The normal criteria to be used here is the relationship between the labour to material cost of filleting. Presently, with an hourly pay rate for filleters of $3.00, the labour cost of producing 1 lb. of fillet (skin-on) varies between 3/4 - 1¢ per lb. depending upon the size of the fish. In comparison to this, the material cost (11¢ per lb. round fish) varies between 25 to 30 cents per pound. It is therefore, logical that an incentive system be based in relation to the above criteria of labour to material cost of filleting.
11. Other criteria, such as quality of workmanship, should also be included in the formula. This depends upon conditions of the work environment and the initial quality of the input material (see Figure 1.29). Table 1.38 gives the results of a spot check on some filleters working at the plant used for this study. As can be seen from this table, the quality of workmanship is quite variable (fillets leaving the filleters are not inspected for quality of workmanship).

FIGURE 1.29 - INCENTIVE MATRIX FOR FILLETING CODFISH

FISH SIZE =
FISH QUALITY =



Wage rates per hour to be placed in these boxes

TABLE 1.38 – SPOT CHECK IN SUMMER OF 1975 ON QUALITY OF FILLETS PRODUCED BY FILLETERS AT THE PLANT USED FOR THIS STUDY

Filleter Number	Number of Defective Fillets				Number of Defect Free Fillets	Defects per 20 Fillets
	Fins	Black Nape	Belly Bones	Other		
1	3	1	–	5	35	4
2	1	–	4	–	40	2
3	–	–	–	–	40	0
4	10	–	–	4	30	6
5	1	3	–	5	35	4
6	–	1	4	2	35	3
7	–	2	1	–	40	1
8	3	2	1	–	40	3
9	–	2	3	5	34	5
10	3	–	–	–	40	1
11	3	–	–	2	35	3

(Fish being filleted – small gut-in cod)

It is true that one should expect a certain number of defects (cheaper to remove by trimmers than filleters - filleters being paid higher wages), but a large number will result in increased production costs. The answer to this problem lies in the training of filleters - better and more intensive instruction in manipulation of the knife so that defect free fillets are cut from the fish during the filleting operation. A close look at the design of filleting tables would also help improve this situation.

Such an approach to an incentive system is considered to be just and fair both to management and workers, since most of the present systems of payment in fish plants do not consider the relationship of size with standard output rate as well as the relationship of speed against yield.

5.10 CONCLUSIONS AND RECOMMENDATIONS

5.11 Objective 1 - Effect of Overall Fish Length Upon Input and Output Quantities and Percentage Yield

This study has shown that there was a linear relationship between:

1. Overall length in inches and input as pounds of gut-in fish per hour (input increased with length);
2. Overall length in inches and number of fish filleted per hour (number decreased with length);
3. Overall length in inches and pounds of skin-on fillets produced per hour (output increased with length);
4. Overall length and percentage yield of skin-on fillets for 2 of the 4 filleters used in the study (yield decreased with length);

and that these relationships were significant at $P < 0.05$.

It must be remembered that the above are experimentally derived, empirical relationships and that they have validity only over the range of fish lengths used in this study.

5.12 Objective 2 - Effect of Experience Upon Input and Output Quantities and Percentage Yield

It has been suggested that when setting standards for industrial operations, the most experienced operator should be selected for the time study - better co-operation, less hesitant in his movements, makes fewer mistakes, etc. This study has shown that although the most experienced operator had a high input as pounds of gut-in fish per hour, or fish per hour, his output of skin-on fillets per hour was lower than that of 2 of the other 3 experienced filleters.

5.13 Objective 3 - Effect of Filleting Table Layout Upon Cutting Rate

A reduction in (a) unproductive activities (33 percent reduction in time taken for the get fish motion, 19 percent for the place fillet motions), and (b) the number of eye fixations (22 percent reduction in time) could be obtained by conversion from a group to an individual work place filleting table. However, the aforementioned conversion would introduce certain non-productive miscellaneous activities (get box of fish, get fillet pan, place, empty fish box, place pan of fillets) into the filleting cycle, said activities taking up to 30 - 36 seconds between the filleting of each box of fish (4 to 18 percent, depending on the size of the fish, of the total cycle time per box of fish filleted).

5.14 Objective 4 - Effect of Cutting Time Upon the Percentage Yield of Skin-on Fillets

Two of the four filleters utilized in this study had a high correlation between speed and yield for the small, small + medium and medium fish size categories (average yield was constant), the results for one of the filleters being significant at $P < 0.05$. However, a carefully controlled experiment needs to be designed to study this relationship for each of the fish size categories used in this study. This experiment could be broadened to include the experience factor.

5.15 Recommendations

The following are man-machine interactions which require further investigation:

1. The relationship between input quantity, output quantity and percentage yield for other species of fish (flounder, redfish)- Fish plants located at St. John's, Gaultois, Burgeo and Ramea rely upon a single species, redfish, for their supply of fish; those located at Trepassey, Burin, Marystown, Grand Bank and Fortune rely upon flounder.
2. The relationship between speed and yield - This report has indicated that, for two of the four filleters selected, there was a relationship between speed and yield. However, a carefully controlled experiment needs to be carried out to study this relationship for each of the fish size categories used in this report.
3. The relationship between fish size and performance rating - This report has indicated that performance rating is a maximum for medium sized fish (18 - 22 inches overall length); decreasing as the fish size deviates from this value. The reasons for this deviation requires further investigation.
4. The effect of training methods upon output and percentage yield - Filleter B cut less fish and gave a lower percentage yield than filleter C, despite the fact that they had the same number of years filleting experience. An experiment should be set up wherein a number of inexperienced filleters would be divided

into two groups; group 1 being immediately told the results of their actions and asked to correct any deficiencies, the results of group 2 being kept secret.

5. The use of intelligence and manual dexterity tests to determine if a person has the inherent skills necessary to become a filleter .

6. The designing of an individual work place to reduce or eliminate the percentage of the total filleting time (35 percent) spent in non-productive activities (get fish, place fillet, turn fish).

7. The effect of height of the filleting surface upon input quantity output quantity, percentage yield and performance rating - (2 to 4 inches is the recommended height of the elbow above the filleting surface, however, this may not be true for fish filleting).

8. The effect of tool sharpness upon each of the factors mentioned in item 7. A dull knife results in an increased pressure having to be applied to move the blade through the flesh, therein increasing filleting time.

9. The effect of filleting and trimming at the same work place - filleter handing the skin-on fillet to the trimmer for removal of the pin bones - upon each of the factors mentioned in item 7. The plant used in this study has recently converted to this type of system and it has worked satisfactorily.

10. The effect of quantity of fish per box upon performance. The plant used in this study weighted out 75 pounds of fish per box; one of its sister plants utilizes 100 pounds per box - does the longer filleting time increase fatigue.

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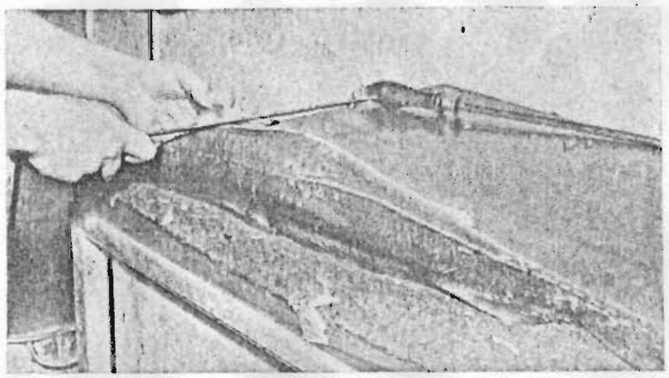
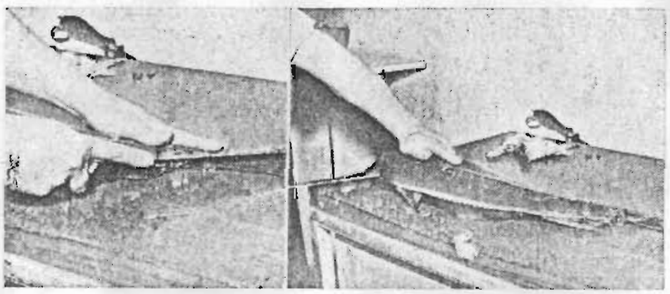
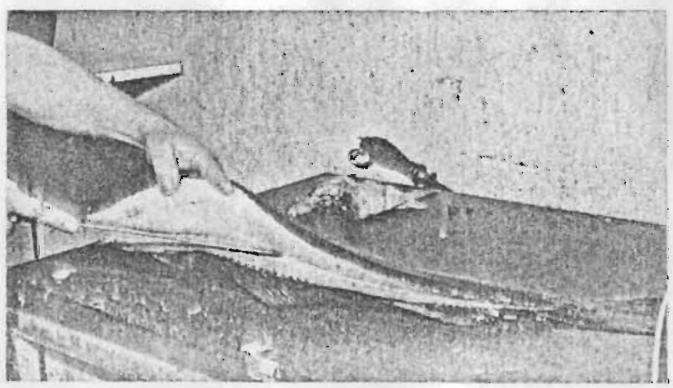
APPENDIX A - METHOD USED TO FILLET HEAD-OFF GUT-OUT CODFISH IN ENGLAND



Head is cut off and lugs or shoulders removed.



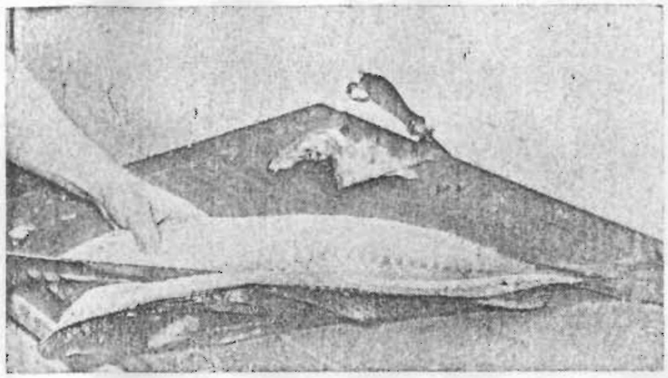
Knife is run from the tail to the head end along the top of backbone, aiming for the centre round bone. The point of the blade should not go beyond the centre bone.



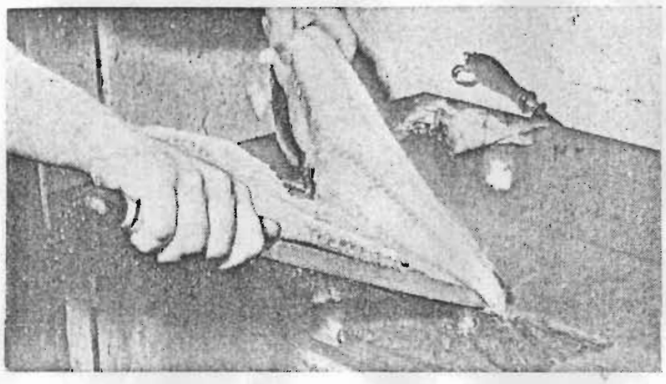
Cut over top of round centre bone from tail to head end, stopping half-way up fish at rib bones.

APPENDIX A

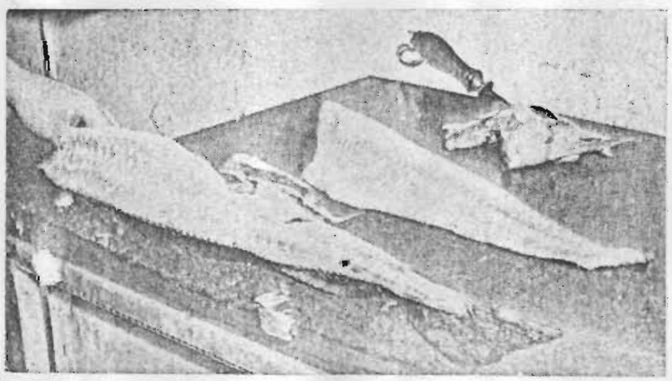
(continued)



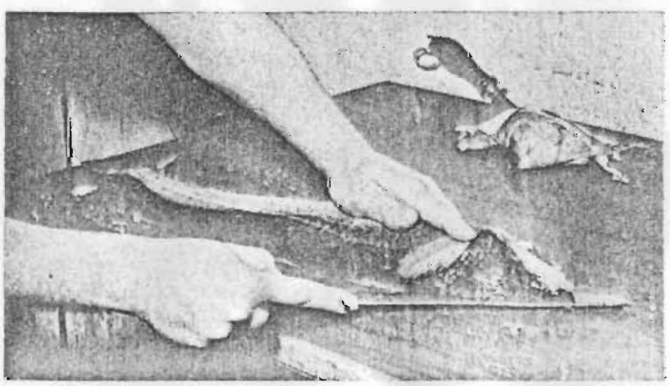
Fish is turned on to belly and cut is continued to head end.



Knife is reversed and fillet is separated from bone by a cut from head to tail.



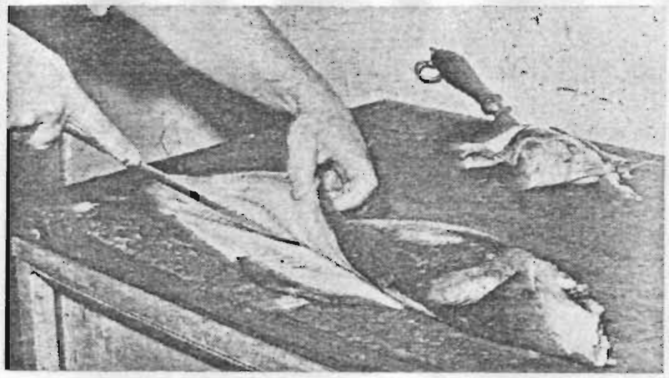
Flap trimmed off.



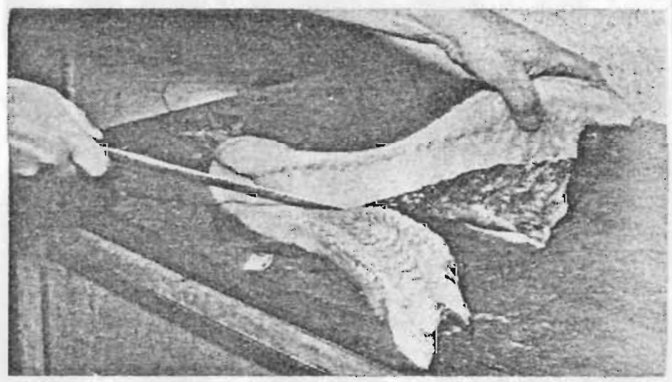
Fish turned over and cut is made on top of bone from head to tail, aiming for the round centre bone.

APPENDIX A

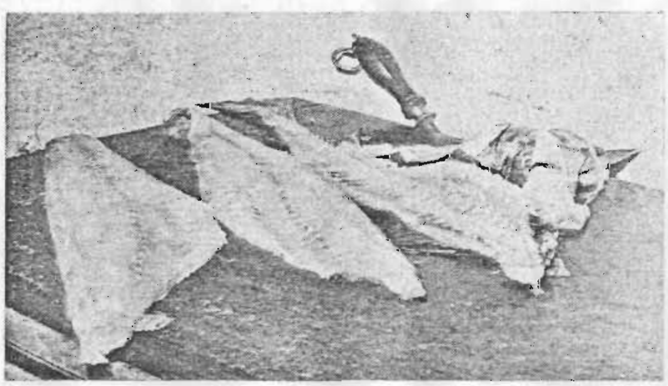
(continued)



Knife is continued over top of centre bone at the tail section and flesh is cut away.



Fish is turned on to belly and fillet is separated from rib bone by a cut from head end.



Flap is then trimmed away. The finished article.

TABLE I

Grades - Groundfish (Atlantic Coast)

	Grade 1	Grade 2	Grade 3
General Appearance: (lustre and bleaching)	Bright with metallic lustre. Very little, if any, bleaching.	Some loss of metallic lustre. Some bleaching may be apparent.	Bloom completely gone, Colour faded or bleached.
Eyes:	Bright, translucent, usually full but in some cases may be slightly sunken and somewhat dull.	Dull, slightly sunken. Slightly cloudy.	Dull and sunken. May be cloudy, dull, white or opaque.
Gills: (colour)	Bright red to slightly pinkish red.	Pinkish red to brownish red. Some mucus may be present.	Brownish red to brown or gray. Frequently covered with thick bacterial mucus.
(odour)	Fresh odour characteristic of species to faint sour odour.	Faint sour or fishy odour to medium sour odour.	Medium to strong sour odour.
Slime:	Usually clear, transparent and uniformly spread but occasionally may be slightly milky or opaque.	Becoming turbid, opaque and milky, with marked increase in amount of slime present on skin surface.	Thick, sticky yellowish or grayish in colour.
Odour: (poke end)	Fresh to very faint sour odour	Slightly sour or fishy odour.	Medium to strong sour.
(at neck when breaking)	No odour to very slight odour.	Slightly sour.	Sour or putrid.
Consistency of flesh:	Firm and elastic to the touch. Occasionally slightly soft.	Moderately soft and some loss of elasticity.	Generally soft and flabby.
Kidney:	Bright red	Loss of original brilliance.	Kidney blood brownish in colour.
Backbone:	Normal colour, no discoloration.	No discoloration to slight pinkish red.	Red to dark red in colour.
Belly flaps:	No discoloration to slight discoloration.	Slight discoloration.	Marked discoloration.
Vent:	Normal in shape and colour.	May show slight protrusion.	Protruding and may be discoloured.

Appendix C - Standard for: Fish, Prepared, Fresh and Frozen - 32-Gp-141d, March, 1974

5.3.2. Class B - Fish fillets acceptable under this standard shall comply with the following quality requirements.

5.3.2.1. - Fillets shall not be ragged or torn and the flesh shall be firm and resilient.

5.3.2.2. - There shall be no organoleptically detectable spoilage.

5.3.2.3. - The flesh shall be free from any abnormal conditions such as chalky, jellied, diseased, parasitized or similarly affected tissue.

5.3.2.4. - Fillets shall be free from napes and belly flaps, where such is good commercial practice.

5.3.2.5. - The flesh shall be free from foreign matter.

5.3.2.6. - Fillet and fillet portions shall not contain defects such as blood clots, pieces of skin and bruises, at a rate found in good commercial practice.

5.3.2.7. - Skin-on and skin-on fillet portions shall be satisfactorily scaled in accordance with good commercial practice.

5.3.2.8. - Excepting pin bones, fillets and fillet portions shall not contain bones at a rate exceeding that found in good commercial practice.

Source - Fisheries and Marine Service, Department of Environment

TABLE I—REACH—R

Distance Moved Inches	Time TMU A	B	C or D	E	Hand in Motion A	Hand in Motion B
1/2 or less	2.0	2.0	2.0	2.0	1.6	1.6
1	2.5	2.5	[illegible]	[illegible]	[illegible]	2.3
2	4.0	4.0	[illegible]	[illegible]	[illegible]	2.7
3	5.3	5.3	7.3	5.3	4.5	3.6
4	6.1	6.4	8.4	5.8	[illegible]	4.3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	7.4	9.3	10.8	[illegible]	[illegible]	[illegible]
8	7.9	10.1	11.5	9.3	[illegible]	[illegible]
9	8.3	10.8	12.2	9.9	6.9	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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	[illegible]	19.8	16.7	11.3	15.8
[illegible]	[illegible]	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	[illegible]	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 [illegible] 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.

TABLE II—MOVE—M

Distance Moved Inches	Time TMU A	B	C	Hand in Motion B
1/2 or less	2.0	2.0	2.0	[illegible]
1	2.5	2.9	3.4	2.3
2	3.6	4.6	5.2	2.9
3	4.9	5.7	6.7	[illegible]
4	6.1	6.9	8.0	4.3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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	[illegible]
12	12.9	13.4	15.4	[illegible]
14	14.4	14.6	15.9	[illegible]
16	16.0	15.8	18.7	12.8
18	17.6	17.0	20.4	14.2
[illegible]	19.2	18.2	22.1	[illegible]
[illegible]	[illegible]	19.4	[illegible]	17.0
24	[illegible]	[illegible]	25.5	18.4
[illegible]	[illegible]	21.8	[illegible]	19.8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	24.3	[illegible]	[illegible]

Wt. Allowance Wt. (lb.) Up to	Factor	Constant TMU
2.5	1.00	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	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.

TABLE III—TURN AND APPLY PRESSURE—T AND AP

Weight		Time TMU for Degrees Turned 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

APPLY PRESSURE CASE 1—16.2 TMU APPLY PRESSURE CASE 2—10.6 TMU

igure 12. Standard time values for various classifications of motions. Times are recorded in a special time unit called a time measurement unit (TMU). 1 TMU = 0.0006 minute. Courtesy MTM Association

TABLE IV—GRASP—G

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 1/2".
1C2	8.7	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter 1/4" to 1/2".
1C3	10.8	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter less than 1/4".
2	5.6	Regrasp.
3	5.6	Transfer Grasp.
4A	[illegible]	Object jumbled with other objects so search and select occur. Larger than 1" x 1" x 1".
4B	[illegible]	Object jumbled with other objects so search and select occur. [illegible] to 1" x 1" x 1".
4C	[illegible]	Object jumbled with other objects so search and select occur. Smaller than [illegible].
5	0	Contact, sliding or hook grasp.

TABLE V—POSITION*—P

CLASS OF FIT		Symmetry	Easy To Handle	Difficult To Handle
1—Loose	No pressure required	S	[illegible]	[illegible]
		SS	[illegible]	[illegible]
		NS	[illegible]	[illegible]
2—Close	Light pressure required	[illegible]	[illegible]	[illegible]
		SS	[illegible]	[illegible]
		NS	21.0	[illegible]
3—Exact	Heavy pressure required.	S	[illegible]	[illegible]
		SS	46.5	[illegible]
		NS	[illegible]	[illegible]

*Distance moved to engage—1" or less.

TABLE VI—RELEASE—RL

Case	Time TMU	DESCRIPTION
1	2.0	Normal release performed by opening fingers as independent motion.
2	0	Contact Release

TABLE VII—DISENGAGE—D

CLASS OF FIT	Easy to Handle	Difficult to Handle
1—Loose—Very slight effort, blends with [illegible]	4.0	[illegible]
2—Close—[illegible]	[illegible]	[illegible]
3—Tight—Considerable effort, hand recoils markedly.	22.9	[illegible]

TABLE VIII—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.

Figure 12. *continued*