# Job Design for Manual Fish Processing Process Improvement



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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering in Engineering Management
(CU-Warwick)
Faculty of Engineering
Chulalongkorn University
Academic Year 2018

การออกแบบงานเพื่อปรับปรุงกระบวนการแปรรูปปลาด้วยมือ



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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
สาขาวิชาการจัดการทางวิศวกรรม ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต
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*บทความนี้นำเสนอการพัฒนาและการทดลองหลักการออกแบบงานและการยศาสตร์ตามหลักสรีรศาสตร์ให้กับโรงงานแปรรูปปลาด้วยมือในท้องถิ่นในการตัดแต่งปลาการกำจัดเกล็ดปลาและการคว้านไส้ปลาเพื่อปรับปรุงประสิทธิภาพของผู้ปฏิบัติงาน โรงงานแปรรูปปลาที่ทดลองในการวิจัยนี้อยู่ในหนึ่งในจังหวัดที่อยู่ติดกับทะเลในภาคใต้ของประเทศไทยคือปัตตานี ซึ่งอุตสาหกรรมเศรษฐกิจชั้นนำของจังหวัดนี้เป็นโรงงานแปรรูปอาหารทะเลและการผลิต อย่างไรก็ตามเนื่องจากโรงงานแปรรูปท้องถิ่นส่วนใหญ่ในจังหวัดนี้ยังคงดำเนินการผลิตผลิตภัณฑ์สัตว์น้ำด้วยตนเองพวกเขาได้รับผลกระทบจากกฎระเบียบที่เข้มงวดมากขึ้นของแรงงานข้ามชาติที่ดำเนินการ โดยรัฐบาลไทยเพื่อตอบสนองใบเหลืองที่ออกให้ประเทศไทยสำหรับกฎหมายที่ผิดกฎหมาย การทำประมง (IUU) โดยสหภาพยุโรป แม้ว่าในช่วงต้นปี 2562 ใบเหลืองนี้ถูกยกขึ้น แต่ผลที่ตามมาของกฎแรงงานข้ามชาติก็ลดจำนวนของแรงงานข้ามชาติโดยเฉพาะในโรงงานนี้ มันกำลังออกจากโรงงานกับคนงานในท้องถิ่นเป็นทางเลือกเดียวซึ่งมีประสิทธิภาพต่ำกว่าเมื่อเทียบกับแรงงานข้ามชาติสำหรับโรงงาน ดังนั้นการปรับปรุงประสิทธิภาพของคนงานจึงเป็นสิ่งจำเป็นเพื่อเพิ่มกำลังการผลิตของโรงงานให้อยู่ในระดับที่ต้องการซึ่งการวิจัยครั้งนี้มีวัตถุประสงค์เพื่อแสดงให้เห็นเนื่องจากกระบวนการที่ทำด้วยมือเหล่านี้เกี่ยวข้องกับการปฏิสัมพันธ์ของมนุษย์บทความนี้ประกอบด้วยการปรับพื้นที่ทำงานและการปรับเครื่องมือในพื้นที่การแปรรูปปลาตามคู่มือการออกแบบงานและการยศาสตร์เพื่อพิจารณาทุกมิติของการอำนวยความสะดวกในการทำงานด้วยตนเองในพื้นที่ทำงานและเครื่องมือต่างๆ ผลลัพธ์แสดงให้เห็นว่าการใช้พื้นที่ทำงานและการปรับเครื่องมือในพื้นที่การแปรรูปปลาของโรงงานตามหลักการออกแบบงานและการยศาสตร์สามารถให้ผลลัพธ์ที่น่าพอใจในการปรับปรุงประสิทธิภาพของคนงาน ดังนั้นจึงช่วยลดความเหนื่อยล้าของผู้ปฏิบัติงานในระหว่างวันเพิ่มและรักษาระดับความสามารถในการผลิตของแรงงานในท้องถิ่นเพิ่มความสามารถของโรงงานและเพิ่มผลกำไรของโรงงานแปรรูปปลาด้วยมือในท้องถิ่นแห่งนี้*



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| สาขาวิชา | การจัดการทางวิศวกรรม | ลายมือชื่อนิสิต ................................................ |
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# # 5971234421 : MAJOR ENGINEERING MANAGEMENT
KEYWORD: Job Design, Ergonomics, Fish Trimming, Fish De-scaling, Fish Gutting, Manul Fish Processing, Local Fish Processing Factory, Fish Processing Improvement

Anawat Benjalak : Job Design for Manual Fish Processing Process Improvement. Advisor: Prof. PARAMES CHUTIMA, Ph.D. Co-advisor: Assoc. Prof. Chuvej Chansa-ngavej, Ph.D.

This paper presents the development and experimental of the Job Design and Ergonomic principles to a local manual fish processing factory in fish trimming, fish de-scaling and fish gutting processes for worker performance improvement. The fish processing factory experimented in this research is in one of the provinces next to the sea in southern Thailand, namely Pattani, where the leading economy industry of this province are seafood processing and manufacturing. However, because most of the local processing factories in this province are still manually processing the aquatic products, they are affected by more stringent regulation of migrant workers implemented by the Thai government in response to the yellow card issued to Thailand for illegal, unreported and unregulated fishing practices (IUU) by the European Union. Although in early 2019 this yellow card was lifted, the consequences of migrant workers' regulations reduce the number of migrant workers specifically in this factory. It is leaving the factory with the local workers as the only option, which have lower performance comparing to the migrant workers, for the factory. Therefore, worker performance improvement is necessary in order to increase the factory capacity to the desired level in which this research aims to demonstrate. Since these manual processes involve human interactions, this paper consists of workspace adjustments and tool adjustments in fish processing areas following the Job Design and Ergonomics guidebooks considering all dimensions of manual work facilitation in workspace and tools to enhance worker capabilities. The results demonstrate that the implementation of workspace and tool adjustments in the fish processing area of the factory following Job Design and Ergonomic principles can deliver a satisfactory result in worker performance improvement. It is thereby relieving worker fatigue during the day, increasing and stabilizing local workers' productivity level, increasing the factory capacity, and increasing the profitability of this local manual fish processing factory.

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| Field of Study: | Engineering Management | Student's Signature .............................. |
| Academic Year: | 2018 | Advisor's Signature ............................. |
| | | Co-advisor's Signature ........................ |

# ACKNOWLEDGEMENTS

I would first like to thank my thesis advisor and co-advisor, Prof. Parames Chutima and Assoc.Prof. Dr.Chuvej Chansa-ngavej of the Chula Systems Engineering at Chulalongkorn University. They were always there in their welcoming offices whenever I ran into a trouble spot or had a question about my research. They allow me to take this paper to be my work but steered me in the right direction like a guiding star in the darkest sky and I am gratefully thankful for his precious comments on this thesis.

I would also like to acknowledge Aroon's local fish processing factory as an examined factory allowing the research to experiment. I would also like to thank all the staff and workers who were involved in the experiments for this research project. Without their passionate participation and input, the research experiments could not have been successfully conducted.

Finally, I must express my very profound gratitude to my parents for their supports and continuous encouragement throughout my years of study and through this research writing. This accomplishment would not have been possible without them. Thank you.

Anawat Benjalak

# TABLE OF CONTENTS

Page

# LIST OF FIGURES

# LIST OF TABLES

# Chapter 1 Introduction

With continuous developments of innovations and technologies in all areas, it cannot be denied that today machines and electronic devices are part of our lives. For manufacturing industries these days, it appears that they have been driven by modern machines and new technologies to optimize their operations. So, the manufacturing industries have been transformed from manual operations to automatic processes which reducing the number of workers involved in production lines. For aquatic products or seafood manufacturing industries, the fish processing industry has evolved a lot in terms of operation techniques when automated systems or machines replace repetitive and dull processes such as cutting, cleaning, and categorizing. However, there are some processes in the fish processing industry where manual manipulation is still necessary, which depends and varies on the type of aquatic products.

The general idea of this research is related to worker performance improvements in manual fish processing industries. This research is mainly focusing on a local manual fish processing Factory southern Thailand that is straggling from potential workers shortage due to the adjustments of labor and fishing practice by the government in response to the yellow card warning for illegal, unreported and unregulated (IUU) fishing practices issued by the European Union in 2015. Since manual processing industries would involve numbers of workers in production lines, suitable work environments in terms of facility, comfort, and safety should be concerned because people are not machines and are essential to all manual manufacturing industries, not just manual fish processing industries. Worker performance is one of the core competencies of this business and reflecting the profits.

Job Design and ergonomics principles are philosophical concepts and practices implying that the suitable workspace and job enrichment level of workers would elevate worker performances and impact the organization by improving its operational capabilities. Because these principles and practices are directly relevant to the manual manufacturing industries, they will be used as core research approaches, guidelines, and references that are experimented in an examined fish processing Factory.

So, this research intends to study the impacts of job enrichment levels of workers and suitable workspace improvement to the performance of workers in the local manual fish processing factories. They are contributing to solve the problem of low-performance workers, which is what the factories are struggling with, in this region.

## 1.1 Background

This section is to provide additional information for the examined manual fish processing factory. The following sections are describing the background of this examined manual fish processing Factory, its general processing steps as well as challenges of manual seafood processing industries in the region have. This section will also explain why the principles and concepts of improving suitable workspace and job enrichment levels of workers in manual seafood processing industries in this region is a critical situation and in need of more researches and studies on worker performance improvements.

### 1.1.1 Examined Fish Processing Factory General Information

For cities that are geographically close to the sea, seafood products are likely one of the primary economic industries for them. So, in this research, a local manual fish processing factory located in Pattani, which is a seaside province in the south of Thailand shown in Figure 1, is where the research is going to be conducted.



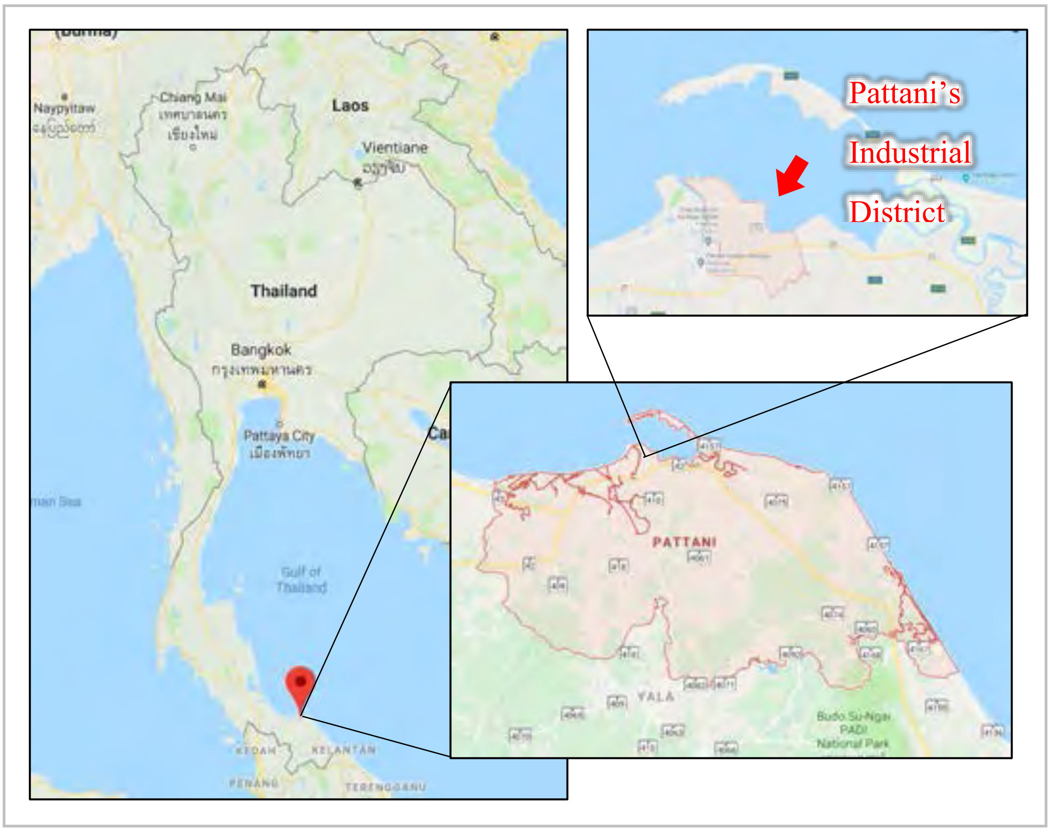



***Figure 1*** *Geographical illustration of Pattani province in Thailand and its industrial district where the examined local fish processing factory is located*

In this province, there are numerous seafood processing Factories established. It consists of a few fully processing system Factories transforming raw seafood products to ready-to-eat meals and smaller Factories which are subsidiary companies performing specific seafood processing functions. Typically, fresh seafood from the fish market or imported frozen seafood from overseas will go through production lines for processing. Then, those sea products are either frozen for exporting globally or being transformed into a different form of products for selling nationwide. However, most of the seafood processing factories in this region are still in manual operations regardless of technologies and innovations of modern automated tools or machinery.

Additionally, the manual fish processing Factory that the research is going to experiment used to process squids for a couple of years before it changed to process fishes for a couple of years. It is a local medium-sized business having up to 60 workers and who is a sub-contractor performing fish trimming, scaling and gutting functions supplying to one of the biggest canned seafood factories in the Pattani.

### 1.1.2 Examined Fish Processing Factory General Process Steps

The general processing steps of this fish processing factory is shown in Figure 2. Starting with frozen blocks of fishes is defrosted if there are no fresh fishes on that order. Then, fishes are trimmed, got scales removed, and got guts removed. After that, the quality and weight of the processed fishes are checked and measured before delivering back to the customer, which in this case is a bigger factory that manufactures canned food products.

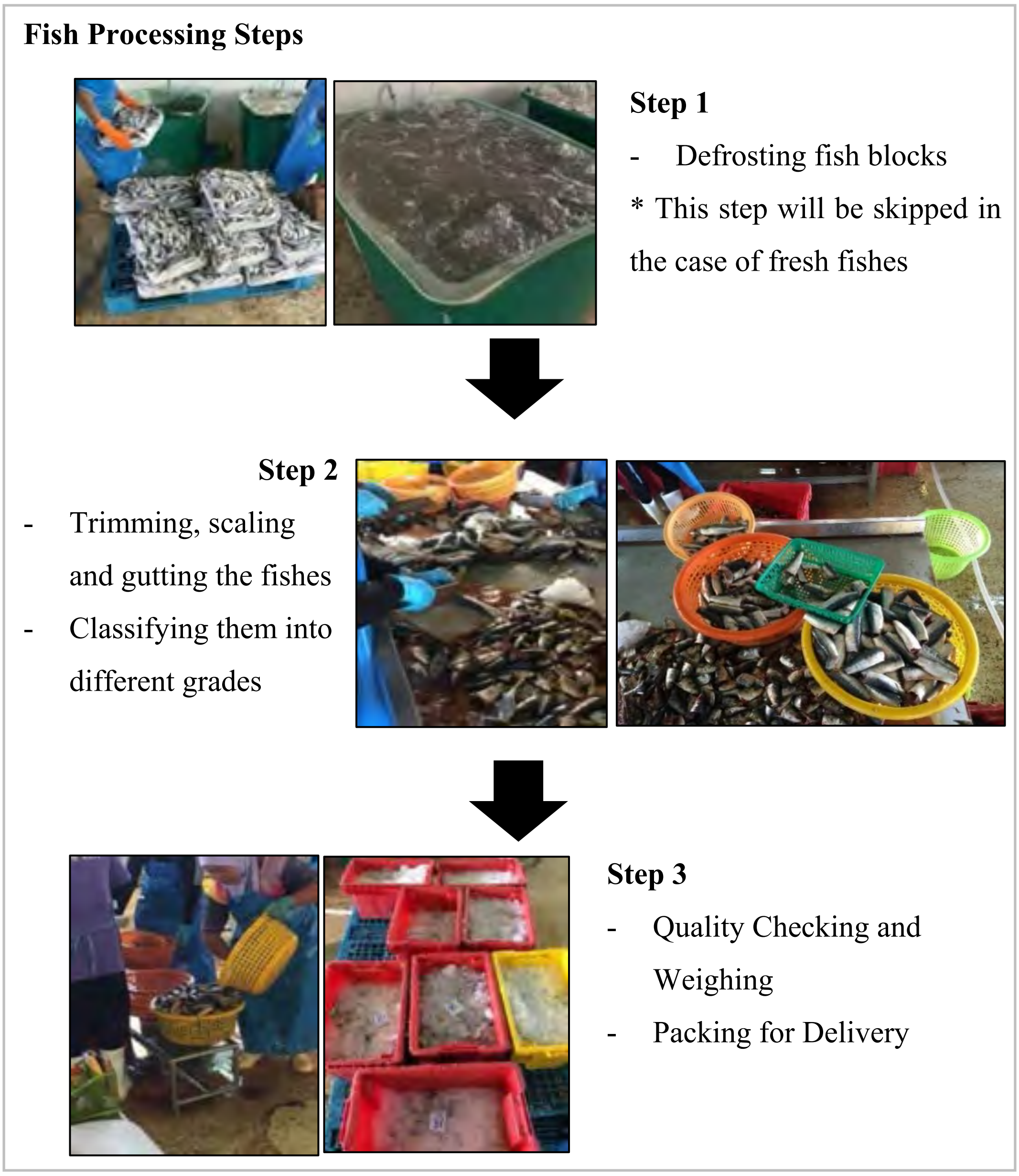



***Figure 2** General fish processing steps of this examined factory*

From Figure 2, the layout of this fish processing factory is, therefore separated into three main areas according to the general processing steps. Those are the defrosting area, processing area, and checking area. However, the most populated area where the majority of the workers are is in the processing area. All worker in this area is assigned to do processing tasks or activities such as fish trimming, fish scaling, and fish gutting in allocated tables or workstations.

The unique part about this fish processing process is at the gutting task where the fish intestine must be removed without breaking or opening the fish belly. Typically, Fish guts removal can be done only from the body cross-section after the head is removed. Thus, if there is going to be a machine for this task, which of course it is possible, there is going to require a decent investment of time and money to develop this machine.



In terms of revenue generation, this local fish processing factory is gaining from the kilogram of fishes processed daily in which segmented into two main categories, A-grade, and B-grade fishes. These two grades have two different pricings, which are 3 and 1 Baht per Kilogram for A-grade and B-grade fishes, respectively. For workers, they are getting paid from the factory the same way factory gets paid from customers but in half of the amounts. For example, if one Kilogram of fishes is processed, factory and workers will both gain 1.5 Baht for A-grade fish and 0.5 Baht for B-grade fishes. For this factory, it is called a Fifty-Fifty gaining model where workers and factory split the amount of gaining by half.

### 1.1.3 Justification of Manual Process Conservation

According to a reliable source of information from this examined local fish processing factory insight as well as observations throughout the seafood industry in this region, the reason for most of the seafood processing factories are still operating manually is as follows.

1. Too unique and complicated processing task for general seafood processing machines available in the market.

2. The investment cost for machinery is not affordable for small local factories.

3. Rotating a variety of marine products to be processed depending on the seasons, customer orders and contracts which have different level complexities and methods to process.

Because most of the seafood processing factories in this region are local family businesses, in other words, implementing automated production lines and specific processing machine is a considerable investment for them. Although an automated process is convincingly able to reduce long-term operating cost by reducing working hours and increase capacity of the factory, but it is not in the case for rotating variety of marine product types to be processed by a factory which means small factories will only process the marine product according to the customer orders or contracts.

For example, one customer, which is the bigger factory, has a contract with a local seafood processing factory to process squids for two years. However, after that, it is changed to sardine processing for three years, which has completely different methods, different levels of complexity, and different tools. Therefore, if a machine is to be used here, the factory would have to own or rent several machines to compromise the change of processes or tasks.

So, considering this aquatic product type dependency, having skillful workers who can perform all kinds of products is safer for a local seafood processing factory in terms of cost and risk of machinery utilization. Therefore, this indicates that workers are the core business competency of the manual seafood processing factories in this region.

### 1.1.4 Examined Fish Processing Factory Business Goals

From the perspective of this manual fish processing factory, what matters to create profit and keep business running is the total weight of fishes in kilograms per day that could be processed by the factory or its daily capacity. In other words, the factory capacity determines its revenue gained. So, increasing factory capacity equals to increasing factory incomes.

As this is a business, not a charity, the factory sets up a goal to gain more profit by increasing its capacity. There are two ways that the factory can do to increase its capacity as follows.

1. To increase the number of workers
2. To improve worker performance

Notice that they are all related to the workers. That is because workers are the engines if this business is a car. To make it goes faster, it is either to increase the horsepower or to make the engine more efficient.

### 1.1.5 Challenges of Examined Fish Processing Factory Business Goals

There are obstacles blocking the factory business goal to increase its capacity. The first obstacle is space limitation, and this is due to the size of the factory where there is a limit to the number of workers occupying the workstations. So, the idea of increasing the number of workers to increase factory capacity is restricted because all the space is almost fully occupied. Otherwise, the factory has to be expanded for more space, but that comes with a massive investment in building the contractions and facilities which is not yet likely to be considered by a small local factory.

Secondly, according to the Thailand Migration Report 2019, it has been an issue due to the status of the Thai fishing industry. It had received a “yellow card” warning that could face a ban on exporting seafood to the European Union because of its illegal, unreported and unregulated (IUU) fishing practices. It leads the Thai government to get rid of outdated fishing laws and issuing a new ordinance to regulate the fishing industry through the adoption of the 2014 Ministerial Regulation concerning Labor Protection in Sea Fishery Work. The government extended the application of the critical provisions of labor law regulating wages and conditions of work to fishing vessels. Migrant fishers and labor in this fishing industry were required to have legal documents.

With this licensing requirement, migrant fishers and workers must hold their identification documents, receive and sign a written contract, and be paid monthly. It leads to migrant fishers, and workers are frustrated by employer practices which hold them in debt bondage which they cannot change employers. It results in reducing the number of migrant workers in this region. This is shown in Figure 4, where the number of migrant workers in this fish cutting factory is significantly reducing to almost not existing from 2015 to 2019.

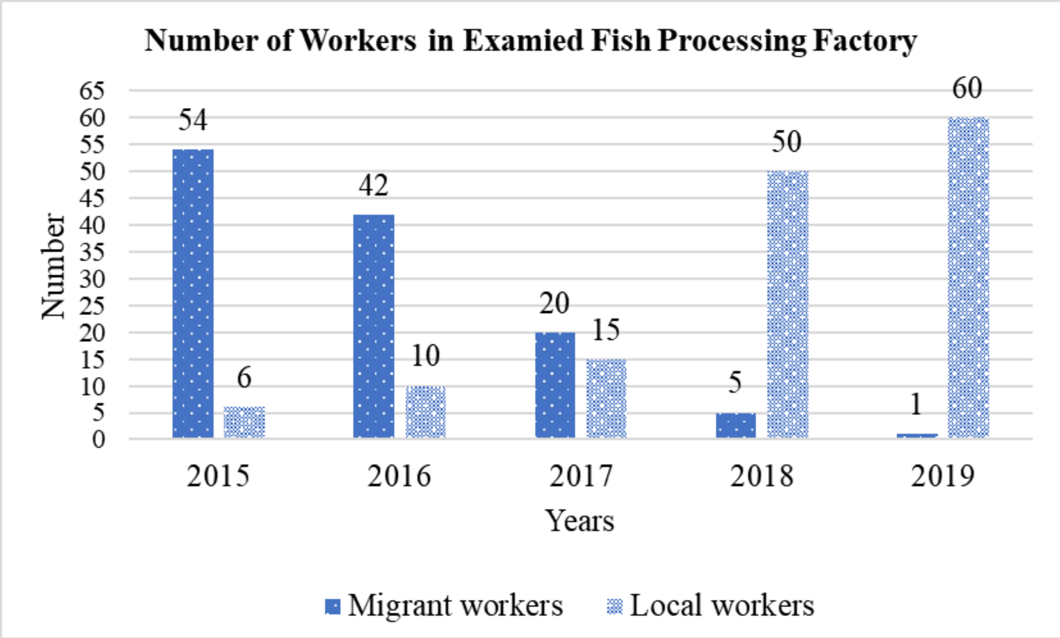



***Figure 3*** *Number of workers in this examined fish processing factory from 2015 to 2019*

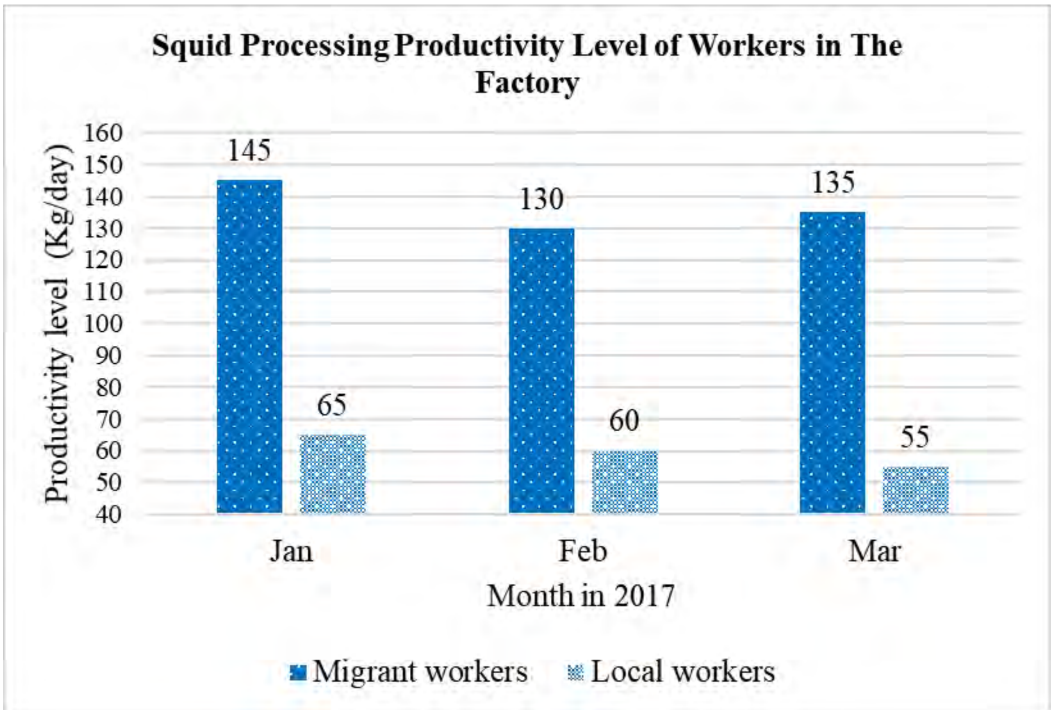



***Figure 4*** *Squid processing productivity level of workers in the examined factory in January to March 2017*

As a result, it leaves the factory with local workers to be hired. This issue is one of the factory obstacles because there is an enormous difference in performance between migrant and local workers. Local workers are generally having lower performance shown in Figure 3, which comparing local and migrant worker performances on manual squid processing from January to March in 2017 is illustrated.

Though, the diagram in Figure 3 showing numbers for squid processing, which is not what the factory is currently doing, it gives useful information to recognize that it is about three times of performance differences between local and migrant workers.

### 1.1.6 Examined Fish Processing Factory Focus

To compromise the obstacles of examined fish processing factory mentioned in the previous section and still serving the goal of the business, which is to increase its capacity, it leaves the factory with the only option which is to enhance the performance of workers.

However, the considerations of performance improvement in workers seem not to be fully adopted and practiced by this factory and the factories in this region as they used to be relying on the migrant workers who already have high motivation and performance. So, it is no doubt that recruiting more migrant workers was more comfortable and a preferred option for them formerly. However, that is not in the case anymore. Due to the shortage of high-performance workers, available local workers are the only choice.

That is why the idea of improving worker performance, particularly in local workers, would ideally fit the factory goal and the industry situations. So, this research would be beneficial to both the factory and local workers in the sense of if it shows a success signal, the factory will have its capacity increases, and local workers can perform better which means to earn more.

## 1.2 Problem Statement

With the situations of the Thai fishery industry, which is threatened by the European Union, it forces the Thai Government to control and regulate the fishery industry in Thailand strictly. Its consequences in reducing the number of potential migrant workforces that effecting the fish processing factory capacity in this region.

So, in order for this local fish processing factory to hit the target of increasing its capacity and at the same time still pursuing the regulation of Thai Government instead of just keep on adding local workers, which has become limited in space, to compensate the capacity discrepancy due to the migrant workers expulsion, this factory must pay more attention to the local workers and find ways to improve their performance and efficiency level.

In summary, the low performance and efficiency of local workers in this examined fish processing factory and other similar factories in the same region results in blockage, and low incremental rate of factory capacity and revenue gained.

## 1.3 Research Question

From the problem statement as well as the factory goal and focus, workers are the essential element for the examined manual fish processing factory. In order to enhance these local worker performances, the factory must work around all the factors that would impact their performances. For example, motivations and accommodations. In the case of works or tasks involving human interactions, there is a philosophical theory called Job Design describing different angles of worker encouragement at work and how to fit the right jobs to workers and vice versa. In the case of more manual work accommodations, Ergonomic principles are the design principles for optimal working postures. So, this leads to the research questions as follows.

1. Do the implementation of Job Design and Ergonomic principles to this manual fish processing improve worker performance?

2. Do the implement of Job Design and Ergonomic principles to this manual fish processing improve factory capacity?

3. Do the implement of Job Design and Ergonomic principles to this manual fish processing cost-effective?

For the first question, it is the question of quantitative measurement of worker performance in terms of productivity and efficiency levels. The second question is related to the quantitative changes in the capacity of the factory affected by the implementation of Job Design and Ergonomic principles. Lastly, the third question is the quantitative financial relation of implementation cost and the revenue and profit created before and after Job Design and Ergonomics principle are implemented on the process. The third question is essential to the factory in whether to adopt the methodology of this research. Regardless of a very successful outcome, if it comes with substantial investment at once and takes too much time for returns, the factory would not be able to afford anyways, as mentioned earlier.

### 1.4 Hypothesis Development

According to the research questions mentioned in the previous section, several hypotheses can be developed based on the existing knowledge and evidence as follows.

1. The improvement of worker performance can be achieved through a suitable implementation methodology of Job Design and Ergonomics principles.

2. The capacity of the factory is raised relative to improving worker performance.

3. Implementation of Job Design and Ergonomics principles increases the revenue gain of the factory which creates the return on investment (ROI) within a month.

As the ROI is the measurement of percentage or ratio of investment return in a designated time, a return of all investment within one month the third pint of hypotheses is what this examined fish processing factory is desired.

### 1.5 Research Objective

Since the expectation of this examined manual fish processing factory is to find alternative possibilities to improve worker performance. Therefore, the objective of this research is to demonstrate that implementing Job Design and Ergonomic principles in manual fish processing factory improve overall worker performance in the processing area, which leads to increasing of the factory capacity.

To reach this objective, the following tasks are aimed to be carried out in this research.

1. Investigating and understanding the current fish processing steps, especially in the processing, are. Then, pinpointing some crucial pain points of the process that slow process down or at what point workers feel uncomfortable.

2. Studying application and implementation case studies of Job Design and Ergonomic principles to design and apply the most feasible concepts that fit this manual fish processing factory in the processing area.

3. Extracting and measuring data and changes in worker performance and behaviors quantitively.

4. Analyzing and discussing the results that are captured and come up with the conclusions of if Job Design and Ergonomic principles answer all the research questions and turn out as the hypotheses.

## 1.6 Scope of Research

The research will be focusing solely on implementing Job Design, and Ergonomics principles to the processing are where workers are usually standing and manually manipulating fishes in the designated workstation, which is one of the central processing areas of this manual fish processing factory apart from defrosting and quality checking area. In this processing area, it includes fish trimming, scaling, gutting, and categorizing activities or tasks.

The reason for this is because Job Design and Ergonomic principles can be applied at any level of an organization that involves human beings. However, the factory aims to increase the capacity, which is in a relationship with the rate of fishes being manually processed by workers in kilograms per day. So, for this research, the focus should be on workers who are in the processing area where the steps before and after this area are not in the scope.

## 1.7 Research Contributions

In terms of academic achievements, this research contributes to evidence supporting the ideas of worker performance improvement in the manual work industry. By implementing Job Design and Ergonomic principles, which are the subjects that have been continuously studied and applied in numerous industries, the results of this research could verify the feasibility of these principles and concepts as well as could be useful for further research and study on worker performance improvement in other similar industries.

In terms of business achievements, this research work is contributing to optimize the benefits of manual seafood processing industries. Improving worker productivity and efficiency are expected to sustainably increase profits as the production volume, and the quality of workers is increased. Secondly, the outstanding performance of workers from the process improvement would strengthen the core competency of the factory.

## 1.8 Guide to The Subsequent Chapters

Throughout this paper, it consists of more essential chapters. Those chapters are Literature review, methodology, Result, Analysis, Discussion, and Conclusion. For the next chapter, which is the Literature review, the principles and concepts of Job Design and Ergonomics in manual work industries will be unfolded. This is to understand and refer more on to theoretical and practical applications of these principles and concepts which helps to appropriately design and adopt methods of research implementations fitting to this specific factory and industry. The methodology section is describing how this research is going to be conducted. It is vital for research to have precise methods, plans, and scopes. So, the direction and focus of the research are maintained. For the Result and Analysis chapter, they are the first chapter of this research. Throughout this chapter, there will be a journey that begins with data collections from experiments. Then, those results and measurements are evaluated through quantitative analysis and visualization. After that, critical discussions on research findings are made according to the data collected, and that leads to the conclusions in which the research questions are answered determining the successfulness of the research. In the end, it will also discuss the area of improvements and what could build on top of this research results for an ultimate benefit for the local manual fish processing industry in this region.

# Chapter 2 Review of Literature

This chapter is consisting of theories, concepts, and similar examples of Job Design and Ergonomic principles implementations that are used to study for the research. The general idea of this research, as mentioned earlier, is associated with worker performance improvement in manual fish processing factories. That means everything that involves worker interactions in the processing area is considered.

When thinking about worker performance improvement in the manual fish processing process, the measurement benchmarks are the quantity and quality of the productions. In this case, it is the number of fishes going in and out through the processing process in a certain amount of time. Imagine if this process is a processing box, the rate and quality of the product going through is the performance of the box which in this case is the capacity of this examined fish processing factory that the research general idea aims to improve. Because processors in the box are the workers, this means the research must find ways to influence those worker performances impactfully to improve factory capacity.

However, the process improvement in terms of worker performance is not a new topic. It is one of the basic terms and general practices that the manufacturers concern in order to improve their operations, reducing cost, and creating flexible capacities. Because of this importance of worker performance improvement, it has drawn attention from many academic researchers to study, experiment and develop some concepts, principles, and critical practical approaches in various perspectives that are useful and adaptable for this examined manual fish processing factory which too is discussed in this chapter.

Without a doubt, when thinking about influencing workers at work, what comes in mind is that the amount of pay motivates workers. Pay rate indeed is one of the motivation factors, but that might not be a sustainable and affordable way in this case as a local and small factory may not able to increase the pay rate because that would increase the cost of the business operations and reduce the factory earnings. So, alternative ways to motivate workers must be applied.



## 2.1 Job Design Concepts

There has been a lot of studies and researches on worker performance improvement in manual processing industries. In relevant to that, Job Design and Ergonomics are common principles that have been developed and applied to manual work processes in term of worker performance and job satisfaction improvement.

### 2.1.1 Job Design Definitions

As mentioned, the Job Design is not new, and it is essential to study its definition as well as the origin of it. According to Oldham & Fried (2016), which reviewed past, present, and future of Job Design, Job Design was a management philosophy first developed by Taylor (1911) back in the old days. The basic idea of job design in the earlier stage was a concept of simplification or standardization of work in which unnecessary movements are eliminated.

Then, there was another Job Design philosophical concept, namely the Motivation-Hygiene theory developed by Herzberg's (1966). This theory argued the earlier definition that that worker performance and job satisfaction would be improved if the work is enriched rather than simplified. This means that apart from the process standardizations, Job Design should also cover the motivation of workers who are the ones operating the process. This theory has mentioned more sophisticated points in which an excellent Job Design should have. For example, the Hygiene Factors, which are the factors that a business should have as a baseline for the workers, including company policy, supervision and relationships, working conditions, salary, and security. Another is motivation factors, which building up on top of the baseline for workers to work encouragingly, includes achievement, recognition, interesting work, increase responsibility, and advancement and growth.



### 2.1.2 Job Design Frameworks

Then, there is a model called Job Characteristic Model (JCM) developed by Hackman & Oldham (1976, 1980). It has overcome the Motivation-Hygiene theory with five core job characteristics and three critical psychological states that lead to the outcomes, see Figure 5. It is investigation deeper into job characteristics concerning alternative outcomes or worker motivation and job satisfaction level. Moreover, this is a model that has been used in job design research until the present day.

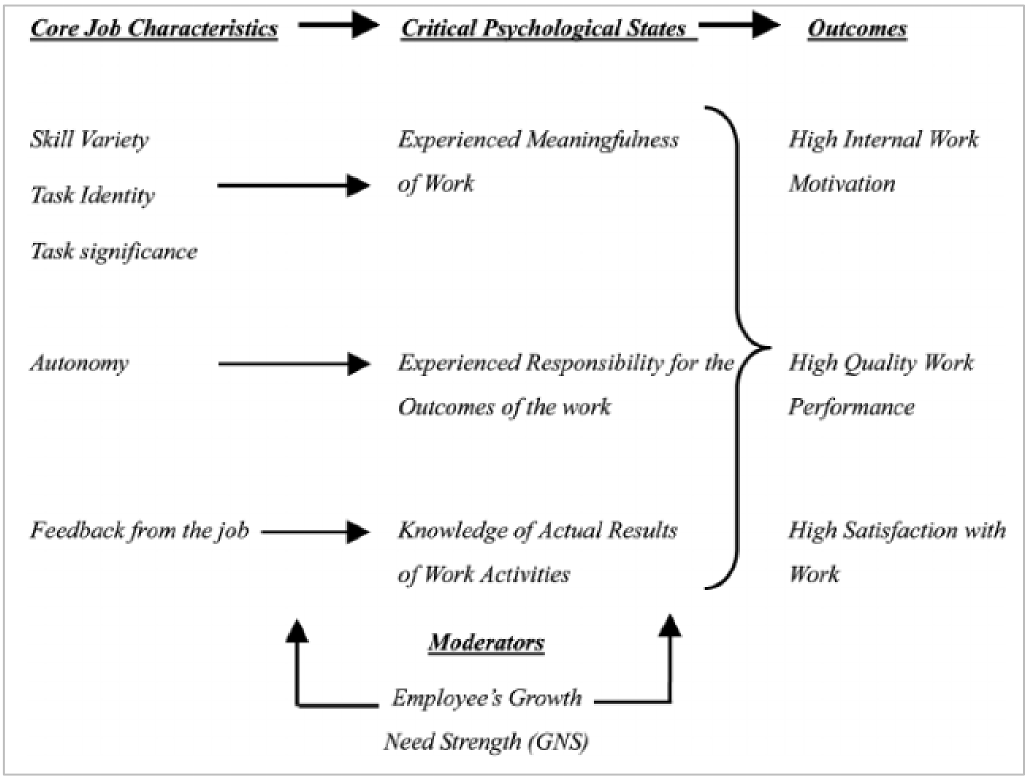



***Figure 5*** *Hackman-Oldham job characteristics model*
*(Adopted from Garg, Pooja & Rastogi, Renu., 2006)*

A necessary explanation of Job Design with Job Characteristic Model is that Job Design is a term of producing a better business outcome from a proper job characteristic configuration considering five areas. The different between JCM and Motivation-hygiene theory is that JCM structures the Job Design concepts in terms of cause and effect and put into an understandable framework but still having the same essences. From Figure 5, JCM has segmented into three areas those are the five core job characteristics that a business should have as an excellent Job Design practitioner and described separately in terms of three critical psychological states in which workers would gain and feel from the core job characteristics. Following the outcomes that the business will obtain.

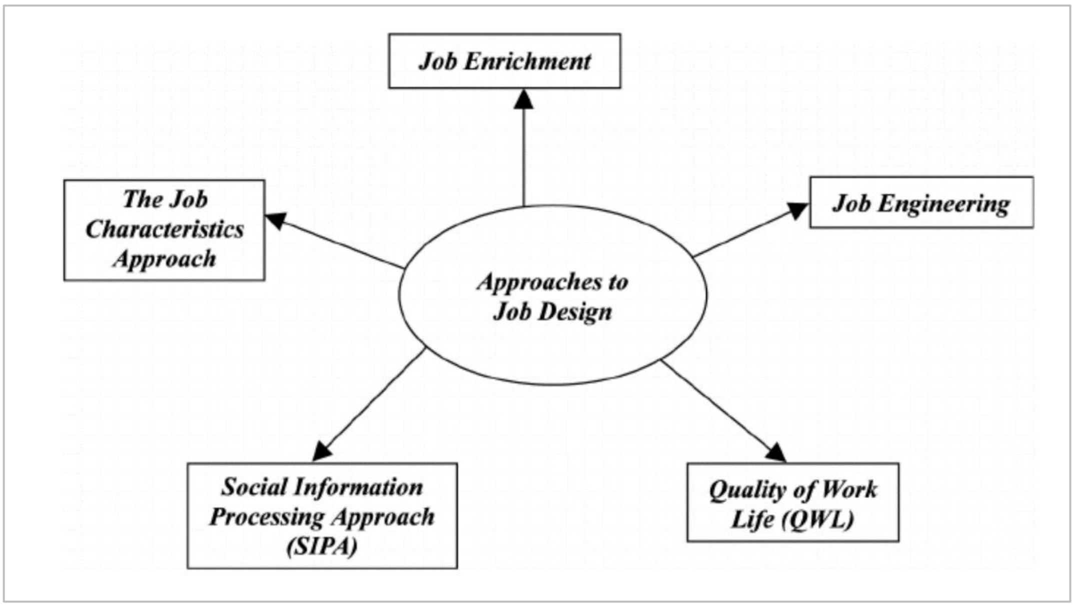



***Figure 6*** *Approach to job design diagram*
*(Adopted from Garg & Rastegi 2006)*

Nonetheless, there is another context from Garg & Rastegi (2006). It has given a new model of Job Design to motivate worker performance and the approach of Job Design illustrated in Figure 6.

This Approach to Job Design consists of five elements as follows.

1. Job enrichment
2. Job Engineering
3. Quality of work-life
4. The social information processing approach
5. Job characteristics approach

It recognizes that all factors and perspectives that affect worker motivations for the manager or industrial owner to consider. Like the JCM, if the five elements of this Job Design Approach are reinterpreted, the meanings and contents are comparable to JCM., Especially the Number 5 element, it is the JCM itself. So, this framework is another simplified version of Job Design concept which still contains the essence of previous concepts and adds more understandability by dimensions users the areas where Job Design should be implemented.

### 2.1.3 Applicable Job Design Dimensions

After all the information and definition of Job Design, it indicates that the meaning and implication of Job design has been evolved along with the job characteristics. For instance, the first definition of Job Design is job simplifying, which if looking at that period, it was in the Industrial Age, where workers would perform one function in the process. So, the simpler the job is, the faster the process. Then, with the invention of tools and automated machines, the characteristic of job involving workers and human interactions has changed to be more complicated as their jobs were replaced by machines or automated system for simple and repetitive tasks. That is why Job Design definitions, concepts, and approaches must cover more in the aspects of job satisfaction and motivations in workers.

However, for this research that aims to study the improvement of worker performance in manual fish processing factory, Job Design approaches and concepts would be limited by the constrains from industry natures. As the scope of the research is focusing on the fish processing area in the factory, which includes fish trimming, scaling, and gutting, the characteristic of the job in this process is not too complicated.

It has a little complexity in one of the tasks, which is fish gutting, where hard to be replaced by an inexpensive, simple machine available in the market.

So, there are dimensions from those Job Design frameworks that seem to be implementable in this manual fish processing factory for triggering the worker motivations and leading to their performance improvement. Those Job Design dimensions are as follows.

1. Working condition and achievement from Motivation-Hygiene

2. Task significance and autonomy of Core Job Characteristics from JCM

3. Job Engineering and Quality of work-life from the Approach of Job Design

The fundamental consideration of these dimension selections is that apart from increasing worker pay rate in this examined manual fish processing factory, what seems motivate workers are better working environments, tools, and workstations. So, it can be concluded that the Job Design for this manual fish processing factory is the right condition to work that would encourage workers to feel in control, increase in capability and make them perceive that it is possible to achieve more and gain more.

## 2.2 Ergonomic Principles

After Job Design concepts are reviewed, it comes up with an assumption that to improve worker performance in the manual fish processing process area in this examined factory is to provide the right working conditions and facilitate workers with better equipment. So, Ergonomic principles are practical ways to do so as the definition of the term Ergonomics implies describing next.

### 2.2.1 Ergonomics Definitions

One definition of Ergonomic practices in the workspace given by Fernandez (1995) is that it is a study of workspace and tools modification in consideration of physiological and biomechanical capabilities to optimize the efficiency of the work system. Additionally, ergonomics in workplace design principles are listed and proven to be effective in terms of work system improvement.

Moreover, according to Bergamasco et al. (1988) in the guideline for designing job featuring repetitive task, the term Ergonomics is described as principles to minimize the work-related musculoskeletal disorder or the risk of injury at work and proposing three designing measures for the Ergonomics application as follows.

1. The structural measure concerns the awkward posture and movement of the worker at work.

2. Organization measures which, concerns the activities of workers in the workspace and interaction of workers to the equipment or tools.

3. Training and re-training measure, which is the measure to support and monitor the previous two measures.

So, this guideline suggests that discovering and analyzing manual work levels and conditions for a specific industry must be done first. This is because the different industry has a different level of manual work and it is also essential to understand and figure out the right spots to implement Ergonomic principles accurately and optimistically.

### 2.2.2 Ergonomics Guidelines

Practically, there are a lot of guidebooks available to approach the ergonomic work environment. For example, the guidebook of Easy Ergonomics, A Practical Approach for Improving the Workplace by OSHA Consultation Service, Education and Training Unit (1999) and Ergonomics Guidebook for Manual Production Systems by Rexroth Bosch Group (2012). These books contain much information related to the ergonomics design rules such as the consideration of body height, work is, reach zone, parts presentation, range of vision, lighting, equipment adjustments. However, there is one handbook written by MacLeod (2013) that seems to be the most feasible guideline for this research as it points out ten distinct Ergonomic principles as follows.

1. Work in the natural posture
2. Reduce excessive force
3. Keep everything in easy to reach
4. Work at proper heights
5. Reduce excessive motions

6. Minimize fatigue and static load

7. Minimize pressure points

8. Provide clearance

9. Move, exercise and stretch

10. Maintain a comfortable environment

Nonetheless, these ergonomics handbooks and guidelines have things in common when it comes to the Ergonomics design rules. For instance, they are considering all the senses of safety and comfort. However, these ten ergonomic principles from MacLeod (2013) handbook seem to be most viable in combination with the three ergonomic measures from Bergamasco et al. (1988) for this research. This is because detailed descriptions of each Ergonomic points are fully provided, summarized, and visualized into an easy-to-follow structure as well as its gives complete recommendations and suggestions in which could be essential references throughout the research. See Appendix 1 for the detail descriptions of Ergonomic principles from MacLeod (2013).

### 2.2.3 Approach to Ergonomic Principles Application

In this case, for this examined manual fish processing factory. What can this research make use from the three Ergonomic measures and the ten Ergonomic principles are firstly to follow the first and second measure of Ergonomics design which is to investigate the current posture of fish cutting process by referring to the ten

Ergonomic principles to find out the malpractices both in the task itself and workstations. Then, according to the third point of the Ergonomic design measure, identifying adjustments, tools, and extra equipment to solve those malpractices and finally to monitor if those adjustments fit with this manual fish processing.



## 2.3 Practical Ergonomics Research Examples

For more evidence of Ergonomic principles used cases, there is a public domain report on practical demonstration of Ergonomic principles by Moore et al. (2011) describing and demonstrating Ergonomics with experiments. One of the experiments is on the effects of postures on muscle activity in different parts of a human body by using electromyography devices to measure muscle signals in activities of different postures. The results turned out that the postures that create strong signals to the muscles insert some fatigue to the body. So, to perform tasks ergonomically, it is to use natural postures and not limit to the awkward postures for an extended period. For example, in the keyboard set-up, the ideal position should have no tilt between the wrists and arms at all. Also, in the standing work posture, where the result shows that it is best for the shoulder and upper body muscles if the elbows are parallel with the body. There are still a lot of more exciting experiments in this report, which is useful for a practitioner as the concepts and principles are proven to be true.

There are similar research works to this Job Design and Ergonomics in manual fish processing processes that have been published and could be used as a guideline for this research. There are for examples, an Ergonomic approach for Modifying the Workstation Design of Food Processing Enterprises by Kumari (2018), Identification of Ergonomics Risk Factors in the Fishery Industry by Yusuff et al. (2008), Harmful

Postures and Musculoskeletal Symptoms Among Fish Trimmers of a Fish Processing Factory in Ghana: Quansah (2005), and Ergonomics Application to Work Design on Seafood Processing Line by Nguyen (2016). These four pieces of research have the same goal that is to analyze the postures of workers in manual seafood industries then modify the workspace, tools, and environments to investigate the reduction of injury risk and the changes in workers efficiency. However, they have used a slightly different method to measure and score the posture of workers. Those methods are called the Quick exposure checklist (QEC), Rapid Entire Body Assessment (REBA) analysis, and Rapid Upper Limb Assessment (RULA). The results of these researches turned out into a similar miner. That is when the Ergonomics principles are applied, the scores of theses analysis are better in a way that workers feel less pain to their body, which helps to reduce the risk of injuries. Additionally, these similar researches have some recommendations of workspace modifications for an optimal work position, which would be highly useful for this research as they are the experiments from the closest industry.

The difference that this research has from theses similar researchers is that it does not only concern about impacts affecting workers in the production line in terms of risk of injury reduction that Job Design and Ergonomics create because it is already shown that it is true. However, this research is considered more on how the proper working spaces resulted from Job Design and Ergonomics implementation create value to the business which in this case are worker performances and the factory capacities.

## 2.4 Literature Review Conclusion

Job Design is a concept with frameworks for job satisfaction in workers concerned by the manufactures. Workers will superlatively enrich their jobs if all the dimension of Job Design is reached. However, all dimensions may not apply to all jobs due to the unique limitations and constraints that each job has. Nonetheless, accomplishing a feasible dimension that suits the situations and conditions would already create benefits to the business. On top of that, it can be said that Ergonomic principles are part of Job Design concepts. It is a practical guideline supporting the workspace design, which improves capability and comfortability at work of workers and allows the worker to achieve more.

To conclude this chapter, Job Design, and Ergonomic principles are more than just to motivate workers by giving rewards or more pay rates. They are the process improvement design frameworks that account all angles in terms of what a person as a worker needs in order to effectively and encouragingly perform the tasks. This convincingly would create a win-win situation for both workers and ultimately the business which is what this research intends to demonstrate as its objective.

# Chapter 3 Research Methodology

This chapter intends to explain how this research is going to be conducted comprehensively. From the objective and scope of research. Which aim to demonstrate that improving and adjusting the process in manual fish processing factories following Job Design and Ergonomics principles lead to improving worker performances and factory capacities. With the support of information and evidence from the Literature reviews chapter, approaches to implement the Job Design and Ergonomic principles, particularly on this manual fish processing factory, are attained. The flow of general methodology for this search is shown in Figure 7 below.

**Research Methodology**

**Realization**

- ❖ Recognize the current situation of the factory
- ❖ Study processing and operating steps completely

- ✓ Factory goal and focus
- ✓ Description of a complete processing flow

➡

**Analyzation**

- ❖ Analyze the current processing steps with Job design and Ergonomic principles
- ❖ Identify malpractices and pain points
- ❖ Suggest areas of improvements

- ✓ As-is analysis
- ✓ Identification of malpractices and pain points in the process
- ✓ Identification of feasible adjustment areas
- ✓ List of feasible adjustments

➡

**Examination**

- ❖ Develop experimental groups, environments and measurements
- ❖ Implement the adjustments
- ❖ Observe and collect data

- ✓ Experimental group set ups
- ✓ Measurement of parameters
- ✓ Records of results collected, and changes observed
- ✓ Result verifications

***Figure** 7 Research Methodology Flow*

From Figure 7, the methodology is broken down into three extensive steps representing the approach of how to apply Job Design and Ergonomics principles in this research. Start with a complete description of the current fish processing process following by an As-is analysis which identifies and investigates Job Design and

Ergonomics malpractices in this manual fish processing process. Then, the work process and environment modifications according to the analysis are designed describing in the Implementation Methods topic. After that, tracking, observing, and supervising workers performances and behaviors are explained in the Data Gathering section. These are the steps adopting from the three ergonomic design measures by Bergamasco et al. (1988) in combination with the tasks in the research objectives, which is to know the situation, fix the pinpoints and monitoring the results. Before last, implementation cost estimation is going to be calculated. This is another important topic for identifying the cost-effective of the Job Design and Ergonomic implementations on this manual fish processing factory. Finally, the research Timeline is shown.

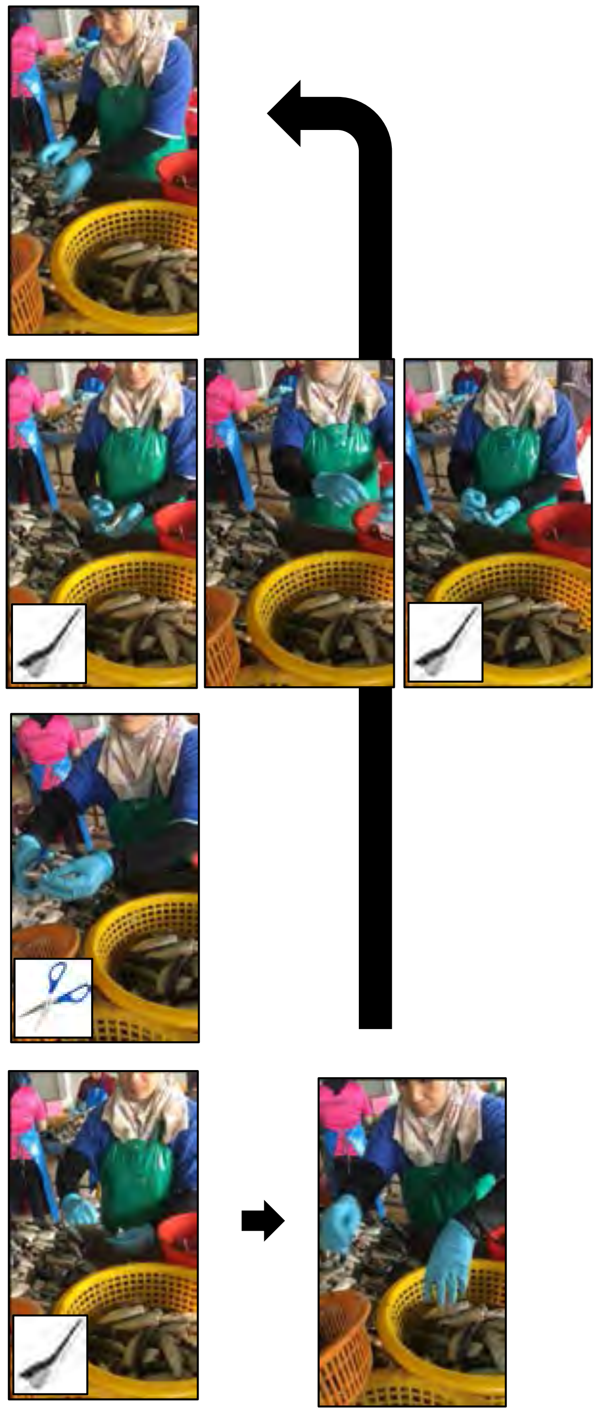
## 3.1 Fish Processing Area Process Description

For any improvement design works, it is essential first to understand, experience, and visualize what and how the ongoing process is because this would increase the accuracy and effectiveness of later analysis of the work process and environment.

As mentioned earlier in the cope of research in the Introduction Chapter that the focus area of improvement is at the fish processing area where most of the population is concentrated and as it is the core competency of the factory. This manual fish processing can be split into five observable activities, as illustrated in Figure 8.

**Fish Processing Are Process Flow**

1. Grab the fish from bulk of fishes on the table
2. Remove fish scales
   - One side
   - Clean spoon
   - Another side
3. Switch to scissor to trim fish head and tail
4. Switch to spoon to remove fish guts



5. Categorize and put the fish into the basket according to its grade

***Figure 8*** *Usual processing flow in processing area of examined manual fish processing factory*

Additionally, it depends on the seasons, whether fresh or frozen fishes are going to be processed by the factory. Typically, the first half of the year would have more fresh fishes. In this case, if they are fresh or frozen fishes, it will not affect the overall research conduction a lot because the defrosting process would be generally operated in advance which would not create a delay to the later processes and the fishes after defrosting are almost has the same texture as fresh fish. Therefore, this makes no difference for workers in terms of the texture and could be neglected for worker performance influencing factors.



After the fishes have gone through the defrosting process regardless if they are fresh or frozen, workers are assigned with the task to cut and clean those fishes. Referring to Figure 8, those five fish manipulating activities are explained as follows.

1. Grabbing the fishes

The first activity is when fishes from the deforesting process are transferred to the workstations and placed on top of the working table in front of each worker. Workers reach out to grab a fish from a bulk of fishes one by one onto their one palm and with a small stainless spoon on the other hand.

2. Removing the fish scales

In the second activity, workers then use the spoon to remove scales by grabbing the bowl side of the spoon and use the handle side of the spoon to slide along the fish body against the scale’s direction. The de-scaling is done for both sides of the fish bodies but, in between de-scaling, workers must clean the spoon to get rid of the fish scales that stick on the spoon by using water in a side bucket on the table.

3. Trimming the fishes

The third activity is when workers switch the tool in their hands to a long shape scissor to trim the head and tail of the fishes according to the size required by the customers. The trimming must be done very accurately at the right spot to get the sized desired. As well as the scissor must be very sharp because it will ruin the cross-section tissue of the fish if repeat trimming at the same sport.

4. Removing fish guts

This activity is when workers switch the tool in hands back to the spoon then again grab the bowl side of the spoon and use the handle side of the spoon to remove the fish gut. This is by inserting the spoon handle into the fish belly, which was open from trimming activity. After that, workers gently scoop out all the gut out of the belly and avoid breaking the belly open.

5. Categorizing the fishes

The last activity is when the fish that has been processed is put into classification baskets. There are mainly three baskets in front of workers on the table. One is for A-grade fishes that have firm tissues and are nicely cut without broken belly. Another is for B-grade to fishes those lose properties of A-grade. The third basket for unwanted parts such as fish guts, fish scales, fish heads, and tails.

The manual fish processing, or the sequence of activities above then is repeated by the workers throughout the day at least for 8 hours. Apart from the fish processing activities and considering more on the work environments, workers are allocated in a long fixed-height stainless table with a maximum of 4 workers per table. Workers are provided with all necessary tools and uniforms which according to The Ministry of Public Health such as a small stainless spoon, a long sharp scissor, vary the size of baskets, a pair of gloves, a pair of boots, an apron and a hat. The factory also has standard air ventilation makes the temperature inside the factory suitable to work.



## 3.2 As-is Analysis

The As-is analysis is going to be about analyzations of the given information or in this case the current manual fish processing activities and environments from the previous section describing the detail processes to point out some malpractices and what can be fixed, adjusted or improved in terms of Job Design and Ergonomics in the workspace.

### 3.2.1 Analysis Table

Recalling the ten ergonomic principles, As-is analysis, in this case, will use those ten points to assess the current manual fish processing in Table 1 as follows.

***Table 1** As-is Analysis table*

| The Principles | Principle Descriptions | Analysis |
|---|---|---|
| 1. Work in natural posture | Providing the best positions in which to work are those that keep the body "in neutral" such as maintaining the "S-curve" of the spine, keeping the neck aligned, keeping elbows at sides. | Not all workers work in natural S-curve spine and their necks aligned as they stand. Especially, for the taller ones. While, the shorter ones must lift their elbow in order to perform the tasks. |

| | | |
|---|---|---|
| 2. Reduce excessive force | Excessive force on joints that can create a potential for fatigue and injury. For example, pulling a heavy cart might create excessive force for your back. | It seems that this manual fish processing does not have heavy tasks that create excessive force for workers bodies. |
| 3. Keep everything in easy to reach | Think about the "reach envelope." This is the semi-circle that your arms make as you reach out. Things that you use frequently should ideally be within the reach envelope of your full arm. | It seems that the current workstation has everything in reach envelop of workers. Including fishes, tools and baskets which are all on the table. |
| 4. Work at proper heights | A good rule of thumb is that most work should be done at about elbow height, whether sitting or standing. There are exceptions to this rule, however. Heavier work is often best done lower than elbow height. Precision work or visually intense work is often best done at heights above the elbow. | This manual fish processing process is considered as a medium task so the job should be done at the same height of workers elbow height. However, that does not happen to all the workers here especially the taller ones or shorter ones because the table height is fixed. |
| 5. Reduce excessive motions | Think about is the number of motions made throughout a day, whether with fingers, wrists, arms, or back. | There are excessive motions happened when workers need to clean the spoon and switch back and forth between the spoon and scissor. |

| | | |
|---|---|---|
| 6. Minimize fatigue and static load | Holding the same position for a period of time is known as static load. It creates fatigue and discomfort and can interfere with work. | Static load applies to workers feet here when workers must stand at the same position for sometimes. |
| 7. Minimize pressure points | Watch out for is excessive pressure points, sometimes called "contact stress." For example, squeezing hard onto a tool, leaning your forearms against the hard edge of a worktable. | There seems to have a pressure point in the process when workers use the spoon by holding it on the bowl side which is not a proper usage. |
| 8. Provide clearance | Being able to see is another version of this principle. Equipment should be built, and tasks should be set up so that nothing blocks vision. | It seems that there is no problem with clearance in this process as there is not a lot of tools. |
| 9. Move, exercise and stretch | The ideal is to be able to alternate between sitting and standing throughout the day. For some tasks, such as customer service, desks are available that move up and down for this purpose. | There are not enough alternative postures for workers as their stand and worker. They can only switch their weight between both legs. |

| | | |
|---|---|---|
| 10. Maintain a comfortable environment | This principle is more or less a catch-all that can mean different things depending upon the nature of the types of operations. For example, tasks can be affected by poor lighting. Concerns include glare, working in your own shadow, and just plain insufficient light. | In terms of lighting, it seems that the workstation already provides workers enough lighting for all tables. |

### 3.2.2 Analysis Development

From the As-is analysis in Table 1, the Ergonomics malpractices are summarized. First, there is ergonomics malpractice of worker height with the table height. So, as shown in Figure 9, the taller worker will have to bow more when they during the activities which result in them not to have in an S-curve spine, straight neck, and proper working height. On the other hands, the shorter workers who must lift their elbows to be able to perform the tasks on the table that is too high for them creating unnatural hands, arms and shoulders position which causes the muscle strain.



***Figure 9*** *Malpractice of worker heights with the table height*

***Figure 10*** *The only standing posture of workers in this fish processing area*

Secondly, there is ergonomics malpractice of workers posture illustrated in Figure 10. The worker must stand and complete the tasks for at least 8 hours a day, which creates static loads to their feet, and they do not have proper alternative standing and stretching postures to reduce some fatigue.


***Figure 11*** *Excessive pressure and unnatural hand position occur when holding the spoon*

Thirdly, there is malpractice in the way workers use the tools. The handle side of the spoon and the way workers hold the spoon are not proper, which creates an excessive pressure point to their hands, as shown in Figure 11. Also, the way that workers are switching between tools creates the excessive motions which result in time-consuming as illustrated back in Figure 8.

### 3.3 Implementation Methods

From the analyzation of the current manual fish processing in the previous section, it can be seen that there are two areas, which are workspace adjustment and tool adjustment, that this fish processing factory should be dealing with to align the manual fish processing with to Job Design and Ergonomics principles. To provide more explanations of the research methods structurally, the following subsections will start with the setups of the research following the process adjustments.

### 3.3.1 Experimental Group Setups

As the objective of the research is to demonstrate how Jon Design and Ergonomics principle that would theoretically create a suitable workspace and improves the well-being of workers in manual works, this demonstration would, however, be conducted separately from the usual process. This is to set up a separated minor division or an experimental group that is isolated from the leading group. So, this research conduction does not affect current business operations. In the case of this manual fish processing, there will be another station placed among the usual stations.

Usually, a station of the fish processing process in this factory consists of 4 workers standing at equally distributed areas of a stainless table. For this experimental group, it is going to be the same involvements but, to reduce the complexity of the later workspace and tool adjustment designs, the criteria to select the workers for the experimental group are as follows.

1. Similar in height
2. Young to middle ages
3. Living close to the factory

The reason for workers to have a similar height is because the height of workers is relevant to and involved in the new design of the table. Young to middle age workers are expected because it is going to be a comprehensive data collection and monitoring, which requires excellent physical straight and a certain level of obedience. The reason for chosen workers needs to live near the factory because punctuation when it starts and stops the experiment is essential, which late arriving at the factory, might cause a delay which disrupts the data collecting process. Therefore, the chosen ones to be part of this experimental research group are in Table 2 below.



***Table 2*** *List of experimental group members*

| Worker | Gender | Height | Age | Distance away |
|---|---|---|---|---|
| A | Female | 156cm | 26 | In the factory |
| B | Female | 157cm | 30 | In the factory |
| C | Female | 155cm | 28 | In the factory |
| D | Female | 158cm | 27 | In the factory |

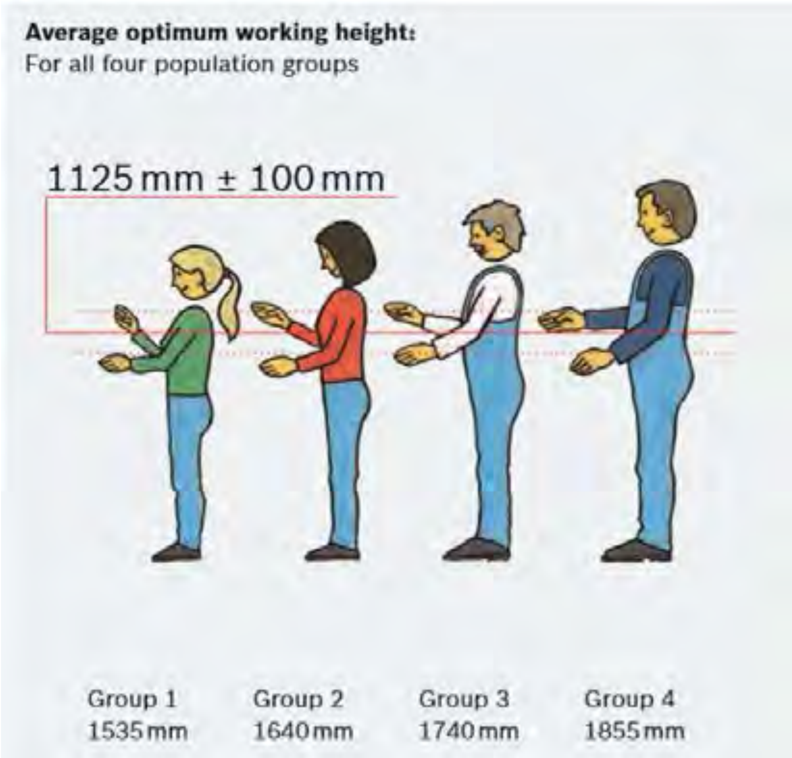
### 3.3.2 Workspace Adjustment

The workspace adjustment has two parts those are changing the table height to suit the workers' height and providing alternative supports to the way the workers stand at fish the station.

*Proper Table Height*

From the ten ergonomic principles, it suggests that for a regular or medium type of work, meaning the work that does not require high precision or oppressive forces, the table height should allow the workers to perform the task on the table with their elbows in the natural position.

In another context, according to body height and working height recommendations given by Rexroth Bosch Group (2012) in Ergonomics Guidebook for Manual Production Systems, it has given an optimal working height to the workers' height as in Figure 12 below.




| Work contents | Working heights in mm | | | |
|---|---|---|---|---|
| | Group 1 | Group 2 | Group 3 | Group 4 |
| **High requirements for** Visual inspection Fine motor skills | 1100 | 1200 | 1250 | 1350 |
| **Medium requirements for** Visual inspection Fine motor skills | 1000 | 1100 | 1150 | 1250 |
| **Low requirements for** Visual inspection **High requirements for** Elbow room | 900 | 1000 | 1050 | 1150 |

***Figure 12*** *Optimal working height to the workers height*
*(Adopted from Ergonomics Guidebook for Manual Production Systems by Rexroth Bosch Group 2012)*

From the figure of optimal working height above, it can numerically design the suitable table height that is proper for this experimental group. The average height of workers in the experimental group is 156.5 cm. Thus, the optimal working position of these workers for this manual fish processing process, as a medium type of works, is at about 100 cm approximately. However, the height of the table should be shorter than that because it must leave some space for placing tools and fishes on the table. So, with another 10 cm shorter, as suggested by the diagram will be one of the workspace adjustments applies explicitly to the new table height for this research. The design diagram of this table design is in Figure 13 below.

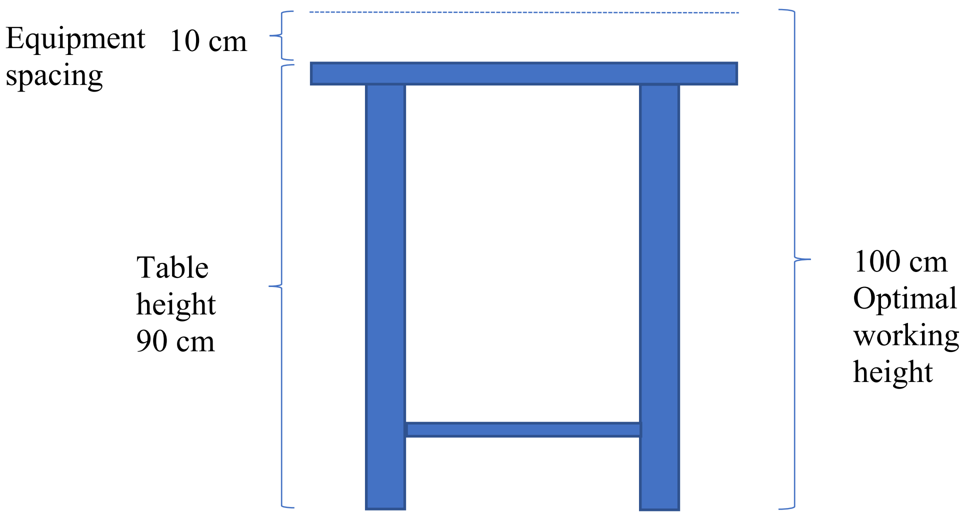



***Figure 13*** *New table height design*

This appropriate table and working height are also advised as the way to keep the spine of the worker in a proper s-curve and elbows at the natural position, which reduces the potential stiffness at work.

*Standing Support*

For the standing supports, workers in the manual work environment should have alternative postures if they have to be in the same workstation for an extended period, as suggested by the ten ergonomic principles. This is because when a person is in the same posture for some time, the static load is created, which causes fatigue to parts of the body holding the body weight. Naturally, a body will tend to eventually move the static load to a different part of the body by changing body posture. However, if there are few alternatives postures applicable, the fatigue will quickly drain the body straight which affects workers performance.

There are several suggestions to this standing support from the ten ergonomic principles and OSHA Consultation Service. One of those is to provide footrest to the workspace, which in this case could be part of the table enabling workers to rest on one of their feet on it. Another is to provide a sit-stand stool where workers can rest on the stool every so often. These adjustments are illustrated in Figure 14 below be part of the table enabling workers to rest one of their feet on it. Another is to provide a sit-stand stool where workers can rest on the stool every so often. These adjustments are illustrated in Figure 14 below.

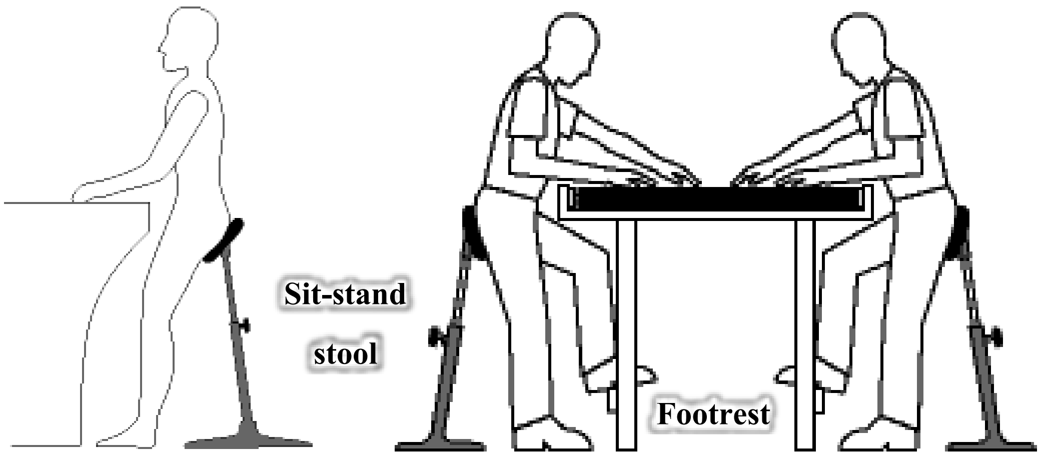



***Figure 14*** *Working positions*
*(Adopted from Canadian Centre for Occupational Health and Safety [www.ccohs.ca])*

It can be seen from the diagram above that with the new adjustment of standing supports, workers in the fish processing process will have at least three alternatives standing postures. For example, necessary standing with two feet on the ground, standing with one foot is rested on the footrest and lending on the stool with or without a foot on the footrest.

### 3.3.3 Tools Adjustment

From the As-is analysis, improper tooling and tool switching are the two pinpoints that this manual fish processing process has regarding the tools. So, what could be introduced to the process are as follows.

*Proper Tools*

Without a doubt, using a metal spoon for scales and guts removing in this manual fish processing process is improper. Though it is a cheap and easy way to do the task, it potentially creates muscle strain to workers hands as the spoon is held in a way that is not meant to.

According to the ten ergonomic principles guidebook, this is activity creates some excessive pressure point to the part of a person body. Notably, the hands and the suggestion for this case is to have the tool that provides comfort to the hands when holding and allowing the hands to be in a natural position, but still provide the functionalities that the process needs. So, reducing the excessive pressure points from hand-holding tools is expected to extend the tolerance level of workers, which gives workers more time to achieve the tasks.

*One-For-All Tools*

For this manual fish processing process, removing the excessive motions from tools switching, which in this case is a switch between a metal spoon and a scissor as identified in the As-is analysis, could be attained by making the activity not to switch. This means that if all the functionalities of different tools are combined, workers only must hold a single tool and be careless about changing the tool.

Considering that three functions consisted of the spoon and scissor, those are de-scaling, guts removing, and trimming. This single tool must have a horizontal metal part that can descale the fishes, a long narrow tip part that can be used to remove the guts and a scissor-liked part to trim the fishes. On top of the tool that, the One-For-All tool should be providing some comforts to the hands, which allows the worker to hold and repetitively use the tool for a more extended period. So, holding only one tool but can still perform all required tasks would increase concentration level and add additional time slots for workers to accomplish the tasks.

The change of manual fish processing process flow with the implementation of the One-For-All scissor is expected in Figure 15. The steps expected to change in the fish processing process with the application of One-For-All scissor are steps 2, 3, and, where the switching between tools is disappeared.

**Expected Changes on Fish Processing Area Process Flow with One-For-All**

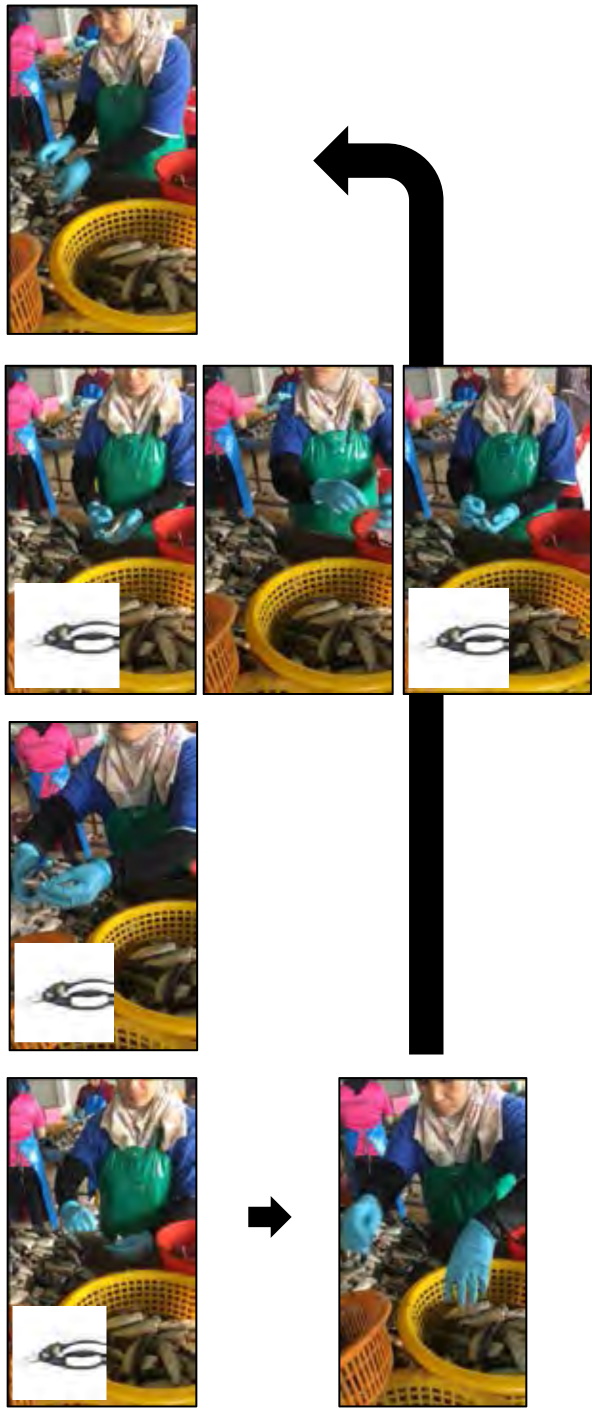
1. Grab the fish from bulk of fishes on the table

*2. * Remove fish scales*

- ***One side***
- ***Clean scissor***
- ***Another*** **side**

*3. * Trim fish head and tail*

*4. * Remove fish guts*



5. Categorize and put the fish into the basket according to its grade

***Figure 15*** *Fish processing process flow with the One-For-All scissor*

## 3.4 Measurement Parameters

The measurement parameters under the objective of this research, which aims to demonstrate the improvement of workers performance in manual work, can be addressed by two factors. Those are productivity and efficiency levels in which these two parameters are reflecting the performance of workers. Plus, another parameter concerning the financial aspect of implementations, which is the revenue created.



### 3.4.1 Measuring of Worker Productivity Level

This measurement aims to quantitively collect the data of the number of fishes processed in Kilograms by a member of the experimental group in a period, including both A-grade and B-grade fishes.

During the data collection, the amount of all processed fishes in Kilogram generated by each member in the experimental group will be weighed and recorded every working hour in a day from the start to end consisting of 8 hours.

The daily and hourly productivity level of workers would imply the factory capacity and workers capacity, respectively. This means that if looking from the factory perspectives, the daily production level or its daily capacity is a spotlight. While looking at the hourly production level of workers determines at what point of the day workers can do best and worst which is also relevant to the daily factory capacity.

### 3.4.2 Measuring of Worker Efficiency Level

This measurement aims to quantitatively collect the data of the manual fish processing process on the amount of wanted or A-grade fishes out of the total in Kilograms conceived by a worker in the experimental group in a period.

Like workers productivity level measurement, this efficiency level measurement will have the amount of both A-grade and B-grade fishes generated by a worker in the experimental group measured every hour for at least 8 hours a day. However, the difference is that this measurement concerns the ratio of wanted and less-wanted fishes, which are A-grade and B-grade fishes, respectively.

The amount of both A-grade and B-grade fishes generated from the experimental group will be weighed and recorded every hour in a day. So, the higher the portion of A-grade fishes generate hourly and daily by the experimental group, the higher their hourly and daily efficiency level.

For this manual fish processing factory, quality is another crucial factor determining its revenue. Apart from increasing the factory capacity, which is a business goal, converting the number of less wanted to want fish grades would undoubtedly benefit the factory in terms of gaining. This is about how much will become the factory, and workers get paid by the customer. As more A-grade fishes generated, the higher gain the factory and workers get.

### 3.4.3 Revenues Created

For this revenue created measurement, this aims to collect the data of factory and workers gaining in Thai Baht converted from outputs or processed fishes from the experimental group. However, this measurement would only be in days domain as the gaining per hour is not concerned by the factory and does not produce different outcomes because income is in daily anyways.

Considering that the customer is paying for A-grade and B-grade fishes at 1.5 baht and 0.75 baht per Kilogram respectively, which is the same for both factory and worker as mentioned that this is fifty-fifty gaining model. The presentation of revenue created later on could represent either revenue gain created by the worker of the factory and the equation used for this calculation is as follows.

$$Revenure\ Created\ = (A_{Grade} \times 1.5) + (B_{Grade} \times 0.75)$$

Additionally, this information of revenue created would also use to analyze the return on investment (ROI) afterward.

3.4.4 Pair t-test Analysis Application

To statistically verify that if there is a significant change to the experimental group in terms of performance and revenue created after the adjustments are implemented, a statistic measurement methodology called Pair t-test is used. According to the Handbook of Biological Statistics by McDonald 2014, it describes the usage of the Pair t-test is when we are interested in the difference between two variables for the same subject. In this case, the experimental group is the same subject, and the two variables are the measurement result before and after the adjustment.

However, in this research, the calculation of the Pair t-test will be done on a spreadsheet, and what interested to be verified is the P-value. According to the assumption of the Paired t-test that if the P-value is less than 0.05, which is a significant level, that means there is evidence of significate change to the subject after some treatments.

### 3.5 Implementation Cost Estimation

The cost estimation of all equipment involves in this fish processing process adjustment is Table 3 Below. Remarking that this implementation cost calculation is for the final design of tools and equipment for the research.

***Table 3** Equipment Cost Records*

| Item | Unit | Cost per unit (THB) | Shipping cost (THB) | Total Price (THB) |
|---|---|---|---|---|
| Fish cutting scissor | 4 | 1,000 | 780 | 4,780 |
| Stainless Table | 1 | 6,500 | 500 | 7,000 |
| Sit/stand stool | 4 | 2,000 | 4,680 | 12,680 |
| | | | Total cost (THB) | 24,460 |

As mentioned in the data gathering section where revenue created from the implementation of the adjustment will be considered, this information of implementation cost will also be used as part of return on investment (ROI) analyzation.

***Table 4*** *Project planer*

| STEPS | ACTIVITIES | Jan-19 | | | | Feb-19 | | | | Mar-19 | | | | Apr-19 | | | | May-19 | | | | Jun-19 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 1 | **Establishing the Current Manual Fish Processing workflow** | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.1 Obtaining a detail current fish cutting process steps | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.2 Analyzing current postures, movements of workers and surrounded equipment in fish cutting process workstations | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | **Applying Job Design and Ergonomic Principles** | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2.1 Studying and Understanding the Job Design and Ergonomic principles applications | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2.2 Identifying and capturing feasible adjustments of fish cutting process according to Job Design and Ergonomic principles. | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2.3 Implementing the feasible adjustments | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | **Collecting, Analyzing and interpreting the collected data** | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3.1 Collecting data | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3.2 Analyzing and Interpreting the data | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | **Writing a Complete Dissertation** | | | | | | | | | | | | | | | | | | | | | | | | |
| | 4.1 Outlining the complete dissertation | | | | | | | | | | | | | | | | | | | | | | | | |
| | 4.2 Drafting the complete dissertation | | | | | | | | | | | | | | | | | | | | | | | | |
| | 4.3 Finishing the complete dissertation | | | | | | | | | | | | | | | | | | | | | | | | |

# Chapter 4 Results

The objective of this chapter is to display raw data collected and observed from the experimental group according to data gathering and data measuring methodologies described in the Methodology chapter.

This Results chapter consists of three main sections. One is illustrating all actual implementation of workspace and tool adjustments in the manual fish processing process. The other two are revealing both quantitative and descriptive figures before and after implementing the adjustments from Job design and ergonomic principles.

## 4.1 Adjustment Results

Referring back to the development of Job design and Ergonomic principles alignment analysis or the As-is analysis in the Methodology Chapter, this section is showing what and how those new adjustments are applied on the floor. Moreover, it is also informing some of the unanticipated circumstances causing the adjustments to be bent from the first design by some angles but still following the Ergonomic principles from the guidebook.

### 4.1.1 Workspace Adjustment

The first adjustment designed for this manual fish processing workspace is to provide an appropriate or optimal working height to the experimental group. The actual implementation is illustrated in Figure 16 as follows.


***Figure 16*** *Transformation of a worker working postures in manual fish processing process*

With the height similarity of workers in the experimental group, the optimal working height is calculated in Methodology Chapter to be about 90 cm matching with the average workers' heights in the experimental group of 156.5 cm suggested by the Ergonomic Manual Workstation Guidebook.

Figure 16 shows that with adjustment of optimal working height and appropriate table height to the height of workers has changed their postures when working to follow the Ergonomic principles of the natural straight neck, S-curve spine, and natural elbows positioning.

Another adjustment to the workspace is the standing supports. Concerning the table height adjustment, providing alternative working postures while still maintain the natural position of body parts is recommended by the guidebook.

Mentioning that with the support of sit-stand stool and footrest from the Ergonomic work adjustment design, it provides more alternative working postures to the experimental group shown in Figure 17.

***Figure 17*** *Alternative standing posture examples*

However, before this final implementation was taking place, there was a concern on the sit-stand stool height during the trial. Initially, the stool planned to be used as static where its height could not be adjusted. This was a concern because if a worker is leaning on a stool that is not at the right height, the actual height of a worker will reduce a bit. This results in the optimal working height of workers to vary when the posture is altered. So, additional to the right height of the table, the right stool height is also concerned.

After making some trail investigations to find the right height of the stool, it is found that most appropriate stool height should be at the level of a person but not lower or higher but just right in the middle. So, when workers are leaning, they do not have to lower their body much, which makes their working height still in range and keep their posture in the natural position. Plus, the level of a person but is not the same, even their height is the same. The immediate solution to handle this overlooked concern was to have a height-adjustable stool which is shown in Figure 18 below.


**Figure 18** Sit-stand stool used for standing support

### 4.1.2 Tool Adjustment

Combining Job Design and Ergonomic principles which is to create job enrichments and work capability and comfortability in workers, the experimental group is provided with multiple functional and comfort handling tools shown in Figure 19.

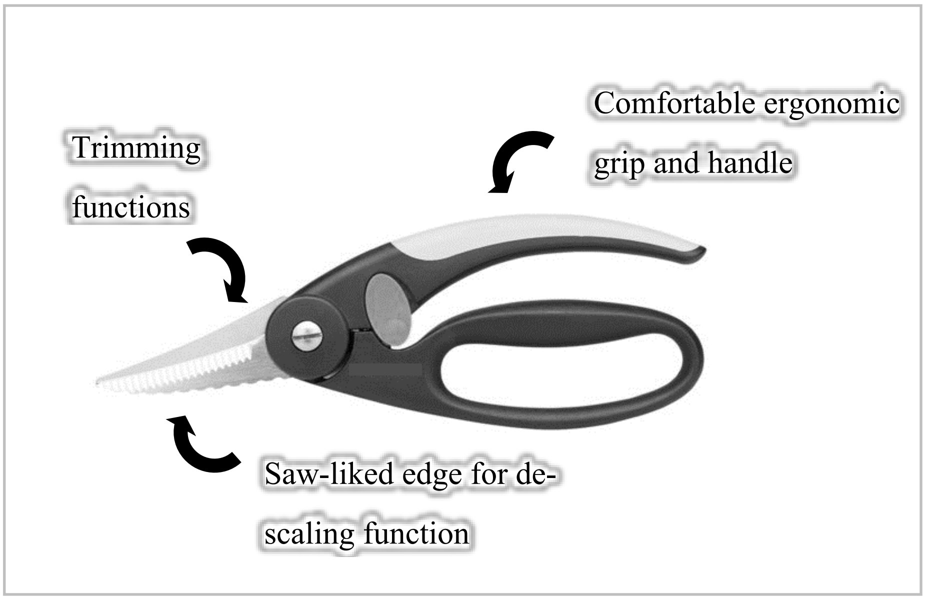



***Figure 19*** *One-For-All scissor used for tool adjustments*

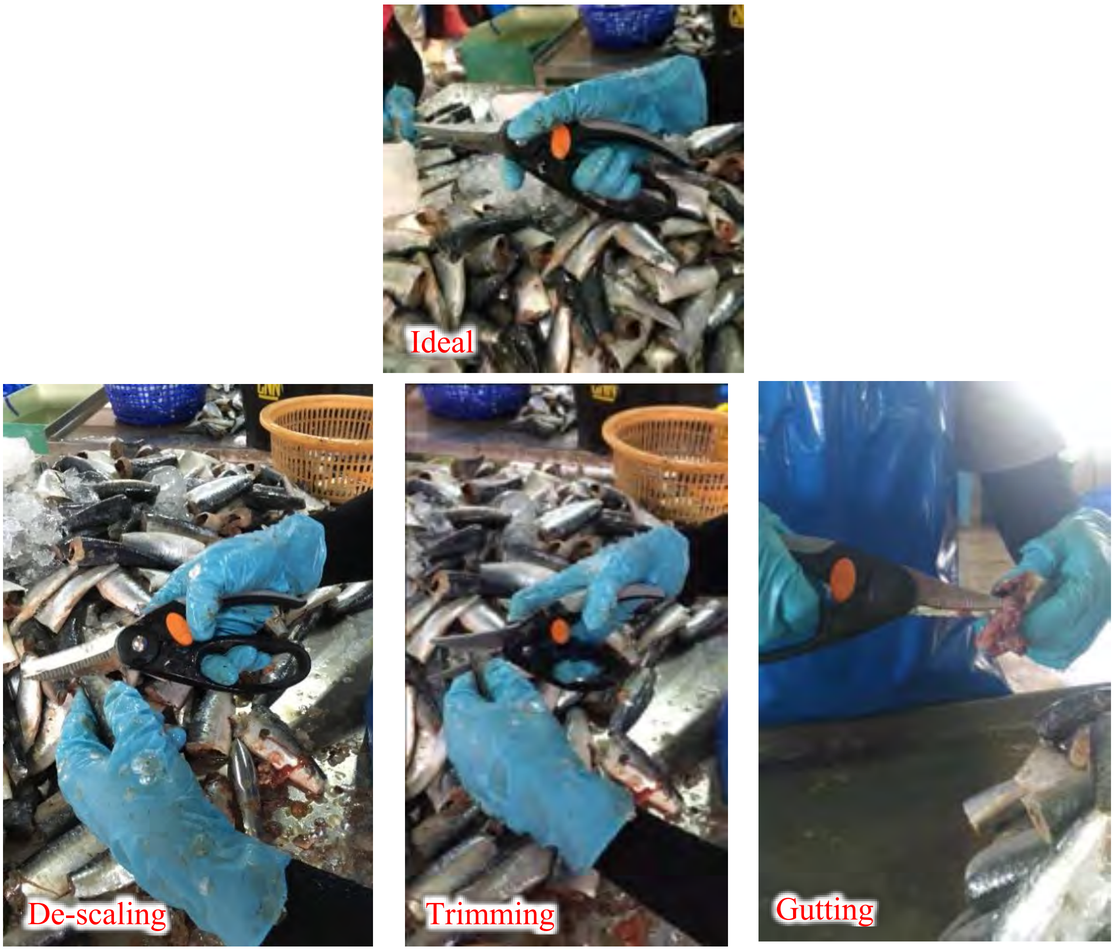



***Figure 20*** *Handling of scissor in different functionalities*

Figure 20 illustrates that functionality and comfortability are combined into a scissor that transforming the way workers in the experimental group process the fishes by getting rid of some unnecessary steps or movements such as tools switching. Moreover, with the Ergonomic design handle of the scissor, the comfortability levels of hands are maintained.



However, before this scissor was chosen to be used by the experimental group, there was a critical concern on one of the functionalities of the tool, which is the gutting function. Transforming the gutting activity from the metal spoon handle to the tip of scissor is ergonomically more appropriate in terms of matching the right tool to the right task. However, because of the tips of the scissor is shaper and longer than the spoon handle, it makes the task harder for workers as they must be extra careful not to open the fish belly up which slows down the process.

So, the design of a multifunctional scissor in Figure 19 is used, which has shorter and blunter metal tips and edges expecting to reduce the rate of accidentally cut open fish bellies during gutting activity.

## 4.2 Pre-Implementation Results

Before the all workplace and tools adjustments are implemented, some performance parameters of the experimental group were measured including fish processing productivity rates, production efficiency and, most importantly to the business is the revenue created by this experimental group as follows.

### 4.2.1 Productivity Level

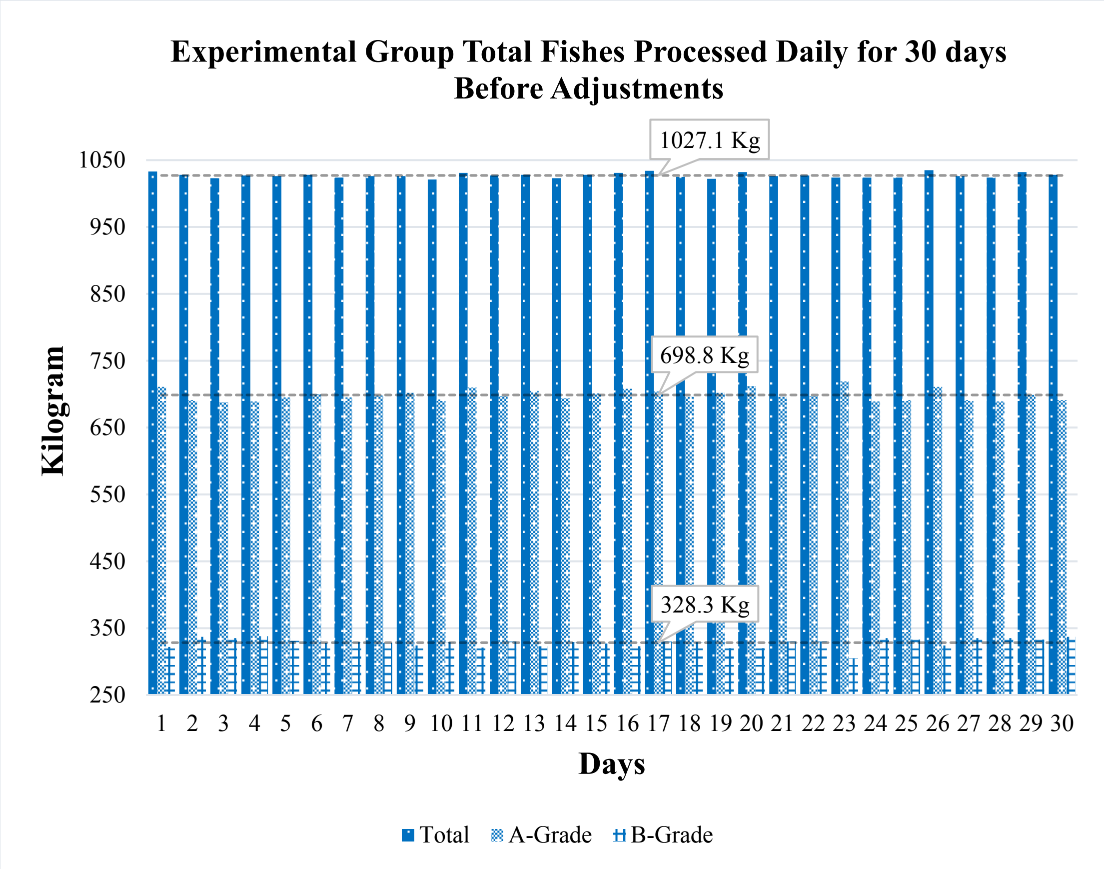



***Figure 21*** *Experimental Group Total Fishes Processed Daily for 30 days Before Adjustments*

***Table 5*** *Productivity figures before adjustments*

| Productivity figures per day before adjustments | Quantity |
|---|---|
| Average Total fishes generated | 1027.1 Kg/day |
| Average A-grade fishes generated | 698.8 Kg/day |
| Average B-grade fishes generated | 328.3 Kg/day |

In terms of the volume of fishes processed per day for 30 days as shown in Figure 21, it can be seen that the average total fish processing rate of this experimental group where the volume of A-grade and B-grade fished are combined is approximately at 1027.1 Kilograms per day. The graph pattern also shows that, before the adjustments are implemented, the productivity level of this experimental group is very consistency whereby the volume discrepancies in both A-grade and B-grade fished generated each day is low or no significant swinging at all. It indicates that the capacity of this experimental group is about 1027.1 Kilograms per day for a table as conclude in Table 5.

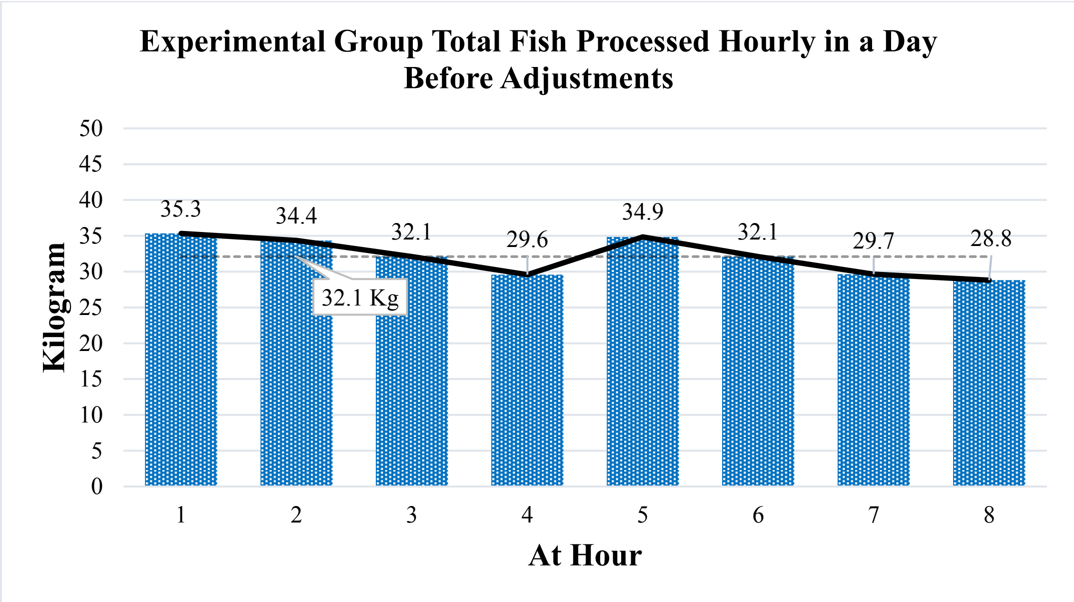



***Figure 22*** *Experimental Group Total Fish Processed Hourly in a Day Before Adjustments*

***Table 6*** *Productivity figures per hour before adjustments*

| Productivity figures per hour before adjustments | Quantity | |
|---|---|---|
| | Morning | Afternoon |
| Average total fishes generated | 32.1 Kg/hr. | |
| Maximum total fishes generated | 35.3 Kg/hr. | 29.6 Kg/hr. |
| Maximum total fishes generated | 34.9 Kg/hr. | 28.8 Kg/hr. |
| Max. to Min percentage change | - 16.13 % | - 17.48 % |

In terms of the volume of fishes processed per hour in a day for 30 days, as shown in Figure 22, Throughout the day the productivity is up, and down, which consists of two peaks. For the first two hours of the day, the number of fishes processed by this experimental group tends to be high and reducing until the fourth hour. Then the number goes up again at the fifth hour and reduces towards the last hour of the day.

This shows that there is a pattern of and a relationship between time and productivity rate in a day. It is calculated that the reduction of productivity from the first to the fourth hour is about 16.13 percent and from the fifth to the eighth hour is about 17.48 percent concluded in Table 6.



### 4.2.2 Efficiency Level

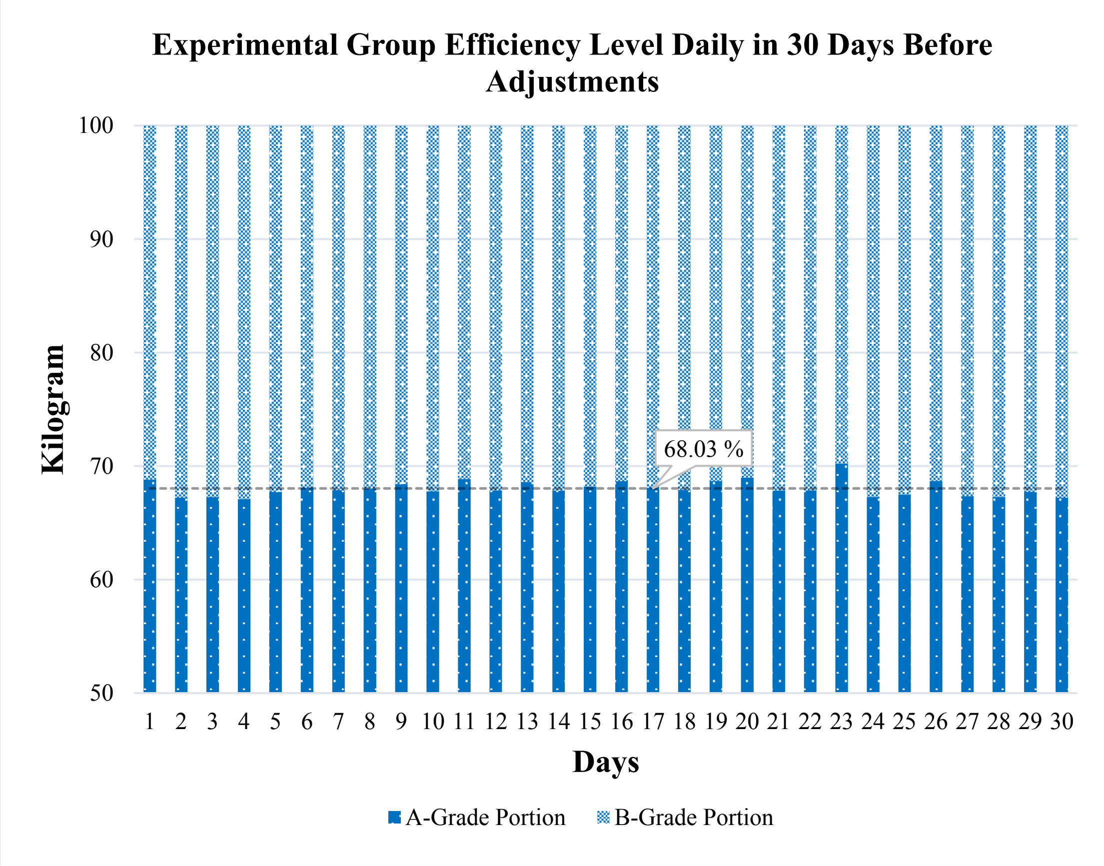



***Figure 23*** *Experimental Group Efficiency Level Daily in 30 Days Before Adjustments*

***Table 7*** *Efficiency level figures per day before adjustments*

| Efficiency level figures per day before adjustments | Quantity |
|---|---|
| Average percentage A-grade fishes generated per day | 68 % |
| Average percentage B-grade fishes generated per day | 32 % |

Concerning the production efficiency or the ratio of A-grad and B-grade fishes generated by the experimental group in each day for 30 days, it is illustrated in Figure

23 that the percentage of A-grade fishes produced, which is the grade expected by the factory, does not vary. In the average of 30 days, it is about 68 percent, and 32 percent of A-grade and B-grade fished respectively from the total fishes generated per day. Indicating that the efficiency of this experimental group is about 68 percent for daily performances concluded in Table 7.



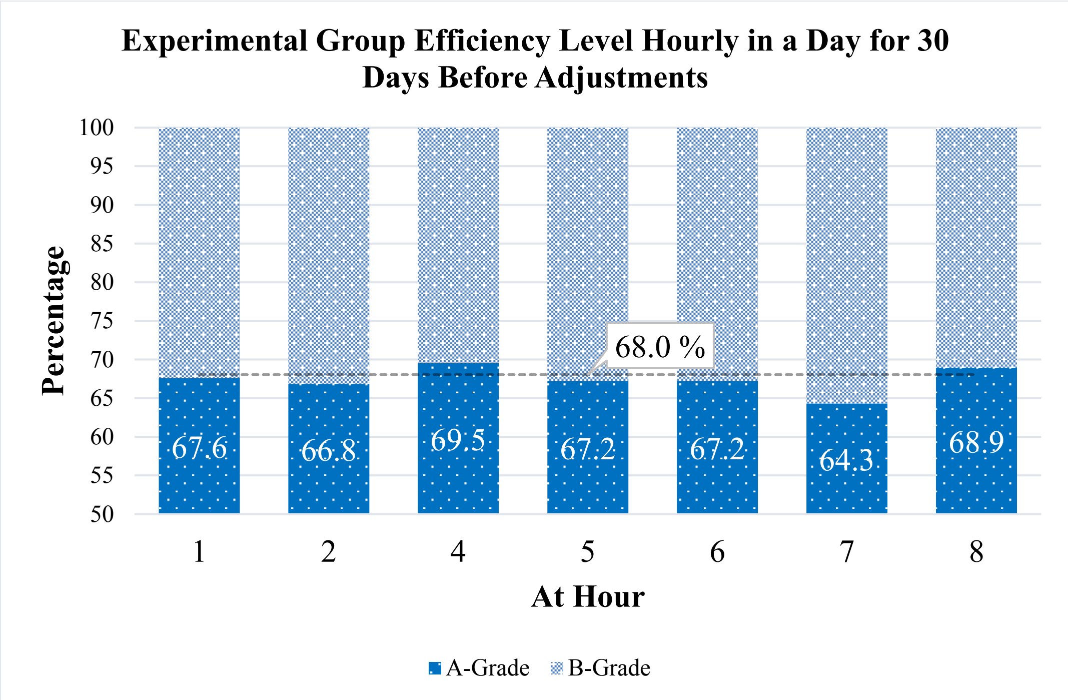



***Figure 24*** *Experimental Group Efficiency Level Hourly in a Day for 30 Days Before Adjustments*

***Table 8*** *Efficiency level figures per hour before adjustments*

| Efficiency level figures per hour before adjustments | Quantity |
|---|---|
| Average percentage A-grade fishes generated per hour | 68 % |
| Average percentage B-grade fishes generated per hour | 32 % |
| Maximum percentage A-grade fishes generated | 72.7 % |
| Minimum percentage A-grade fishes generated | 64.3 % |
| Max. to Min percentage change | 8.4 % |

In terms of efficiency or the ratio of A-grade and B-grade fishes generated by the experimental group in each hour a day for 30 days, there is a single-digit oscillation between the highest at 72.7 percent and lowest at 64.3 percent as shown in Figure 24 and Table 8. It seems that the efficiency of the experimental group is higher in the second, fourth, and eighth hours during the day though the differences are only 8.4 percent maximum, which is not very significant. This pattern indicates that the experimental group is more efficient at the end of the first and second half of the day.



### 4.2.3 Revenue Created

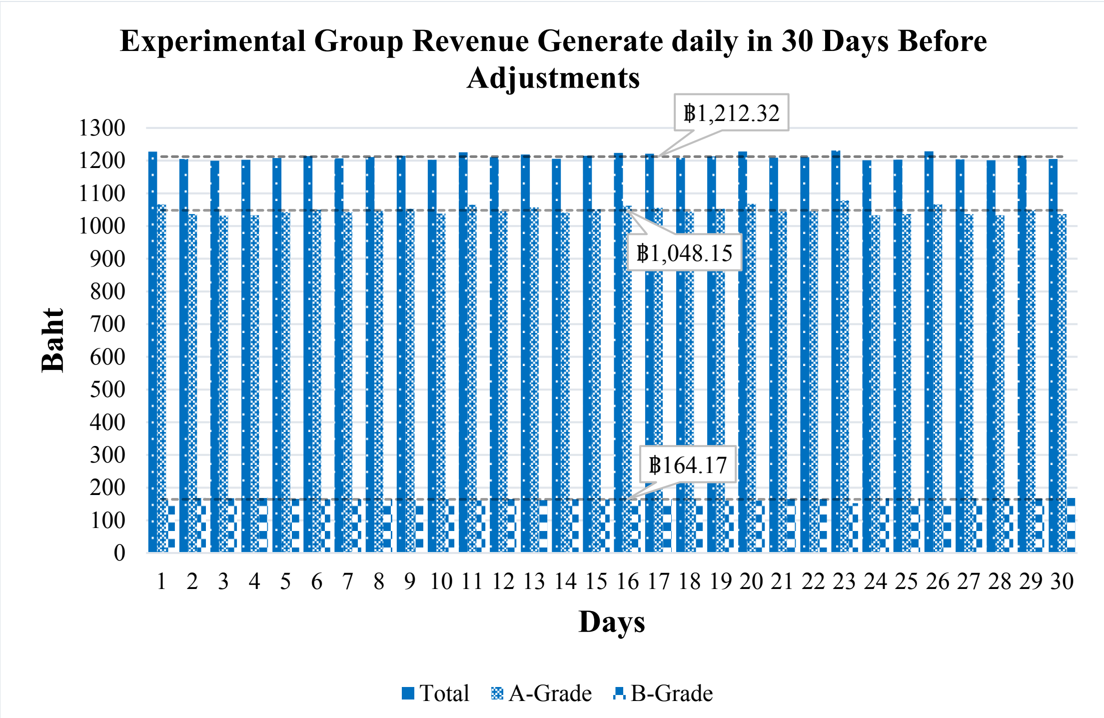



***Figure 25** Experimental Group Revenue Generate daily in 30 Days Before Adjustments*

***Table 9*** *Revenue created figure per day before adjustment*

| Revenue created figures per day before adjustments | Quantity |
|---|---|
| Average revenue generated per day | 1212.32 Baht/day |
| Average revenue generated from A-grade fishes per day | 1048.15 Baht/day |
| Average revenue generated from B-grade fishes per day | 164.17 Baht/day |
| Percentage revenue generated from A-grade fishes | 87 % |
| Percentage revenue generated from B-grade fishes | 13 % |



For the most critical measurement of the business, after the calculations of revenue stated in the Methodology Chapter, the revenue created or the money that this experimental group makes initially per day in these 30 days is approximately 1212.32 Baht as illustrated in Figure 25 and Table 9. Again, because of the volume of fishes processed by the experimental group is steady, there is no surprise pattern because it is not many differences in revenue created each day.

## 4.3 Post-Implementation Results

After measuring designated parameters on the experimental group before the adjustments of workspace and tools are implemented, this section will disclose the performance results of the same experimental group using the same measuring parameters which are processing productivity rates, production efficiency and the revenue created.

However, the data is not presented just only in daily and hourly domains. In addition to that, the data presented will also separate into three phases, namely Phase 1, Phase 2, and Phase 3. The reason to add this separation is that, after implementing the design adjustment, there is a pattern of data which are shown and explained the following sections.

### 4.3.1 Productivity Rates

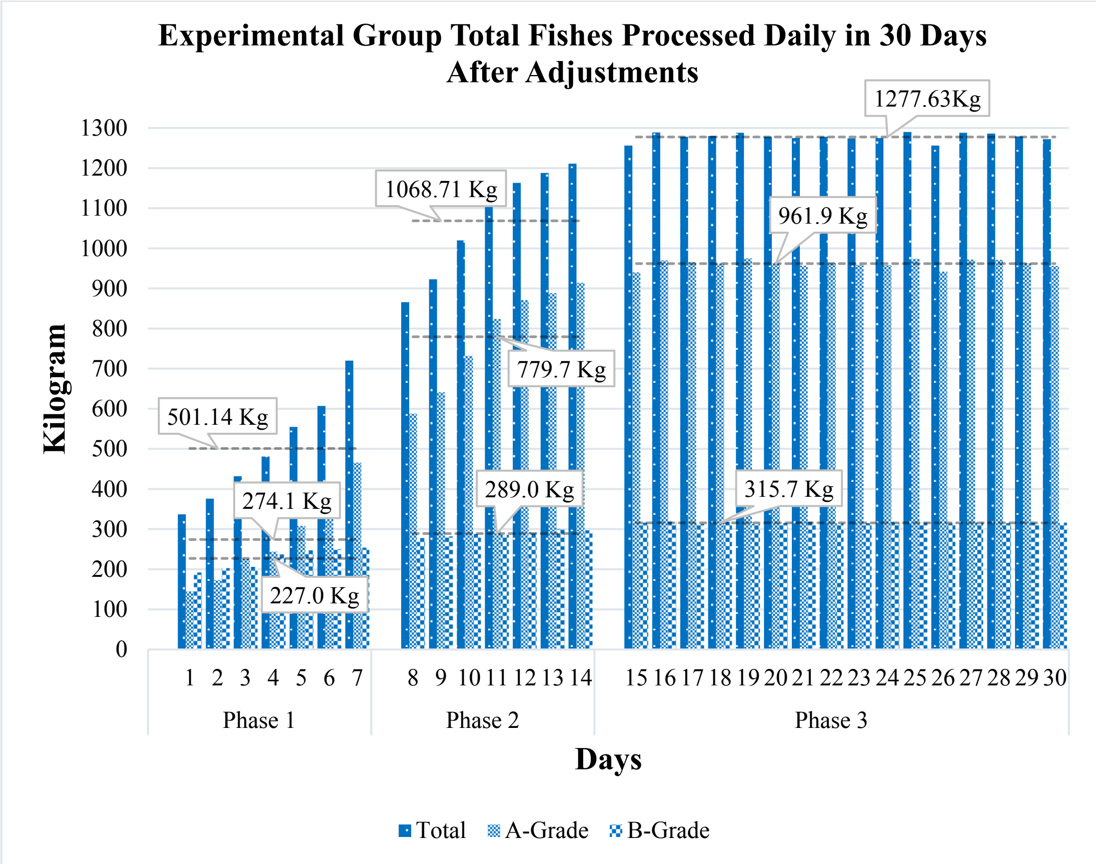



**Figure 26** Experimental Group Total Fishes Processed Daily in 30 Days After Adjustments

***Table 10*** *Productivity figures per day after adjustments*

| Productivity figures per day after adjustments | Quantity | | |
|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 |
| Average Total fishes generated | 501.14 Kg/day | 1068.71 Kg/day | 1277.63 Kg/day |
| Average A-grade fishes generated | 274.1 Kg/day | 779.7 Kg/day | 961.9 Kg/day |
| Average B-grade fishes generated | 227.0 Kg/day | 289.0 Kg/day | 315.7 Kg/day |

Regarding the volume of fishes processed daily by the experimental group after the adjustments, it can be seen from the graph in Figure 26 that the total of fishes processed per day starts very low from day one then increases progressively until day 14 before it starts to saturate. Surprisingly, at earlier days between days 1 and 4, the number of A-grade fish generated is lower than or equals to the number of B-grade fishes. However, the number of B-grade fishes generated has lower incremental rate and tends to saturate earlier at a lower number which is about 315 Kilograms comparing to the number of A-grade fish generated which saturates at about 960 Kilograms given in Table 10.

Moreover, if consider this information in terms of phasing, it can be separated by the average of total fish products into three phases where, From Table 10, the number in Phase 1 is 501.4 kilograms per day which is even lower than the average number before the adjustment by half. Then, Phase 2 is where the average is 1068.71 Kilograms per day, which is slightly higher than the number before adjustments. Finally, Phase 3 is where the productivity level is stable and significantly higher than before.

So, this graph of total fish volume generated rate by the experimental group after the adjustments indicates that with the new workspace and tools are applied, and the experimental group need approximately two weeks before getting the familiarity and maintaining its productivity level.

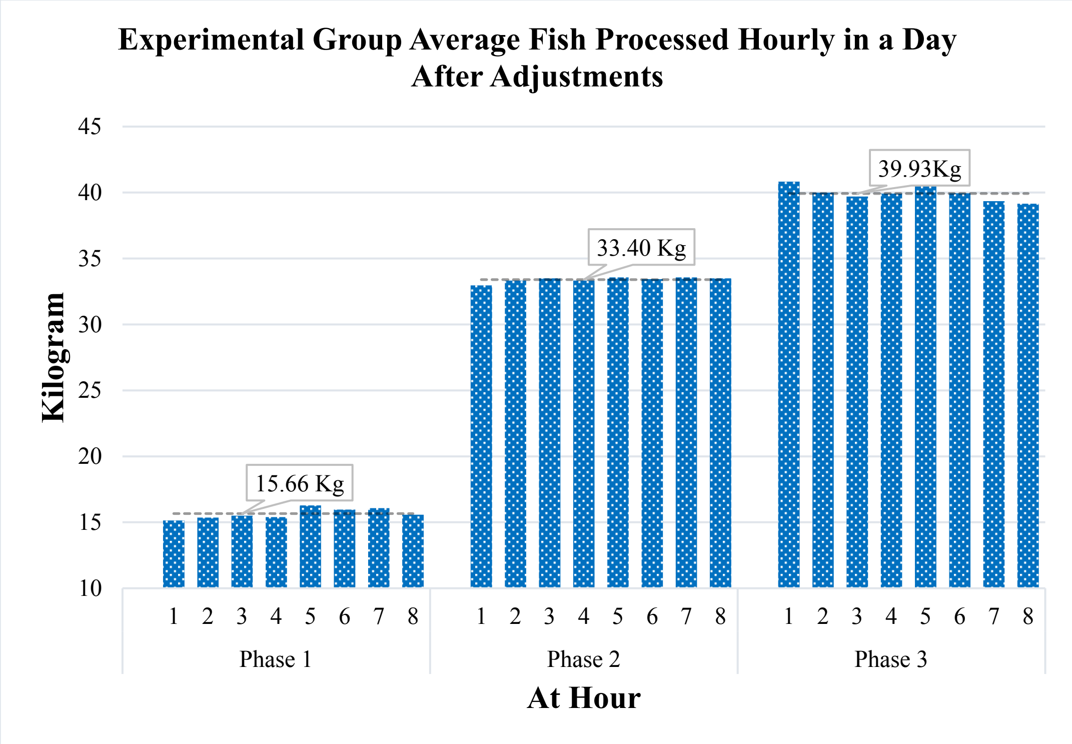



***Figure 27*** *Experimental Group Average Fish Processed Hourly in a Day After Adjustments*

***Table 11*** *Productivity figures per hour after adjustments*

| Productivity figures per hour after adjustments | Quantity | | |
|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 |
| Average total fishes generated | 15.66 Kg/hr. | 33.40 Kg/hr. | 39.93 Kg/hr. |
| Maximum total fishes generated | 16.29 Kg/hr. | 33.57 Kg/hr. | 40.83 Kg/hr. |
| Minimum total fishes generated | 15.14 Kg/hr. | 33.32 Kg/hr. | 39.16 Kg/hr. |
| Max. to Min percentage change | 7.02 % | 1.81 % | 4.10 % |

In Figure 27, the number of fishes processed hourly by the experimental group after the adjustments is illustrated. This is again separated into three phases where Phase 1 and 2 are before the productivity level is saturated, and Phase 3 is when the productivity rate has become stable. From the graph and Table 11, it can be seen clearly that the volume of fish generated at hour 1 to 8 in each phase seems to be very consistence where only the overall volume in each phase is changed by almost three times from phase 1 to 3 which increases from about 15 to 40 Kilograms each hour.

#### 4.3.2 Production Efficiency

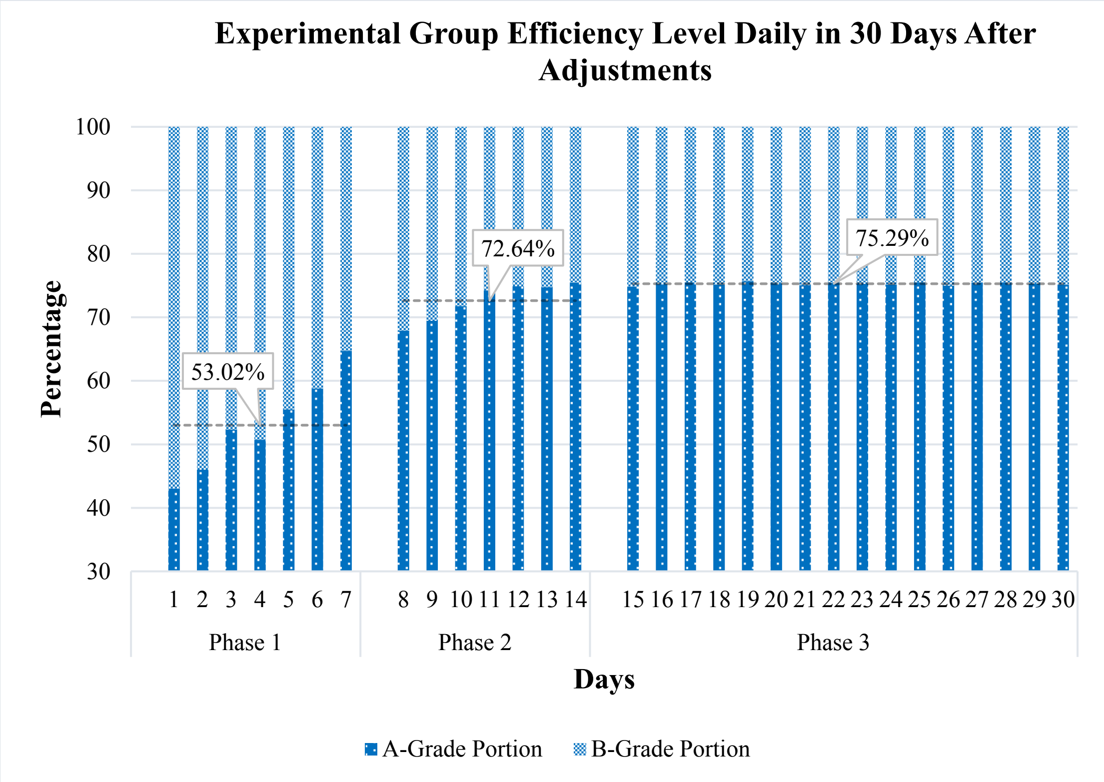



***Figure 28*** *Experimental Group Efficiency Level Daily in 30 Days After Adjustments*

***Table 12*** *Efficiency figures per day after adjustments*

| Efficiency figures per day after adjustments | Quantity | | |
|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 |
| Average percentage A-grade fishes generated per day | 53.02 % | 72.64 % | 75.29 % |
| Average percentage B-grade fishes generated per day | 46.98 % | 27.36 % | 24.71 % |

Regarding the daily production efficiency of this experimental group after the adjustments, it is illustrated in Figure 28 above. From the graph, it is presented in the three phases with the percentage of A-grade and B-grade fish generated daily. From Table 12, the percentage of daily production efficiency or the percentage of A-grade fishes generated is increasing from about 53.02% to 75.29% in Phase 1 to 2 then stay at that level throughout the Phase 3. In alignment with the productivity rate graph, this indicates the improvement of efficiency which takes about two weeks before it saturated.

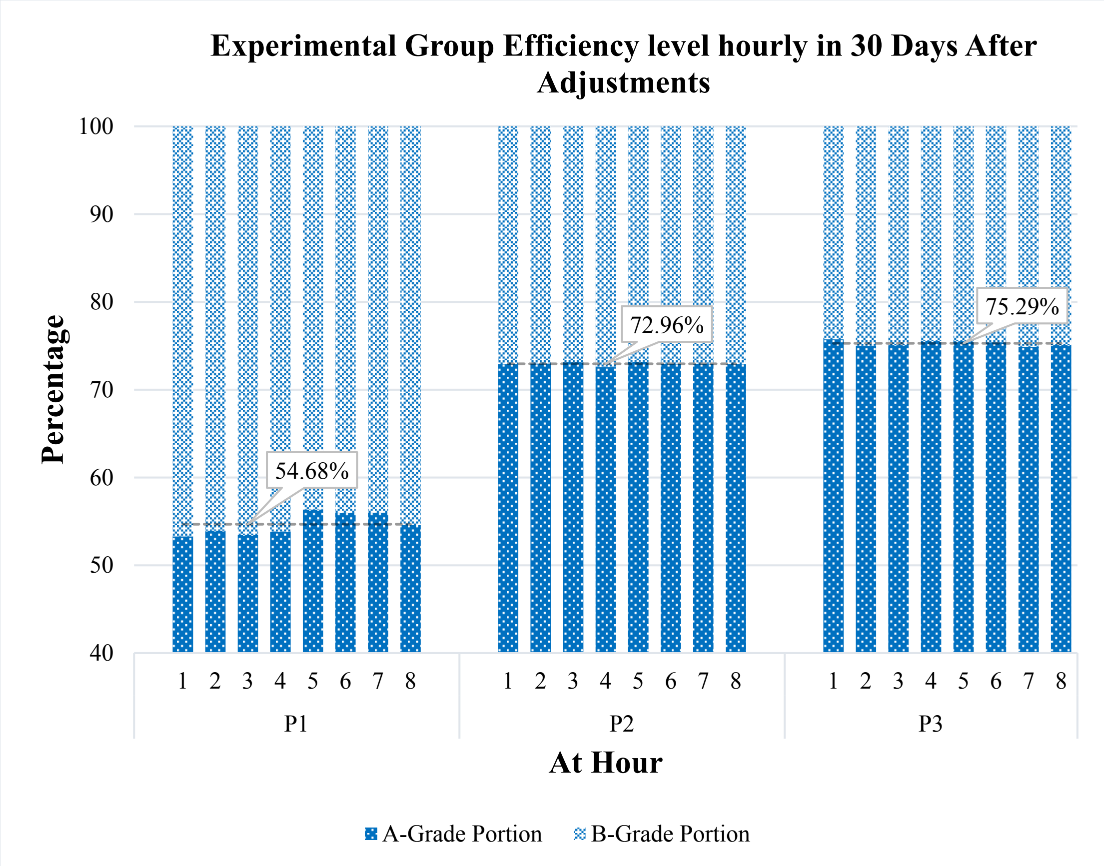



***Figure 29*** *Experimental Group Efficiency level hourly in 30 Days After Adjustments*

***Table 13*** *Efficiency figures per hour after adjustments*

| Efficiency figures per hour after adjustments | Quantity | | |
|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 |
| Average percentage A-grade fishes generated per hour | 54.68 % | 72.96 % | 75.29 % |
| Average percentage B-grade fishes generated per hour | 45.32 % | 27.04 % | 24.71 % |
| Maximum percentage A-grade fishes generated | 56.40 % | 73.00 % | 75.7 % |
| Minimum percentage A-grade fishes generated | 53.30 % | 79.09 % | 75 % |
| Max. to Min percentage change | 3.10 % | 6.09 % | 0.7 % |

In terms of hourly production efficiency of this experimental group after the adjustments as shown in Figure 29, the ratio of A-grade and B-grade fishes generated throughout hour 1 to 8 in all phases is like a straight line where, From Table 13, the percentage of A-grade fishes generated hourly increases significantly from Phase 1 to 3 which is about a 20% increase. This also indicates that throughout the day, the efficiency level of the experimental group is more stable with the percentage change as low as 0.7 percent.



### 4.3.3 Revenue Created

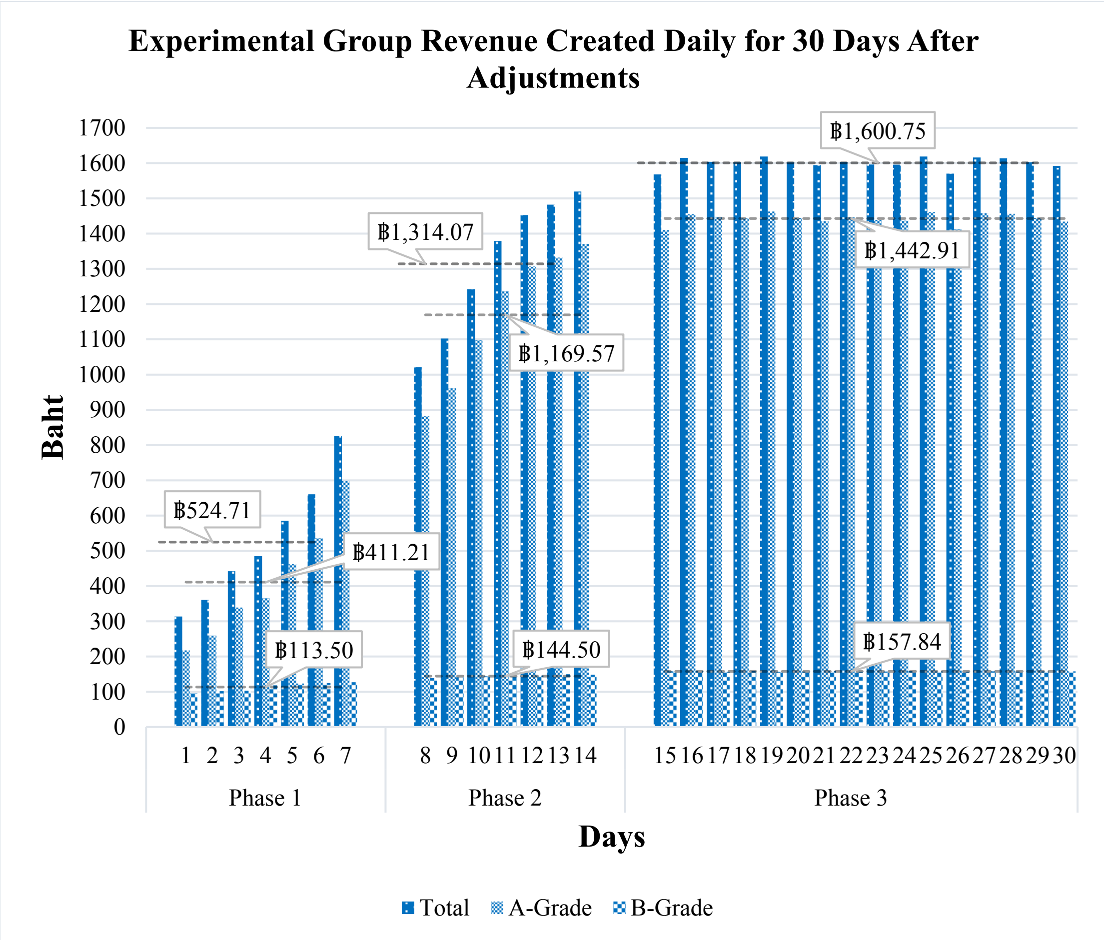



***Figure 30*** *Experimental Group Revenue Created Daily for 30 Days After Adjustments*

***Table 14*** *Revenue created figures per day After adjustments*

| Revenue created figures per day After adjustments | Quantity | | |
|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 |
| Average revenue generated | 524.71 Baht/day | 1317.07 Baht/day | 1600.75 Baht/day |
| Average revenue generated from A-grade fishes | 411.21 Baht/day | 1169.57 Baht/day | 1442.91 Baht/day |
| Average revenue generated from B-grade fishes | 113.50 Baht/day | 144.50 Baht/day | 157.84 Baht/day |
| Percentage revenue generated from A-grade fishes | 78.37 % | 89.00 % | 90.14 % |
| Percentage revenue generated from B-grade fishes | 21.63 % | 11.00 % | 9.86 % |

From Figure 30 and Table 14, for the revenue created by the experimental group after the adjustment, the average revenue in a phase is increasing from about 524.71 Baht per day at Phase 1 to 1600.75 Baht per day in Phase 3. From the graph, the considerable increase in revenue created daily comes from the volume of A-grade fishes generated that increase drastically while the revenue created from B-grade fishes stays below 160 Baht per day.

# Chapter 5 Analysis

This chapter is comprised of results captured and analyzations where the comparison of results before and after implementing the workspace and tool adjustments according to Job Design and Ergonomic principles.



## 5.1 Results Pattern Analysis

From the Result chapter, it can be seen from all the graphs after workspace and tool adjustments are implemented that there is an existing pattern of productivity level, efficiency level and revenue gain dropping before eventually rising as the days go on. Moreover, comparing that with the pattern of graphs before the adjustments, which is averagely steady throughout, the overall performances of the experimental group after the adjustments are significantly lower for a week in Phase 1. Then, they are all catching up a week later in Phase 2. Finally, in Phase 3, the overall performance of the experimental group overtakes the numbers before adjustments significantly and starts to saturate as the days go on.

The steady pattern of performances before the adjustments was expected even before the data gathering starts. It gives the research the information of quantitative performance indications not only of the experimental group but of the whole factory if scaling this up. Also, this current performance indications can be used as a ceiling to brake to peruse the business goal as this research aims to.

What was overlooked before data gathering is the drop-and-rise patterns of the experimental group performance after the adjustments. These patterns clearly show the learning curve of the experimental group. In other words, it required approximately two weeks before the experimental group started to familiarize the new adjustments.

It can be identified that the part of adjustments needed familiarity from the experimental group is at the new tools or the One-For-All scissor which is illustrated in Figure 26 that in Phase 1 the number of A-grade fishes generated a day was lower than the B-grade. As mentioned earlier that the tip of the cutting scissor is sharper than the spoon handle although it was changed to the bunter design, workers still need to find the way or the right angle to use the scissor tip for fish gutting carefully. However, it shows that the experimental group has got its way through as the performance was breaking the ceiling in Phase 3.

Regarding the performance comparison before and after adjustments according to the Job Design and Ergonomic principles guidelines, the comparable information should, however, be at the saturation state of the numbers to identify the final and distinct changes. In this case, Phase 3 performances of the experimental group after the adjustments are used from all parameters.

## 5.2 Productivity Level Analysis

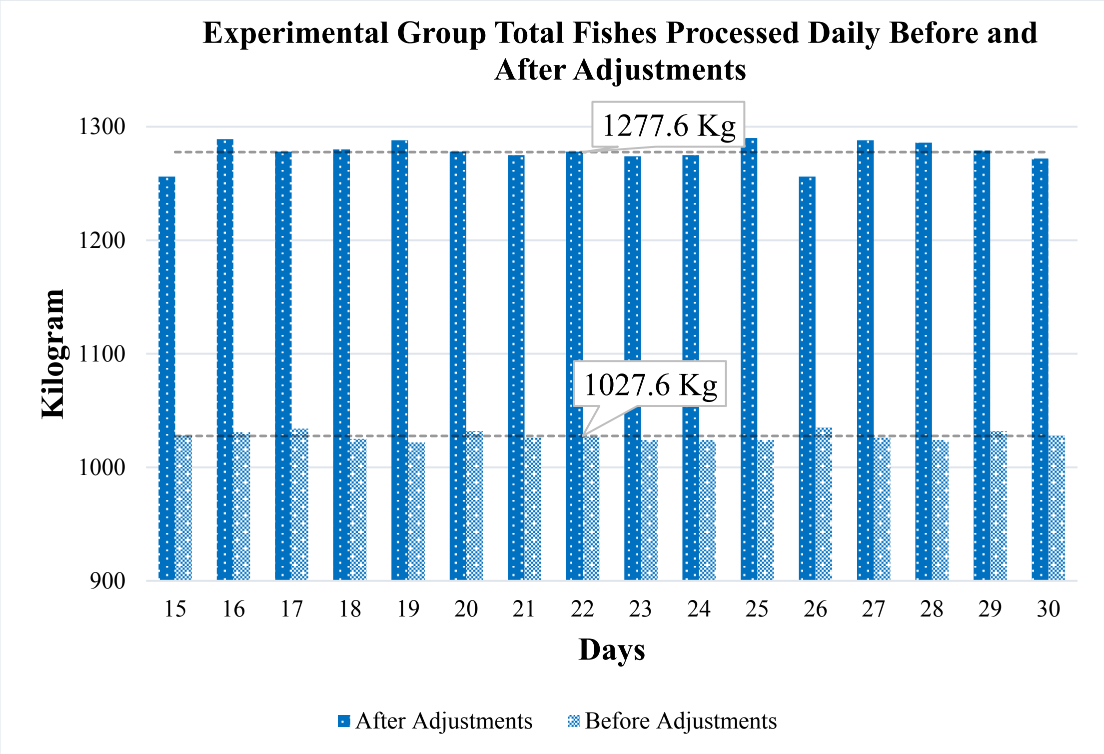



***Figure 31*** *Experimental Group Total Fishes Processed Daily Before and After Adjustments*

***Table 15*** *Daily productivity analysis figures*

| Daily productivity analysis figures | Quantity | |
|---|---|---|
| | Before adjustments | After adjustments |
| Average Total fishes generated | 1027.6 Kg/day | 1277.6 Kg/day |
| Percentage changes in average | 24.33 % | |

Concerning the daily productivity level comparison before and after the adjustments of the experimental group, Figure 31 shows that the productivity level of the experimental group in Phase 3, which is in 15 days from day 15 to 30, is supposedly higher than the productivity level before the adjustments in the same period. So, if the average numbers of experimental group productivity level before and after adjustments are calculated, it is shown in Table 15 that it in increases from 1027.6 Kilograms per day to 1277.6 Kilogram per day which is a 24.33 percent increase.

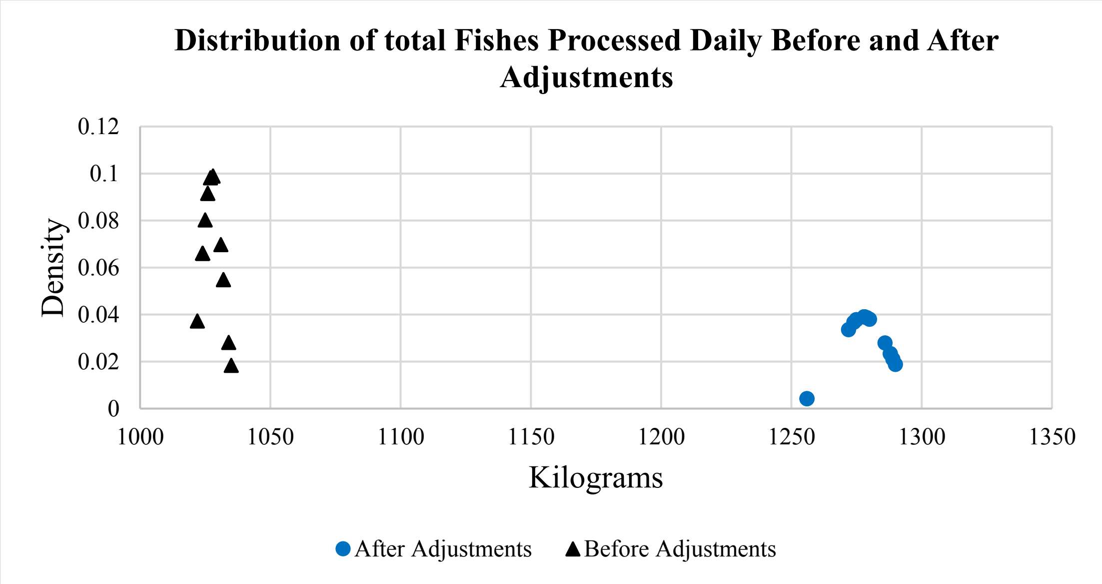



***Figure 32*** *Distribution of Total Fishes Processed Daily Before and After Adjustments*

***Table 16*** *t-Test: paired two sample for means of total fishes processed before and after adjustments*

| | ***Before Adjustments*** | ***After Adjustments*** |
|---|---|---|
| Mean | 1027.625 | 1277.625 |
| Variance | 16.11666667 | 104.65 |
| Observations | 16 | 16 |
| Pearson Correlation | -0.407856683 | |
| Hypothesized Mean Difference | 0 | |
| df | 15 | |
| t Stat | -80.51261866 | |
| P(T<=t) one-tail | 1.70322E-21 | |
| t Critical one-tail | 1.753050356 | |
| P(T<=t) two-tail | 3.40644E-21 | |
| t Critical two-tail | 2.131449546 | |

Statistically, it can be verified from the Table 16 and Figure 32 that there is a significant change to the experimental group fish processing productivity level daily where the P-value is significantly lower than 0.05 in the t-Test table and the normal distribution of productivity level after the adjustments are shifted far beyond the distribution of productivity level before. Although there is more variance in the After results, the mean is significantly higher.

So, these numbers prove that Job Design and Ergonomic principles on the workspace and tool adjustments significantly improve daily productivity level or the total number of fishes processed by the experimental group per day of manual fish processing by 24.33 percent.

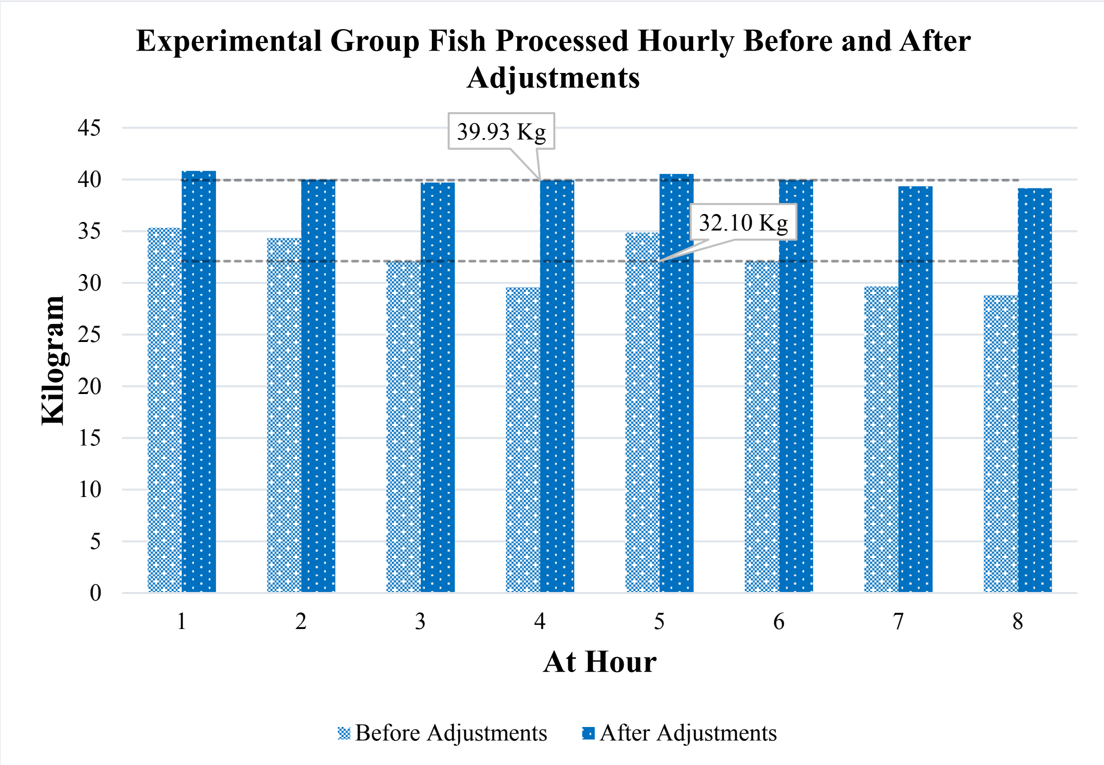



***Figure 33*** *Experimental Group Fish Processed Hourly Before and After Adjustments*

***Table 17*** *Hourly productivity analysis figures*

| Hourly productivity analysis figures | Quantity | |
|---|---|---|
| | before adjustments | after adjustments |
| Average Total fishes generated | 32.10 Kg/hr. | 39.93 Kg/hr. |
| Change in total fishes generated percentage | 24.93 % | |
| Maximum fishes generated hourly | 35.33 Kg/hr. | 40.83 Kg/hr. |
| Minimum fishes generated hourly | 28.81 Kg/hr. | 39.15 Kg/hr. |

| | |
|---|---|
| Change in maximum percentage | 15.65 % |

About the hourly productivity level before and after the adjustments of the experimental group. In Phase 3 or from day 15 to 30, Figure 33 and Table 17 show that the number of fishes processed per hour of the experimental group after the adjustments is leveled at about 40 Kilograms throughout the day, which is higher than the maximum outcome of the Before results by about 5 Kilograms.

The interpretation in terms of fatigue in workers or the relationship of productivity level over time that occurs in the Before results, it is shown clearly that this relationship is reduced at its best where the decreasing of productivity level over time is less noticeable.

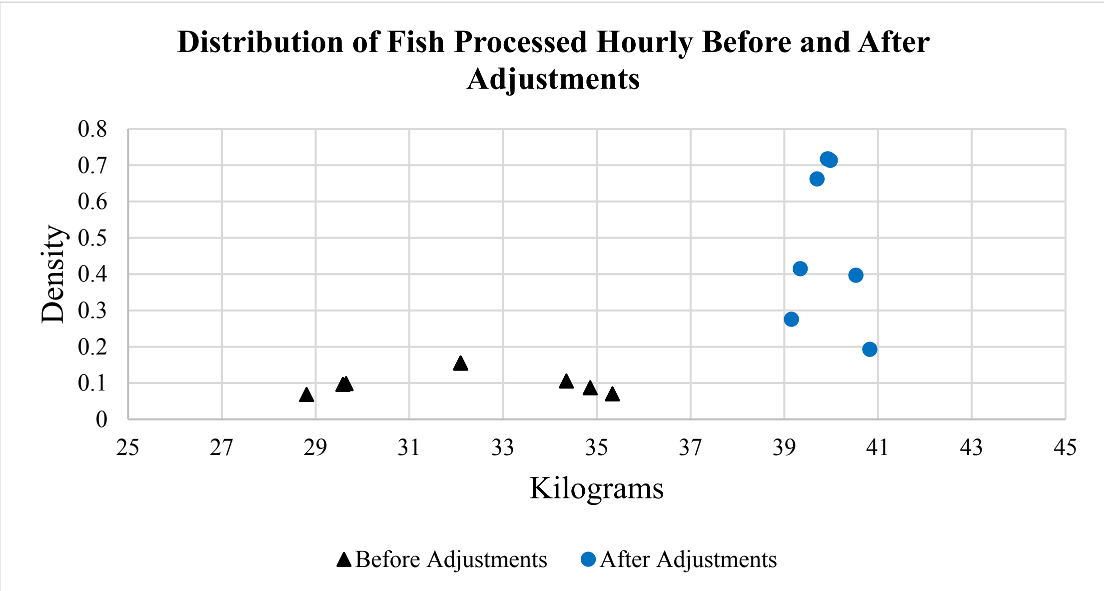



***Figure 34*** *Distribution of Fish Processed Hourly Before and After Adjustments*

***Table 18** t-Test: Paired Two Sample for Means of Fish Processed Hourly Before and After Adjustments*

| | ***Before Adjustments*** | ***After Adjustments*** |
|---|---|---|
| Mean | 31.63452 | 39.79688 |
| Variance | 5.720913 | 0.205729 |
| Observations | 7 | 7 |
| Pearson Correlation | 0.822306 | |
| Hypothesized Mean Difference | 0 | |
| df | 6 | |
| t Stat | -10.6105 | |
| P(T<=t) one-tail | 2.06E-05 | |
| t Critical one-tail | 1.94318 | |
| P(T<=t) two-tail | 4.13E-05 | |
| t Critical two-tail | 2.446912 | |

Statistically, it can be verified from the Table 18 and Figure 34 that there is a significant change to the experimental group hourly fish processing productivity level where the P-value is significantly lower than 0.05 in the t-test table and the normal distribution of hourly productivity level after the adjustments are shifted away from the distribution before. The distribution also shows that there is less spread of numbers for the After results whereby they tend to stay closer to the mean. This means that there are lesser variations or more stable in the amount of fish processed in each hour in a day.

Therefore, this information convinces that Job Design and Ergonomic principles design on the workspace and tool adjustments improve hourly productivity level or the number of fishes processed by the experimental group per hour by 15.65 percent minimum as well as reduce the fatigue in workers significantly throughout the day.

## 5.3 Efficiency Level Analysis

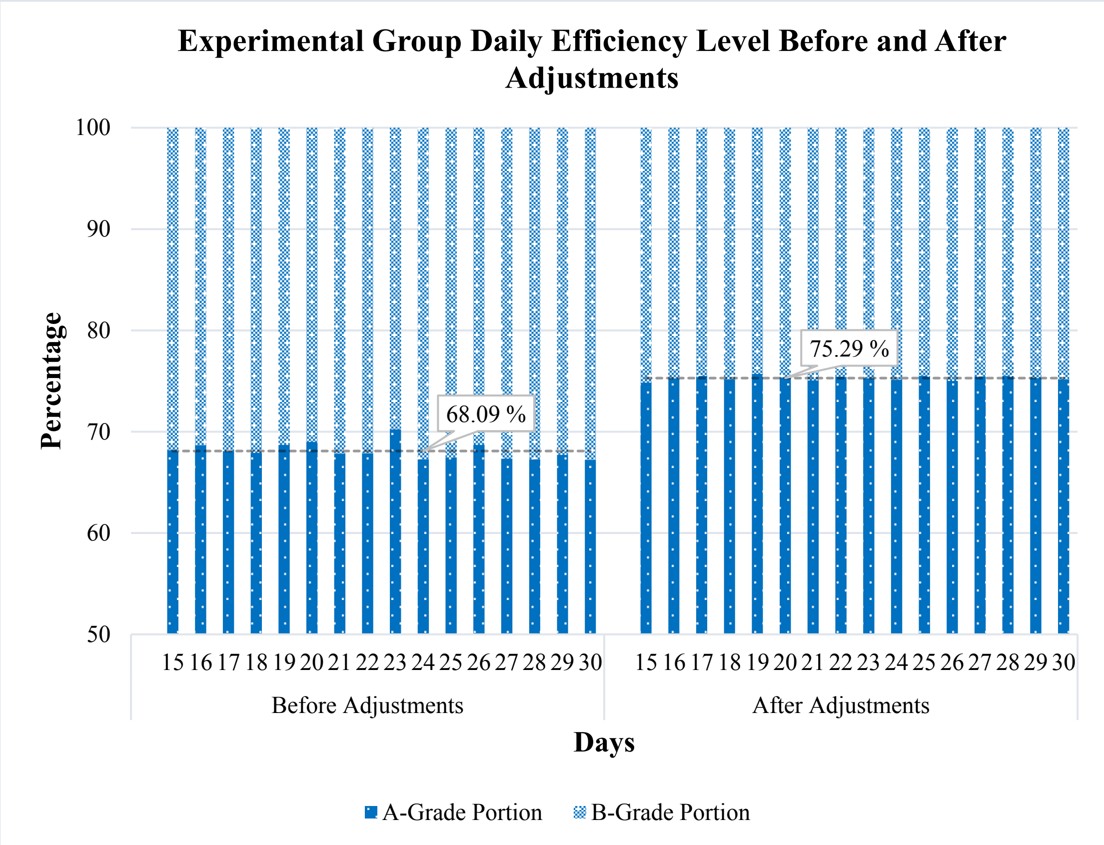



***Figure 35*** *Experimental Group Focus Group Daily Efficiency Level Before and After Adjustments*

***Table 19*** *Daily efficiency analysis figures*

| Daily efficiency analysis figures | Quantity | |
|---|---|---|
| | Before Adjustments | After Adjustments |
| Average efficiency level | 68.10 % | 75.29 % |
| Change in total fishes generated percentage | 7.20 % | |
| Maximum percentage fishes generated hourly | 70.22 % | 75.70 % |
| Minimum percentage fishes generated hourly | 67.22 % | 74.84 % |
| Change in maximum percentage | 5.52 % | |

Regarding the daily efficiency level of the experimental group before and after the adjustments comparison when the numbers are saturated, Figure 35 illustrates the percentages of A-grade and B-grade fishes generated from day 15 to 30 which is in Phase 3 for After results. It can be seen clearly that the percentage of A-grade fishes generated is higher after the adjustments, and workers are familiar with the new tools. The average efficiency levels of before and after adjustments in the period are calculated and compared in Table 19. Quantitively, there is an increase of 7.2 percent of A-grade fishes generated daily level when the experimental group are implemented with the adjustments.

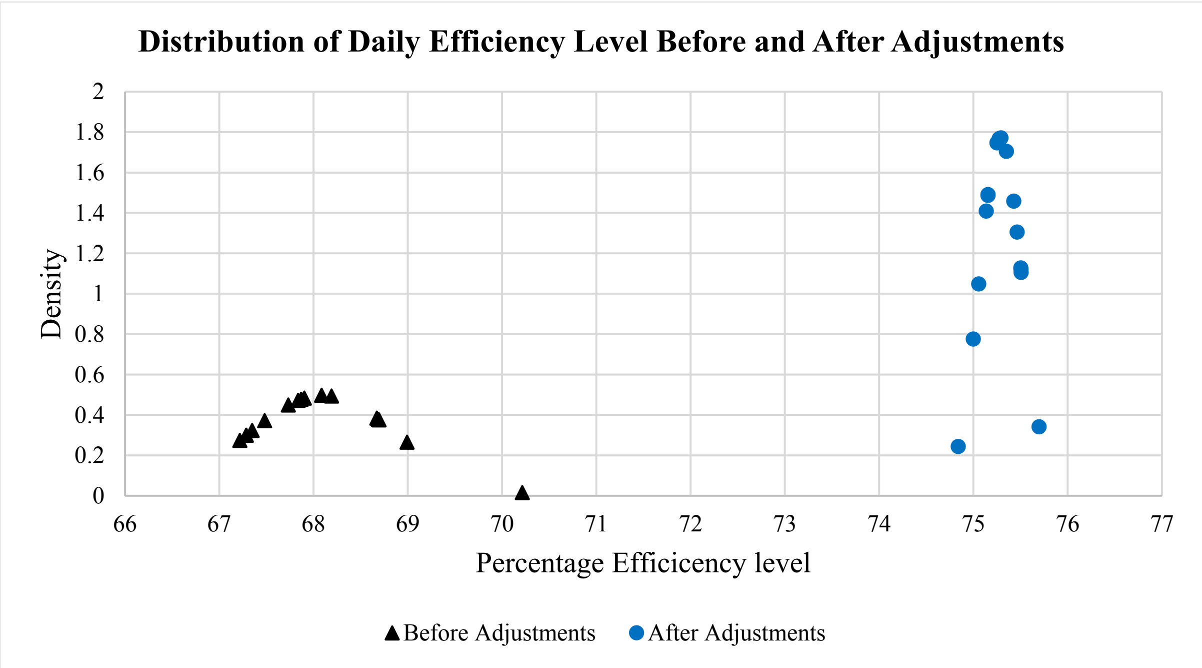



***Figure 36*** *Distribution of Daily Efficiency Level Before and After Adjustments*

***Table 20*** *t-Test: Paired Two Sample for Means of Daily Efficiency Level Before and After Adjustments*

| | ***Before Adjustments*** | ***After Adjustments*** |
|---|---|---|
| Mean | 68.08695511 | 75.31964086 |
| Variance | 0.688981324 | 0.039028383 |
| Observations | 15 | 15 |
| Pearson Correlation | -0.031781196 | |
| Hypothesized Mean Difference | 0 | |
| df | 14 | |
| t Stat | -32.59790973 | |
| P(T<=t) one-tail | 6.62264E-15 | |
| t Critical one-tail | 1.761310136 | |
| P(T<=t) two-tail | 1.32453E-14 | |
| t Critical two-tail | 2.144786688 | |

Statistically, it can be verified from the Table 20 and Figure 36 that there is a significant change to the experimental group daily efficiency level where the P-value is significantly lower than 0.05 in the t-test table and the normal distribution of daily efficiency level after the adjustments are shifted away from the distribution before. The distribution also shows that there is less spread of daily efficiency level in the After results whereby they tend to stay closer to the mean. This means that there is more stable in the volume of A-grade fishes generated in a day.

So, in respect of daily efficiency level where considering only the volume of A-grade fishes generated as an expected outcome from this experimental group, it implies that workspace and tool adjustments to this manual fish processing process increases the numbers in kilogram of A-grade fished generated daily by at least 5.52 percent minimum and on average of 7.2 percent.

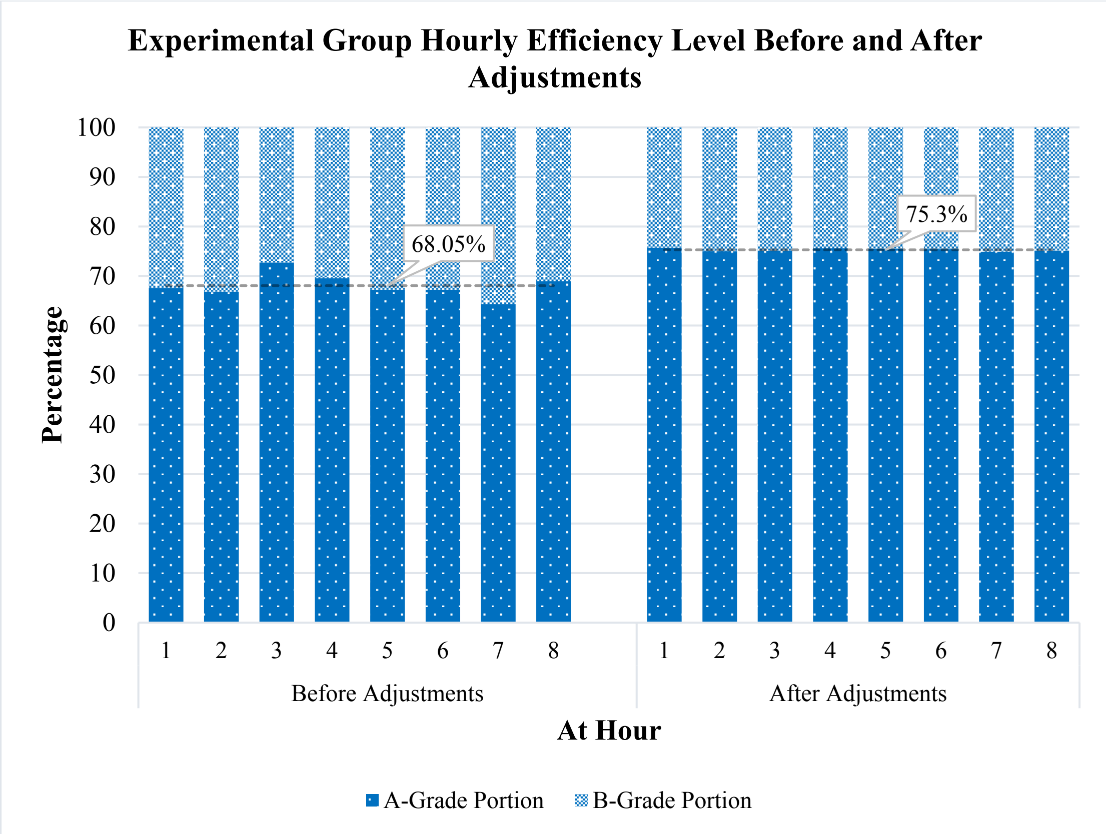



***Figure 37** Experimental Group Hourly Efficiency Level Before and After Adjustments*

***Table 21** Hourly efficiency analysis figures*

| Hourly efficiency analysis figures | Quantity | |
|---|---|---|
| | Before Adjustments | After Adjustments |
| Average percentage A-grade fishes generated per hour | 68.05 % | 75.30 % |
| Change in percentage A-grade fishes generated | 7.25 % | |
| Maximum percentage A-grade fishes generated | 72.7 % | 75.7 % |
| Minimum percentage A-grade fishes generated | 64.3 % | 74.9 % |
| Max. to Min percentage change | 8.4 % | 0.8 % |
| Peak difference | 3 % | |

In terms of the hourly efficiency level of the experimental group before and after the adjustments are implemented, which is illustrated in Figure 37 and Table 21. The average ratio between A-grade and B-grade fished generated in each hour a day for 15 days at the saturation. it shows that firstly the ratios of A-grade and B-grade fishes generated hourly are more consistent with new adjustments, but secondly, there is just a small increase in overall A-grade percentage by about 3 percent matching with the peak of Before results which usually occurs at the third hour.

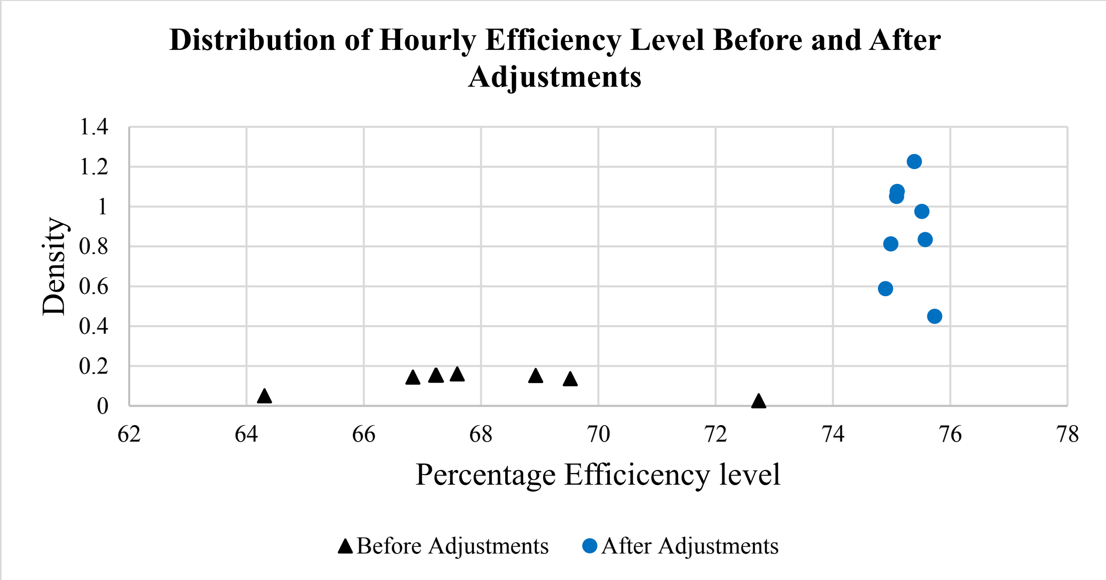



***Figure 38*** *Distribution of Hourly Efficiency Level Before and After Adjustments*

***Table 22*** *t-Test: Paired Two Sample for Means of Hourly Efficiency Level Before and After Adjustments*

| | *Before Adjustments* | *After Adjustments* |
|---|---|---|
| Mean | 68.11323393 | 75.22403161 |
| Variance | 6.948544185 | 0.072267402 |
| Observations | 7 | 7 |
| Pearson Correlation | 0.209128202 | |
| Hypothesized Mean Difference | 0 | |
| df | 6 | |
| t Stat | -7.255040038 | |
| P(T<=t) one-tail | 0.000174262 | |
| t Critical one-tail | 1.943180281 | |
| P(T<=t) two-tail | 0.000348524 | |
| t Critical two-tail | 2.446911851 | |

Statistically, it can be verified from the Table 22 and Figure 38 that there is a change to the experimental group hourly efficiency level where the P-value is lower than 0.05

in the t-test table and the normal distribution of hourly efficiency level after the adjustments are slightly shifted away from the distribution before. The distribution also shows that there is less spread of hourly efficiency level in the After results whereby they tend to stay closer to the mean. This means that there is more stable in the volume of A-grade fishes generated each hour in a day.

Therefore, this even emphasizes that the efficiency level by the hour of the experimental group is maintained and slightly higher with Job Design and Ergonomic principles on workspace and tool adjustments. However, it indicates that the adjustments do not only increase the number of A-grade fishes generated, but both the fish grades are increased. This means that the volume of B-grade fishes, which is the less expected grade, does not significantly decrease but increase along with the A-grade volume making the efficient level of the experimental group after the adjustment does not to change much in percentage or only at 7.25 percent in average.

## 5.4 Revenue Created Analysis

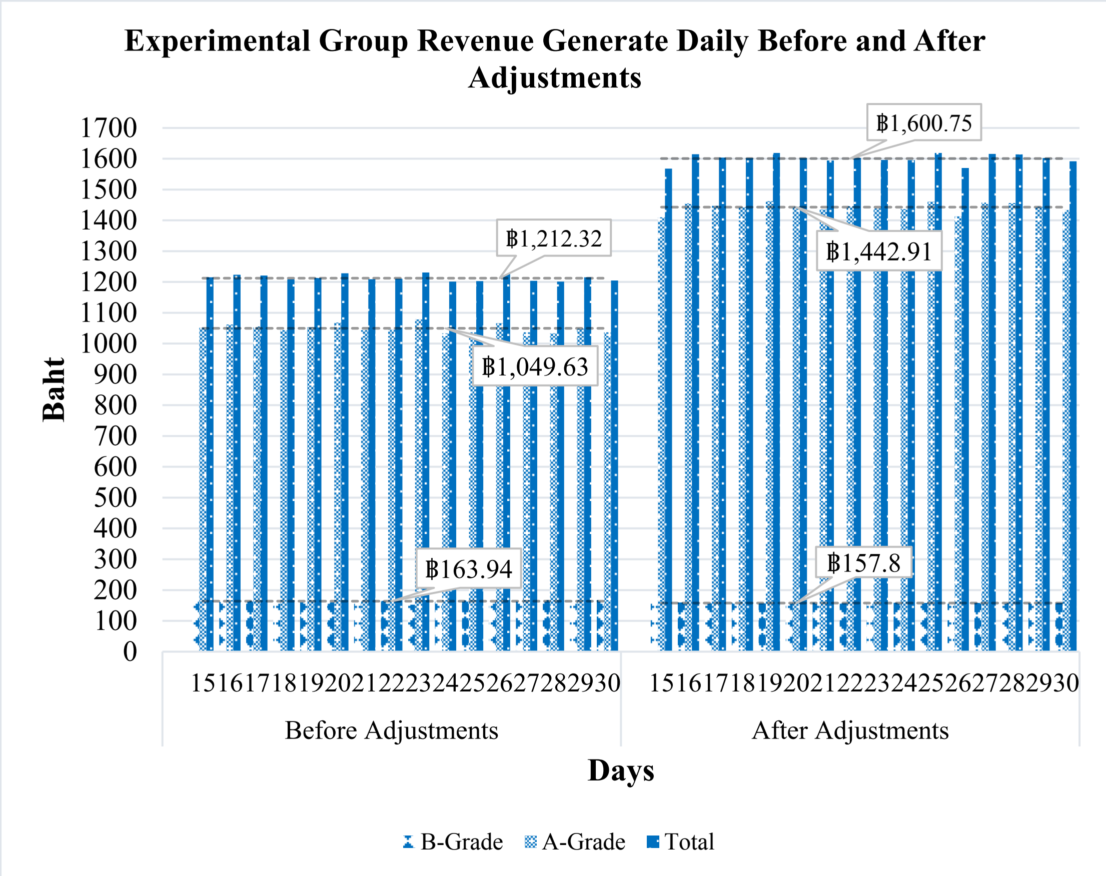



***Figure 39*** *Experimental Group Revenue Generate Daily Before and After Adjustments*

***Table 23*** *Revenue created analysis figures*

| Revenue created analysis figures | Quantity | |
|---|---|---|
| | Before Adjustments | After Adjustments |
| Average revenue generated | 1212.32 Bath/day | 1600.75 Bath/day |
| Average revenue generated from A-grade | 1049.63 Bath/day | 1442.91 Bath/day |
| Average revenue generated from B-grade | 163.94 Bath/day | 157.84 Bath/day |
| Percentage revenue generated from A-grade | 86.58 % | 91.14 % |
| Percentage revenue generated from B-grade | 13.42 % | 9.86 % |
| Percentage overall revenue created changes | 32.04 % | |

For the comparison of revenue created by the experimental group before and after the adjustments, it can be seen from Figure 39, which illustrated the amount in Thai Baht of revenues before and after the adjustments for 15 days after at saturation, that the total revenue created daily by the experimental group with adjustments is significantly higher. However, the total revenue created is segmented into A-grade and B-grade, the incremental of the total revenue comes from A-grade fishes, while the revenue created from B-grade fishes seemingly stays at about the same value.

According to the numbers in Table 23, the average total revenue created increases from 1212.32 Baht per day to 1600.75 Baht per day, which is about a 32.04 percent increase after the adjustments. However, after the adjustments, revenue created from A-grade fish is the portion that has a significant incremental in comparison to the B-grade fish portion, which does not change much.

Below, it can be statistically verified from the Table 24, Table 25 and Table 26 that there are changes to the experimental group daily revenue gained in total, from A-grade fishes and from B-grade fishes respectively where their P-values were lower than 0.05 values in the t-test tables. The normal distributions of daily revenue gained from total and A-grade fishes after the adjustments illustrated in Figure 40 and Figure 41 respectively are shifted away from the distributions before. For the daily revenue gained from B-grade fishes, its distribution after the adjustments in Figure 42 has the mean to be slightly lower than before, and it also shows that there is less spread of revenue gained in the After results whereby, they tend to stay closer to the mean.

This indicates that implementation of workspace and tool adjustments following Job Design and Ergonomic principles significantly increase the total revenue gain from and of this experimental group by 32.04 percent where most of the incremental come from the increase of A-grade fishes generated.

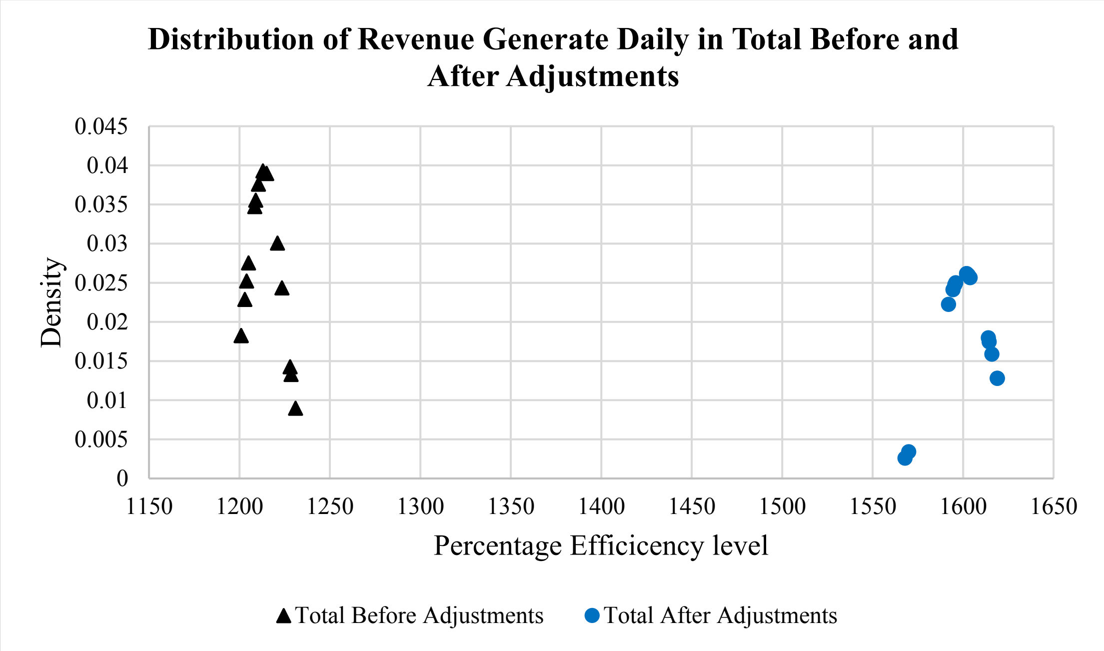



***Figure 40*** *Distribution of Revenue Generate Daily in Total Before and After Adjustments*

***Table 24*** *t-Test: Paired Two Sample for Means of Revenue Generate Daily in Total Before and After Adjustments*

| | ***Before Adjustments*** | ***After Adjustments*** |
|---|---|---|
| Mean | 1213.466667 | 1602.933 |
| Variance | 109.9809524 | 166.0667 |
| Observations | 15 | 15 |
| Pearson Correlation | -0.37884354 | |
| Hypothesized Mean Difference | 0 | |
| df | 14 | |
| t Stat | -77.5379653 | |
| P(T<=t) one-tail | 3.82968E-20 | |
| t Critical one-tail | 1.761310136 | |
| P(T<=t) two-tail | 7.65937E-20 | |
| t Critical two-tail | 2.144786688 | |

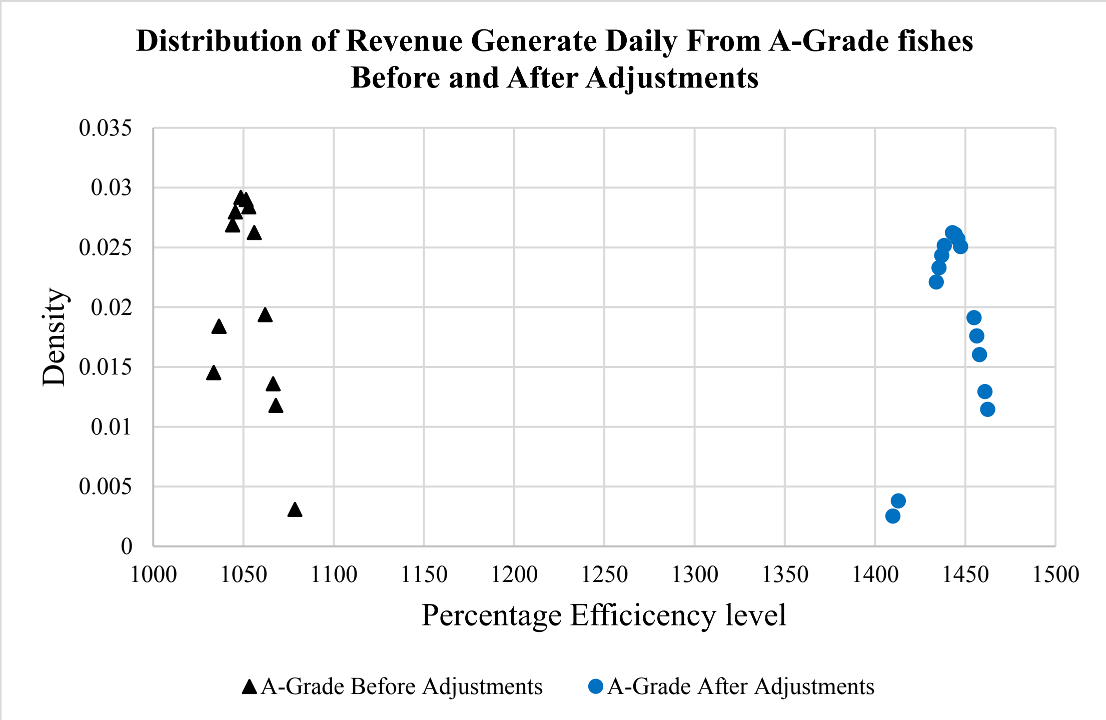



***Figure 41*** *Distribution of Revenue Generate Daily From A-Grade fishes Before and After Adjustments*

***Table 25*** *t-Test: Paired Two Sample for Means of Revenue Generate Daily From A-Grade fishes Before and After Adjustments*

| | ***Before Adjustments*** | ***After Adjustments*** |
|---|---|---|
| Mean | 1049.5 | 1445.1 |
| Variance | 198.5357143 | 165.4714 |
| Observations | 15 | 15 |
| Pearson Correlation | -0.30324927 | |
| Hypothesized Mean Difference | 0 | |
| df | 14 | |
| t Stat | -70.3788545 | |
| P(T<=t) one-tail | 1.48169E-19 | |
| t Critical one-tail | 1.761310136 | |
| P(T<=t) two-tail | 2.96339E-19 | |
| t Critical two-tail | 2.144786688 | |

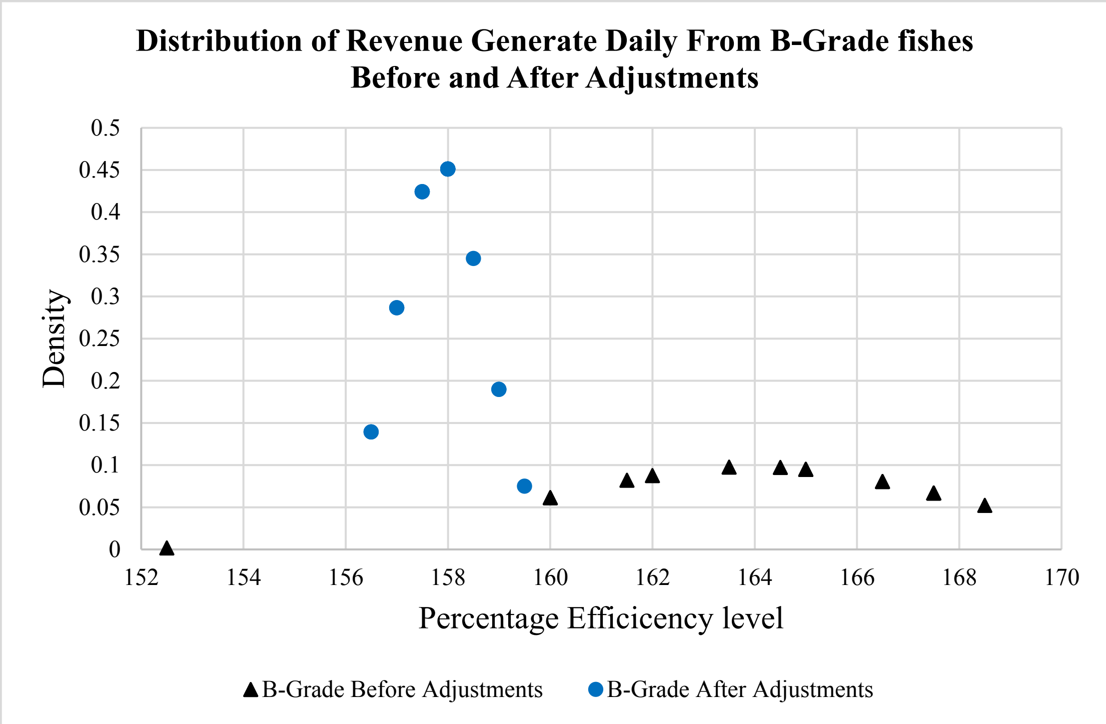



***Figure 42*** *Distribution of Revenue Generate Daily From B-Grade fishes Before and After Adjustments*

***Table 26*** *t-Test: Paired Two Sample for Means Distribution of Revenue Generate Daily From B-Grade fishes Before and After Adjustments*

| | ***Before Adjustments*** | ***After Adjustments*** |
|---|---|---|
| Mean | 163.9666667 | 157.8333 |
| Variance | 17.65952381 | 0.809524 |
| Observations | 15 | 15 |
| Pearson Correlation | 0.206232785 | |
| Hypothesized Mean Difference | 0 | |
| df | 14 | |
| t Stat | 5.776656039 | |
| P(T<=t) one-tail | 2.39751E-05 | |
| t Critical one-tail | 1.761310136 | |
| P(T<=t) two-tail | 4.79503E-05 | |
| t Critical two-tail | 2.144786688 | |

### 5.5 Return on Investment (ROI) Analysis

In terms of ROI analysis, which is looking at the ratio between the net profit and cost of investment in a period, the formula used for the calculation is as follows.

$$ROI = \left(\frac{Net\ gain_{in\ expected\ period}}{Total\ investment}\right) \times 100$$

Where, in this case, the Net gain is the difference of revenue created after the adjustment, and Total investment is the amount of money on all tools and equipment for the adjustments.

The purpose of this analysis is to measure the percentage of return on money invested per period. It means that how much money the factory would get in return in the percentage out of the total investment in a defined period, which is 30 days for this research.

From Table 3 and Table 23 where the change of revenue created by the experimental group is found, and the total implementation cost is calculated respectively, if convert all the change of revenue created for the investment return, the calculation of ROI of this case is blow.

$$ROI = \left(\frac{(1600.75 - 1212.32) \times 30}{24460}\right) \times 100$$

$$ROI = 47.64\ \%$$

From the calculation, ROI in a month, in this case, turns out to be 47.64 percent. This indicates that the factory would only get almost half of the investment cost back within a month. In other words, with this amount of implementation cost, it would take approximately two months before the factory regains all the investments back.

# Chapter 6 Discussion and Conclusion

The purposes of the chapter are to summarize and generalize all imperative findings from the research, to discuss and criticize the research conductions and the literature reviews, to verify the research objectives achievement, and lastly to describe further and future application opportunities of the potential findings from the research.



## 6.1 Research Findings Discussions

### 6.1.1 Imperative Findings

To contain all research results and analyses, which are translated to the research findings, in one place by a single glance. Table 27 below summarizes all essential changes in terms of performance found and captured from the experimental group in the manual fish processing after the implementation of workspace and tool adjustments following Job Design and Ergonomics principles and guidelines.

Remark that these following findings are captured and calculated from the period that members in the experimental group already get used to the adjustments or when their outcomes reach the saturation state which means the learning period when their outcomes are not stable is not considered.

***Table 27*** *Numerical Summarization of Research Findings*

| Measures | Changes and Findings | Percentage |
|---|---|---|
| Daily productivity level | Significantly increase | + 24.33 % |
| Daily A-grade fishes generated | Significantly increase | + 37.65 % |
| Daily B-grade fishes generated | Slightly decrease | - 3.75 % |
| Hourly productivity level | Significantly increase | + 24.93 % |
| Daily efficiency level | Fairly increase | + 7.20 % |

| | | |
|---|---|---|
| Hourly efficiency level | Fairly increase | + 7.25 % |
| Daily revenue created in total | Significantly increase | + 32.04 % |
| Daily revenue created from A-grade fishes | Significantly increase | + 37.47 % |
| Daily revenue created from b-grade fishes | Slightly decrease | - 3.86 % |
| ROI | Take approximately two months to breakeven | 47.64 % |

Because of the research objective and research questions that outline the research achievements in terms of worker performance and the return on investment, there are mainly three outcome measure dimensions enclosed in the table above. Those are productivity level, efficiency level, and revenue created. Across the table, there are some significant changes, but there are also some are fair or slight changes.

### 6.1.2 Fatigue Relief

To mention again for the productivity and efficiency level measures, the day domain is to measure the overall performance while the hour domain is to measure the productivity and efficient level at particular time of the day which interprets specific information in terms of fatigue level. The evidence from Figure 33 and Figure 37 show the comparison of hourly productivity and efficiency level throughout the day of the experimental group before and after the adjustments. It reflects clearly what creates the swing patterns in those chats is the fatigue that the experimental group has. The clue is the repetition of a pattern where it tends to peak in the morning and after lunch, which is after the experimental group is taking breaks before the number goes down in later hours. Therefore, after the adjustments, the swing pattern in hourly productivity and efficiency level during the day is relieved to be more stable and raised by up to 23.93 percent and 7.25 percent for hourly productivity and efficiency level respectively.

### 6.1.3 Dissatisfaction of Efficiency Level

For the fair increase in daily and hourly efficiency level, this information implies that the ratio between A-grade and B-grade fishes generated does not change much though the number of all fishes generated in total changed significantly. In other words, the number of B-grade fish converted to A-grade fish generated after the adjustment is still low, which both fish grade potions are increased. If looking back to what has adjusted and close to the fish grade determination the most, it is the tool adjustments where the One-For-All scissor is implemented. As a result, the fair increases in efficiency level surfer that the adjustment of the tool may not help to increase the efficiency level enough though it makes a massive difference to the productivity rate.

After observations and communications with the experimental group on this One-For-All scissor, the feedbacks received from them was it was still hard for them to prevent the fish belly from being destroyed. Even though the scissor helped to reduce the processing time by getting rid of the tools switching gaps, the sharpness of the scissor is still there resulting in them to find the balance point of time spent on carefully removing fish guts and the volume of fishes generated in total. This means if their efficiency level is increased, their productivity level might decrease proportionally.

### 6.1.4 Revenue Gained Portion

The productivity and efficiency levels are relatively linked to the revenue created. Recalling the prizing potion of A-grade and B-grade fishes, which is 1.5 Baht and

0.75 Baht respectively, a small increase in A-grade fishes would make a huge change in revenue gained while for B-grade is not. So, increasing revenue gained can happen in two ways. One is increasing the number of fishes generated or processed. Another is to convert all fishes generated into A-grade. This means to improve both the productivity and efficiency level of the operation. In this case, however, productivity level has increased significantly in contrast to the efficiency level both in days and hour domains.

### 6.1.5 More Than Returns

Through what so-called Fifty-Fifty rewards model that this manual fish processing factory adopted, the number of revenues created measures represent the revenue gain of both the factory and the experimental group. However, the calculation of ROI is considered only on the factory side as the investment comes from it. This means that the experimental group instantly gains all the revenue changes the moment the adjustments are implemented. In another perspective, however, putting debts onto only on the factory could be one way to encourage and motivate workers. This is because the reward is one of the motivation factors of workers according to the Job Design principles. So, if there is a way to gain more without having to lose, they would happy to commit the works. It just a meter of time for the factory for the returns. In this case, the ROI is about 47.64 percent for a one-month period, which is not what expected from one of the hypotheses, it takes about two months to get all the investment in return.

## 6.2 Research Conduction Judgments

The purpose of this section is to retrospect the research conductions if they went according to the plans and expectations of the research methodology. It consists of what went well and what went terrible as in the following subsections.

### 6.2.1 What Went Well

The first thing that went well appears in the research conduction is the creation of the experimental group. The purpose of the experimental group was to isolate a group of workers for the experiment from the majority on-going worker group. This is to reduce the risk of operation disruptions that may or may not occur to the business as a whole. Before the workspace and tool adjustments are implemented, there were not any differences obviously between the experimental group and the regular group in terms of performance. However, when the adjustments got implemented, the performance of the experimental group went down terrifyingly. This was not expected as the expectation was the performance would build-up from previous figures, but it was even lower than it used to be in the first week before it showed signs of improvement in a week after. Therefore, if there were no experimental group, in this case, the factory would have lost a lot in the earlier stage of the experiment.

Additionally, with the qualifications of workers for the experimental group, which state in Table 2, continuity data collection was developed as expected. Because physical identical and area of living were listed in the qualification, the workspace and tool adjustments were standardized and the time to start and end the tasks for data gathering were definite. I was resulting in smooth data collection throughout the research conduction.

Although the creation of an experimental group or experimental group is typical for any developments of unfamiliar or new features to the usual system, this emphasizes that having a trial is a must regardless of the likelihood of risks will occur.

As a result of what went well, on time and smooth daily and hourly data collections were met. As well as, the robustness of the results was developed which distinctively displays the outcomes in what areas the adjustments were effectively influenced and disclosing the room of improvement.

### 6.2.2 What Went Bad

The thing that went bad was the workspace and tool adjustments were not thoroughly thought and designed at in the earlier before ordering the equipment stage. This led to some minor changes to the design and reordering of some parts. For example, when utilizing the right table height and sit-stand stool, the fact a person height will reduce by a bit when leaning on the stool was overlooked. This caused the adjustable stools to be ordered, which cost more money and time for ordering.

Another example was at the first One-For-All fish cutting scissor, which is a scissor that can provide multiple tasks for the fish processing such as trimming, de-scaling, and gutting, its designs and functions were not best fit to the job. This was because the tip of the first scissor was too sharp and long, causing it quickly broke open the fish belly in the gutting process. So, the reordering of more feasible scissors, which blunter tips or metal parts, had to be done and again adding to the investment of time and money.

Another point of what went terrible was except the table that was manufactured in the county, stools and scissors were imported from overseas. The reason for that was because of this specific equipment are not available in the country, and it would take much time to design and build prototypes that best fit all the required functionalities from scratch through local equipment developers. This, therefore, the decision was made to use what feasible and available in exchanged with additional lead times and shipping cost to equipment in the cost estimation of the research.

As a result, these points of what went bad caused a delay and extra cost, which were not factored in the research, at a very initial stage of the research before started collecting data. As well as, it reflects from the result that although the productivity level of the experimental group is significantly increased, the efficiency level is not changed much. Anticipation for this root cause is pointing to the concern that if this One-For-All scissor fits with jobs enough as this closely related to the determination of A-grade and B-grade fishes, which are wanted and less wanted fish grades respectively, generated.

## 6.3 Literature Review Criticization

In this research, Job Design and Ergonomics are two main principles that have been used in combination, as stated throughout the paper. For the Job Design concept, as explicitly identified for this manual fish processing process that jobs in this process should also be designed to facilitate and encourage the workers to do the tasks in order to enhance their performance. Especially for the local workers where their potential is waiting to be unleashed.

From the experiments on the experimental group, the area where the redesigned of jobs in this fish processing process to be more facilitative and encouraging for the workers is at the implementation of One-For-All scissor. By getting rid of the improper tools which were a small metal spoon and a basic scissor and providing the ability to handle multiple tasks single-handedly, these allow the workers to enrich their jobs by making them realize that they can do more and gain more and that reflects in the results from the research.

Therefore, this introduction of proper tools might seem to be a small change in the process, but it is a starting point of job satisfaction in workers. This means that the intention of not giving rewards to motivate workers but allowing them to gain their rewards instead has been fulfilled.

For the Ergonomic principles, the ten Ergonomic principles guideline from MacLeod (2013) is beneficial. This is primarily in the As-is analysis, where it helps to identify the malpractices in the process. This results in a particular direction of workspace and tool adjustments are developed and implemented on the experimental group in the experiment and it can be seen from the results that the posture of the workers in the experimental group has changed.

Nonetheless, the results of the efficiency level were not impressive due to the fact that the design of the One-For-All scissor is not yet suitable enough. There are still rooms for improvement that have to be fulfilled. Anyways, at least it is realized that utilizing Job Design and Ergonomic principles in the right direction for this fish processing factory to enhance their worker performances and increase its capacities.

## 6.4 Conclusion to The Research Questions, Hypotheses and Objective

Recalling the general idea of the research which is related to manual fish processing improvement by implementing Job Design and Ergonomic principles to workspace and working process. Whereby the problem that occurred to the local seafood processing factories in the south of Thailand and especially to this local manual fish processing factory is the lack of potential workers, who can perform the tasks for fish processing superbly daily. The factory has no choice but to rely on the local worker who seems to perform at a lower level to the migrant workers as compared and illustrated in Figure 4 in the earlier chapter. So, it leads to the fact that if the factory wants to increase its daily capacity, improving these local workers performance is the only way. It not because of these workers are not fit or cannot perform the tasks, it is just that their determinations and motivations are lacking making them perform poorly than migrant workers in general.

### 6.4.1 Research Question and Hypotheses Alignment

With the study and implementation of Job Design and Ergonomic principles, which are the theories and guidelines to increase job enrichment in workers as well as improving workers' performance in manual work industries proven by several similar reports and studies. The results and analyses from the experiments can be used to answer the research questions and verify the research hypotheses as follows.

In the sense of worker performance improvement, this has to be broken into two measurements, which are productivity and efficiency level. According to the research findings, it is shown and explained clearly that the productivity level of workers increases by over 20 percent in contrast to the efficiency level, which increases only a single-digit percentage. So, if to answer the question of implementing Job Design and Ergonomic principles to this manual fish processing improves worker performances? The answer is a Yes, but there are yet still gaps to fulfil. Also, for the hypothesis verification, the performance of the workers is indeed increasing, but that likewise depends on how suitable the implementations are. In this case, because of the efficiency level of the workers in the experimental group did not change much and the assumption is on the tool adjustment which is not yet suitable enough making the outcomes not yet at the highest potential.

In terms of the increment of factory capacity, the results and analyses implied the same way for worker performance improvement. Considering the capacity of the factory equals to the productivity level of the workers, it means that the capacity of the factory is increased by over 20 percent, which is a significant number. Moreover, the increase in daily capacity comes from two improvement areas. First, the average volume of fishes generated hourly increases. Second, the volume of fishes generated is stable throughout the day. Therefore, it is verified that the daily capacity of the factory is raised relative to worker performance and the answer to the question of implementing Job Design and Ergonomic principles to this manual fish processing improves factory capacity is a Yes.

With regards to the revenue gain of the factory, the outcomes suggest that the change in revenue gain daily increases by over 30 percent where most of it comes from the increase in the number of A-grade fishes generated. However, if the efficiency level of worker increases more or there are more B-grade fishes converted to A-grade fishes, the change percentage of revenue gain would increase more. On the other hand, if looking at the rate of return on investment in one month, considering all the changes in revenue gained to be for returns, it has to be two months for the factory to reach the break-even point. Therefore, to verify that the implementation of Job design and Ergonomic principles increases the revenue gained of the factory, it is true. However, considering the return on investment targeting for one month, it is not. However, it misses the target by only a month. So, to answer the question of implementing Job Design and Ergonomics to this manual fish processing cost-effective? The answer is depending on how long it is preferred and designated by the factory. In this case, it is for a month, but if the factory is willing to extend the ROI period only by another month, it will get all the investment in return.

### 6.4.2 Research Objective Alignment

After carrying out all the tasks listed to reach the objective of the research, the findings translated from the outcomes and analyses indicate the overall worker performance, factory capacity and revenue gained are improved as evidence which aligned with the research objective. Therefore, it can be concluded that this search has demonstrated that implementing Job Design and Ergonomic principles by modifying and adjusting the work process and the environment in the manual fish processing factory improves overall worker performance in the production line which leads to increasing of the factory capacity. However, this is some areas that could be improved even to enhance the results as mentioned earlier.

So, if the research is going to be used as a guideline or followed by for the other manual processing factories, they can execute the same take sequence stated in the research objective section in the introduction chapter. The differences are only the detail in the task where the identification of the pinpoints and suitable Job Design and Ergonomic principles implementations might defer according to a different type of product or seafood processed. However, the suggestion is that if there is no time limit to the implementation, finding and developing the equipment for the adjustment implementations locally would bring the cost of the implementation down leading to the return on investment to be faster.



### 6.4.3 More Intangible Benefits

Apart from the worker performance and factory capacity improvement, there are also the following benefits that the factory might be getting. One example is that with comfortability and untraditional workspace and tools plus more gaining that guaranteed by the factory, the factory might be attractive for more workers — resulting in increasing in factory value and positioning among other competitors.

Another benefit is that the factory could immerge to be in the top tier contractors list of customers in terms of productivity and efficiency which could potentially increase the cap of fish volume allowance per day from the customer, which means that the factory and workers in the factory would have the chance to increase the revenue gained.

Moreover, this could be a new business opportunity for this factory. Because it has demonstrated that the implementation of Job Design and Ergonomic principles to manual fish processing factory creates benefits, this factory which is the pioneer could become a consultant helping the other local manual factories in the area to achieve the same or better results as this factory did.

## 6.5 Future work

To even enhance the research outcomes by increasing the efficiency level, the tasks have to be repeated, but there will be more time spending on the development of the One-For-All tool or scissor in-country using local tools developers. Keeping good designs of the scissor from oversea and reworking the functions on the metal tip of the scissor, which was the problem.

The same action goes to the other adjustments as well. For instance, the design of the table. Instead of the table having a fixed height, introducing the height adjustment function to it. So, when implementing this to the whole factory, the table height could be adjusted according to the worker groups.

The most important to this is trying to build, develop, and use the equipment for the adjustment in-country or from the local region. Although it would take time to develop or build the equipment, it would reduce the shipping cost by a lot, and it would be much easier for the factory to make further adjustments for the different design if the product changes as well as  it is much faster for the factory to get after services in the future.

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# APPENDIX

## Appendix 1 10 Principles of Ergonomics

Adopted from MacLeod, Dan (2013) The Rules of Work: A Practical Engineering

### Principle 1
### Work in Neutral Postures

Your posture provides a good starting point for evaluating the tasks that you do. The best positions in which to work are those that keep the body "in neutral."

| | |
|---|---|
| **Maintain the "S-curve" of the spine**<br><br>Your spinal column is shaped more or less like an "S." |  |
| It is important to maintain the natural S-curve of the back, whether sitting or standing. The most important part of this "S" is in the lower back, which means that it is good to keep a slight "sway back."<br><br>When standing, putting one foot up on a footrest helps to keep the spinal column in proper alignment. |  |
| Working for long periods with your back in a "C-curve" can place strain on your back.<br><br>Good lumbar support is often helpful to maintain the proper curve in the small of your back. |   |
| The "Inverted V-curve" creates an even greater strain on your back. Even without lifting a load, bending over | |

Guide to Ergonomics

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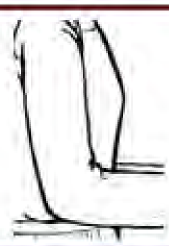
| like this creates a great deal of pressure on the spine.<br><br>One common improvement is to use a lifter or tilter. Or there may be other ways of making improvements depending upon the situation. | <br> |
| **Keep the neck aligned**<br><br>The neck bones are part of the spinal column and thus are subject to the same requirements of maintaining the S-curve. Prolonged twisted and bent postures of the neck can be as stressful as its equivalent for the lower back.<br><br>The best way to make changes is usually to adjust equipment so that your neck is in its neutral posture. | <br> |
| **Keeps elbows at sides**<br><br>The neutral posture for your arms is to keep you elbows at your sides and your shoulders relaxed. This is pretty obvious once you think about it, but we don't always do it. |  |
| Here's an example of changing a workstation to get the arms in neutral. In the illustration at the left, the product is too high, and the employee is hunching her shoulders and winging out her elbows.<br><br>In the right-hand illustration, the product has been reoriented and the shoulders and elbows drop to their relaxed position. |   |

| Keep Wrists in Neutral | |
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| There are several good ways to think about wrist posture. One way is to keep the hand in the same plane as the forearm, as this person is doing here by using a wrist rest along with the computer mouse. |  |
| A slightly more accurate approach is to keep your hands more or less like they would be when you hold the steering wheel of your car at the 10 and 2 o'clock position — slightly in and slightly forward. |  |
| Here's an example of how this principle applies to tool design. Working continuously with the pliers as shown in the left-hand picture can create a lot of stress on the wrist. By using pliers with an angled grip, however, the wrist stays in its neutral posture. |  |

# Principle 2
## Reduce Excessive Force

Excessive force on your joints can create a potential for fatigue and injury. In practical terms, the action item is for you to identify specific instances of excessive force and think of ways to make improvements.

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| For example, pulling a heavy cart might create excessive force for your back. To make improvements it might help to make sure the floor is in good repair, that the wheels on the cart are sufficiently large, and that there are good grips on the cart. Or a power tugger might be needed. |  |
| Or another example of reducing force is to use a hoist for lifting heavy objects, like this vacuum hoist in the drawing. |  |
| Another kind of example is having handholds on boxes or carrying totes. Having the handhold reduces the exertion your hands need to carry the same amount of weight. |  |
| Point:<br><br>There are thousands of other examples and the field of ergonomics includes much information on conditions that affect force. The basic point is to recognize activities that require excessive force, then think of any way you can to reduce that force. | |

## Principle 3
## Keep Everything in Easy Reach

The next principle deals with keeping things within easy reach. In many ways, this principle is redundant with posture, but it helps to evaluate a task from this specific perspective.

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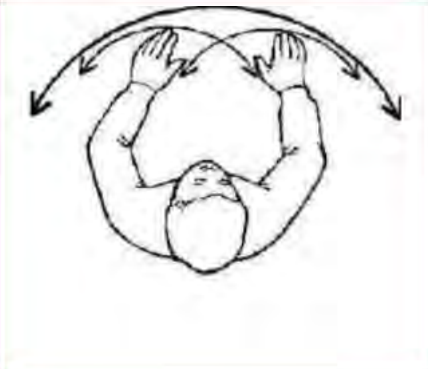
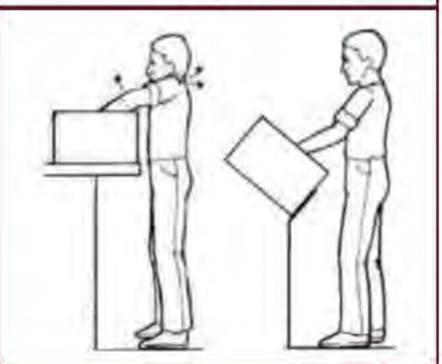
| **Reach Envelope**<br><br>One concept is to think about the "reach envelope." This is the semi-circle that your arms make as you reach out. Things that you use frequently should ideally be within the reach envelope of your full arm. Things that you use extremely frequently should be within the reach envelope of your forearms. |  |
| Much of the time, problems with reach are simply matters of rearranging your work area and moving things closer to you. This is not exactly a hard concept to grasp; what is difficult is having the presence of mind to notice and change the location of things that you reach for a lot.<br><br>Often it is a matter of habit — you are unaware that you continually reach for something that could be easily moved closer. |  |
| Or sometimes, the work surface is just too big, causing you to reach across to get something. One option is just to get a smaller surface. Another option is to make a cutout — this way your reaches are cut, but you still have plenty of space for things. |  |
| Or another common problem is reaching into boxes. A good way to fix this is to tilt the box.<br><br>Once again, there are thousands of other examples of ways to reduce long reaches. The point is for you to think about when you make long reaches, then figure out how to reduce that reach. |  |

# Principle 4
# Work at Proper Heights

Working at the right height is also a way to make things easier.

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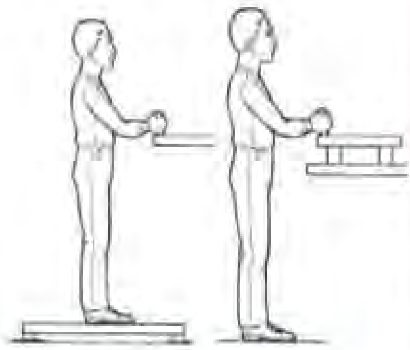
| **Do most work at elbow height**<br><br>A good rule of thumb is that most work should be done at about elbow height, whether sitting or standing.<br><br>A real common example is working with a computer keyboard. But, there are many other types of tasks where the rule applies. |  |
| **Exceptions to the Rule**<br><br>There are exceptions to this rule, however. Heavier work is often best done lower than elbow height. Precision work or visually intense work is often best done at heights above the elbow. |  |
| Sometimes you can adjust heights by extending the legs to a work tables or cutting them down. Or you can either put a work platform on top of the table (to raise the work up) or stand on a platform (to raise YOU up).<br><br>Or to be a little more complicated, there are ways to make stands and work tables instantaneously adjustable with hand cranks or pushbutton controls. |  |

## Principle 5
## Reduce Excessive Motions

The next principle to think about is the number of motions you make throughout a day, whether with your fingers, your wrists, your arms, or your back.

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| One of the simplest ways to reduce manual repetitions is to use power tools whenever possible. |  |
| Another approach is to change layouts of equipment to eliminate motions. In the example here, the box is moved closer and tilted, so that you can slide the products in, rather than having to pick them up each time. |  |
| Or sometimes there are uneven surfaces or lips that are in the way. By changing these, you can eliminate motions.<br><br>As always, there are more examples, but you should be getting the idea. |  |

## Principle 6
## Minimize Fatigue and Static Load

Holding the same position for a period of time is known as static load. It creates fatigue and discomfort and can interfere with work.

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| A good example of static load that everyone has experienced is writer's cramp. You do not need to hold onto a pencil very hard, just for long periods. Your muscles tire after a time and begin to hurt. |  |
| In the workplace, having to hold parts and tools continually is an example of static load.<br><br>In this case, using a fixture eliminates the need to hold onto the part. | <br> |
| Having to hold your arms overhead for a few minutes is another classic example of static load, this time affecting the shoulder muscles. Sometimes you can change the orientation of the work area to prevent this, or sometimes you can add extenders to the tools. |  |
| Having to stand for a long time creates a static load on your legs. Simply having a footrest can permit you to reposition your legs and make it easier to stand.<br><br>We're going come back to this point later. |  |

# Principle 7
# Minimize Pressure Points

Another thing to watch out for is excessive pressure points, sometimes called "contact stress."

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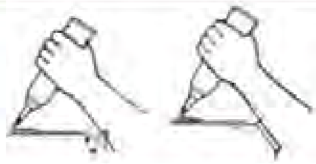
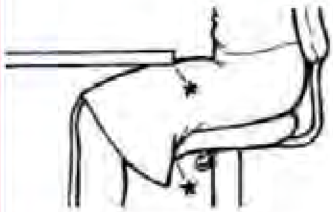
| A good example of this is squeezing hard onto a tool, like a pair of pliers. Adding a cushioned grip and contouring the handles to fit your hand makes this problem better. |  |
| Leaning your forearms against the hard edge of a work table creates a pressure point. Rounding out the edge and padding it usually helps. |  |
| We've all had to sit on chairs that had cushioning and so understand almost everything we need to know about pressure points. A particularly vulnerable spot is behind your knees, which happens if your chair is too high or when you dangle your legs. Another pressure point that can happen when you sit is between your thigh and the bottom of a table. |  |
| A slightly more subtle kind of pressure point occurs when you stand on a hard surface, like concrete. Your heels and feet can begin to hurt and your whole legs can begin to tire. The answer is anti-fatigue matting or sometimes using special insoles in your shoes.<br><br>Like the other basic principles that we've covered so far, pressure points are things that you can look for in your work areas to see if there are ways to make improvements. |  |

## Principle 8
## Provide Clearance

Having enough clearance is a concept that is easy to relate to.

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| Work areas need to be set up so that you have sufficient room for your head, your knees, and your feet. You obviously don't want to have to bump into things all the time, or have to work in contorted postures, or reach because there is no space for your knees or feet. |  |
| Being able to see is another version of this principle. Equipment should be built and tasks should be set up so that nothing blocks your view. |  |

## Principle 9
## Move, Exercise, and Stretch

To be healthy the human body needs to be exercised and stretched.

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| You should not conclude after reading all the preceding information about reducing repetition, force, and awkward postures, that you're best off just lying around pushing buttons. Muscles need to be loaded and your heart rate needs periodic elevation. |  |
| Depending upon the type of work you do, different exercises on the job can be helpful.<br>• If you have a physically demanding job, you may find it helpful to stretch and warm up before any strenuous activity.<br>• If you have a sedentary job, you may want to take a quick "energy break" every so often to do a few stretches. |  |
| If you sit for long periods, you need to shift postures:<br>• Adjust the seat up and down throughout the day.<br>• Move, stretch, and change positions often. |  |
| It actually would be ideal if you could alternate between sitting and standing throughout the day. For some tasks, such as customer service, desks are available that move up and down for this purpose (this is not new; Thomas Jefferson built a desk like this for himself). |  |

# Principle 10
# Maintain a Comfortable Environment

le is more or less a catch-all that can mean different things depending upon the operations that you do.

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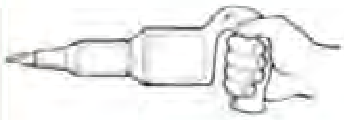
| **Lighting and Glare**<br><br>One common problem is lighting.<br><br>In the computerized office, lighting has become a big issue, because the highly polished computer screen reflects every stray bit of light around. |  |
| But many other types of tasks can be affected by poor lighting, too. Concerns include glare, working in your own shadow, and just plain insufficient light.<br><br>One good way to solve lighting problems is by using task lighting; that is, having a small light right at your work that you can orient and adjust to fit your needs. |  |
| **Vibration**<br><br>Vibration is another common problem that can benefit from evaluation. As an example, vibrating tools can be dampened. |  |

# VITA

| | |
|---|---|
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