# EXPLORATION OF SIMPLE STRATEGIES TO ENHANCE QUALITY CONTROL IN JAMAICAN ARTISANAL FISHERIES

Brian Le´Ron Murray
National Fisheries Authority
Kingston, Jamaica
brian.murray@nfa.gov.jm; brianunuftp2324@gmail.com

Supervisors:

Jónas Baldursson: jonasb@matis.is
Margeir Gissurarson: margeir@matis.is
Aðalheiður Ólafsdóttir: adalheiduro@matis.is

This paper should be cited as: Murray, B. L. 2024. *Exploration of simple strategies to enhance quality control in Jamaican artisanal fisheries.* GRÓ Fisheries Training Programme under the auspices of UNESCO, Iceland. Final project.
https://www.grocentre.is/static/gro/publication/1896/document/Murray23prf.pdf

## ABSTRACT

Jamaica is an archipelagic state possessing a vast marine space that spans up to 274,000 $km^2$ and has one of the highest rates of fish consumption in the region. Artisanal fishers contribute over 90% of the total marine production. However, with fish being a highly perishable product, the percentage of post-harvest loss or any other quality loss is unknown. Although tasked with the mission of sustainability and development of capture fisheries, the National Fisheries Authority is under-equipped in terms of quality control and fish inspection. Therefore, this study seeks to explore simple methodologies for the National Fisheries Authority (NFA) to implement quality control within artisanal fisheries. The Quality Index Method (QIM) scheme and Total Viable Count procedures were employed on gutted and ungutted Atlantic Cod (*Gadus morhua*) samples stored at 2°C and 8°C. The methods were assessed for their suitability to measure shelf life and microbial load in Jamaican fish species. The study also employed a survey directed to 30 respondents situated on six fishing beaches to determine the status of fish handling in Jamaica. The shelf-life study calculated samples held at 2°C for up to 11 days and samples stored at 8°C lasting for six days. The storage temperature significantly affected the spoilage rate, as opposed to the role of gutting. From the survey, the average ice-to-fish ratio calculated among the correspondents was 1.64 to 1 lb. The sample also revealed a high frequency of purchasing ice along with the use of “igloos" (insulated coolers). Gutting on land was preferred over onboard gutting because of perceptions of economic loss. Based on the results, the use of QIM schemes and TVC procedures is recommended to evaluate Jamaican fish species. Although fish-handling practices among artisanal fishers demonstrate some effectiveness, targeted improvements are needed to reduce quality losses and enhance post-harvest management.


**Keywords:** Artisanal fisheries, post-harvest loss, Quality Index Method (QIM), fish handling practices, Total Viable Count (TVC), Jamaica.

TABLE OF CONTENTS

LIST OF TABLES



LIST OF FIGURES

# 1 INTRODUCTION

## 1.1 Background

Located in the Caribbean Sea, Jamaica is an island state encompassing approximately 10,990 $km^2$. Ranked as the third-largest country in the region, it has a tropical marine climate. The mainland is divided into 14 parishes, which together hold roughly 187 fishing beaches (National Fisheries Authority of Jamaica, 2021). The country has several fisheries that serve as crucial natural renewable resources. These resources are dispersed throughout the nation's fisheries waters, supporting the livelihoods of thousands of citizens. The marine area, covering up to 25 times the landmass, features diverse fishing grounds, including the North Shelf, South Shelf, and Offshore Cays (Pedro and Morant Cays). From January to June 2023, marine production contributed up to 3,459 metric tonnes, as reported by the National Fisheries Authority (2023). The local small-scale market caters to numerous Jamaicans with varieties of small and large reef and pelagic species, such as snappers (*Lutjanidae sp.*), parrotfish (*Scaridae sp.*), black jack (*Caranx lugubris*), and blue marlin (*Makaira nigricans*).

Fish are a rich source of vitamins, minerals, and unsaturated fatty acids, and as a protein source containing beneficial constituents, it plays a pivotal role in Jamaica’s food security. As a major ingredient in the national cuisine, fish fosters employment opportunities within coastal communities dependent on its nutritional value. Jamaica has one of the highest fish consumption per capita, estimated at approximately 27.7 kg/year in 2021 (Food and Agriculture Organization of the United Nations (FAO), 2016), underscoring its importance in the diet. Small-scale (artisanal) fishers constitute over 90% of the stakeholders in the fishing industry and are responsible for 92% of the total fish production (National Fisheries Authority, 2023). Although contributing as low as 0.71% to the country's gross domestic product (National Fisheries Authority, 2023), fisheries are crucial to Jamaica´s economic growth. In fact, the industry has maintained the livelihoods of up to 80% of some communities (Aiken and Kong, 2000).

While recognised for its value as a primary product, fish spoil quickly. Any alteration in food products that leads to unacceptable attributes for consumers (Varghese et al., 2022), fish spoilage in tropical regions normally occurs quickly within a few hours after landing (Lakshmanan, 2000). Fish spoilage is the most significant cause of fish loss worldwide, accounting for more than 30% of the total annual fish production (Anagnostopoulos et al., 2022). Highlighting further hazards to consumers, fish is also recognised for its high risk of pathogens which are in turn influenced by the microbes found in marine environments (Ogur, 2022). In Jamaica, fish spoilage complicates the marketability of hauls. In turn, livelihoods such as artisanal fishers and the sustainability of the industry are negatively impacted. Therefore, the reduction and/or prevention of fish spoilage in artisanal fisheries must be achieved through the management of temperature and microorganisms, among other elements. One managerial measure with the potential to achieve these outcomes is quality control.

## 1.2 Rationale

Ahmad (2018) defined quality control as actions that approve the achievement of high-quality goods. For artisanal fisheries, quality control should focus on the potential to promote increased economic value of harvest while reducing losses in the sector. According to the Fisheries Act 2018, the competent authority to perform such exercises is the National Fisheries Authority (NFA). Since December 1949, the NFA (formerly the Fisheries Division) has been primarily responsible for Jamaica´s sustainable utilisation and development of capture fisheries and aquaculture (Jones, 2017). The main functions of this governmental body are managerial, administrative, and conservation roles within the country. In addition to being charged with performing surveillance and compliance duties, the NFA plays a key role as a licencing body and facilitator of capacity-building activities. Most importantly, it is the agenda to conduct regular data collection and scientific research activities.

In 1979, however, Lima dos Santos, on behalf of the Western Central Atlantic Fishery Commission Procedures, reported on Jamaica´s practices in fish handling, processing, and quality control. He described the functions of fish inspection and quality control as non-existent, despite the agency´s functionality in fisheries. Other observations included the agency´s lack of specific sanitary regulations with trained staff and the general operation of inshore vessels using no ice. One of the major suggestions made by Lima dos Santos pertained to the development of the 'Fish Inspection and Quality Control Section'. Upon its establishment, Lima dos Santos suggested that the main activities involve the promotion of improved handling practices for all stakeholders and the planning of fish inspection and quality control activities incorporating multiple site visits and laboratory work (Lima dos Santos, 1979).

According to available records, the frequency of quality control measures taken through the NFA subsequent to the report´s generation is unknown. Even with governmental authorities such as the Ministry of Health and Wellness (MOH) and the Veterinary Services Division (VSD), documentation specific to consistent quality control and assurance in artisanal fisheries is limited. For instance, no evidence of spoilage was found because fishers could not be contacted at the time (Lens, 1977). Any other actions after Lens´s attempts were not implied in later publications. Other examples would include the lack of account of spoilage-related harvest loss for the 1,375 and 1,818 metric tonnes of marine production recorded in the first two quarters of 2023, as reported by the National Fisheries Authority (2023). Moreover, there is uncertainty regarding existing records that demonstrate the maintenance of sanitary fish-handling infrastructure situated across the mainland. Small-scale fishers may even engage in subpar post-harvesting methods, such as failing to utilise enough ice or subjecting their haul to excessive sunlight, by sea or on land. Fortunately, the NFA has the potential to solve these issues by adhering to its proposed policy.

To ensure that consumers have access to secure, healthy, and whole fish and fish products, the NFA intends to set up and apply safety and quality standards for new and existing fish and fishery products (Ministry of Agriculture and Fisheries, 2014). Other notable tactics include, but are not limited to, developing and enhancing fish and fish product inspection and quality control systems, particularly for local consumption, and supporting studies looking into pertinent aspects of safe, healthful products along the value chain (Ministry of Agriculture & Fisheries, 2014). Nonetheless, training stakeholders to be aware of these standards and adopt better approaches to achieve higher quality harvests is an imperative undertaking of the NFA.

Given these intentions, the purpose of this study is to evaluate current post-harvest handling practices and the effectiveness of preservation methods, such as gutting and icing, in maintaining fish quality. This paper will also suggest basic procedures that can be performed in Jamaica to facilitate the rapid assessment of fish quality. The author hopes to facilitate economic and social growth in the sector through this approach.

# 2 RESEARCH OBJECTIVES

First, this research engagement allowed the author to ascertain the standards for conducting sensory and microbiological methods to measure the quality (freshness) of whole fish. This opportunity will provide a reference for performing valid replications of trials on Jamaican fish species. This study will also assess the influence of gutting and storage temperature on quality parameters under conditions similar to those in Jamaica using *Gadus morhua* (Atlantic Cod) samples. Atlantic cod was selected because it is readily available for experimental work; however, its responses to low temperatures (e.g. 8°C) differ from those of tropical Jamaican species, which exhibit more rapid microbial growth at higher temperatures. Therefore, any replication of this study in Jamaica would require the use of elevated storage temperatures that better reflect the spoilage dynamics of tropical species. Furthermore, this study seeks to determine the current status of fish handling practices in Jamaica´s artisanal fisheries and to record these observations that may inform recommendations for improvement.

## 2.1 General objective

- Review methodologies and ideas employed to measure and improve fish quality in artisanal fisheries operating in Jamaica.

## 2.2 Specific objectives

- Study the procedures of Quality Index Method and Total Viable Count to apply on Jamaican fish species.
- Assess the effect of gutting and temperature using *Gadus morhua*.
- Determine the status of fish handling practices in Jamaica.

# 3 LITERATURE REVIEW

## 3.1 Study of Sensory & Microbiological Evaluations.

### *3.1.1 Definition and measurement of fish quality*

Muñoz (2002) spoke of the difficulty of defining ‘quality’ over the years and noted that the term may be defined differently. Despite this challenge, the Jamaican government has adopted the concept of quality as ‘the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs’, as defined in the International Organisation for Standardisation (ISO) 8402:1986 (ISO, 1987). In terms of fish, the term “quality” is connected to numerous characteristics, including safety, nutritional value, and apparent physical properties (Olafsdottir, et al. 2004). As consumers acknowledge the significance of fish as a crucial dietary source (Zang et al., 2019), there is an increasing need for proficient testing methods that can provide quick and accurate results to satisfy the growing concerns regarding food quality and safety (Hassoun, 2015). Among the numerous factors that affect fish quality, freshness is a key

determinant which enables marine products to be evaluated in diverse ways (Bremner, 2000). According to Hassoun (2015), fish freshness is strongly impacted by variables such as rigor mortis, autolysis processes, and microbiological deterioration. These factors collectively impact the texture, smell, and taste of the meat, ultimately contributing to spoilage. As such, it is crucial to assess fish after capture, as the freshness of the product influences prices due to their perceived freshness. Consequently, fresh products incur higher prices in the markets (Kissoon & Badrie, 2001).

### *3.1.2 Sensory evaluation of fish*

Sensory evaluation may be viewed as the incorporation of approaches from various scientific disciplines studying human reactions to stimuli (Torrico et al., 2023). Another perception of the concept is the measurement of the reaction to stimuli resulting from the consumption of food or food products (Mihafu et al., 2020). By utilising our senses, we can draw measurements from foods. These measurements can be related to different studies and can produce information as well as valuable decisions. Zaukuu (2019) and Nimbkar (2021) emphasized the importance of the method in quality control. According to them, sensory evaluation is a fundamental method for evaluating fish quality. This was also highlighted by Calanche (2019) in understanding the relationship between its physicochemical characteristics and sensory responses. Mohan (2018) highlighted that not only are traits that were once immeasurable now observable, but also the approach assists in aligning these same traits with physical and chemical properties to formulate solutions (Sharif, 2017). Moreover, this form of assessment facilitates customer appeal to be reflected in the results (Mohan, 2018). This is done by assessing the sensory characteristics of a product, such as taste, smell, texture, and appearance, which in turn provide insights into consumer preferences and expectations. According to Sharif (2017), sensory attributes typically degrade faster than microbial quality. Therefore, they are observed to determine the shelf life of products. Furthermore, Thu et al. (2020) credited sensory evaluation as an easy and efficient method, while Mihafu et al. (2020) indicated that this method can reveal the shelf life of fish swiftly and economically.

### *3.1.3 Implementation of Quality Index Method (QIM) Scheme*

QIM is a rapid, simple, objective, non-destructive, and reliable tool for measuring freshness (Bernardo et al., 2020). Developed by the Tasmanian Food Research Unit, Australia, and later improved by the European Union, the method has over 100 formats applied by many countries (Mai, 2021). Bernardo et al., 2020 also noted the QIM scheme involve a list of specific sensory attributes with detailed descriptions of freshness-spoilage degrees. These attributes are chosen according to how well they illustrate freshness with storage time in ice (0°C) or any other temperature (Mlingi, 2018). The attributes are scored by a panel of professionals (Joshy et al., 2019) on a restricted scale ranging from 0 (representing very fresh) to 3 (representing spoilt) (dos Santos et al., 2014). For shelf life, the tally of all scores generates what is referred to as a quality index (QI) with the possible linear correlation with storage time (Freitas et al., 2019). Based on this linear relationship, Bonilla et al. (2007) suggested that both the previous and remaining shelf life of a fish species can be estimated once the scheme is tailored and the entire shelf life is established for the species.

In the absence of an established scheme and unknown shelf life, a QI for the fish species is developed in three stages (Bernardo et al., 2020), as shown in Figure 1. Mlingi (2017) described how the initial phase involves skilled evaluators creating descriptors for accurate quality attributes to correspond to the species' spoilage. Thereafter, under the direction of the panel leader, the second step employs the panel engaging the draft QIM in multiple sessions to ratify

the noted observations and suggest modifications (Bernardo et al., 2020). In the final stage, the validation of the developed QIM scheme is performed by shelf-life study of the fish species (López-García et al., 2021). The development of the QIM scheme through this three-stage procedure, as highlighted by Bernardo et al. (2020), is advantageous in providing a strong linear correlation between the freshness of the fish species and storage time at 0°C. In other words, the freshness of the fish is strongly related to the magnitude of the temperature to which it is exposed. For example, Mai (2021) documented the developed QIM scheme for Japanese flying squid (*Tadarodes pacificus*), as shown in Figure 2. The study estimated a shelf life of 12 ± 1.0 days at 0-2°C. Mai (2021) additionally illustrated the changes in QI stored between 0-2°C with a strong correlation between the QI and storage time exhibited with $R^2$ equating to 0.9806.

In contrast, the QIM scheme carries problems based on how it is used (Bernardo et al., 2020). In addition, citing Freitas et al. (2019), the method is usually limited by subjectivity within the analysis, sampling size, required time for panel training, panel size, and species-specificities. Vaz Seixas (2006) and Sykes et al. (2009) exemplified the difference within analysis of cuttlefish (*Sepia officinalis*) through the contradiction of training steps, QIs when rejection occurred and hence shelf-live judged for the samples. These two studies notably highlighted the variation in the number of samples utilised, resulting in a higher range of attributes being monitored. The use of this sensory method permits knowledge of the state of fish during storage to be gathered, considering the differences in species. It has the advantage of being easier to employ and teach than other methods, requiring minimal equipment. Conversely, individuals may experience difficulties in this method due to three factors: the arbitrary nature of sensory analysis, the time required to train the staff, and the need to develop different plans for each species or fish product.

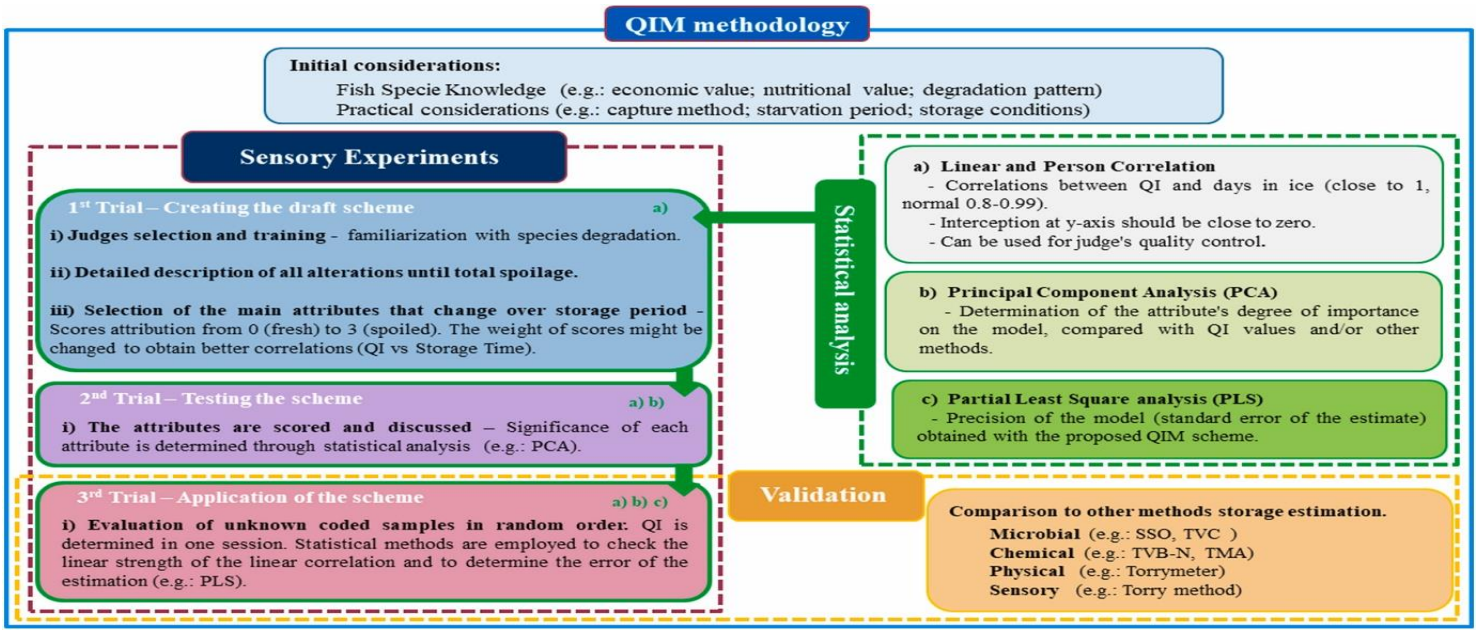


Figure 1: Visualization of the QIM scheme development stages.

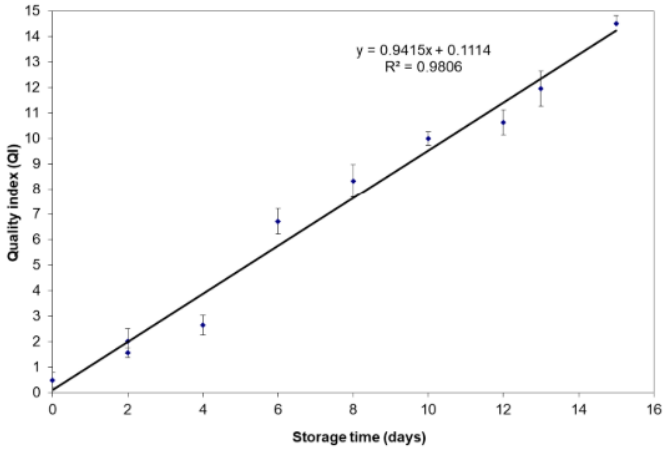


Figure 2: Changes in Quality Index of Japanese flying squid (*Todarodes pacificus*) stored at 0-2°C.

### *3.1.4 Implementation of Microbiological Evaluation: Total Viable Count*

Microbiological evaluation refers to a collection of mechanisms used to measure quality via parameters related to the microbes that reside inside and outside fish. These methods play an essential role in reducing biological contamination for consumers (Gonçalves et al., 2015). While microbes influence the safety of fish and fish products (Sheng & Wang, 2020), they also play a vital role in the degradation of fish products (Huss, 1995). Baten (2018) further emphasised that microorganisms affect various fish species. Baten (2018) also noted that microbes, particularly bacteria, are widely dispersed in nature across both temperate and tropical regions. Conversely, mesophilic bacteria, due to their adaptation to chilled temperatures, allow tropical fish species to experience less microbial activity than temperate fish species (Leroi, 2014). Compared to psychrophiles, mesophilic bacteria are acknowledged to spoil tropical fish species slower than temperate fish species. However, Anagnostopoulos et al. (2022) stated that degradation is triggered by a fraction of microbes referred to as specific spoilage organisms (SSOs). These peculiar numbers of organisms mentioned by Huang et al. (2020) possess faster growth rates and contribute significantly to spoilage. According to Boziaris and Parlapani (2017), SSOs such as Pseudomonas sp. and Carnobacterium sp. are determined by the origin of the fish species and storage conditions. In turn, these microbes induce sensory factors that affect the acceptability and fitness of consumption. Therefore, methods of determination are critical for quality control in the international food industry. Among the different methodologies, such as 16S rRNA sequence analysis, the Total Viable Count (TVC) method is noteworthy because of its significance in evaluating the safety and stability of a product. According to Tang (2023), TVC is the simplest, yet most popular method used to quantify the concentration of living organisms (microbial load) in each sample. In common practice, TVC functions as a means of determining the acceptability of samples within the context of standards, guidelines, and specifications. It is universally accepted that the rate of microbial growth is inversely proportional to the shelf life of fish. The acceptable limit when examining microbial load in fresh raw fish is regulated at $10^6$ cfu/g, as outlined by Mikš-Krajnik et al., 2016. The same reference was agreed upon by Olafsdottir et. al. (1997) where the rejection of fish usually occurred when microbial load is measured between $10^7$ and $10^9$ cfu/g. However, in other sources, such as Comi (2017), spoilage is fully realised at a population of $10^8$-$10^9$ CFU/g. Scenarios which encourage faster microbial rates and an increase in microbial

load are regarded as being minimised as much as possible. For example, temperatures higher than 4°C promote faster microbial growth and shorter shelf life in fish. Chantarachoti et al. (2007) validated this point with Alaska pink salmon samples stored at 14◦C displaying aerobic bacteria counts from 3.4 lgCFU/cm2 to 4.8 lgCFU/cm2 in three days compared to samples stored at 0°C lasting for 16 days with aerobic bacteria counts from 3.4 lgCFU/cm2 to 5.5 lgCFU/cm2.

## 3.2 Assessment of gutting and storage temperature on fish species.

### *3.2.1 Use of Ice in Small Scale Fisheries.*

Fishers use chilling techniques to extend the freshness of their catches (Shawyer & Medina Pizzali, 2003). These tasks are important to perform quickly on fish to prevent rapid spoilage (Graham et al., 1992). According to Calanche (2020), the most efficient technique to impede spoilage is ice. Fishers operating with ice can maximise the economic value of their harvests along with the number of hours spent at sea (Shawyer & Medina Pizzali, 2003). This is possible through the provision of low temperatures which in turn increases the shelf life of fish species such as the Gilthead seabream (*Sparus aurata L.*) studied by Campus et al. (2011). By using ice on fish caught, the reduction in post-harvest loss may even relieve the strain on a country´s fishable resources (Dunbar, 2021). Without the proper use of ice, the spoilage rate is directly impacted. Microbial growth is the main cause of fish spoilage, and a decline in temperature impedes microbial activity, preventing rapid loss of fish quality (Eliasson et al., 2019). This was observed by Odoli et al, (2013) with average TVC to be on $10^2$ - $10^3$ CFU/g and $10^3$ - $10^4$ CFU/g in iced and non-iced samples of Emperor fish respectively. Although the sanitary conditions of vessels and marine species strongly influence spoilage (Speranza, 2021), improper use of ice can reduce fish quality (Rudiro, 2019). Therefore, factors such as the types of ice highlighted by Entee (2015) are crucial for preserving the quality of fish demanded by customers. Indonesia, a tropical country similar to the Philippines, has been noted for the common use of block ice among its fishers (Wibowo, 2017). Block ice, as cited by Shawyer and Medina Pizzali (2003), is an internationally preferred type of ice because of its longer durability while taking up less space than other types. Shawyer and Medina Pizzali (2003) also mentioned the instance of breaking down block ice into smaller pieces for the advantage of uniform cooling for the products. Similarly, another type of ice, tubular ice with dimensions of 10-12 millimetres wall thickness and 50 mm length, is commonly crushed prior to use to promote uniform cooling. Fish in tropical climates may be insufficiently cooled and require ice with a larger surface area, such as flake ice, to chill. The dimensions allow a recommended ice fish ratio of 1:1 for more uniform cooling (Ninan, 2021).

### *3.2.2 The effect of gutting on fish quality*

According to the Codex Alimentarius International Food Standards, gutting is considered the complete removal of the intestinal tract and internal organs of fresh fish (FAO, WHO, 2020). Along with the skin and gills being recognised as major harbours for bacteria (Chatreman, 2020), Khurana (2020) outlined the tract as a complex habitat for a high diversity of microbes. It also serves as a reservoir of powerful digestive enzymes that, if not removed immediately, will cause the flesh to spoil in addition to unacceptable scents and tastes (Lehmann, 2008). When fish are ungutted, food decomposes within the intestines, releasing odorous chemicals (Mishra, n.d.). These chemicals are then diffused within the animal flesh (Mishra, n.d.). If

promptly gutted, this scenario may be avoided, in addition to the risk of biological infestation to promote high quality fish (Alt, 2022). Boziaris (2013), however asserted that while gutting may be performed immediately after harvest, this action does not guarantee high fish quality. Erikson et al. (2018) proved this point by reporting on samples of ungutted shortfinn pompano (*Trachinotus falcatus*). Similarly, Cakli (2006) reported similar outcomes when comparing gutted and ungutted *Sparus aurata* and *Dicentrarchus labrax* samples. When assessed using sensory and chemical procedures, similarities in quality and shelf life were found between the gutted and ungutted fish. The difference noted, on the other hand, was in the microbial counts, where the gutted samples produced slightly more than the ungutted fish. Additionally, Gutted *Merluccius merluccius* samples were reported to have higher counts of spoilage bacteria when studied by Baixas-Nogueras (2009). These counts may, nevertheless, occur below the level of acceptability as a sign of safe consumption, as observed by Bilgin et al. (2016). Gutting may cause unwanted damage to the skin and meat. The skin functions as a barrier against foreign bodies, including bacteria. Once this barrier is breached, exposure permits bacteria to enter and flourish in the product. Therefore, it is imperative that onboard gutting is conducted with precaution and precision to evade or reduce the negative outcomes associated with the procedure (Şengör, 2023). Immediate gutting is still encouraged, along with other processing and handling methods (Kamble, 2023). Although onboard gutting with associated activities may be time-consuming (Nguyen, 2005) and expose fish to a number of contamination sources, good quality control may be achieved through proper cleaning of utensils, working areas, and workers (Visciano, 2023).

### 3.3 Status of Fish Handling in Jamaican Artisanal Fisheries

Artisanal fisheries are characterised by the involvement of fishing households harvesting for local consumption at a minute level using limited resources (FAO, 2015). As a provider of fish in the country, artisanal fisheries comprise stakeholders and activities that determine the condition of products received by consumers (Bedane et al., 2022). Jamaican fishers operating within this scope constitute most of the country´s industry workforce and, since 2023, have supplied up to 97% of its entire marine production (National Fisheries Authority, 2023). While NFA (2023) reported a value of 13, 628.94 metric tons, the measure of post-harvest losses from this production is unknown. As cited by Abelti (2016), tropical developing countries, owing to their high temperatures, have suffered up to 50% in post-harvest losses. Jamaica is an example of a tropical country with ambient temperatures as high as 27°C (Machado et al., 2022). With such temperatures, post-harvest may arise at any detail within the operations of the artisanal fishers. To address these issues, artisanal fishers should be discouraged from participating in improper fish-handling habits, such as using dirty canoes, washing fish in dirty water, or exposing fish to temperature abuse (Diei-Oudad & Mgawe, 2011).

Artisanal fishers from the various fishing beaches operate for an average of 20 days per month (National Fisheries Authority, 2023) with motorised or non-motorised open glass-fibre reinforced plastic canoes as the typical means of conveyance (Aiken and Kong, 2000). Fishers aged between 36 and 55 years are recorded as the highest component of the fishing population, while 10% of the workforce is female (National Fisheries Authority, 2023). These demographic observations suggest low to moderate recruitment in the industry. The observations also suggest that artisanal fisheries demand a workforce of vivacity, proficiency, and willingness to trade their time for extensive exposure to rough weather and sea conditions. However, no source of

information validated the total hours taken to complete one fishing trip. Following Mahon (1995), fishers transverse fishing grounds in and nearby the island shelf and offshore banks, which CFRAMP (2000) stated are geographically and statistically separated into fishing zones, two major ones are the North and South shelves. The North Shelf is known to be a narrow band of 1.6 km (CFRAMP, 2000). This region is characterised by nearly continuous fringing reefs that border the sill reef. The South Shelf, on the other hand, possesses a maximum width of 25 km while maintaining average depths of 20m as described by Aiken and Kong (2000). While embellished with small sections of corals, gorgonians, and seaweeds, most of its perimeter is composed primarily of thriving sill reefs adorned with enormous corals. Wide-ranging reefs and sandy areas are distributed across the eastern shelf. Notably, most fishing is purported to occur along the peripheries of banks that have developed reefs. Such are the Morant and Pedro Banks, which rise precipitously from depths exceeding 500 m to form 20–30-meter-adjusted submerged plateaux. In pursuit of accessing lucrative catches, larger vessels located along the southern coasts, particularly those with horsepower requirements exceeding 40, embark on the arduous journey to these fishing grounds, which are also found among the nine oceanic banks displayed in
Figure 3.

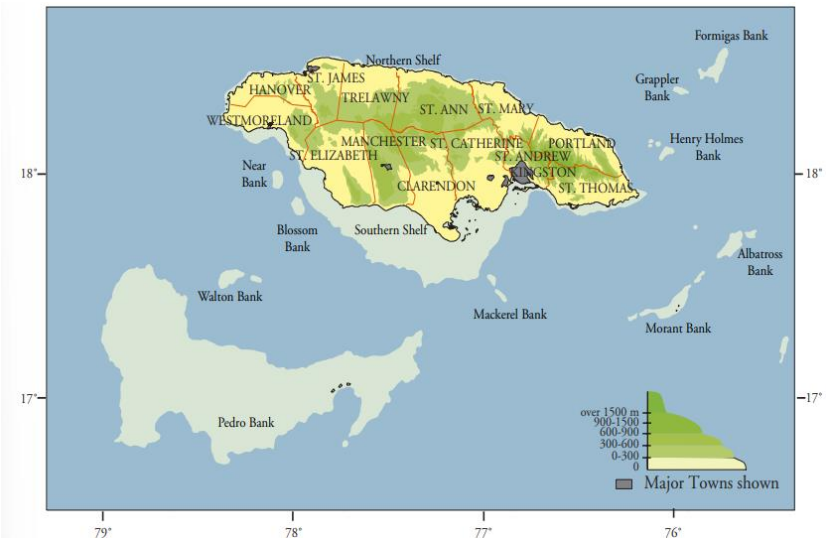


Figure 3: Map illustration of Jamaica´s marine space.

Based on this, artisanal fisheries in the country may be categorised as either mainland or inshore and offshore fisheries (Soares, 2017), where the former is treated as the primary supply of fish (Aiken and Kong, 2000). Mahon (1995) further mentioned that the main fishing gear used as traps captures demersal species. Artisanal fishers are also recognised for predominantly operating with fishing net gear types, followed by handlines and spearguns (Murray and Aiken, 2002). According to Sabu and Sasidharan (2020), fishing gear, such as those used in Jamaica, greatly affects the quality of the fish harvested. Gillnets may contribute to lower quality, as stated by Rouxel and Montevecchi (2018), as opposed to using handlines. Amidst the expanse of Jamaica's fisheries water, including the archipelagic waters of 22,000 km$^2$ and the territorial sea of 17,995 km$^2$ (Jones, 2017), artisanal fisheries are deemed open-access multi-species fisheries (CFRAMP, 2000).

Recent data collected by the NFA (2023) revealed the capture of over 350 fish species, including snappers, with a high species density and treated popular food choice. NFA (2023) additionally noted that the offshore species black jack was consistently harvested and accounted for a significant portion of marine production. All Jamaican fish species are ranked into three market categories and three other groups according to taxonomic family (CFRAMP, 2000). These categories, as seen in Table 1, are based on their value among fishers and consumers, representing the nature of quality within the local market. Fish species such as snappers, groupers, and barracudas are recorded by CFRAMP (2000) as highly valued and usually marketed individually but are hardly available due to excessive fishing.

Table 1: Market Quality of Jamaican Reef fish

| Market Category | Level of Value | Examples |
|---|---|---|
| Quality Reef Fish | Highest/Most expensive prices | Stoplight Parrotfish (*Sparisoma virde*); White Mullet (*Mugil curema*) |
| Common Reef Fish | Moderate/Intermediate prices | Bluestriped Grunt (*Haemulon sciurus*); Atlantic Tripletail (*Lobotes surinamensis*) |
| Trash Reef Fish | Lowest/Cheapest prices | Porcupinefish (*Diodon hystrix*); Buffalo Trunkfish (*Lactophyrys trigonus*) |

# 4 METHODOLOGY

## 4.1 Study of Sensory & Microbiological Evaluations.

### *4.1.1 Raw Materials*

Atlantic cod (Gadus morhua) was chosen as the sample species based on its availability and controlled handling conditions. The selection of fish was also influenced by knowledge of the shelf life under (ice 0°C) as 15 days. Forty-five (45) fresh whole and ungutted Atlantic Cod (*Gadus morhua*) fish weighing approximately 83 kg were acquired from Hafid-Fiskverslun ehf. (Iceland). Samples originated from Sandgerði (fishing zone 17) and were caught by the fishing vessel 2799 - Daðey GK-777. The landing occurred on February 22nd, 2024. Equally sized and weighed samples were stored in insulated boxes for immediate delivery.

### *4.1.2 Training of Sensory Panel*

The study incorporated one training session lasting for two hours to guarantee that the four student assessors scored each attribute accurately and objectively. One experienced assessor within the panel also assisted in the training session. The QIM scheme for the whole *G. morhua* stored in ice (as shown in
Figure 4) was introduced within the session to accentuate and discuss the changes that occur in each attribute. Thereafter, a mock sensory session was organised to expose student assessors to

the various alterations within each attribute as were possible between recently harvested cod and cod that underwent at least two days of spoilage.

| Quality parameter | | Description | Score |
|---|---|---|---|
| Appearance | Skin | Bright, iridescent pigmentation | 0 |
| | | Rather dull, becoming discolored | 1 |
| | | Dull | 2 |
| | Stiffness | In rigor | 0 |
| | | Firm, elastic | 1 |
| | | Soft | 2 |
| | | Very soft | 3 |
| Eyes | Cornea | Clear | 0 |
| | | Opalescent | 1 |
| | | Milky | 2 |
| | Form | Convex | 0 |
| | | Flat, slightly sunken | 1 |
| | | Sunken, concave | 2 |
| | Color of pupil | Black | 0 |
| | | Opaque | 1 |
| | | Gray | 2 |
| Gills | Color | Bright | 0 |
| | | Less colored, becoming discolored | 1 |
| | | Discolored, brown spots | 2 |
| | | Brown, discolored | 3 |
| | Smell | Fresh, seaweedy, metallic | 0 |
| | | Neutral, grassy, musty | 1 |
| | | Yeast, bread, beer, sour milk | 2 |
| | | Acetic acid, sulphuric, very sour | 3 |
| | Mucus | Clear | 0 |
| | | Milky | 1 |
| | | Milky, dark, opaque | 2 |
| Blood | Color | Red | 0 |
| | | Dark red | 1 |
| | | Brown | 2 |
| Fillets | Color | Translucent, bluish | 0 |
| | | Waxy, milky | 1 |
| | | Opaque, yellow, brown spots | 2 |
| Quality Index (0–24) | | | |

*Figure 4:QIM scheme of whole G. morhua.*

### *4.1.3 Implementation of Quality Index Method (QIM) Scheme*

The shelf-life study of whole gutted and ungutted Atlantic cod samples was conducted according to the procedures described in the Sensory Evaluation for Fish Freshness manual (Martinsdóttir et al., 2001). A panel of four student assessors and two experienced assessors stationed at Matis was enlisted to judge the samples. The established QIM scheme for Atlantic cod (*Gadus morhua)* was used to evaluate the fish samples presented at each session. According to the sampling plan shown in **Error! Reference source not found.**, each session comprised s ix individual fish samples representing the different gutting and storage temperature conditions. An arbitrary 3-digit code was assigned to each fish sample in all sessions. In addition, the placement of samples within the sensory room was done in a randomised manner to eliminate subjectivity among the panel. The spoilage progress was compared to that of raw Atlantic cod in ice with a QI of 18 as the point of sensory rejection.

Table 2: Sampling plan of Atlantic Cod according to storage time and time of gutting.

| | **Samples Stored at 8°C** | | **Samples Stored at 2°C** | |
|---|---|---|---|---|
| **Day** | Ungutted 8°C | Gutted 8°C | Ungutted 2°C | Gutted 2°C |
| **0** | - | - | 3 | - |
| **3** | 3 | 3 | - | - |
| **4** | 3 | 3 | - | - |
| **5** | 3 | 3 | - | - |
| **7** | - | - | 3 | 3 |
| **10** | - | - | 3 | 3 |
| **12** | - | - | 3 | 3 |
| **Total** | 9 | 9 | 12 | 9 |

### *4.1.4 Implementation of Microbiological Evaluation: Total Viable Count*

Before the initial steps of all sensory sessions, portions of flesh acquired from the three fish samples of each group were gathered to weigh approximately 20 g. The portions were then minced and transferred to a sterile stomacher bag to be homogenised with a Stomacher (Seward Stomacher 400) for 1 min. From the fish homogenates, 1 mL of 1/10 dilutions were transferred with pipettes to Petri plates. Melted iron agar at 45 °C was poured onto the plates, and the contents were mixed. After solidification, the plates were covered with a thin layer of iron agar. The plates were incubated at 22 °C for 48 h. The colonies which formed on the plates were counted and calculated to express the microbial load as log CFU/g of fish.

## 4.2 Assessment of gutting and storage temperature on fish species.

### *4.2.1 Preparation of Fish Samples*

The samples were separated into four groups according to the time of gutting and storage temperature during a six-hour period before the studies commenced (Figure 5). Group A was labelled for 12 ungutted individuals stored at 8 °C until the predetermined sampling days, while Group B comprised nine individuals stored at 8°C and gutted at the start of the experiment (day 0). Groups C and D were treated similarly to Groups A and B, respectively, with a storage temperature of 2°C.

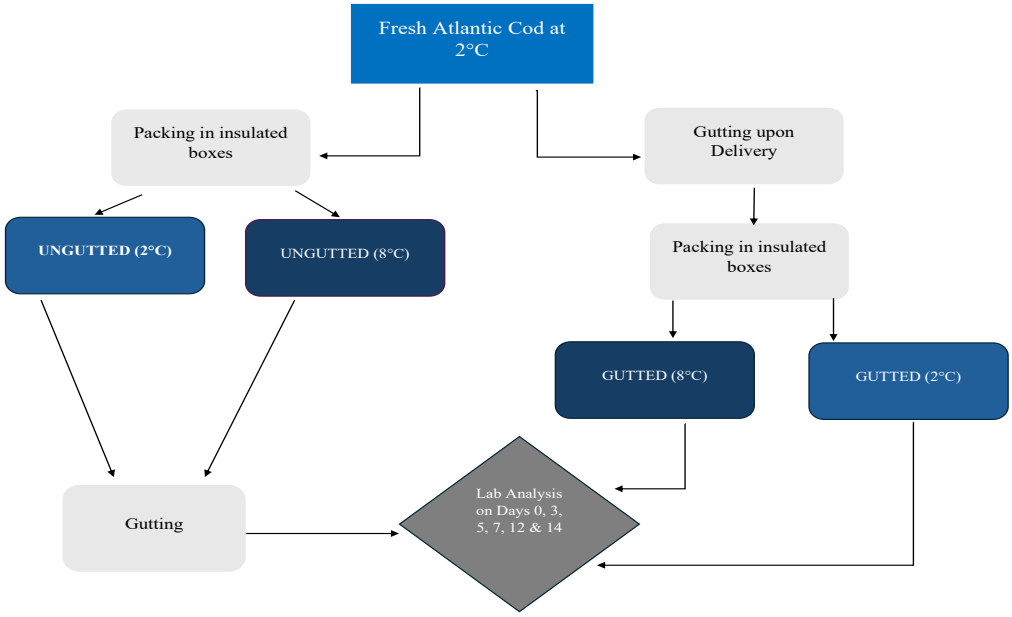


Figure 5: Flowchart of Atlantic Cod samples according to storage temperature and time of gutting.

## 4.3 Status of Quality Control in Jamaican Artisanal Fisheries

### *4.3.1 Utilisation of Questionnaire-led Interviews*

The research task relied on the collection of artisanal fisher data pertaining to fish quality. The data collected included, but were not limited to, the practices of gutting and icing, along with the percentage of fish spoilage experienced. A 10-minute questionnaire was developed considering the probable literacy difficulties in the target group. A team of officials from the NFA was enlisted and deployed to conduct interviews. A small review committee was organised to evaluate the effectiveness of the interview method, which was tested with a small group of artisanal fishers. The interview technique was improved based on feedback and findings from the pilot phase to enhance its accuracy and reliability. The interviews were conducted by an assigned team. Records gathered from interviews were compiled upon receipt, and status checks were immediately conducted to uphold the integrity and timeliness of the research process.

### *4.3.2 Sample size and study area.*

The NFA officials targeted 30 artisanal fishers situated across the mainland. The interviews were held on prominent fishing beaches situated along the North and South shelves, as listed in Table 3. This approach to site selection simplifies the process of data collection within the constraints of limited time and resources. The table below lists the sites visited by the extension officers.

Table 3: List of fishing beaches visited to conduct interviews.

| **Fishing Beaches Visited** | |
|---|---|
| **North Shelf** | **South Shelf** |
| River Bay, St. James | Whitehouse, Westmoreland |
| Discovery Bay, St. Ann | Rocky Point, Clarendon |
| Bryan´s Bay, Portland | Holland Bay, St. Thomas |

# 5 RESULTS

## 5.1 Study of Sensory & Microbiological Evaluations

### *5.1.1 Changes in Sampling Days*

At the beginning of the experiment, three individuals held at 2°C were utilised as the control group instead of the six individuals mentioned. During the course of the experiment, the groups stored at 8°C showed faster degradation than expected. Therefore, under the advice of the project supervisors, the eighth day of sampling (Day 7) was replaced with the fifth day (Day 4). This alteration resulted in Groups A and B being assessed for a total of six days (i.e. Day 5 was declared as the final day for the two groups).

### *5.1.2 Implementation of QIM on Ungutted and Gutted Fish at 2°C and 8°C*

The average QI values for the ungutted and gutted samples stored at 8°C were calculated to be $17.5 \pm 1.1$ and $17.6 \pm 0.9$, respectively. The linear correlation of the ungutted samples displayed $R^2 = 0.9724$ at 8°C. At the same temperature, $R^2 = 0.9846$ for the linear correlation of the gutted

samples. Figure 6 shows the samples held at 8°C, which reached the acceptability limit shortly after day 5. With the knowledge of the samples belonging to a haul occurring on the 22nd of the second month, the total shelf life for fresh whole Atlantic cod was found to be six (6) days.

The samples held at 2°C were assessed until they were rejected by the panel on day 12. At the lower temperature, ungutted and gutted samples obtained average QI values of 19.4 ± 2.1 and 19.5 ± 2.2, respectively. Linear correlations generated by both groups illustrated $R^2 = 0.9806$ for ungutted samples and $R^2 = 0.9875$ for gutted samples.

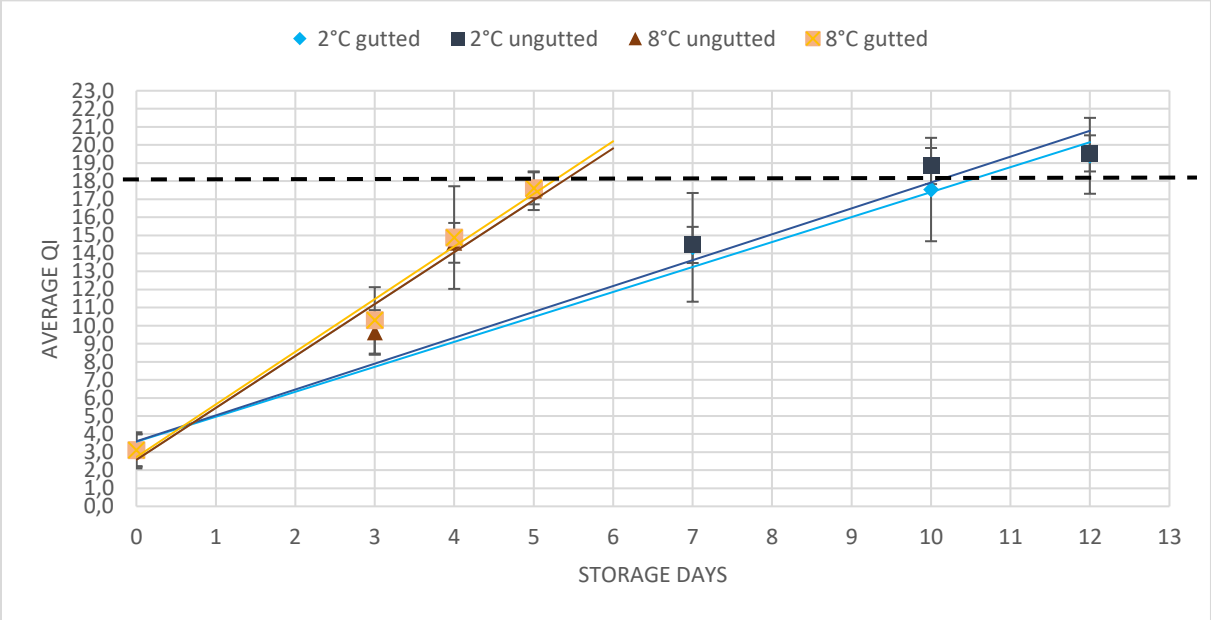


Figure 6: Average QI of whole Atlantic Cod samples stored at 2 and 8°C.

*5.1.3 Changes in Attributes and Difference amongst judges.*

Bright and iridescent skin appearance and elastic texture recorded on day 1 changed to visible dull and very soft to the touch by day 5 for the 8°C stored samples. Similar changes occurred in samples kept at 2°C by day 12. The colour of the fillets initially registered as translucent and bluish to assessors became opaque by days 5 and 12 for the 8°C and 2°C samples, respectively. The red to brown blood colour corresponded to similar timing according to the two temperature studies. The eyes of the samples were clear and convex with black pupils in the established control group. By days 5 and 12, however, assessors responded to opaque and sunken possessing gray pupils. The gills appeared bright red with clear mucus and a seaweed odour at the start of the assessments. Both ungutted and gutted samples showed discoloured gills covered in dark opaque mucus and a pungent odour. The QI scores for both ungutted and gutted samples stored at 8°C showed low linear correlation for each attribute against storage time (*Figure 7*). For ungutted and gutted samples stored at 2°C, however, QI scores showed higher linear increases with storage days. Except for the gill mucus, the minimum and maximum average QI for all attributes were observed on days 3 and 12, respectively. No significant differences were observed between the gutted and ungutted samples at either temperature.

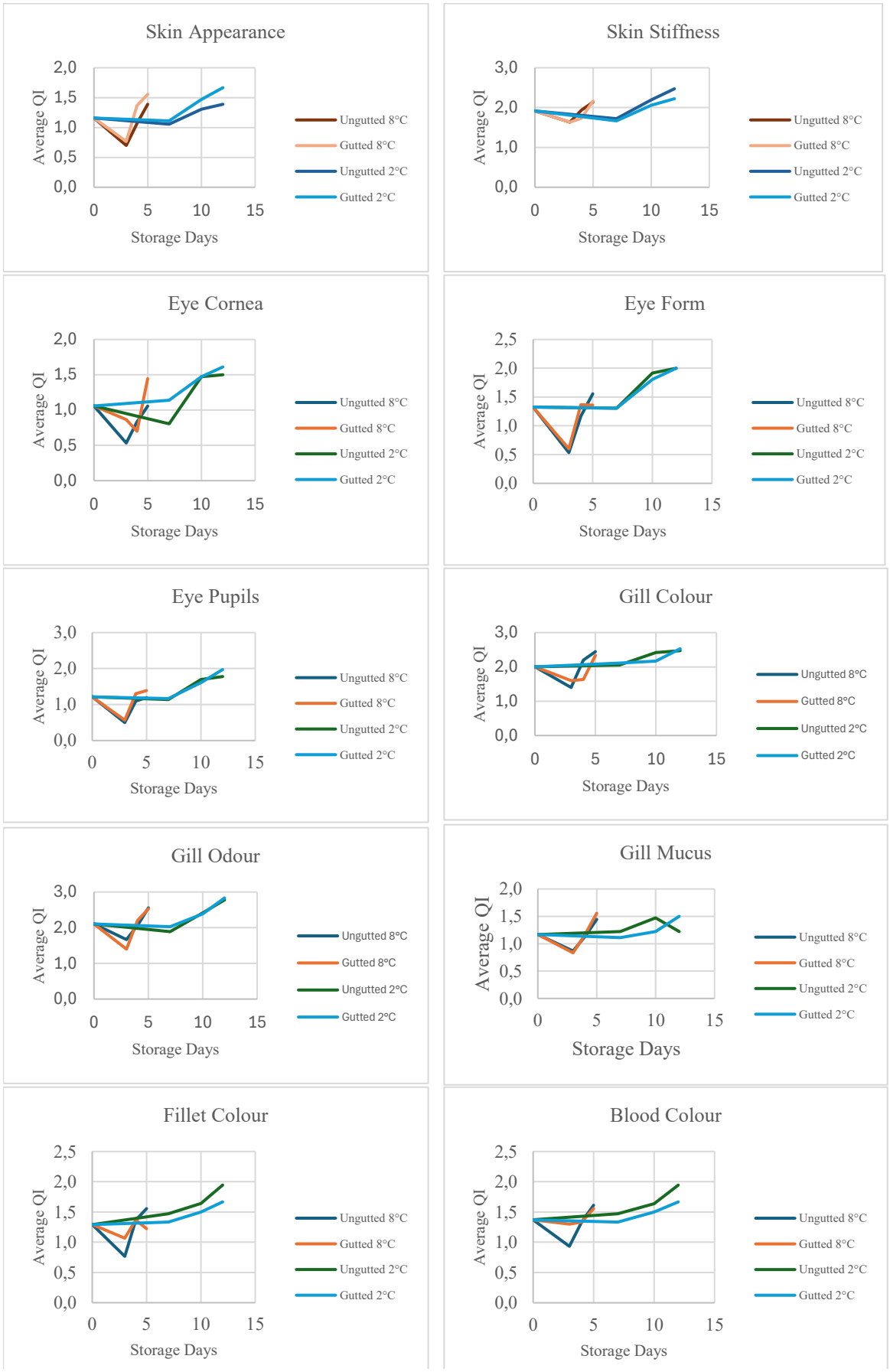


Figure 7: Observation of changes in attributes of Atlantic cod.

### *5.1.4 Implementation of TVC on Ungutted and Gutted Fish at 2°C and 8°C*

The results of the microbiological analysis are presented in Figure 8. The microbial load for all samples was initially recorded as less than 1 log (CFU/g). The ungutted samples stored at 8°C showed very rapid growth up to day 3, but all sets of samples achieved 4 to 6 log (CFU7g) indicating an increase that was neither linear nor constant. The gutted samples held at 8°C were the only set that maintained an increase in microbial growth without decreasing at any point during the trial. The observation also indicated that the gutted samples stored at 8 °C had a higher number of microbes than the ungutted samples stored at the same temperature. Figure 8 also shows a similar scenario shared between the gutted and ungutted samples held at 2°C, where the former achieved higher levels of microbes throughout the sampling period. Thus, these results illustrate that storing fish gutted a few hours after being caught produces more microbial growth than storing the fish ungutted for a longer period. Figure 8 also illustrates that no significant difference in the growth of TVC grown on the extracted flesh of fish stored at either 2°C or 8°C was observed ($P > 0.05$). The time of gutting also exhibited no significant difference ($P > 0.05$) in the experiment.

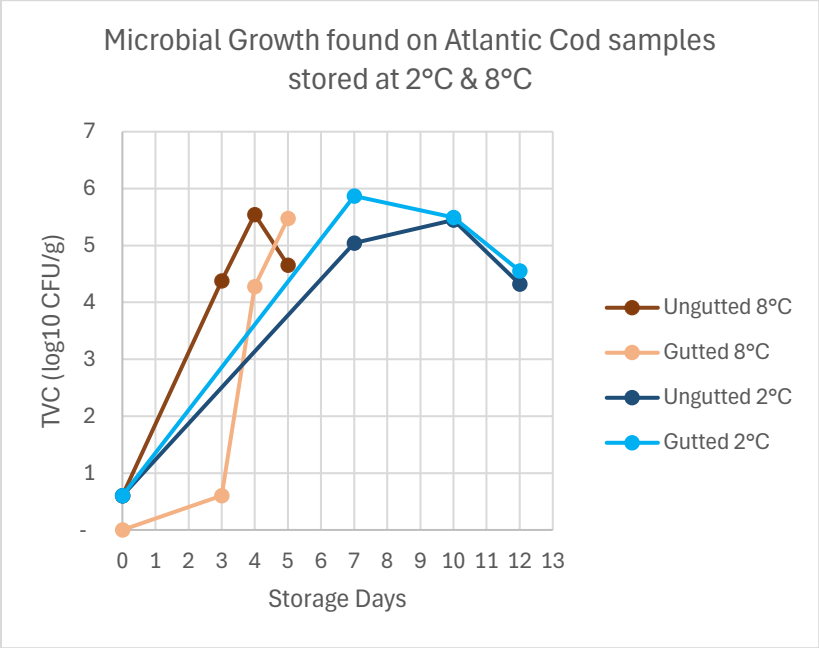


Figure 8: Comparison of microbial growths in Atlantic Cod samples stored at 2°C and 8°C.

## 5.2 Status of Fish Handling Practices in Jamaican Artisanal Fisheries

### *5.2.1 Use of Ice in Small Scale Fisheries.*

Most correspondents reported experiencing little to no spoilage in their catch. From the various values collected, the survey illustrated an average ice-to-fish ratio of 1.64:1 in pounds for all respondents. When separated based on major fishing grounds, the South Shelf had more pounds of catch than the North Shelf. There was a higher use of ice in the South Shelf, possessing an ice ratio of 2.04:1 in pounds compared to 1.25:1 calculated from the North Shelf. While half of the sample was aged between 36 and 55 years, the youngest and oldest age groups displayed the use of the greatest amount of ice within the North and South shelves, respectively. The

survey recorded three variables of fishing frequency: once a week, thrice a week, and daily. From both shelves, most correspondents operated three times a week. These correspondents also used the least amount of ice during fishing. Correspondents reported various durations for selling most, if not all, of their catch. From the observations, correspondents who take approximately three to six hours to sell their haul utilise the most ice (3.9 lbs for one pound of fish). The least ice usage was realised from the respondents selling their goods between one to three hours, followed by those who take no longer than six hours (0.5 and 0.9 lbs for each pound of fish).

The survey recorded the occurrence of ice manufacture and purchase among the sample population. The proportion of the sample that purchased ice was higher than the proportion of respondents who self-manufactured their ice. The survey further displayed that the number of correspondents from the southern beaches attesting to ice making surpassed those located at the North Shelf (**Error! Reference source not found.**). The instrument revealed the use of three t ypes of ice. The use of block and tubular ice was slightly higher on the northern fishing beaches. Crushed ice, however, was more commonly used at southern beaches. Eighty percent of the sample population declared using an igloo to store fish during and after their fishing trips. Both shelves conceived one correspondent employing freezers to maintain the quality of their catch. Three correspondents reported storing fish on the vessel floor instead of a storage unit. All correspondents agreed that the use of ice affected the freshness of their marine products.

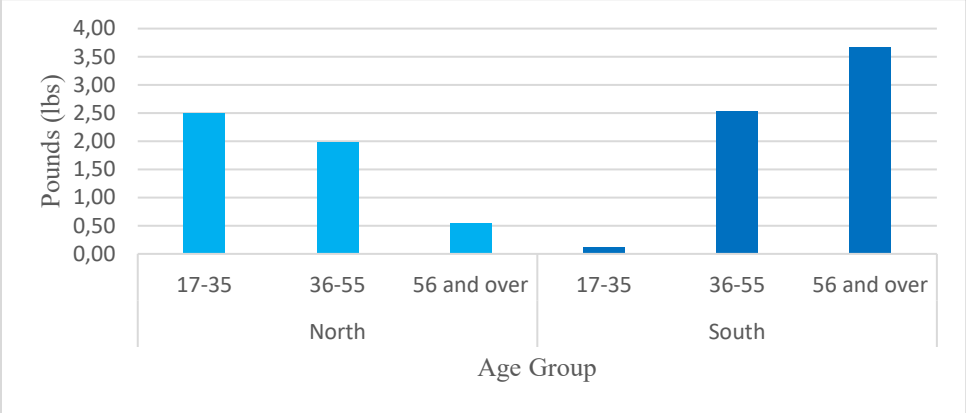


Figure 9: Average weight of ice used according to age group.

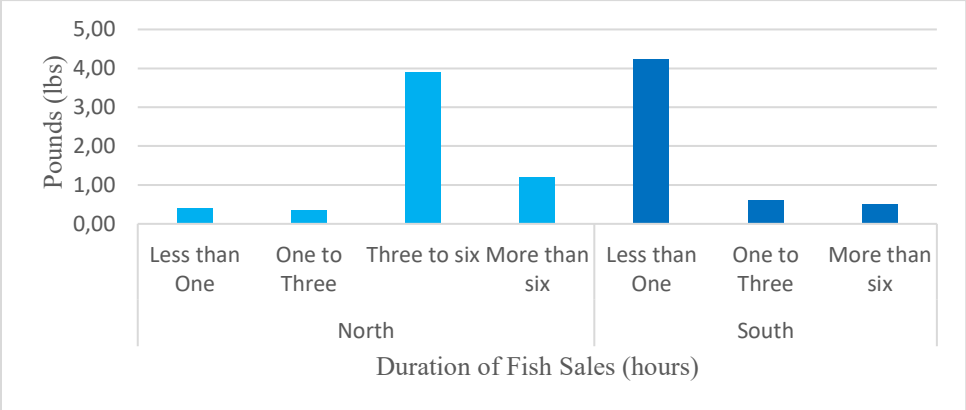


Figure 10: Average weight of ice used according to duration of fish sales.

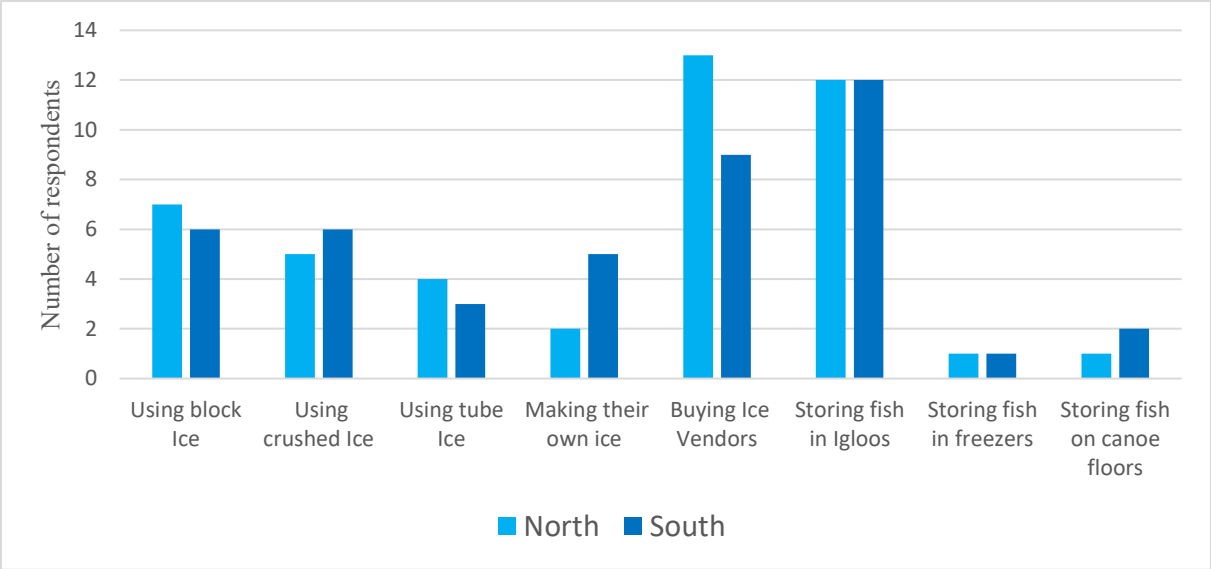


Figure 11: Frequency of fish handling practices related to storage temperature.

### *5.2.2 The effect of gutting on fish quality*

Half of the sample population admitted to being responsible for gutting their catch. The survey reported that two-thirds of the respondents preferred to have their fish gutted on land rather than onboard their vessels, with a majority on the North Shelf (Figure 12). Only five correspondents from the entire sample shared their reasons for not gutting onboard their vessels. The reasons are as follows: gutting onboard is time-consuming; the landing site is too near to consider gutting in the vessel; and gutting the fish before landing causes a loss of income. Further observations, however, underlined higher occurrences and willingness from the South Shelf to gut fish onboard vessels. More respondents from the northern fishing beaches washed fish with untreated seawater than with piped freshwater. This same number of correspondents conversely, surpassed the numbers of those using such water on the opposite end. Seven correspondents, mostly from the South Shelf, disclosed washing their harvest with limited volumes of potable water. Most correspondents also agreed that gutting influenced the attribute of freshness.

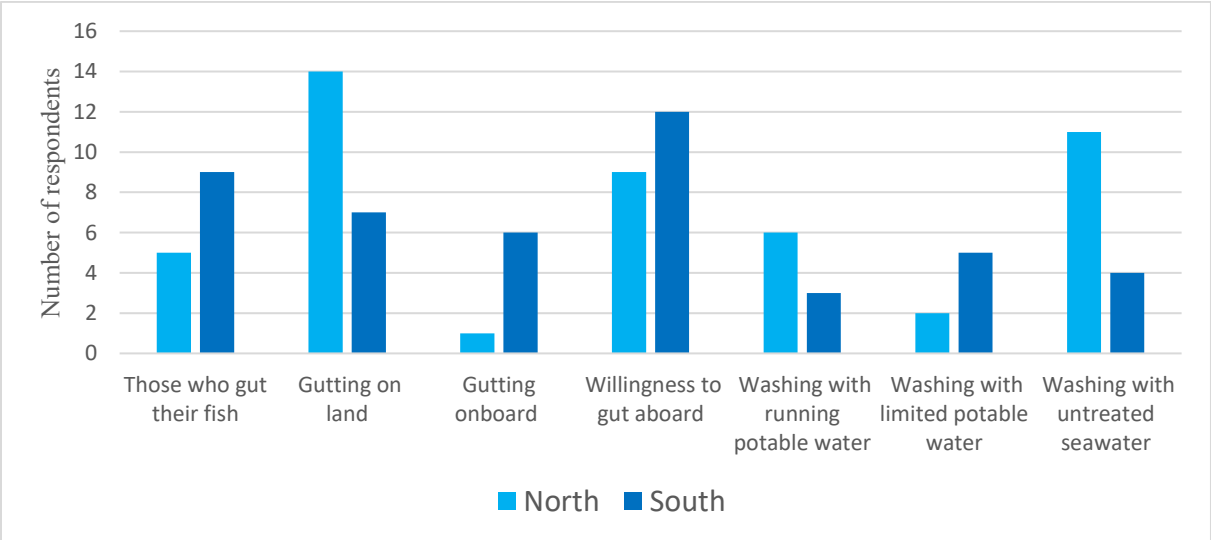


Figure 12: Frequency of fish handling practices related to gutting.

*5.2.3 Other details impacting fish quality.*

Results from the correspondents from both shelves displayed snappers, followed by parrotfishes, as the most targeted fish species. The results also stated that the fishing gear denoted as handlines and fish pots were found to be the most frequently used methods among the sample population. Eighty percent of the sample stated their willingness to participate in training geared toward learning and improving fish quality in the sector. Additionally, 20% had already received relevant training on the subject matter of food safety. Only a third of the sample population noted procuring a food handler´s permit. As few as three correspondents reported ministerial agencies taking samples from their fishing beaches. On the other hand, especially on the north shelf, as many as 14 correspondents claimed to have witnessed officers from these agencies pursue inspections related to fish quality.

# 6 DISCUSSIONS

## 6.1 Study of Sensory & Microbiological Evaluations

The purpose of all sensory and microbiological evaluations is to not only ascertain the measure of the freshness a product possesses, but more importantly encourage a standard of excellence in said product. With the understanding that QIM (Mai, 2021) and TVC (Huss, 1995) are simple yet standardised methods internationally, artisanal fisheries in Jamaica have the opportunity to establish quality control standards. These methods would not only cater safe foods to the local market (Varghese et al., 2022) but also encourage a level of competitiveness for the nation´s marine production. With knowledge of shelf life and aspects influencing fish freshness mentioned by Sharif (2017), fishers may reduce issues of post-harvest loss and strain on the current fish stocks (Dunbar, 2021). In addition, the implementation of quality control measures in artisanal fisheries may encourage consumer confidence in the local market. The implementation of QIM by the NFA will provide a series of reliable information for any commercially harvested fish species. For example, consumers and fishers can do well in purchases and sales of spiny lobster (*Panulirus argus*), knowing that with adequate chilling, the shelf-life of the fresh product is up to 10 days (Gonçalves et al., 2015). Nevertheless, the agency must be aware of weaknesses such as assessor subjectivity and low sample numbers that may be presented throughout the utilisation of the procedures highlighted by Freitas et al. (2019). Therefore, QIM and TVC procedures may be applied to evaluate the actual shelf life of numerous targeted fish species within artisanal fisheries. For impact within a short space of time, the NFA is recommended by this study to employ the procedures on snappers and parrotfishes, which are seen as the most targeted species among the sample population. Appropriate accommodations, including consistent training sessions, should be instituted to enjoy the simplicity and reliability of these evaluations.

## 6.2 Assessment of gutting and storage temperature on fish species.

In the instance of the experiment conducted, *G. morhua* samples visualized no significance of gutting on quality according to the QIM scheme used. Similar results were reflected in the study conducted by Erikson et al. (2018), as the gutted and ungutted shortfin pompano (*Trachinotus falcatus*) shared the same estimated shelf-life of 18 days and hence did not encourage gutting before the use of chilling techniques. Atlantic cod samples are indicative of similar strategies.

In other words, gutting should not be pursued without responsible temperature control. Regarding microbial load, the experiment conducted by the author showed no significant difference between the ungutted and gutted samples at both temperatures. This is in contrast to the observations made by Bilgin et al. (2016). Although the whole and eviscerated fish samples did not exceed the limit of acceptability, as in the author´s experiment, there still occurred a significant observed difference when gutting was applied. However, it should be noted that the lack of replication within the TVC procedure renders these results unviable. The same experiment highlighted the variation between the two different storage temperatures. The QIM scheme developed informed the author that the shelf life at 0°C was 15 days. Shifting the storage temperature from 0°C to 2°C reduced the duration to 11 days. The observations are similar to the results obtained by Campus, o.fl., (2011), where the fish samples held at 4 °C were reached a limit of acceptability six days slower than the samples temperature abused at 8°C. Stakeholders, such as those operating the vessel Daðey GK-777should therefore ensure freshness is maintained in their catch by keeping it close to 0°C for as long as necessary (Mlingi, 2018). It should be noted that any Jamaican fish samples undergoing similar experiments may react differently from the Atlantic cod samples used. This difference may be in accordance with the corresponding microbes pointed out by Leroi (2014). Therefore, if this study were to be replicated with fish caught in Jamaican waters, such fish may respond better to low storage temperatures than the Atlantic cod caught in Sandgerði, Iceland. More importantly, where both North and South shelf fishing grounds experience approximate ambient temperatures of 27°C (Machado et al., 2022), artisanal fishers in Jamaica have a duty to execute chilling techniques, such as ice, to achieve acceptable storage temperatures.

### 6.3 Status of Fish Handling Practices in Jamaican Artisanal Fisheries

The entire sample population reported little to no spoilage in their fishing activities. In other words, less than 10% of the marine production is said to be lost, according to the respondents. While this may be resolved as good news compared to the rest of the world, as reported by Anagnostopoulos et al. (2022), the results are questionable due to the lack of follow-up questions to verify such measures. Another observation that is viewed by the author as questionable is the percentage of respondents who confessed to cleaning their vessels after every fishing trip. Unfortunately, the survey did not include supporting questions to magnify how cleaning is done and how much time is taken to pursue such tasks. This information would then be compared to the matter of sale duration with the fishers´ harvests, engaging the matter of effort versus fish quality. In the future, the author will take the opportunity to revisit and record such findings to better describe the dynamics of fish handling and fish quality in artisanal fisheries.

The average ice-to-fish ratio calculated from the sample population exceeded the required ratio mentioned by Ninan (2021). Even when separated, both the North and South shelves illustrated similar results, indicating positive acceptance of icing among artisanal fishers regardless of location. The age groups of ≥ 56 and 17–35 years were located in the North and South shelves, respectively; however, they were lower than the recommended ratios. While the sample size is not large enough to draw definite conclusions, the author believes that productivity added with relative competence strongly influences the weight of ice utilised by a crew. Older fishers, though possessing years of experience and valuable knowledge in the field, may not have the

zeal or strength to dependably exert themselves in their occupations. The opposite scenario may be true for the fishers counted as the youngest group in the industry. The groups sorted in terms of time taken to complete sales after harvest produced more concerning results, with only three of the seven groups of correspondents showcasing an ice-to-fish ratio not below 1:1. Fishers admitting to finishing sales either within a period of three to six hours or more in the North Shelf had more pounds of ice used. Such results were expected given the long durations; fishers would ensure that the freshness of the fish was maintained for consumer assurance, as suggested by Shawyer (2003). Those taking less than one hour to conclude sales at southern beaches, on the contrary, may not necessarily need as much ice as reported from the ratio measured in Figure 10. Fishers enduring longer sale durations must apply more pounds of ice to reduce the microbial load of the fish species.

Both block ice and crushed ice appeared to be the two most favourable ice types among the respondents. Reflecting on the characteristics identified by Shawyer and Medina Pizzali (2003), Jamaican fishers travelling for relatively long hours appreciate the value of ice enduring until the harvests are landed. Crushed ice is used for effective and rapid cooling of the harvested fish due to its increased surface area in contact with the fish. Based on the observations in Figure 11, tube ice may be used as a supplemental type of ice to replace the previously stated types. The survey results strongly indicate that ice manufacturing is a viable streamlining option for North Shelf operations. Fishers situated on the southern beaches may also have more personal facilities to generate ice, especially as block ice or crushed ice. These results suggest that the southern beaches are not laden with as many ice vendors as the northern region. Further investigations should be performed in the future to confirm these observations and suggest the establishment of ice factories to support marine production and handling. The choice of more appropriate storage equipment to maintain low temperatures was evidently high among the respondents. The widespread use of igloos for fish storage underscores the importance of proper infrastructure to maintain freshness throughout the supply chain. It is also suggestive that artisanal fishers are aware of the high ambient temperatures in Jamaica (Machado et al., 2022). With all respondents agreeing that ice affects fish freshness, the behaviour of using fish handling to prevent temperature is acceptable. However, the NFA must not ignore the occurrence of canoe floors being used as a method of storage. Such means promote unwarranted exposure to direct sunlight and physical trauma of the product.

The survey revealed that most correspondents preferred to gut their catch on land rather than onboard their vessels. Although the percentage of reasons given for being unwilling to gut onboard was low, the answers shed necessary light on why gutting on land is preferred. The list of reasons revealed that fishers value the amount of time spent on certain duties at sea. More importantly, the list suggested the method of selling the catch: by weight, including the viscera. Once consumers purchase the catch from the fisher and/or vendors, they are given the option to have their products gutted by ‘specialised’ cleaners at an extra cost. Based on the results of the correspondents’ willingness to gut onboard, the possibility of increasing the current prices of all commercial fish species may be a supported suggestion. This also raises the question of how to address the role of specialised cleaners based on landing sites. Although half of the respondents confessed to being responsible for gutting their hauls, the survey did not clarify how frequently the same respondents pursued this role. With the understanding that catching fish is labour-intensive, the role of gutting and cleaning may be better to delegate and expand employment. Therefore, should the action of onboard gutting be stipulated by stakeholders, the

incorporation of cleaners within the fishing crew should also be considered to prevent efficiency and time management.

Another element relieved by the survey was the frequency of washing the product with water. The option of using untreated seawater revealed the highest number of correspondents admitting to using such means to survive. Compared with the number of correspondents reported to use tap water, the results are indicative of low availability of cleaning facilities with piped water, along with the perspective of sea water gathered by fishers or cleaners being safe enough to wash the product while gutting. Although the study had no verifying factor to confirm the presence of adjacent seawater at the sampled fishing beaches, the likelihood of the medium contaminating fish hauls cannot be ruled out.

The Jamaican local market is not indicative of being heavily driven by the quality of fish pertaining to spoilage. Prices are not based on how the harvest was handled. It is strongly influenced by the weight of the fish being sold and the availability of the targeted fish species. However, the ranking of fish species value is reflected in the survey, where snappers and parrotfishes which are deemed to have the highest value, are found with the highest number of correspondents. Due to time and labour limitations, the relationship between categories and their respective treatment upon capture was not manifested. This study investigated questions such as the amount of ice used by fishers to store high-quality fish compared with fish considered low-value or trash fish. It also examined the effects of specific fishing gear on the quality of harvested species, as previously reported by Sabu and Sasidharan (2020). Considering Rouxel and Montevecchi (2018) conclusions on gillnets, exploring the more frequently used methods such as fish pots and handlines in Jamaica may provide useful content to improve fish quality when hauling. Moving forward, if training sessions on fish handling practices are realised within both shelves, there may be a possibility of a mental shift in how fish are sold. Nevertheless, further research is needed to verify this outcome. Since the majority of the fishermen are willing to be trained in better fish handling practices, these identified gaps can be addressed through training and capacity building for the fishermen to promote the sale and consumption of healthy fish in Jamaica.

## 7 CONCLUSION

The use of the Quality Index Method scheme and Total Viable Count method will prove useful to guide and record quality within Jamaican fish species. The study indicated that for a successful application of these methods, the number of samples must be adequate to provide replicates and observe trends among the data. It is also imperative for the panel to be not only well manned but, more importantly, well trained with the various fish samples. No significant differences were observed between the gutted and ungutted Atlantic Cod samples. With a significant difference found between the two temperatures (2 °C and 8 °C) and no significant difference pertaining to the timing of gutting of the samples, it is concluded that the effect of storage temperature as opposed to gutting greatly influences the quality of fish at harvest. Therefore, the author suggests the use of low temperatures equal to or below 0°C as soon as fish are hauled. The manner of gutting onboard is recommended to be explored through extensive research in Jamaica to prove its significance in improving fish quality.

The survey provided basic baseline data suggestive of improved fish handling practices in Jamaica. While artisanal fishers are aware of and employ good practices with ice and igloos, there is still room for improvement. It is highly recommended to pursue training sessions and inspections for fish quality, especially within the regions supplied by the South Shelf in response to contribution. However, the survey lacked elements to provide more crucial baseline data to indicate how fishers check fish quality if they are aware of the subject, along with the methods employed onboard and after to attain high quality in their harvests. Nevertheless, the survey highlighted the need for the NFA to address the challenges of fish handling across Jamaica's artisanal fisheries. By tailoring interventions to specific demographic and regional characteristics, the NFA can guide artisanal fishers to enhance sustainability, productivity, and profitability of the fisheries sector. This approach could include focused training programs for younger fishers, region-specific gear regulations, enhanced infrastructure for fish handling and storage, and comprehensive educational outreach to improve compliance with regulations. Such targeted strategies could ultimately lead to a more robust and sustainable artisanal fishery, supporting both local communities and the broader economic and ecological well-being of Jamaica.

ACKNOWLEDGEMENTS

I express my gratitude to Matís –Icelandic Food and Biotech R&D for allowing my studies to be conducted using their facilities. Special thanks towards Jónas Baldursson, Aðalheiður Ólafsdóttir and Margeir Gissurarson for your sound guidance and patience while supervising my project. Special thanks to Olanrewaju Femi Olagunju for his support and wisdom in constructing this research paper.

I thank the staff of the GRÓ Fisheries Training Programme for the opportunity to learn and craft my talents within an environment conducive to advancements in the fisheries profession. I am also grateful to the UNESCO GRÓ FTP Fisheries Training Programme for sponsoring this research project.

My gratitude also goes out to my institution, the National Fisheries Authority of Jamaica, in collaboration with the Ministry of Agriculture, Fisheries, and Mining, for releasing and supporting me during the past six months to pursue this programme.

Finally, to the cohort of 2023 fellows, close family, friends, and loved ones, I appreciate you for all the times of fellowship, devotion, and love you have offered. It shall never be forgotten.

REFERENCES

Abelti, A. L. (2016). Postharvest and nutritional loss assessment of fish at different handling stage from Genale River, Southeastern Oromia. *International Journal of Fisheries and Aquatic Studies, 4*(6), 263-266.

Ahmad, I. (2018). *Implementation of Quality Control.* Retrieved from https://doi.org/10.5772/intechopen.77060

Aiken, K.A. and Kong, G.A. (2000). The marine fisheries of Jamaica. *The ICLARM Quarterly*, 23 - 35.

Alt, K. G. (2022). Gene expression and allergenic potential of Pseudoterranova bulbosa L3 from different infection sites in North Atlantic cod (Gadus morhua). *Journal of fish diseases, 45*(8), 1073-1086.

Anagnostopoulos, D. A., Parlapani, F. F., & Boziaris, I. S. (2022). The evolution of knowledge on seafood spoilage microbiota from the 20th to the 21st century: Have we finished or just begun? *Trends in Food Science & Technology, 120*, 236-247. doi:https://doi.org/10.1016/j.tifs.2022.01.004

Baten, M. A., *(2018). Bangladesh Journal of Fisheries, 30*(1), 103–111. https://www.academia.edu/38282209/Baten_et_al_2018_Bangladesh_J_Fish_30_1_103_111_pdf

Baixas-Nogueras, S. B.-C.-N.-C. (2009). Effects of Gutting on Microbial Loads, Sensory Properties and Volatile and Biogenic Amine Contents of European Hake (Merluccius merluccius var. mediterraneus) stored in Ice. *Journal of Food Protection*, 1671-1676.

Bedane, T. D., Agga, G. E., & Gutema, F. D. (2022). Hygienic assessment of fish handling practices along production and supply chain and its public health implications in Central Oromia, Ethiopia. *Scientific Reports, 12*(1), 13910.

Bernardo, Y. A. A., Denes, K. A., Rosario, D. K. A., Delgado, I. F., & Conte-Junior, C. A. (2020). *Fish Quality Index Method: Principles, weaknesses, validation, and alternatives—A review.* Comprehensive Reviews in Food Science and Food Safety, 1–20.

Bilgin, Ş. İ., Günlu, A., Diken, G., & Genç, İ. Y. (2016). Effects of gutting process on the shelf life of cultured meagre (Argyrosomus regius ASSO, 1801) stored at 4 ± 1 °C. *Food Science and Technology, 36*(2), 344–350. doi:10.1590/1678-457x.0102

Bonilla, A. C., Sveinsdottir, K., & & Martinsdottir, E. (2007). Development of Quality Index Method (QIM) scheme for fresh cod (Gadus morhua) fillets and application in shelf life study. *Food control, 18*(4), 352-358.

Boziaris, I. S. (2013). Introduction to seafood processing—Assuring quality and safety of seafood. *Seafood Processing: Technology, Quality and Safety*, 1-8.

Boziaris, I. S., & Parlapani, F. F. (2017). Specific Spoilage Organisms (SSOs) in Fish. In *The Microbiological Quality of Food* (pp. 69-98). doi:10.1016/b978-0-08-100502-6.00006-6

Bremner, A. &. (2000). A critical look at whether "freshness" can be determined. *Journal of Aquatic Food Product Technology, 9*, 5-25.

Cakli, S. K. (2006). Effects of gutting and ungutting on microbiological, chemical, and sensory properties of aquacultured sea bream (Sparus aurata) and sea bass (Dicentrarchus labrax) stored in ice. *Critical Reviews in Food Science and Nutrition, 46*(7), 519–527.

Calanche, J. B. (2019). Aquaculture and sensometrics: the need to evaluate sensory attributes and the consumers' preferences. *Reviews in Aquaculture.* doi:doi:10.1111/raq.12351

Calanche, J. P. (2020). Design of predictive tools to estimate freshness index in farmed sea bream (Sparus aurata) stored in ice. *Foods, 9*(1), 69.

Campus, M., Bonaglini, E., Cappuccinelli, R., Porcu, M. C., Tonelli, R., & Roggio, T. (2011). Effect of modified atmosphere packaging on Quality Index Method (QIM) scores of farmed gilthead seabream (Sparus aurata L.) at low and abused temperatures. *Journal of Food Science, 76*(3), S185–S191. doi:https://doi.org/10.1111/j.1750-3841.2011.02051.x

CARICOM, World Food Programme. (2023). *Caribbean Food Security & Livelihoods Survey: Natural Hazards and the Cost of Living Crisis - Regional Summary Report | May 2023.* Greater Georgetown: CARICOM.

CFRAMP. (2000). *Jamaica national marine fisheries atlas.* CARICOM Fisheries Unit.

Chantarachoti, J., Oliveira, A. C. M., Himelbloom, B. H., Crapo, C. A., & McLachlan, D. G. (2007). *Alaska pink salmon (Oncorhynchus gorbuscha) spoilage and ethanol incidence in the canned product.* Journal of Agricultural and Food Chemistry, 55(7), 2517–2525. https://doi.org/10.1021/jf062245m

Chatreman, N. S. (2020). Prevalence and distribution of pathogenic bacteria found in fish and fishery products: A review. *Journal of Fisheries and Life Sciences, 5*(2), 53-65.

Comi, G. (2017). Spoilage of meat and fish. In *The Microbiological Quality of Food* (pp. pp. 179-210). doi: https://doi.org/10.1016/b978-0-08-100502-6.00011-x

Diei-Oudad, Y., & Mgawe, Y. (2011). *Post-harvest fish loss assessment in small-scale fisheries: a guide for the extension officer.* Rome: FAO.

dos Santos, A. P., Kushida, M. M., Viegas, E. M., & Lapa-Guimarães, J. (2014). Development of Quality Index Method (QIM) scheme for Acoupa weakfish (Cynoscion acoupa). *LWT - Food Science and Technology, 57*(1), 267-275. doi:https://doi.org/10.1016/j.lwt.2014.01.010

Dunbar, A. M. (2021). Factors influencing the sustainable utilization of artisanal fisheries: A case of West Point, Liberia. *International Journal of Fisheries and Aquatic Studies, 9*(2), 52-59.

Eliasson, S., Arason, S., Margeirsson, B., Bergsson, A. B., & Palsson, O. P. (2019). *Effects of on-board bleeding methods and superchilling on quality of cod and saithe.* Reykjavik: University of Iceland.

Entee, S. (2015). *Post-harvest processing value chain literature review report.* Narragansett, RI: Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island and SNV Netherlands Development Organization.

Erikson, U., Truong, H. T., Le, D. V., Pham, P. D., Svennevig, N., & Phan, V. T. (2018). Harvesting procedures, welfare and shelf life of ungutted and gutted short-fin pompano (Trachinotus falcatus) stored in ice. *Aquaculture.* doi:10.1016/j.aquaculture.2018.06.085

FAO. Food and Agriculture Organization of the United Nations (2015). *Artisanal Fisheries.* Retrieved from The Fish Project: http://thefishproject.weebly.com/artisanal-fisheries.html

FAO, WHO . (2020). *Code of Practice for Fish and Fishery Products.* Rome: Food and Agriculture Organization of the United Nations. doi:https://doi.org/10.4060/cb0658en

FAO. Food and Agriculture Organization of the United Nations. (2016). *The State of World Fisheries and Aquaculture. In Contributing to Food Security and Nutrition for All.* Retrieved from https://www.fao.org/3/i5555e/i5555e.pdf.

Freitas, J., Vaz-Pires, P., & Câmara, J. S. (2019). Freshness Assessment and Shelf-Life Prediction for Seriola dumerili from Aquaculture Based on the Quality Index Method. *Molecules (Basel, Switzerland), 24*(19), 3530. doi:10.3390/molecules24193530

Gonçalves, A. A., de Lima, J. T., & de Paula, F. E. (2015). Development of Quality Index Method (QIM) scheme for spiny lobster (Panulirus argus, Latreille, 1804) stored in ice. *Food Control, 47*, 237–245. doi:doi:10.1016/j.foodcont.2014.07.010

Graham, J., Johnston, W., & Nicholson, F. (1992). Ice in Fisheries. *FAO Fisheries Technical Paper. No. 331*, 75. Retrieved from http://www.fao.org/DOCREP/T0713E/T0713E00.HTM (1 of 3)5.7.2006 14:55:13

Hassoun, A. (2015). Quality Evaluation of Fish and Other Seafood by Traditional and Nondestructive Instrumental Methods: Advantages and Limitations. *Critical Reviews in Food Science and Nutrition*, 00–00. doi: doi:10.1080/10408398.2015.1047926

Huang, J., Zhou, Y., Chen, M., Huang, J., Li, Y., & Hu, Y. (2020). Evaluation of negative behaviors for single specific spoilage microorganism on little yellow croaker under modified atmosphere packaging: biochemical properties characterization and spoilage-related volatiles identification. *Lebensmittel-Wissenschaft & Technologies*, 110741. doi:10.1016/j.lwt.2020.110741

Huss, H. H. (1995). *Quality and quality changes in fresh fish.* Rome: FAO.

Lehmann, S. P. (2008). Effect of previous gutting on rancidity development in horse mackerel (Trachurus trachurus) during frozen storage at )20 C. *International Journal of Food Science and Technology*, 270 - 275. doi:doi:10.1111/j.1365-2621.2006.01429.x

ISO, I. S. (1987). Quality systems.

Jones, E. (2017). *Environmental and Social Management Framework for the PCCR Project.* Kingston: Fisheries Division: Ministry of Industry, Commerce, Agriculture and Fisheries.

Joshy, C. G., Ninan, G., Panda, S. K., Zynudheen, A. A., Kumar, K. A., & & Ravishankar, C. N. (2019). Development of Demerit Score-Based Fish Quality Index (FQI) for Fresh Fish and Shelf Life Prediction Using Statistical Models. *Journal of Aquatic Food Product Technology*, 1–10. doi:doi:10.1080/10498850.2019.1693

Kamble, A. B. (2023). Quality Issues and Mitigation Strategies to Improve the Quality of Fishes Available in Bhima River Basin. *Just Agriculture, 3*(12), 365.

Khurana, H. S. (2020). Gut microbiome of endangered Tor putitora (Ham.) as a reservoir of antibiotic resistance genes and pathogens associated with fish health. *BMC Microbiology, 20*(1), 249. doi:https://doi.org/10.1186/s12866-020-01911-7

Kissoon, J., & Badrie, N. (2001). Handling Practices, Consumer Perception, And Quality Evaluation Of Fresh Carite (Scombejromorus Brasiuensis) In Trinidad, West Indies.

Lakshmanan, P. T. (2000). *Fish spoilage and quality assessment.* Cochin: Society of Fisheries Technologists (India).

Lens, D. J. (1977). *Jamaica - Identification of Fishery Development Project: Final Report.* Washington, D.C.: FAO/IDB Cooperative Programme. IDB.

Leroi, F. (2014). Role of bacteria in seafood products. In F. Leroi, *Seafood Science: Advances in Chemistry, Technology and Applications* (pp. 458-482).

Lima dos Santos, C. A. M. (1979). *Report on fish (fresh fish) handling, processing and quality control in Jamaica* (WECAF Reports No. 6). Food and Agriculture Organization (FAO), Western Central Atlantic Fishery Commission.

López-García, M. M., Ramil-Novo, L. A., Vázquez-Odériz, M. L., & Romero-Rodríguez M. A., R. (2021). A QIM-Based Evaluation of Sensory Quality of Frozen–Thawed Roundnose Grenadier (Coryphaenoides rupestris) and Its Applications. *ACS Food Science & Technology, 1*(3), 392-398.

Machado, C. B., Maddix, G.-M., Francis, P., Thomas, S.-L., Burton, J.-A., Langer, S., . . . Tonon, T. (2022). Pelagic Sargassum events in Jamaica: Provenance, morphotype abundance, and influence of sample processing on biochemical composition of the biomass. *Science of The Total Environment, 817*, 152761. . doi:https://doi.org/10.1016/j.scitotenv.2021.152761.

Mahon, R. (1995). *Fisheries for large pelagics in Jamaica: A review and options for development.* https://doi.org/10.13140/RG.2.2.30901.01769

Mai, N. T. (2021). Quality Index Method for Freshness Assessment of Chilled Japanese Flying Squid (Todarodes pacificus). *Asian Food Science Journal, 20*(6), 110-121.

Martinsdóttir, E., Sveinsdóttir, K., Luten, J. B., Schelvis-Smit, R., and Hyldig,. (2001). *Reference manual for the fish sector: Sensory evaluation of fish freshness.* AB IJumiden, The Netherlands: QIMEurofish.

Mihafu F. D, Issa J. Y, Kamiyango M. W. (2020). Implication of Sensory Evaluation and Quality Assessment in Food Product Development: A Review. *Current Research in Nutrition and Food Science, 8*(3). doi:http://dx.doi.org/10.12944/CRNFSJ.8.3.03

Mikš-Krajnik, M., Yoon, Y.-J., Ukuku, D. O., & Yuk, H.-G. (2016). Volatile chemical spoilage indexes of raw Atlantic salmon (Salmo salar) stored under aerobic condition in relation to microbiological and sensory shelf lives. *Food Microbiology, 53*(Part B), 182–191.

Ministry of Agriculture & Fisheries. (2014). *Final Draft National Fisheries and Aquaculture Policy.* Unpublished.

Mishra, P. S. (n.d.). *Spoilage in fish and shellfish products* (Vol. 2, p. 59).

Mlingi, R. J. (2017). *Transfer of sensory methodology to artisanal fisheries by development and application of Quality Index Method (QIM).* United Nations University Fisheries Training Programme Iceland. Final project. Retrieved from http://www.unuftp.is/static/fellows/document/Ritha17prf.pdf

Mohan, C. O. (2018). Sensory evaluation of fish products. *ICAR-Central Institute of Fisheries Technology.*

Munoz, A. M. (2002). Sensory evaluation in quality control: an overview, new developments and future opportunities. *Food Quality and Preference, 13*(6), 329-339.

Murray, A. and Aiken, K.A. (2002). Artisanal fishing in Jamaica today: A Study of a Large Fishing Site. *57th Gulf and Caribbean Fisheries Institute*, 216-234.

National Fisheries Authority. (2023). *JAMAICA FISHERIES: Quarterly Statistics Report Volume 2: Issue 3.* Kingston: National Fisheries Authority.

National Fisheries Authority. (2023). *Jamaica FIsheries: Quaterly Statistics Report Volume 2: Issue 1 April - June 2023.* Kingston: National Fisheries Authority, Jamaica. Retrieved from https://www.moa.gov.jm/document-catergeries/report

National Fisheries Authority of Jamaica. (2021). Summary Statistics of registered fishers. *Vol 1*, p1.

Nguyen, H. Q. (2005). *Guidelines for handling and preservation of fresh fish for further processing in Vietnam*. UNU–Fisheries Training Programme. *(Publisher location: Reykjavík, Iceland)*

Nimbkar, S. A. (2021). Novel Techniques for Quality Evaluation of Fish: A Review. *Food Reviews International*, 1–24. doi:doi:10.1080/87559129.2021.1925291

Ninan, G. (2021). Handling, Chilling and Freezing of Fishery Products. *ICAR-Central Institute of Fisheries Technology.*

Odoli, O. C., Oduor-Odote, P. M., Ohowa, B., & Onyango, S. O. (2013). *Evaluation of fish handling techniques employed by artisanal fishers on quality of Lethrinids and Siganids fish genera at landing time along the Kenyan coast using sensory and microbiological methods.* African Journal of Food, Agriculture, Nutrition and Development, 13(5), 8167–8186. https://doi.org/10.18697/ajfand.60.12340

Ogur, S. (2022). Pathogenic bacteria load and safety of retail marine fish. *Brazilian Journal of Biology, 82*, e262735.

Olafsdottir, G. L. (2006). Influence of storage temperature on microbial spoilage characteristics of haddock fillets (Melanogrammus aeglefinus) evaluated by multivariate quality prediction. *International Journal of Food Microbiology, 111*, 112-125.

Olafsdottir, G., Martinsdottir, E., Oehlenschlager, J., Dalgaard, P., Jensen, B., Undeland, I., ... Nilsen, H. (1997). Methods to evaluate fish freshness in research and industry. *Trends in Food Science & Technology, 8*, 258–265.

Olafsdottir, U. N. (2004). Multisensor for fish quality determination. *Trends in Food Science & Technology, 15*(2), 86-93. . doi:https://doi.org/10.1016/j.tifs.2003.08.006

Rouxel, Y., & Montevecchi, W. (2018). Gear sustainability assessment of the Newfoundland inshore northern cod fishery. *Ocean & Coastal Management*, 163, 285–295. doi:doi:10.1016/j.ocecoaman.2018.05.018

Rudiro, N. D. (2019). Analysis of small-scale fish handling development in Rembang waters. *Russian Journal of Agricultural and Socio-Economic Sciences, 90*(6), 130-134. doi:https://doi.org/10.18551/rjoas.2019-06.17

Sabu, S., & Sasidharan, A. (2020). Impact of fishing on freshness and quality of seafood: A review. *International Journal of Fisheries and Aquatic Studies*, 193-198.

Şengör, G. F. (2023). Sustainable Fishery and Food Safety. *Sustainable Aquatic Research, 2*(2), 1-1. doi:10.5281/zenodo.8296499

Sharif, M. K. (2017). Sensory evaluation and consumer acceptability. *Handbook of food science and technology, 10*, 361-386.

Shawyer, M., & Medina Pizzali, A. F. (2003). *The use of ice on small fishing vessels* (FAO Fisheries Technical Paper No. 436). Food and Agriculture Organization of the United Nations.

Sheng, L., & Wang, L. (2020). The microbial safety of fish and fish products: Recent advances in understanding its significance, contamination sources, and control strategies. *Comprehensive Reviews in Food Science and Food Safety*. doi:doi:10.1111/1541-4337.12

Soares, L. K. (2017). Walking the talk of the small-scale fisheries guidelines in Jamaica. In S. Jentoft, R. Chuenpagdee, M. J. Barragán-Paladines, & N. Franz (Eds.), *The small-scale fisheries guidelines: Global implementation* (pp. 115–135). Springer International Publishing. https://doi.org/10.1007/978-3-319-55074-9_7

Speranza, B. R. (2021). Innovative preservation methods improving the quality and safety of fish products: Beneficial effects and limits. *Foods, 10*(11), 2854.

Sykes, A. V., Oliveira, A. R., Domingues, P. M., Cardoso, C. M., Andrade, J. P., & Nunes, M. L. (2009). Assessment of European cuttlefish (Sepia officinalis, L.) nutritional value and freshness under ice storage using a developed Quality Index Method (QIM) and biochemical methods. *LWT - Food Science and Technology, 42*(1), 424–432. doi:https://doi.org/10.1016/j.lwt.2008.05.010

Tang, J. Y. (2023). Detection of microbiological hazards. In V. Andersen, H. Lelieveld, & M. Y., *Food safety management* (pp. 835-850). Academic Press.

Thu, H. B., Thi, P. D., Van, T. P., Hoang-Dung, T., Van, N. T., Van, D. A., & Thi, N. M. (2020). A quality index method for squid Uroteuthis (Photololigo) chinensis (Gray, 1849) preserved on ice. *Foods and Raw materials, 8*(2), 216-222.

Torrico D.D., Mehta A., Borssato A.B. (2023). New methods to assess sensory responses: a brief review of innovative techniques in sensory evaluation. *Current Opinion in Food Science, 49*(100978).

Varghese, S. M., Parisi, S., Singla, R. K., & Begum, A. A. (2022). Food safety and quality control in food industry. In *Trends in Food Chemistry, Nutrition and Technology in Indian Sub-Continent,* (pp. 31-44). Cham: Springer.

Vaz-Pires, P., & Seixas, P. (2006). Development of new quality index method (QIM) schemes for cuttlefish (Sepia officinalis) and broadtail shortfin squid (Illex coindetii). *Food Control, 17*(12), 942–949. doi:https://doi.org/10.1016/j.foodcont.2005.07.004.

Visciano, P. (2023). Good Hygiene Practice on Board Vessels for Fish Quality and Safety. 1-14. doi:https://doi.org/10.20944/preprints202308.2159.v2

Wibowo, S. U. (2017). *Case studies on fish loss assessment of small-scale fisheries in Indonesia* (FAO Fisheries and Aquaculture Circular No. 1139). Food and Agriculture Organization of the United Nations.

Zang, J., Xu, Y., Xia, W., & Regenstein, J. M. (2019). Quality, functionality, and microbiology of fermented fish: a review. *Critical Reviews in Food Science and Nutrition*, 1–15. doi:doi:10.1080/10408398.2019.1565491

Zaukuu, J. L. (2019). Emerging trends of advanced sensor based instruments for meat, poultry and fish quality– a review. *Critical Reviews in Food Science and Nutrition*, 1–18. doi:doi:10.1080/10408398.2019.1691972