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Investigations of Various On-Board Handling and Unloading Operations Influencing the Overall Quality of Groundfish

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INVESTIGATIONS OF VARIOUS ON-BOARD HANDLING AND UNLOADING OPERATIONS INFLUENCING THE OVERALL QUALITY OF GROUNDFISH

by

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ABSTRACT

The machinism and procedures for comprehensive fish quality assessments have been described and discussed. By using physical and laboratory techniques, the initial (landing), secondary as well as post-processing qualities have been evaluated with various on-board operations such as gutting, washing, bleeding, etc. and unloading. During 1979 to 1984, nine major investigations have been carried out for cod and haddock with samples between 60 to 2000 pounds. The details of advantages of various operations in term of overall quality preservation have been analyzed and discussed. It is believed that one-step gutting/bleeding operation for the fish within two to three hours after catching, and with proper washings and unloading handling ,would be most useful procedure in order to produce excellent quality product. The results and comments in this report will not give the recommendations but provide various technical informations to the Atlantic fisheries for their applications, improvements and new developments.

RÉSUMÉ

Le mécanisme et les procédures d'évaluation complète de la qualité du poisson sont discutés et décrits. À l'aide de techniques physiques et de laboratoire, on a évalué la qualité initiale (au débarquement), secondaire et après transformation de produits de la pêche ayant fait l'objet d'opérations de traitement à bord telles que l'éviscérage, la saignée, le lavage, etc. et de diverses méthodes de déchargement. La période s'étendant entre 1979 et 1984 a donné lieu à neuf études importantes sur la morue et l'aiglefin, la taille des échantillons ont varié de 60 à 2 000 livres. On fait l'analyse et discute du détail des avantages des diverses opérations sur le plan de la préservation générale de la qualité. On estime que l'opération combinée d'éviscérage et de saignée pendant les trois heures suivant la capture associée à des méthodes de lavage, de déchargement et de manutention favorables, constituerait la procédure la plus efficace de préparation d'un produit de qualité excellente. Les résultats et observations contenus dans ce rapport ne renferment pas de recommandations. Le document fournit néanmoins à l'industrie de la pêche de l'Atlantique les renseignements techniques nécessaires pour l'application et l'amélioration des procédures ou pour la mise au point de nouveaux procédés.

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1. INTRODUCTION

In the early 1980's, Canada has exported approximately $1.5 billion annually from fish and seafood products. Because the rate of catch is already at or near the maximum level to permit fish stocks to grow we must give a very high priority to maintaining high quality in all fish and fish products in order to earn more money for each fish caught and to maintain our leadership and high reputation in the world market.

Since export sales result from quality fish capably marketed, the focus of our fisheries should move from quantity to quality. International market conditions indicate that Canadian fisheries products must be of consistently high quality to maintain our expanded sales. There is no doubt that a solid base of overall fish industry excellence must be established to meet this objective. Moreover, it is believed that upgrading initial landing fish quality and freshness and over-all quality preservation of the catch with improved handling, chilling and unloading, should be the most important operations for the DFO Quality Enhancement Program. Since all fish quality deteriorations taking place (enzymatically and biochemically) are irreversable, industry cannot improve freshenss, texture, color, flavour and taste of fish to produce quality products except when fish from catching to landing are well preserved. Primary or landing fish quality preservation with various operations and pretreatments, at-sea, and at dockside as well as inland transportation and holding before processing have been well documented and discussed in past years. However, it is difficult to obtain a comprehensive report to apply some generally acceptable and practical techniques and information for our present investigation in evaluating major gutting, bleeding, washing and unloading operations in both total controlled laboratory conditions to full scale field trials at sea. However, a review of most technical reports and industry documents have been made with some brief remarks. The complete list is attached with this report in the reference section.

By adopting some of the techniques and methods developed from our FES (Fish Engineering Science) laboratory in Halifax, some comprehensive procedures and guidelines have been developed and recommended to be applied to assessing the primary (landing), secondary (end-of-line fillet) and post-process frozen quality. These have been employed to evaluate some handling and pre-treatments as well as some improved models of equipment for the fish industry in order to preserve and improve the over-all landing quality. Since more than 35 tests have been carried out in past years, only a part of some selected and condensed results are included and discussed of this report. In particular, some major operations which effect the overall quality of groundfish, such as gutting, bleeding, washing and unloading, etc. are comparatively discussed and described in this report.

2. EXPERIMENTAL AND TESTING METHODS

2.1 Sampling

The summarized information and data of the experimental fish are listed in Table 1. Samples 1, 2, and 6 were taken directly from the aquarium in the Halifax Laboratory about 2-4 weeks after catching. Samples for tests 3, 4, and 5 were made using a 2-stage sampling system where a fish sample taken at the beginnng was reduced 50% to the testing quantity required.All samples were well iced and boxed except some samples from tests 7, 8 and 9 in which some penned fish were also included. Precautions were established to maintain all onboard operation to meet the DFO codes of practice, but some minor variations in the operation of different fishing vessels and catching method cannot be completely eliminated.

2.2 GBW Evaluation Under Controlled Condition

Comprehensive experiments (Test 1 and 2) have been carried out in the Halifax Laboratory using live fish held in our aquarium. Experiment 3 was only a brief evaluation confirming texture gap changes as well as ATP degradation in various post-mortem cod fillets. Five groups (about 10 fish per group) such as GBW, B_1/GBW, B_2/GBW, G and UG as specified in Table 2, were used for various quality evaluation. Live fish taken from the tank, were placed in a 100-lb box without ice for 1½ hour, then the fish were divided into 5 groups and treated as required.

2.2.1 **GBW Group.** Fish were gutted by hand and then well washed with seawater. During gutting and washing, it is considered that the fish was partially bled. This recommended definition was also applied to fish gutted at sea in the various field trials.

2.2.2 **B_1/GBW Group.** Fish were bled for about 20-25 minutes in air after throat-cutting and then gutted and washed with seawater as above.

2.2.3 **B_2/GBW Group.** Fish were bled for about 20-25 minutes in air after bob-tail cutting, and then gutted and washed as above.

2.2.4 **G Group.** Fish were gutted by hand without washing. The fish were iced within about 10 minutes of gutting.

2.2.5 **UG Group.** This is the control group of round fish. No treatment was applied to this group before icing.

Fish in the above five groups were well iced in 100-lb boxes after samples (2 fish from each group) were taken for quality evaluation. The boxes of iced fish were stored in our cold Laboratory (+3°C) for the differential quality assessments for a period of 2 weeks after catching time.

Physical, chemical and organoleptic grading for round fish and fillet samples were conducted. Some photographic records were made for comparison of the color and texture changes, but no yield, frozen and PPQ was made for this experiment.

2.3 Scale-up GBW Operation at Sea

About 17 trials were performed in the past years. Cod was the major fish tested with haddock being used for only a few tests. The at sea operation (B_1/GBW) of complete bleeding followed by gutting and washing was only tested for haddock of sample 5 (Table 1) in thisstudy. Thus, most scale-up experiments consists of GBW groups either hand or mechanically gutted followed by various washings, and the control group (UG). Sometimes the G group, gutted without washing was also studied for comparison and to demonstrate quality differences to the fishermen of the community. All fish were boxed and well iced for evaluation. In addition, some data from our dockside grading project, unloading evaluation and onboard washing tests were also used for some comparative studies. A typical example of the scale-up GBW operation, which used about 1,200 lbs. of fish, is described in the attached Figure 1.

2.4 Unloading and Washing Evaluation

Various investigations and assessements of unloading and washing have been conducted in our Region in past years. These projects included not only quality variations but also other operational factors. In this report, some data from dockside grading, degree of damage and end-of-line quality from selected trials, are presented for comparative evaluation. A comprehensive procedure for evaluating fish unloading operations is described in Figure 2. The details of work sheets for unloading evaluations are attached in Appendix A. A few trials on comparative washing operations onboard using aregular box washer, a rotary washer, as well as some specific washing with active chlorines were also selected for this report. The detail of the washing experiment design were reported separately and the damage and physical evaluation methods are identical to the unloading operation.

2.5 Recommended Procedures for Overall Fish Quality Assessment

Since a great number of factors and considerations are involved and vary from time to time, it seems impossible to develop a comprehensive method for evaluating the overall fish quality which can be accepted by industry, fishermen, technical experts and government management. However, it is understood that for most cases, a part of the simplified comprehensive quality evaluation is required and would provide enough information and data to solve the problems from the industry and regulatory staffs point of view. Therefore, comprehensive quality evaluations are only carried out for assessing the complex problems involved in some technical research and development projects. The recommended procedures for overall fish quality evaluation is illustrated in the flow sheet in Figure 3. The evaluation is divided into two groups, such as primary grading from dockside samples (S) and secondary quality assessment from (SP) samples after the cutting the operation in plant.

2.5.1 Primary Quality Assessment

Primary quality assessment (GS group) which determines initial landing quality to be used as grades at selling point, is performed for the fish sample at the landing site. Physical grading using DFO grading standard (Appendix B) can give satisfactory results for most cases. The proposed new point of sale grading for Atlantic groundfish established in June 1984 was not used for this report but included in Appendix E for further investigations. The damage evaluation should be also included for most handling and equipment examinations. However, more reliable, scientific information and data are required for various analysis and compound evaluations. Therefore, some biochemical parameter evaluations as well as the time consuming organoleptic tests should be also conducted. With good statistical correlation as described in Appendix C, organoleptic tests can be eliminated and physical grading can be scientifically confirmed by some quality indices.

For fish caught - age less than 2 days on ice, the post mortem quality changes are usually too little to be determined by physical grading since most bacterial, enzymatic and chemical quality deteriorations have an induction period. Thus, differential (or delayed) quality evaluations such as S_2, S_3 and S_4 are required to provide more information from pre-loading, chilling and handling treatment, etc. The fish sampled as S_1 at dockside are well iced in the box and stored in a cold fish room. S_2, S_3 and S_4 samples are taken 2, 4 and 7 days after landing, respectively for differential quality evaluations, using identical procedures to S_1.

2.5.2 Secondary Quality Evaluation

As illustrated in Figure 2, samples (SP group) taken at the end of the cutting line in the processing plant, are to be tested for secondary quality assessment. This involves fillet physical grading, yield estimation, and post-process quality (PPQ) evaluations. PPQ is determined by both physical and chemical tests for the packed fillets frozen at -15°C for 1, 3 and 6 months. Biochemical and organoleptic evaluations are also conducted in cases where physical grading cannot give reliable grade results. Overall, texture, color, and odour are important parameters used in the physical evaluation of SP sample assessment. For some investigations, samples from S_2-S_4 groups from differential quality evaluations, may be also evaluated using the complete or part of the above secondary quality evaluation.

2.5.3 Testing Methods for Quality Measurement

When considering grading parameters for any food commodity the first attributes which come to mind are the gross characteristics of size, shape, color, odour and perhaps texture-features which register almost automatically on initial exposure to the product. Subsequent examination then reveals information at a more discriminating level such as deformities, discoloration, bruises, evidence of spoilage and the presence or absence of parasites. Final acceptance, since dealing with food, should however depend on sensory attributes determined by a trained taste panel. Such an evaluation is unfortunately a time and labour intensive operation requiring the training of panelists, repeated sampling, and statistical evaluation of results. Therefore we suggest the adoption of a practical alternative to eliminate the costly time and human error factors in the procedure, namely: the indexing of sensory data to chemically derived parameters.

For fish in the post mortem period, various bacterial, enzymatic and chemical reactions begin to take place to decrease fish freshness and the overall quality. The method to follow-up these changes and for determining the fish grade can be classified into three groups: physical, biochemical and organoleptic evaluations. The procedures and guidelines of the physical grading operation is described in Appendix B. The organoleptic taste panel evaluations can be made using our previously recommended procedure outlined in DFO Technical Report No. 902 (1980). The procedures for many biochemical and instrumental measurements for scoring fish quality have been reviewed and reported in our recent manuscript (TSIM - No. 503, 1984). For the present investigations, TVB, FFA and Hx are used for evaluating the fresh fish quality; TBA, TVB, FFA and EPN used for PPQ estimation of frozen samples. Since these parameters have been well correlated with taste panel results, they can be directly used for quality assessment with good, reliable results.

3. RESULTS AND DISCUSSION

The information for the major experimental fish is listed in Table 1. The descriptions and abbreviations for the operations in this report are summarized in Table 2, and these are used for data presentation and discussion in this section. The details of guidelines and procedures for grading and scientific quality evaluation have been described and reviewed in other reports, but some standards and data sheets as well as operations are described in Figures 2 and 3, and appendices A, B, C, and D. Great efforts have been made to avoid variations during sampling and quality assessment. However, some possible differences might still be present due to seasonal and geographical factors and various operations and handling at sea, in particular, during scale-up tests. Nevertheless, the present report should provide some important information to bring to light some major factors which may influence the overall quality changes from catching to processing. We also should indicate that more tests as well as a semi-commercial (220,000 kg) follow-up investigation to confirm the results will be required to alleviate possible misleading information and overstatement of our present report before any recommendations or changes to the codes of practice can be made.

As in the national quality enhancement program and various dockside grading projects, on-board gutting, bleeding and washing have been widely discussed. Various problems and limitations have been experienced. There is no doubt that in general, these operations for groundfish are good for quality and freshness preservation and help to achieve better resource utilization and more economic returns for the fisherman's effort. However, considerations on product requirements from the market place, the feasiblity and limitations of various catching methods and fishing vessels, and some other time-dependent factors, should be also discussed and reviewed before any management recommendation can be made. For the present investigation, only technical evaluations and scientific comparative studies have been described. These should provide some useful information to support various DFO management plans.

3.1 GBW Operation Under Controlled Condition

Most of our Atlantic groundfish meet the requirements for GBW fish on the basis of our definition in Table 2. Bleeding live fish before gutting is a very time-consuming operation. Only limited tests were conducted to compare quality advantages with various operations. The selected results of primary quality evaluation (S-sample group, dockside grading) have been listed in Table 3. Fish with caught age (ice) up to 9 days were classified into TA, TB as acceptable and TF as rejected. A few haddock samples were tested and the results showed no significant difference from cod. The summarized comparison of this data is illustrated in Figures 4 and 5. Under laboratory controlled conditions, four groups of UG (control), GBW, G, B_1/GBW were investigated for a period of 12 days in ice. Physical, biochemical and organoleptic evaluations were applied to test all fish samples. From Figure 4, we observed that the difference between GBW and B_1/GBW on overall primary quality is very small, except for some color improvement. Based on our results, no significant changes can be determined between UG (control) and GBW for 2 or 3 day old fish under the controlled conditions. However, a great difference between UG and GBW was evidenced by day 7, where about 80% GBW fish was grade TA, and the UG fish was more than 90% rejected. Also, the secondary quality results in Table 5 and PPQ in Table 6 should be also considered. Most important, fish gutting without complete washing was completely rejected at day-4, and no fish were graded as TA after 2½ days icing. We strongly believe that without proper washing operations, gutting will produce negative effects on fish quality and should not be employed.

3.2 GBW Operation of Field Tests

The scale-up GBW investigations were made in cooperation with the fish industry and all on-board operations were performed by professional fishermen on their own vessels. The overall quality of fish can include very broad terms such as market requirements, product definition and consumer's demand etc. However, we must convert these major areas of quality to primary quality (dockside), secondary quality (end of line), and post-processed quality (PPQ, frozen quality), to provide the technical data to study the influence on fish quality from various GBW operations. Physical evaluation was mainly used for S and SP samples with biochemical tests only used for some samples to confirm the results. For PPQ grading, both biochemical and physical procedures were employed to determine quality.

As is shown in Figure 5, UG fish can be completely rejected at 3 days in ice after catching, and GBW fish can be held in ice at TA and TB grades for 5 and 9 days respectively after catching. However, it is difficult to differentiate between UG and GBW samples within 1½ days after catching, by physical assessment. Details of the results for UG and GBW fish with caught age up to 9 days are listed in Table 3 (Exp. 3E, 3F and 5E).

Selected results of secondary quality (end of line) and yield of cod and haddock with caught age of 4, 7 and 9 days are presented in Table 4. The yield percentage was based on the production of untrimmed fillets and is listed for preliminary comparison. Both UG and GBW fish at 4 days from experiental 3F and 3B showed little difference on grade percentages. At day 9, GBW fish in 3F had 50% grade TA and no TF but these were changed to 20% and 25% in experiment 3B. We believe that this is due to catching and handling variations as well as some seasonal reasons. The summarized data was also shown in Figure 6. It indicated that the percentage changes in grades between UG and GBW fish are quite clear and demonstrates the advantage of the GBW operation. Since our groundfish are mostly landed with a caught age of 4-8 days, it can be simply stated that a GBW operation is certainly essential for our industry because no processor can afford to lose 75% of their fish.

The majority of groundfish fillets were frozen and sold within about 6 months of freezing. PPQ results in Table 5 and Figure 7 should provide some information relating the operation at sea to the quality of the frozen cod fillets. The frozen investigations were carried out at an elevated condition of -15°C, (-26°C or lower in our industry), to complete our comparative test within a year. The advantages of GBW fish are indicated clearly in both Table 5 and Figure 7 for even day-2 fish which showed little difference in UG and GBW sampling during the dockside evaluation. GBW fish certainly has a higher percentage of Grade TA than the UG sample during various caught ages and frozen periods (Table 5). For combined acceptable grades (TA and TB) (Figure 7), the 4-day GBW fish can be maintained at 92 and 75% for 3 and 6 months respectively frozen at -15°C, while UG fish show 62 and 50% remaining under the same conditions. Differences of GBW and UG fish under various comparisions gives strong evidence to support the inclusion of the GBW operation in our fishery.

3.3 Other Factors Influencing Fish Quality

In our 4X haddock assessment, a few preliminary investigations were conducted to provide some data to relate quality changes with fish age and the death struggle. The data is very limited, and is not suitable to any meaningful interpretations except for simple observations. From the data presented in Table 6, we have noticed that haddock of between the age of 3 and 5 did not show any significant quality grade variation for both UG control and GBW fish samples iced for 7 days after catching. Moreover, it seems that a longer trawling time (180 minutes) decreases the excellent grade TA from 50 to 10%. This has been reported previously and the death process as related to fish quality may require more investigation.

3.4 Quality Consideration from Special Bleeding Operation

Comprehensive investigations of bleeding operation have been conducted with various physical and laboratory quality evaluations. The particular attention has been made to the color and texture damage during variuos holding storage. Photographic recording data were also made but not included in this report.

Based on the overall quality evaluation, the difference on grading change between GBW and B_1/GBW fish samples are too little to be observed. The variations of the changes of color and texture of UG, GBW and B_1/GBW samples have been summarized in Table 8 by using our 5-point evaluation sheet. The quality changes between UG and GBW or B_1/GBW fish are very significant and important after the fish iced over 1½ days (Figure 4). The color and texture improvement by gutting and bleeding operations showed in Table 8 provided identified results. The changes and color improvement between GBW and B_1/GBW are just slight difference for the regularly bled fish for first 5 days hold in ice. However, the texture or grading of B_1/GPW fish indicated some negative evidence in comparison with GBW samples. Therefore, we feel that the present GBW operation at sea will be good for the needs of the present quality enhancement concerns. Some further study should be carried out for B_1/GBW handling operations to confirm its advantages on quality preservation.

3.5 Unloading and Washing Operation

Using box unloading as a reference, old and new type air unloaders were comparatively evaluated. Some selected results of fish with a caught age of between 4-12 days from both pen or boxed on board, have been listed in Table 7. TA, TB and TF or primary grading are the same as in the GBW investigation. The TI, TII, and TIV grades both acceptable and equivalent to previous TA and TB, were used for evaluating secondary quality for the practical reasons of the fish plant. The data indicated that the grade compositions and changes for the penned fish of 4 to 8 days using the new improved air unloader, are comparable to the identical fish using box unloading. TI quality of fillets from the above unloaded fish indicates about a 10% drop when using the new air unloader rather than box unloading. The summarized data from 8-day penned cod with new and old air unloaders is presented in Figure 8. Based on TA grade only, total (TA and TB) acceptable grades, the reject percentages, yield percentage, and PPQ data, the greatest differences have been observed between two types of air unloaders made by the same company. The quality preservation and fish damage of the fish unloaded by the new air unloading operation, give very encouraging results compared with box unloading. However, it should be understood that the quality loss for the fish over 8 days old is much larger using the same operation. Since unloading is a major operation in improving the landing quality, we strongly feel that a more comprehensive investigation of fish unloading and equivalent evaluation is certainly needed.

SELECTED DOCUMENTS AND PUBLICATIONS

Key to Listing

Documents and publications are arranged alphabetically by senior author using the following format. Following the listing of the author(s), the year of publication, the title of the article and location of the article are given. The subject matter of the article is then categorized (in brackets) using the code: G-gutting; C-chilling; B-bleeding; Bx-boxing; W-washing; U-unloading; GH-general handling and Q-quantity. The articles may be assigned more than one code according to the subject matter and scope. A superscript [1] on the the brackets surrounding the categorization indicates the refereced material is available in the Library, 1707 Lower Water Street while an * indicates the reference is available in our literature files. A superscript [a] indicates that we have an abstract or summary of the article in our files.

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TABLE 1 Some information on major experimental fish.

Exp. No.	Exp. Date	Fishing Area	Species	Sample Size	# of Tests	Catching Information
1	May 1979	Terrence Bay, N.S.	Cod	80 lbs.	4	Trap caught, live fish
2	March 1980	Terrence Bay, N.S.	Cod	160 lbs.	2	Trap caught, live fish
3	Fall & Winter 1981	South Shore & St. Mary's Bay, N.S.	Cod & Haddock	1,200 lbs.	7	Nearshore trawler and longliner
4	Summer 1982	Scotian Shelf	Cod	2,000 lbs.	4	Offshore trawler
5	Summer & Fall 1982	4X Area	Haddock & Cod	400 lbs.	6	Nearshore trawler
6	July 1983	Terrence Bay, N.S.	Cod	60 lbs.	2	Trap caught, live fish
7	1981-83 Dockside Grading Project	4VN & Canso	Cod	1,000 lbs.	-*	*Some data from these projects have been used for comparative investigations in this report.
8	1980, 1982 Unloading Project	S.F. Region	Cod & Haddock	"	-*	
9	1983, 1984	Canso Area	Cod	"	2*	

TABLE 2 Abbreviations and definitions of various operations and treatments used in this study.

Operation	Abbreviation	Description
Round fish, control	UG	Fish is not gutted, but some brief wash on board.
Gutting, bleeding & washing	GBW	Fish is gutted alive or in pre-rigor stage less than 3 hours after catching, by hand or machine at sea, followed with washing cycle. Partial bleeding is taking place during gutting and washing operation.
Gutting	G	Fish is gutted as GBW, but no washing is used. This is used as second control for comparison only.
Gutting & washing	GW	Fish is gutted then washed 3 hours after catching, it is considered bleeding cannot be occurring.
Live bleeding (throat cutting)	B_1	Live fish is bled by throat cutting, for 20 minutes in air or in seawater before gutting.
Live bleeding (bob-tail cutting)	B_2	Live fish is bled by bob-tail cutting, for 20 minutes in air or in seawater before gutting.
Live bleeding then GBW	B_1/GBW	Live fish is bled for 20 minutes, followed by using above GBW operation.
Box unloading	UL-B	Fish is unloaded by 100 lb or 500 lb boxes.
Air unloading (old type)	UL-AO	Fish is unloaded by old model air unloader (ABCO company 1960's(?)).
Air unloading (new type)	UL-AN	Fish is unloaded by new improved model air unloader (ABCO company, designed in 1981-2).
Regular washing	W_1	Fish is washed reasonably well at sea.
Special washing	W_2	Fish is washed by specific washer as indicated.

TABLE 3 **Selected results of primary quality evaluations (S-sample group) from some experiments of gutting / bleeding / washing operations.**

			S_1 (% grade)				S_2 (% grade)				S_3 (% grade)			
EXP. REF	FISH	OPERATION	Caught Age*	TA	TB	TF	Caught Age*	TA	TB	TF	Caught Age*	TA	TB	TF
2B	Cod	UG (control)	2	100	0	0	4	80	20	0	8	0	10	90
		G	2	40	60	0	4	0	20	80	8	0	0	100
		GBW	2	100	0	0	4	100	0	0	8	60	40	0
		B_1/GBW	2	100	0	0	4	100	0	0	8	70	30	0
		B_2/GBW	2	100	0	0	4	100	0	0	8	60	40	0
3E	Cod	UG (control)	2	80	20	0	4	10	42	38	9	0	20	80
		GBW	2	100	0	0	4	70	30	0	9	0	50	50
3F	Cod	UG (control)	2	90	10	0	4	30	50	20	9	0	30	70
		GBW	2	90	10	0	4	60	40	0	9	10	50	40
5B	Haddock	UG (control)	2	100	0	0	7	0	45	55				
		GBW	2	95	5	0	7	45	55	0				
		B_1/GBW	2	100	0	0	7	55	45	0				
5E	Haddock	UG (control)	2	90	10	0	7	0	40	60				
		GBW	2	100	0	0	7	40	50	10				

*days

TABLE 4 **Selected results of secondary quality evaluation of fish fillet (SP - sample group) from some experiments with various gutting / bleeding / washing operations.**

			SP_{-2} (% grade)					SP_{-3} (% grade)				
EXP. REF	FISH	OPERATION	Caught Age*	TA	TB	TF	% Yield	Caught Age*	TA	TB	TF	% Yield
2B	Cod	UG (control)	4	40	60	0	-			N/A		
		GBW	4	70	30	0	-			"		
		B_1/GBW	4	70	30	0	-			"		
3F	Cod	UG (control)	4	20	50	30	43	9	0	25	80	42
		GBW	4	80	20	0	42	9	50	50	0	41
3B	Cod	UG (control)	4	20	40	40	44	9	0	25	75	-
		GBW	4	65	25	10	43	9	20	55	25	-
5B	Haddock	UG (control)			N/A		47	7	0	35	65	47
		GBW			"		46	7	35	60	5	46

*days

TABLE 5 **Secondary quality evaluation of PPQ results from frozen cod fillets (SP - sample group) stored at -15°C from a selected experiment of gutting / bleeding / washing operations.**

EXP. REF	OPERATION	Caught Age (days) (iced)	PPQ Frozen Quality at -15°C (% grade) 3 month	TA	TB	TF	6 month	TA	TB	TF
3C	UG (control)	2		45	40	15		20	45	35
	GBW	2		80	20	0		60	30	10
3C	UG	4		10	60	30		0	55	45
	GBW	4		45	45	10		30	50	20
3C	UG	7		0	45	55		0	15	85
	GBW	7		10	65	25		0	40	60

TABLE 6 Variations of primary quality assessments of 4X Haddock in terms of fish age and trawling time.

Description	Primary Quality Grade (%) (S-Sample) at Caught Age of 7 Days (Iced)		
	TA	TB	TF
3 years old, UG control	0	40	60
3 years old, GBW	40	50	10
5 years old, UG	0	45	55
5 years old, GBW	45	55	0
*Fish with trawling time 30 min., GBW	50	50	0
*Fish with trawling time 180 min., GBW	10	85	5

*Data obtained from only one trial.

TABLE 7 **Selected comparison of primary (landing) grading and secondary qualtiy assessemnt (end line, SP - sample)* for cod of various caught ages and unloading operations.**

Caught Age (Day)	Unloading	% Primary (landing) Quality (TA-TB-TF)	% Secondary (end of line) Quality (TI-TII-TIII)
4 (Pan)	UL-B (Box)	90-10-0	88-10-2
4 (Pan)	UL-AN (New Air)	92-8-0	67-16-7
8 (Pan)	UL-B	60-38-2	75-15-5
8 (Pan)	UL-AN	50-45-5	67-16-7
12 (Pan)	UL-B	40-45-15	70-20-10
12 (Pan)	UL-AN	25-50-25	51-28-21
11 (Box)	UL-B	50-45-5	79-15-6
11 (Box)	UL-AN	40-40-20	63-22-15

*Commercial grade system was used as Grade TI, TII, and TIII, all acceptable, equivalent to our Grade A and B.

TABLE 8 **Comparison of Color and Texture changes of cod fillets from fish with Special Bleeding (B_1/GBW) and GBW operation.**

Caught Age in Ice (days)	Scale Point*		
	UG (Control)	GBW	B_1/GBW
A. Color Observation			
0	4	5-	5+
2	3	4	5
5	3-	4	4
7	2	3	3
B. Texture (gaping) Evaluation			
0	5	5	5
2	4	5	5-
5	2+	4	4-
7	1	3	3-

* Scale Point: 5-excellent, 4-good, 3-average, 2-below average, 1-not good.

Figure 1: Selected example of GBW experiment at sea.

Fig. 1. Selected example of GBW Experiment at sea.

QUALITY ENHANCEMENT PROJECT - I. GUTTING

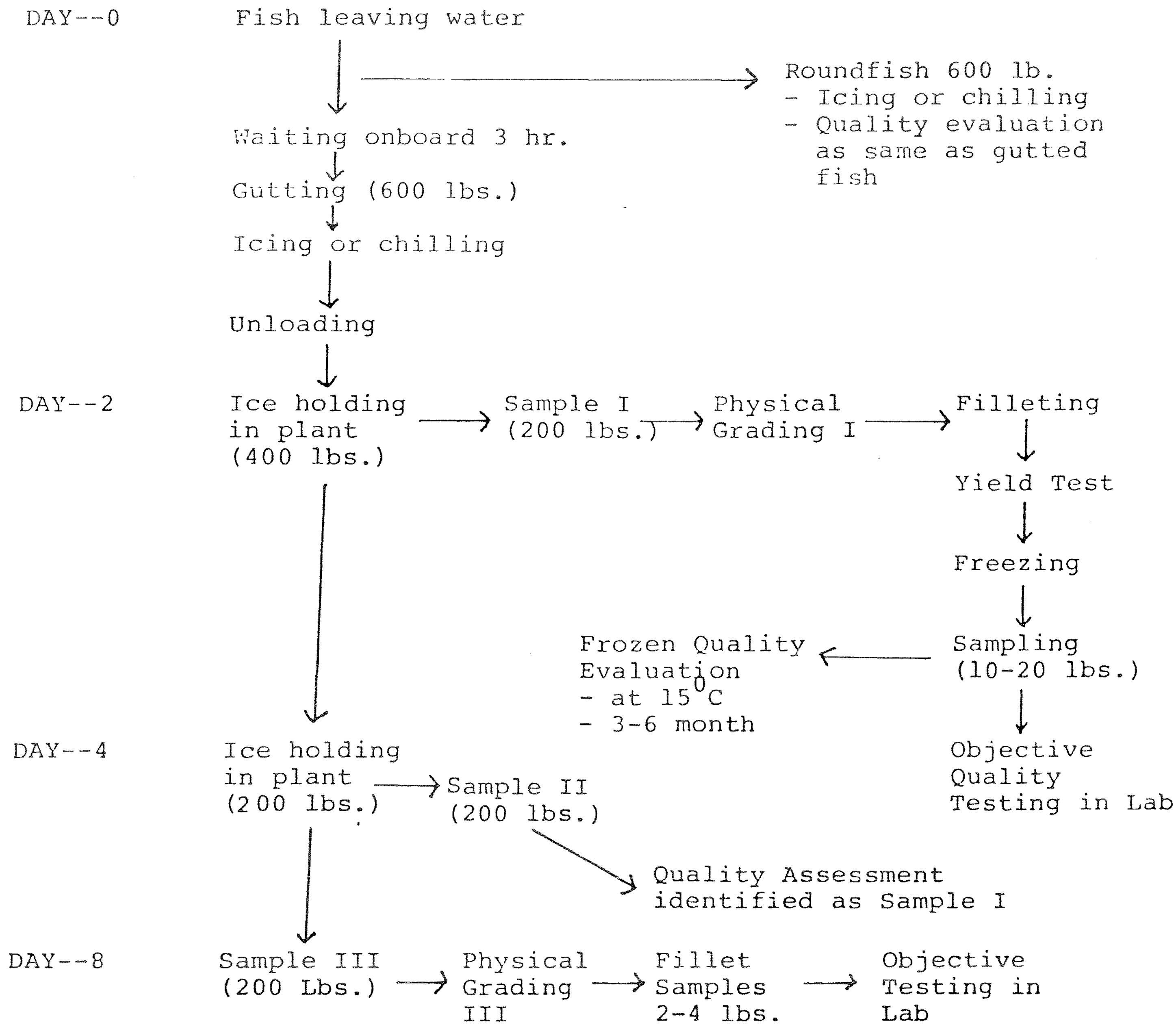


Figure 2: Comprehensive procedure for evaluating fish unloading operation.

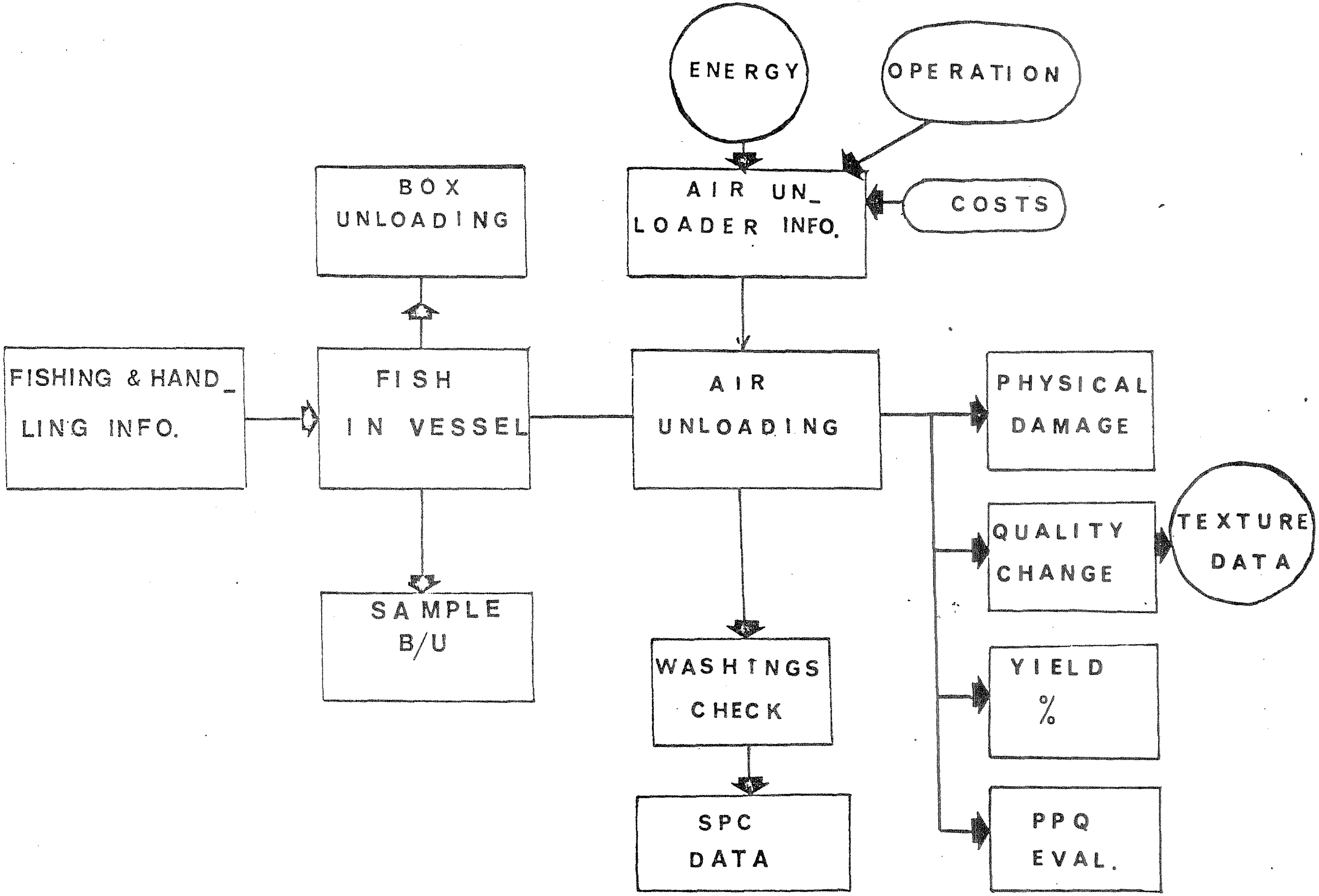


Fig. 2. COMPREHENSIVE PROCEDURE FOR EVALUATING FISH UNLOADING OPERATION

Figure 3: Quality evaluation for various on-board pretreatments.

Fig. 3. QUALITY EVALUATION FLOW-SHEET FOR VARIOUS ON-BOARD PRETREATMENTS KE/82

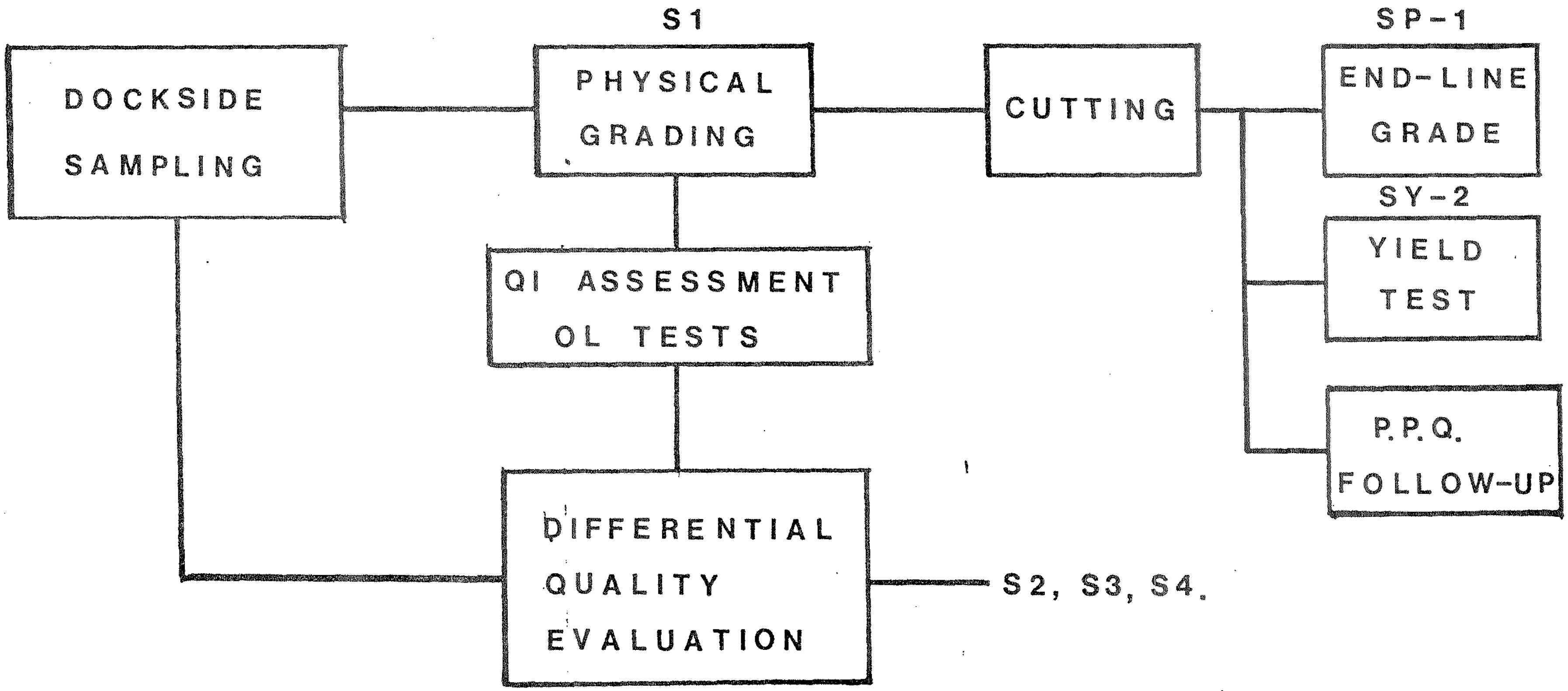
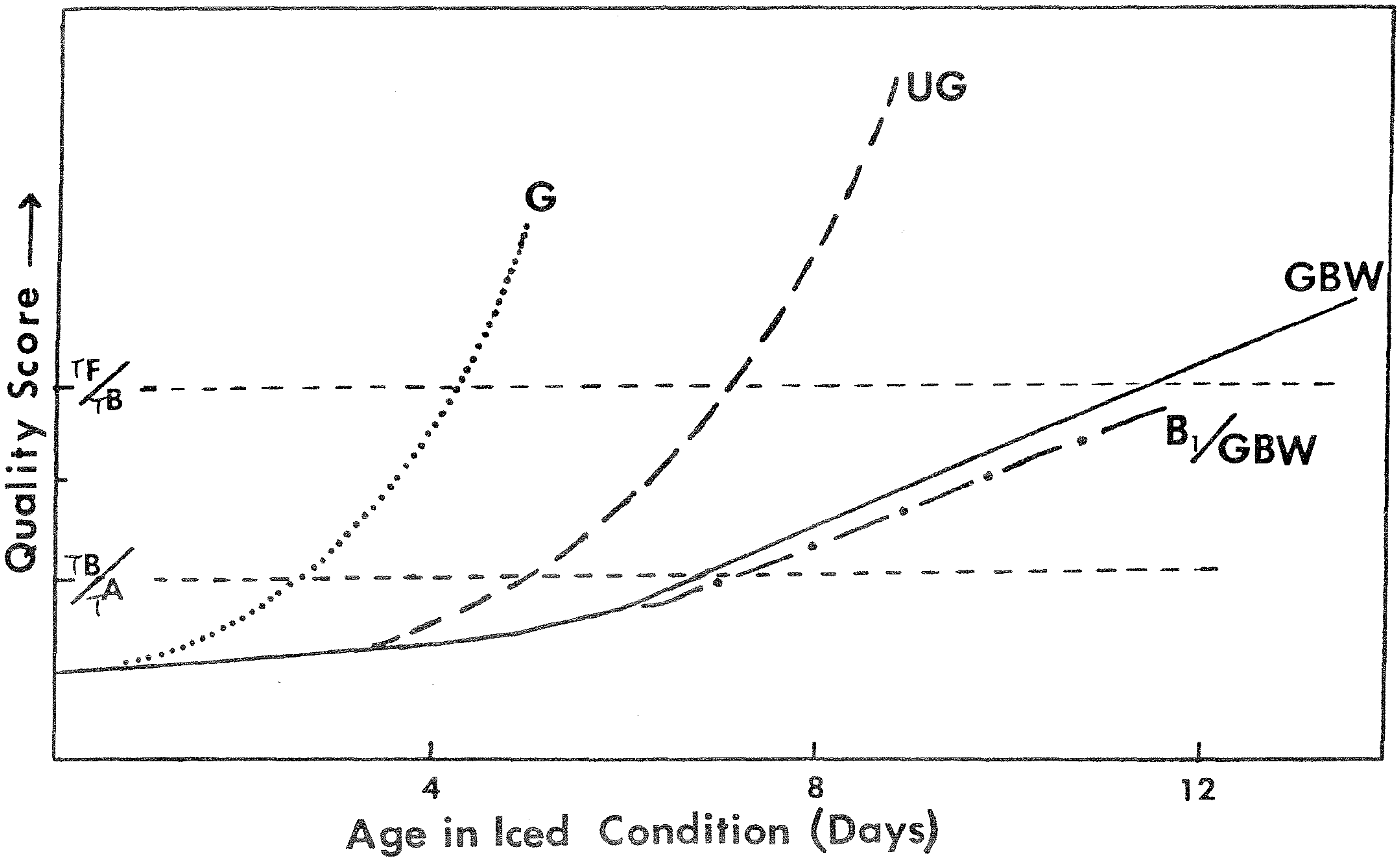


Figure 4: Comparisons on primary quality change of cod from laboratory experiments with various GBW operation.

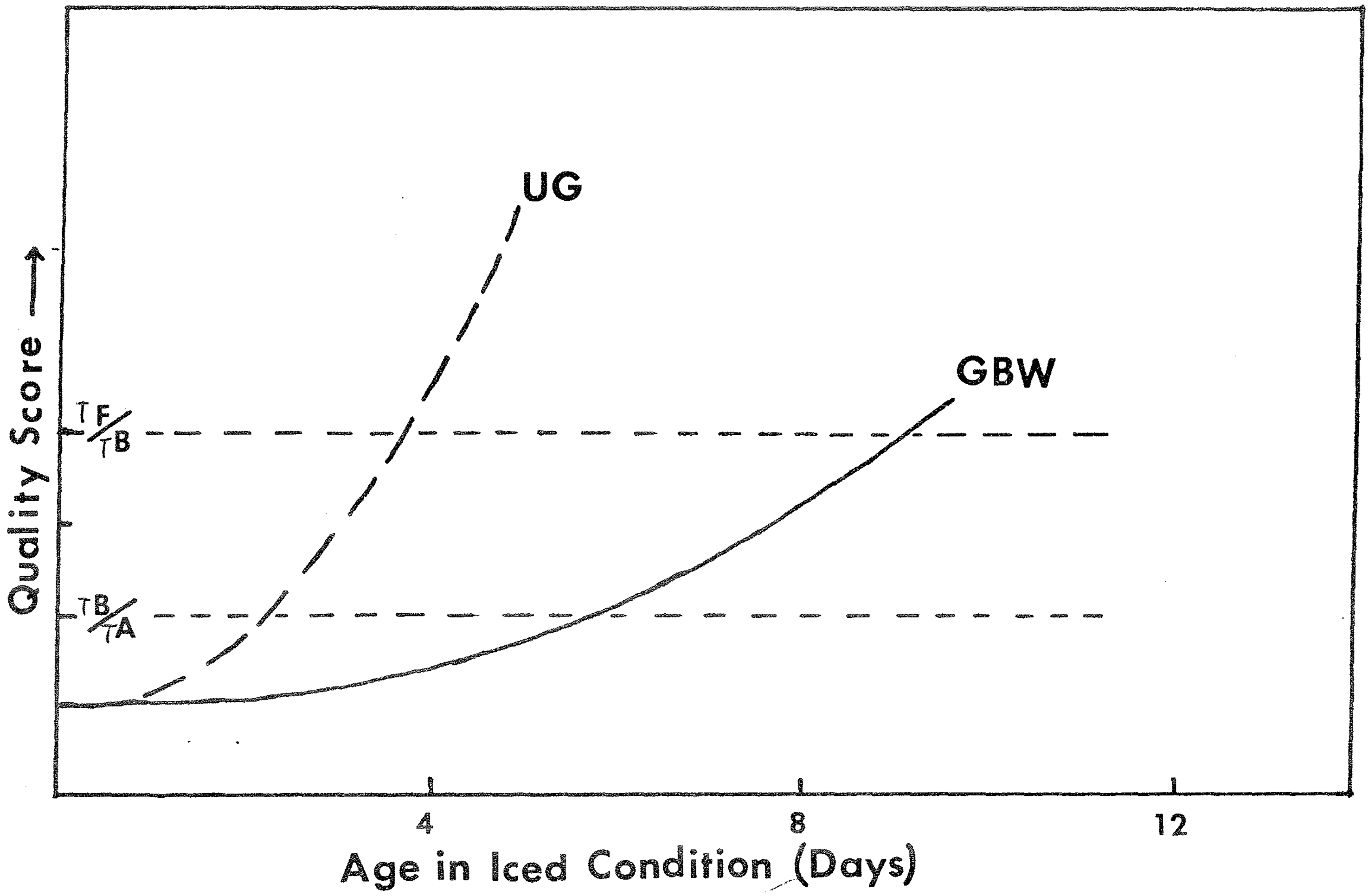
FIG.4. Comparisons on primary quality change of cod from laboratory experiments with various GBW operation



*Tests made under total controlled condition.

Figure 5: Comparisons of primary quality (landing) change of cod from the field trials with GBW operation at sea.

FIG. 5. Comparison of primary quality (landing) change of cod from the field trials with GBW operation at sea.



* Results from field tests with GBW operation at sea.

Figure 6: Comparison on secondary quality changes (fillet at end of line) **with** caught ages of 2-7 days in ice.

FIG.6. Comparison on secondary quality changes (fillet at end of line) with caught ages of 2-7 days in ice.

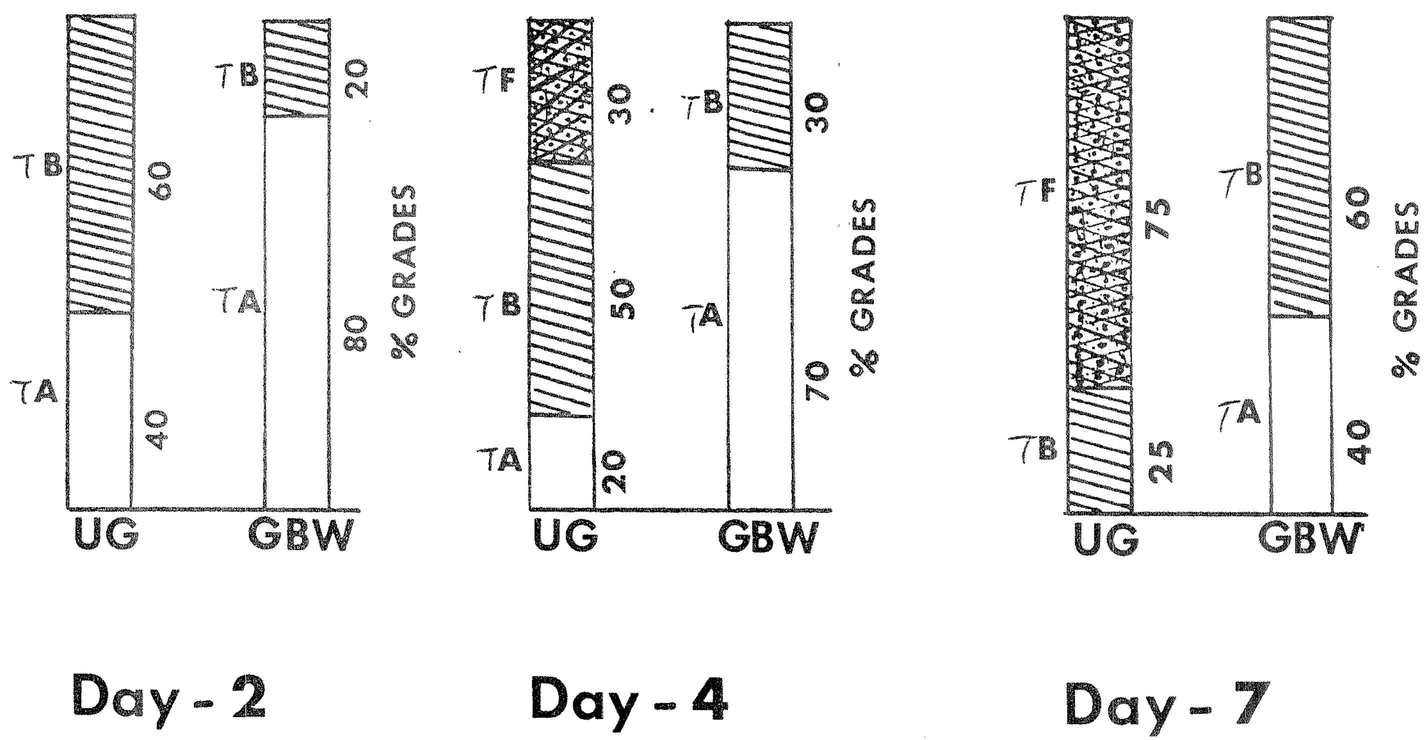


Figure 7: Comparison of post-process quality (PPQ) change for fillets cut within 2-7 days caught age on ice, and then frozen at -15°C for 3-9 months.

FIG. 7. Comparison of post-process quality (PPQ) change for fillets cut within 2 - 7 days caught age on ice, and then frozen at - 15°C for 3-9 months.

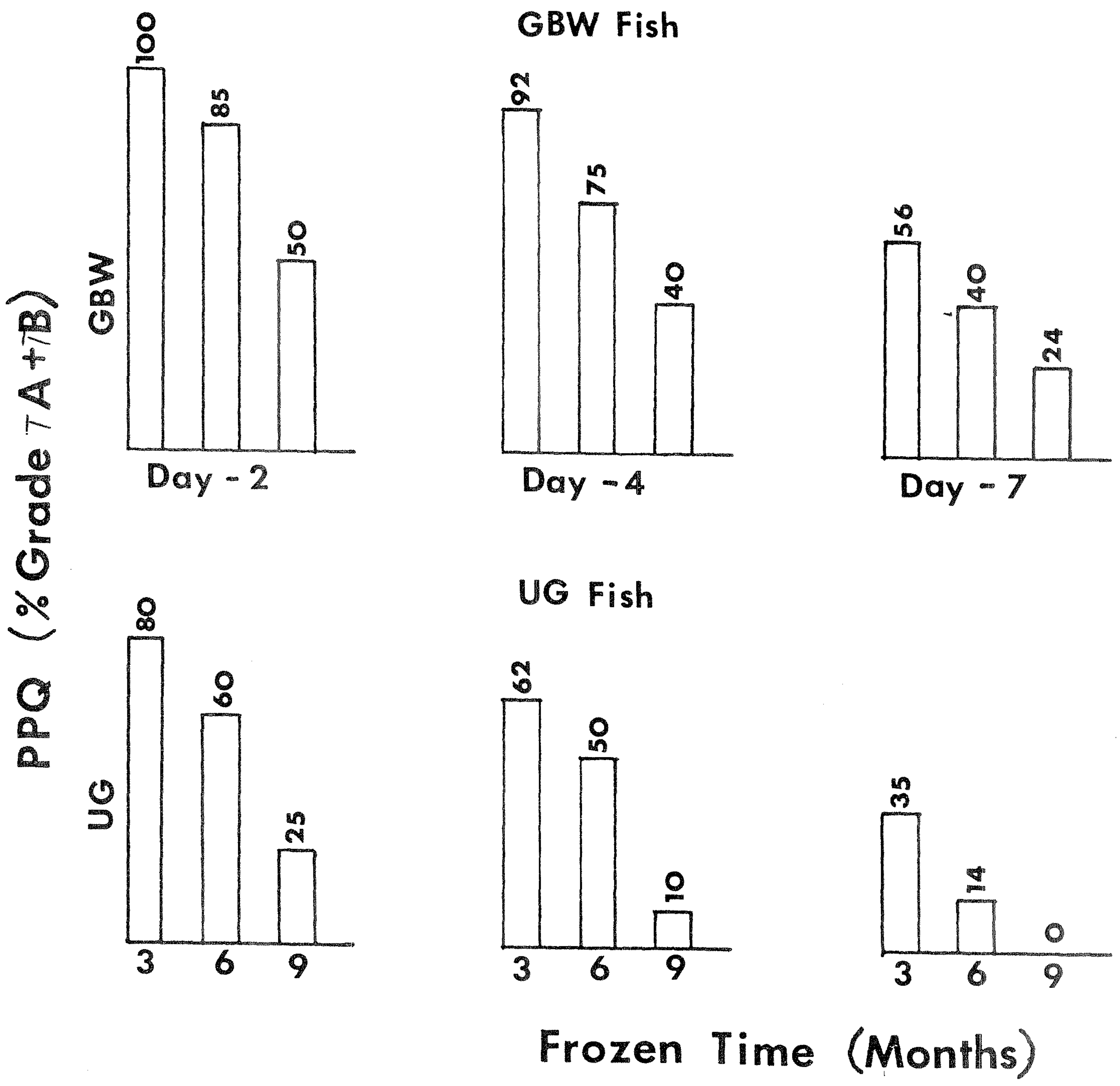


Figure 8: Comparison on primary quality (landing), yield and PPQ for fish iced and penned on board for 8 days with various unloading operations.

FIG.8. Comparison on primary quality (landing), yield and PPQ for fish iced and panned on board for 8 days with various unloading operations.