Trials to Investigate the Effect of Onboard Hopper and Conveyor Systems on Fish Quality

Seafish Report No. SR506

August 1997

Sea Fish Industry Authority
Seafish Technology

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Summary

There has been a trend away from traditional, manually based, methods of fish handling on whitefish vessels as fishing operations have tended to become more intensive and crewing tighter. The trend is towards shelterdecks with incorporated fish reception and mechanised handling systems. However, there is concern that fish quality may be affected, particularly by deep fish hoppers and associated elevators.

This project was set up to investigate possible fish quality and chilled storage life effects on whitefish handled by deep hopper systems. Two seatrips were carried out on commercial whitefish vessels from Peterhead during September 1996. These vessels were about 21 metres long, one a pair seiner and the other a pair trawler. Haddock were taken from the top and bottom of hoppers and assessed for whole and fillet damage/rejection on commercial processing with further assessment of chilled storage life at Seafish Hull.

There was an apparent, bottom of hopper, softening effect to whole fish but this was not reflected in reduced fillet yields or freshness. However this effect was minimal compared with the levels of damage found to occur before the hopper, i.e. as a result of fishing method. Albeit from limited data, there was a significant effect of fish softening and fillet rejection (up to 3%) with long tows of about 4.5 hours as opposed to minimal rejection and much less softening from 2 hour tows. However, overall yields were still good and this is attributed to the fact that the sample boxes were not overfilled in stowage as is typical boxing practice for these vessels. Observations of the fish handling systems indicated that both careful design and operation are needed to avoid risk to fish quality. The stowage of fish in bins was efficient but questions remain as to adverse effects on fish quality with the depth of packing involved.

Some consideration of hopper design is thought necessary as it is preferable that integral elevators are avoided. Further investigation of the fish quality effects with bin depth and alternative icing techniques – possibly using shallower bins and/or binary ice is recommended. Additionally the consideration of further investigation of the effects of towing time is recommended.

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1. Introduction

This work resulted from the Grampian Port Quality Audits carried out at Peterhead and Aberdeen during the summer of 1995. Compared to a similar survey ten years earlier, it was apparent that there had been a trend towards shelterdecks and fish reception hoppers and more mechanised handling of fish. Processors were of the opinion that deep hoppers could be having an adverse affect on fish quality through physical damage. With the possibility of the catch being held in the hopper at depths up to 2 metres it was thought that fish may suffer from crushing within the hopper. Further, the integral elevator effectively pulls fish from the base of the hopper and it was felt that the moving flights could also cause damage.

This Seafish funded project was set up to investigate possible fish quality and chilled storage life effects on white fish, passing through a deep hopper system, by taking samples on commercial fishing trips. These fish were then to be followed through to assessment at processing and in the Seafish Laboratory at Hull.

It was decided that seatrips on suitable vessels operating from the Grampian region would be made during the late summer of 1996 when seasonal conditions of large catches and soft fish can exacerbate handling problems.

2. Objectives

To investigate the effect on fish quality of the combined deep hopper/conveyor systems currently used for on board fish reception.

To obtain indications, where possible, of the fish quality effects of other aspects of mechanised handling onboard.

3. Overview of Mechanised Handling Developments in the White Fish Fleet

Generally, over the last 10 years, fishing operations have become more intensive and crewing tighter. The larger vessels in the white fish fleet, apart from beam trawlers are largely based in Scotland where there has been a trend away from traditional manually based methods of fish handling, towards shelterdecks with incorporated hoppers and mechanised fish handling systems. Additionally, there is now a trend towards the use of pallet bins instead of boxes for fish stowage on the larger and more recent vessels.

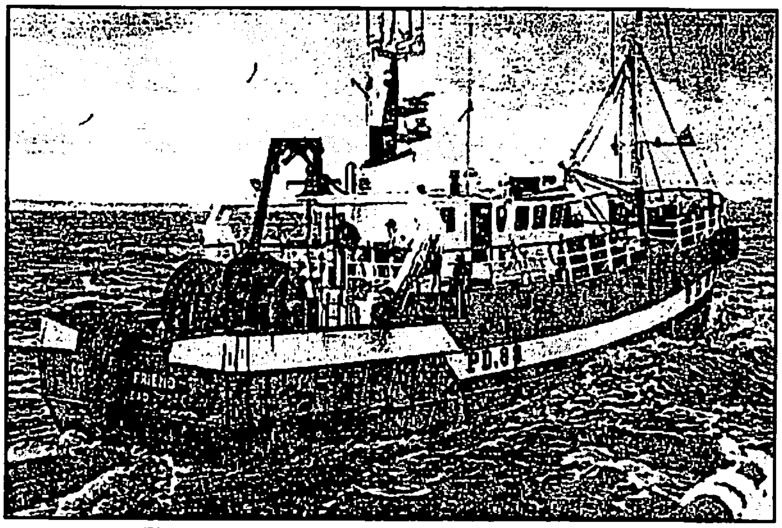


Figure 1 - Three quarter shelterdeck vessel

Changes in fishing technique, such as to pair seining, have led to longer towing times and larger hauls. Equally, the adoption of mechanised handling systems, originally promoted as supporting fish quality by quicker handling of the fish into stowage and easing workload may have encouraged reduced crewing with loss of the claimed advantage.

The traditional fish handling method on typical UK vessels of up to about 25 m length catching round white fish, started with the fish being picked up from the open deck pounds and put into boxes. Gutting was normally from these boxes into baskets or directly into the fish washer. After washing the fish was usually passed down into the hold in baskets and bulked or boxed with little or no further sorting.

On vessels with fish reception hoppers, set into the shelterdeck, fish can be taken aboard in quantity and gutting attended to without having to box up from pounds. There are two main types of hopper. One is a deep hopper extending full depth of the shelterdeck and requiring an elevator to transport the catch to working height for gutting by crew. The elevator is usually an integral part of the hopper and takes fish from it, up through a tunnel to the gutting conveyor. The other type of hopper is shallower and extends about half depth from the shelterdeck to a working height, usually with a chute to a gutting table. After gutting, the fish are washed and put into the fish room. This may make use of further conveyor systems.

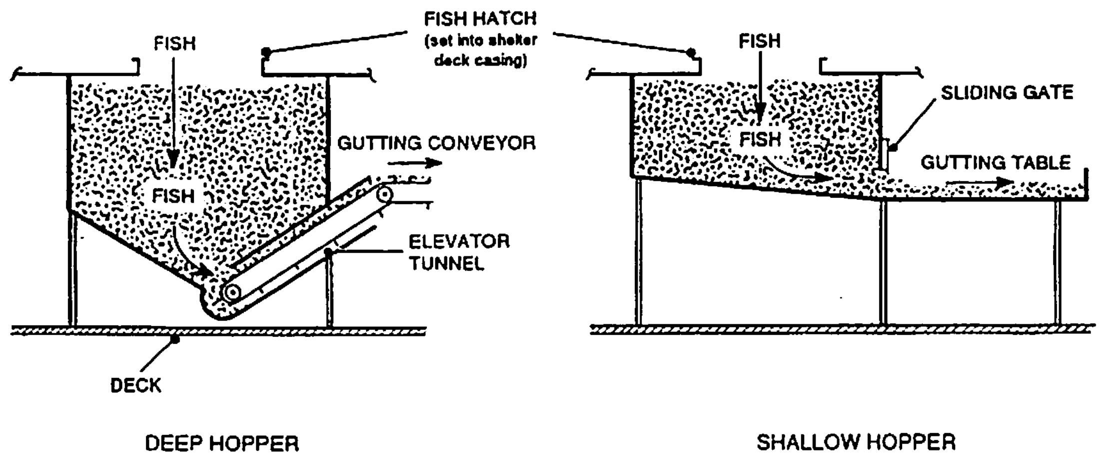


Figure 2 - Basic types of fish reception hoppers

Most deep hoppers have vertical partitions to reduce the effects of rolling motion. Measures to relieve depth and pressure at the entrance to the elevator are less practicable. Some vessels have a plate directly over the mouth to the elevator so that fish can only enter from the side. Setting the elevator outside hopper with a gravity feed to it, is uncommon.

Shelterdecks and hoppers latterly installed on traditional seiners generally have been very simple arrangements, the hopper being of the shallow type with the fish emptying by gravity into an elongated chute doubling as a gutting tray. Sorting and washing then being in a fairly traditional way. Where capacity is needed for larger catches such as with pair seining the hoppers are often of full depth type with elevator transport to a gutting conveyor but generally with fairly traditional fish handling thereafter.

New vessels with shelter decks incorporated as part of their initial design, have generally been larger than the vessels that they replaced and typically have the hopper full depth and set forward on the working deck to the starboard side, with the elevator and gutting conveyor system running aft. The rest of the system, whether traditional or more mechanised, being amidships with the flow of handling forward to the hatch opening to the hold. These systems are more likely to include semi continuous washers and further elevator/conveyor/chute transport to the hold and possibly with bin stowage instead of boxes. Incorporation of gutting machines is rare.

Space is taken up on the working deck on many vessels for storage of empty stack only boxes and this can contribute to a cramped layout of the handling system. Often there may be a lack of integrated design of the fish handling systems with hoppers designed by the boatyard and the rest of the system by the machinery manufacturer. Also, fish handling may not figure highly in the design of vessels with the gear working and other considerations being predominant and possibly to the detriment of quality.

4. Trials Methodology

4.1 Approach to Trials

The first step was to consider how to carry out the trials and then to make a visit to Peterhead and Aberdeen to find suitable vessels and processors to participate in the work. The methodology was then confirmed and arrangements made.

The aim was to make a single sea trip on each of two vessels with deep hopper and elevator systems in order to take samples and observe operations. If possible, one vessel was to have a mechanised washer and fish transport system to the hold. Further, it was desirable that stowage of fish in bins could be observed. As it was desirable that small and larger sized fish could be sampled, the question of the fishery being prosecuted at the time came into selection of vessels as did the very important factor of willingness of the skipper to co-operate.

In respect of follow up at processing, inspection of whole fish would be needed as well as accurate, commercial yield data. For assessment of effects on freshness and chilled storage life, laboratory assessment was required.

4.2 Vessels and Fish handling Systems

Two vessels participated in the trials, the pair seiner MFV 'PTARMIGAN' (BCK 26) and the pair trawler MFV 'STARLIGHT' (PD150), both sailing from Peterhead. The fish handling arrangements of these vessels are described below with further details of the vessels given in Appendix I.

4.2.1 Fish Handling Arrangements - MFV 'PTARMIGAN'

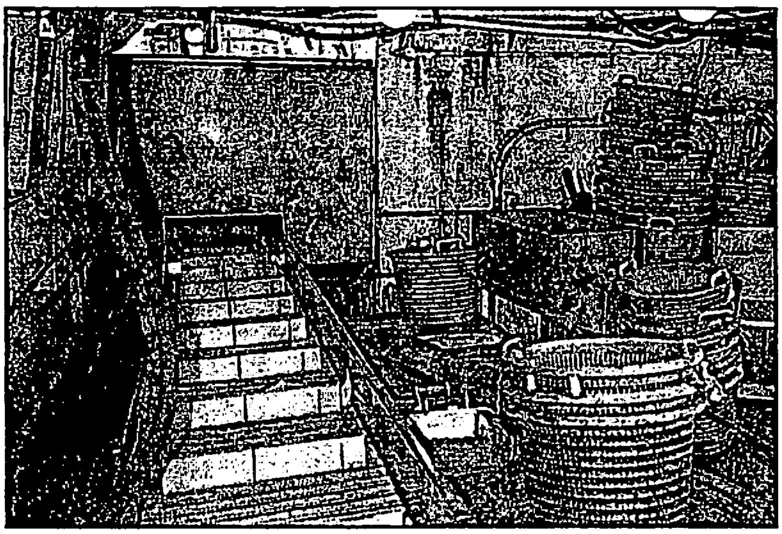
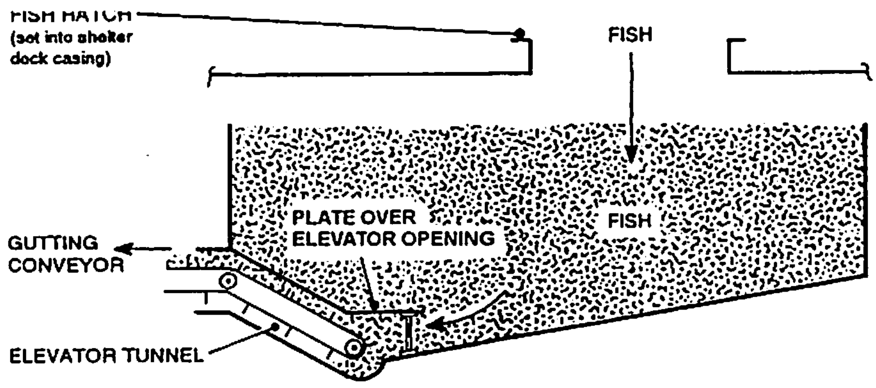


Figure 3 - Fish handling area on MFV 'PTARMIGAN'

The fish reception hopper, set slightly below the shelterdeck on the starboard side of the wheel house was full depth (about 1.6 m maximum internal height, estimated fish capacity of 160 boxes) with a typical elevator configuration feeding the fish forward to a working height conveyor at which the crew stood (with their backs to shelterdeck) to gut the fish and sort them by species and size into baskets on racks. When full, the baskets of fish were washed in Balcomie type (rectangular) batch washers before lowering into the hold for boxing. The fish were stowed in 70 ltr plastic boxes in a fully insulated but unchilled hold.



OVERALL DIMENSIONS 4.4m x 1.4m x 1.6m

Figure 4 - Configuration of hopper on MFV 'PTARMIGAN'

4.2.2 Fish Handling Arrangement - MFV 'STARLIGHT'

The full depth fish hopper (1.8 m maximum internal height, estimated fish capacity 70 boxes) was set into the forward, starboard side of the shelter deck with an elevator feed from its after end to the gutting conveyor. The gutting conveyor was in a similar position to that on the MFV 'PTARMIGAN' but with the crew gutting and sorting the fish into compartments with bottom gates. The various selections being released as required into a wide chute feeding to a 'U' configuration, semi-continuous fish washer. The fish is then transported via an elevator and a chute pipe to bin stowage in the fishroom.

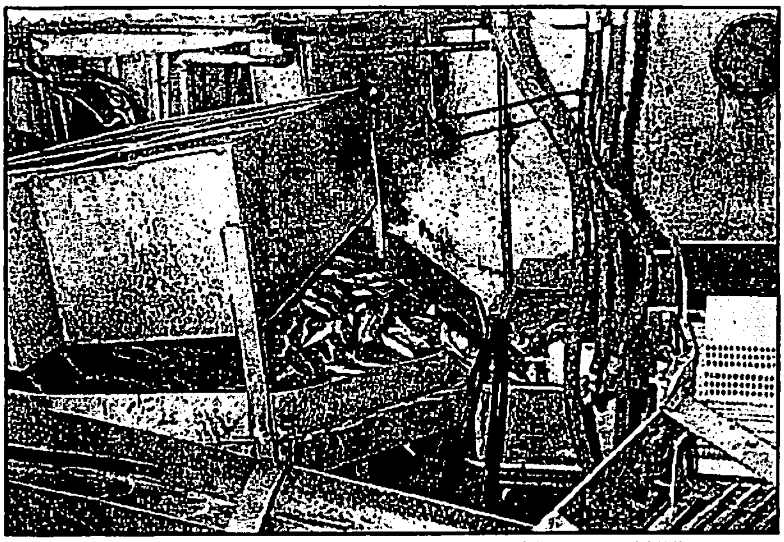
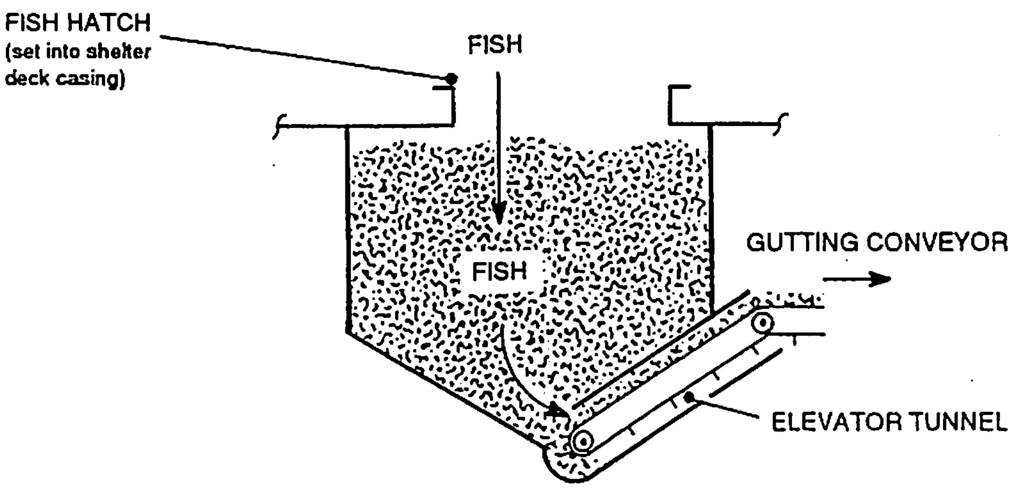


Figure 5 - Fish handling area on MFV 'STARLIGHT'



OVERALL DIMENSIONS 2.5m x 1.5m x 1.8m

Figure 6 - Configuration of fish hopper on MFV 'STARLIGHT'

4.3 Processor

Norsea Foods Limited of Aberdeen who had helped in previous trials, were approached and agreed to participate in the commercial assessment and yield aspects of the trials. The fish were to be commercially processed into cold smoked fillets.

4.4 Procedure

4.4.1 Fish Sampling and Handling Procedure

Fish samples of target weight 7 stone (44.5 kg) each were to be taken from the top and bottom of both full and half full hoppers, as this unit was standard for assessment at the factory. Both top and bottom samples were taken from the same haul of fish. One box was taken directly from the top (the top being the control) immediately after the hopper was filled . Immediately after that, one or two boxes were taken from the bottom via the discharge elevator. The fish were then carefully gutted, washed and boxed to ensure that any quality differences found were the result of the trial conditions.

4.4.2 Quality Assessment

4.4.2.1 Damage to Whole Fish

Assessment was at the factory as damage grading at sea was not feasible. The grading was carried out by project staff and each fish from each box was assessed according to the following scheme for softening to the fleshy part of the body.

5	None
4	Slight softening (slight, general, loss of firmness)
3	Considerable softening (visible signs of squashing together with substantial loss of firmness to touch)
2	Extensively to grossly softened (severe squashing and/or gashing)

Note was also made of any marking to the head or other signs of damage such as bruising.

4.4.2.2 Damage to Fillets

A filleter was to be assigned to the trials fish with the fillets cut under commercial conditions but with care. The factory manager was then to assess the fillets according to a scheme as shown below. This was a development based on the processors criteria for rejection of fillets unfit for cold smoked product for multiple retail sale and was to enable overall assessment of damage. The scheme was also considered to be applicable for wet fillet retail sale.

5	Little or no gaping
4	Significant gaping, (shallow splitting in muscle blocks - ie not deep to skin- to about 10% of fillet area)
3	Substantial gaping, (shallow splitting up to 30% of area of fillet)
2	Gross gaping, (shallow splitting to more than 30% of area of fillet and/or deep splitting ie to right to skin of fillet)

After grading the fillets went through the smoking line.

4.4.2.3 Determination of Fillet Yield
The gross weight of the fillets from each batch unit was taken to give the gross yield including any fillet rejects. Where a batch had some fillet rejects then this was deducted to arrive at the net (actual) yield of acceptable fillet for smoking.

4.4.2.4 Whole Freshness and Chilled Storage Life Assessment
The Torry Research Station (TRS) sensory assessment scoring schemes for raw and cooked freshness were used. Some whole fish from each batch were assessed to obtain a picture of raw freshness at factory reception. Further, fish from each sample unit were taken to the Seafish Laboratory at Hull for raw and cooked assessment by a panel of Fish Technologists at intervals over subsequent chilled storage life on ice. Details of the T.R.S. assessment scheme are given in Appendix II.

5. Trials Results and Discussion

5.1 Trials Record

The field trials covered the period 29th August to 4th October 1996 and included two seatrips and follow up at factory. After initial factory assessment, samples were stored on ice at Seafish for up to 18 days after catching.

Seatrip 1 - MFV 'PTARMIGAN'

Sailing from Peterhead on 30th August 1996 and returning on 7th September 1996 (9 days) and fishing east of Shetland in mostly fine and warm weather conditions.

Seatrip 2 - MFV 'STARLIGHT'

Sailing from Peterhead on 21st September 1996 and returning on 1st October 1996 (10 days) fishing close to the coasts off Caithness and the Hebrides in mostly warm weather conditions.

The handling record for the trials fish is given in Figure No. 7 below.

Figure 7 - Sample handling record

Sample Batch	Vessel/ Date	Tow Time (hrs)	Quantity Fish In Codend	Hopper Conditions	Sampling from Hopper	Assess-ment at Factory	Assess-ment at Laboratory
1	PT 3 Sept	4.5	Approximately 160 boxes of small haddock	FULL (160 boxes)	TOP 1 box BOT 2 boxes	9 Sept	12 Sept to 19 Sept
2	PT 3 Sept	5	Approximately 80 boxes of small haddock	HALF FULL (80 boxes)	TOP 1 box BOT 2 boxes		
3	PT 5 Sept	4	Approximately 300 boxes of small haddock	FULL (160 boxes)	TOP 1 box BOT 2 boxes	10 Sept	
4	ST 25 Sept	2	Approximately 70 boxes of medium haddock	FULL (70 boxes)	TOP 1 box BOT 2 boxes	3 Oct	7 Oct to 16 Oct
5	ST 26 Sept	2	Approximately 70 boxes of medium haddock	FULL (70 boxes)	TOP 1 box BOT 2 boxes		
6	ST 30 Sept	2.5	Approximately 70 boxes of small haddock	FULL (70 boxes)	TOP 1 box BOT 2 boxes	4 Oct	
7	ST 1 Oct	2	Approximately 30 boxes of small haddock	HALF FULL (30 boxes)	TOP 1 box BOT 2 boxes		

Key:
PT - 'PTARMIGAN'
ST - 'STARLIGHT'

It was estimated that up to 80% of the pair seined haddock were discarded as undersize whereas there was very little discard of the pair trawl fish which was taken on different grounds. The small and medium haddock were of EU size grades 3 and 2 respectively.

5.2 Damage to Whole Fish

Very few grossly damaged fish were observed onboard, either generally or on boxing of the samples. However, the more detailed inspection and damage assessment of fish at the factory showed that there was a significant amount of damage to fish.

Figure No. 8 below compares the overall damage results for all top and all bottom of full hopper fish.

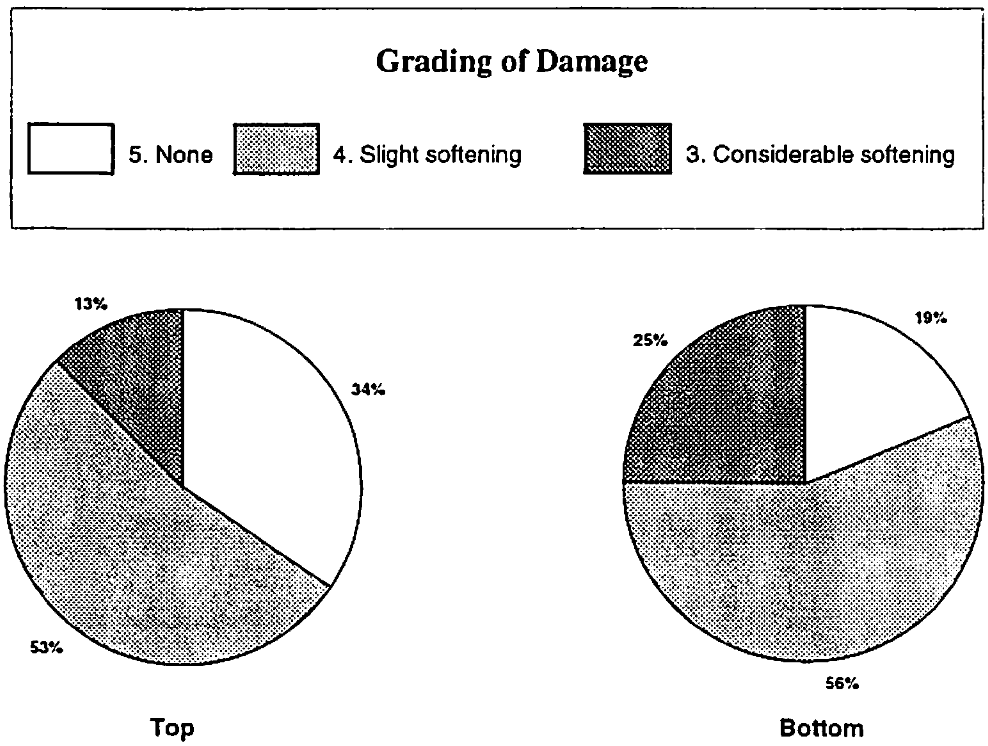


Figure 8 - Damage to whole fish in full hoppers

There was damage to top fish which must have been the result of catching, with further damage to bottom fish. The percentage of un-softened fish in the bottom of the hopper dropped from 34% to 19% whilst the amount of substantially softened fish (Grade 3) doubled to 25%.

Figure No. 9 overleaf shows the damage to fish from half filled hoppers.

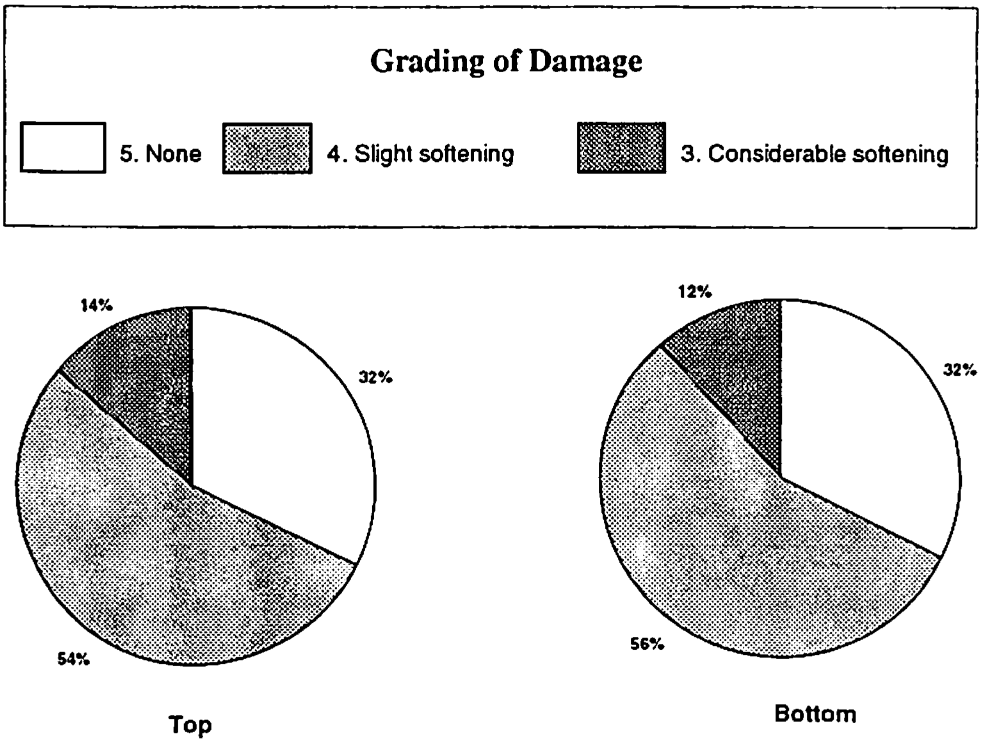


Figure 9 - Damage to whole fish in half filled hoppers

There was no significant difference between the top and the bottom fish from half filled hoppers indicating that at the shallower depths there was no effect. The damage to these fish was, of course, similar to that at the top of full hoppers. As catching effects appeared to be significant to damage, Figure Nos. 10, 11 and 12 below break down the results for full hopper sampling into the different sizes of fish and their catching conditions.

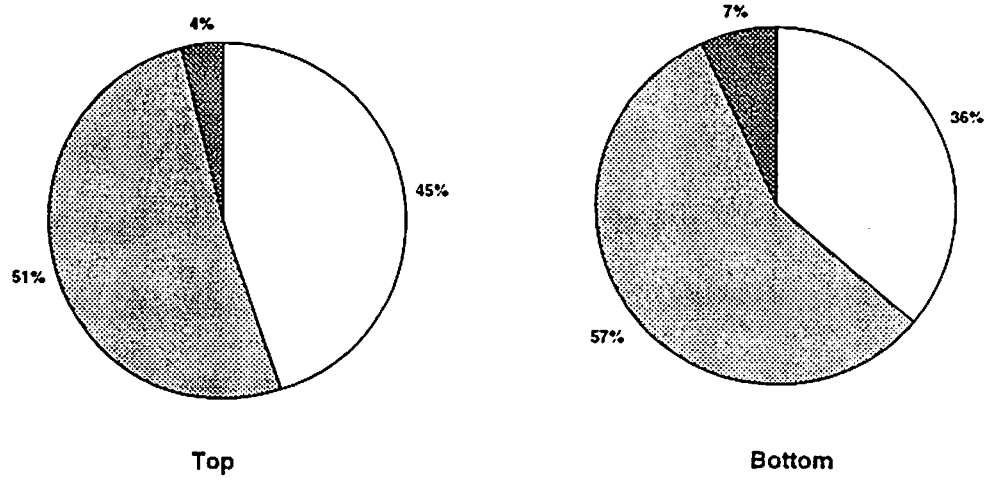
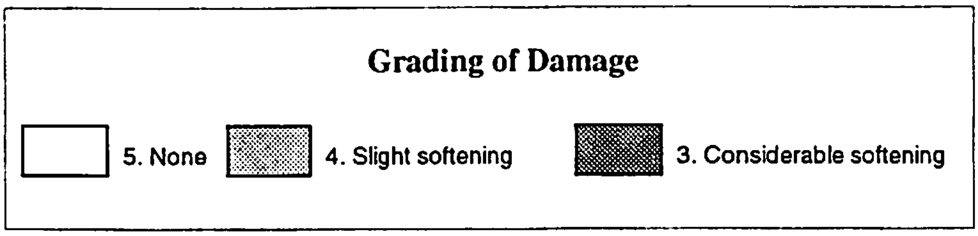


Figure 10 - Damage to 2 hour tow medium sized fish in full hoppers



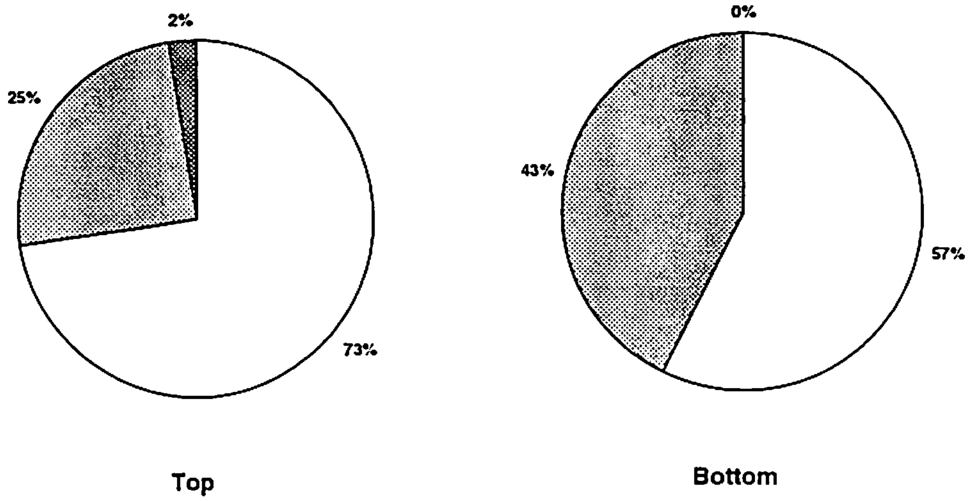


Figure 11 - Damage to 2 hour tow small fish in full hoppers

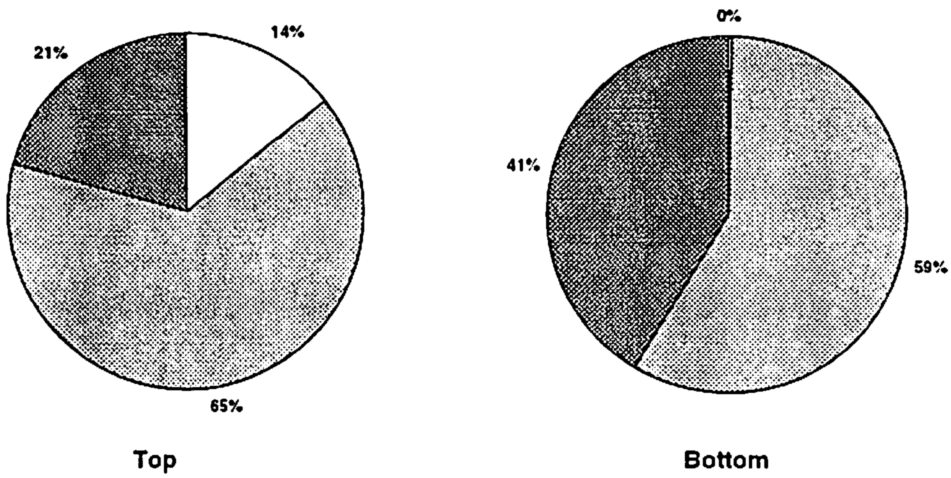


Figure 12 - Damage to 4 - 5 hour tow small fish in full hoppers

The initial damage (top of hopper) to the medium sized fish (Figure No. 10) following a 2 hour tow was less than that shown in Figure No. 8 for all fish, as was the increase of damage to the bottom of the hopper samples. However, some damage as a result of hopper depth was still apparent. The small fish from similar tow times of about 2 hours (Figure No. 11) had less initial damage than their medium sized counterparts with 75 % of the top fish being unsoftened and with little increase in damage to the bottom fish. Although the sample sizes were not large, the indications were that the medium sized fish may have been intrinsically softer than the small fish which were caught on different grounds. However, there was a marked contrast between these small fish and the small fish from 4 to 5 hour tows (Figure No. 12). Here both the initial damage and that to bottom of hopper fish was much greater, with all of the bottom fish having suffered slight or substantial softening. Nevertheless it cannot be assumed that the increase of damage to bottom fish was completely the result of pressure and mechanical effects in the hopper. The bottom of hopper fish may have been in the net for longer than those at to the top and suffered more as a result.

5.3 Fillet Damage, Yield and Commercial Quality

Most of the fish were cut into single fillets, but due to the time pressures of filleting small fish in this way, some boxes were cut into butterfly fillets.

Figure No. 13 below, compares the damage results for the fillets assessed for all top of hopper fish and all bottom of hopper fish. Softening was manifested by degree of gape and there was little blotching and discolouration. Grade 2 fish were rejected whilst grade 3 were acceptable but borderline.

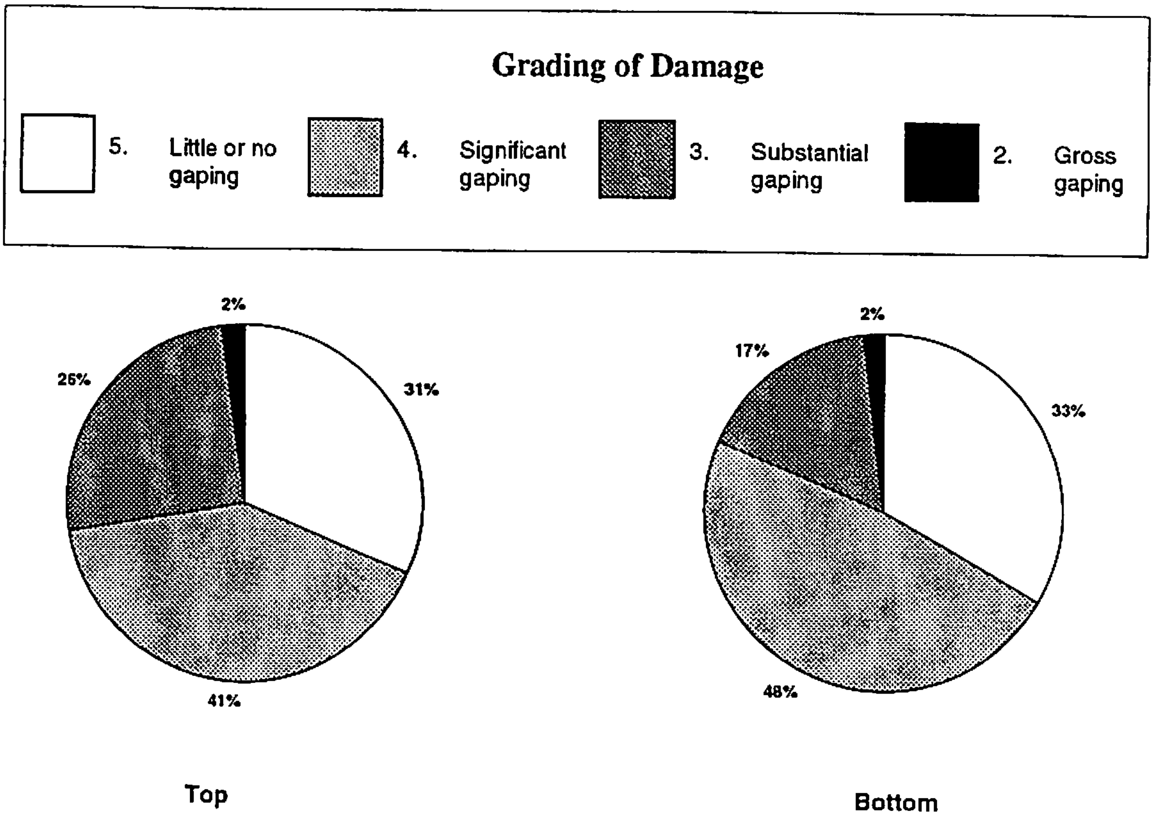


Figure 13 - Fillet damage to all fish from full hoppers

The overall pattern was one of considerable damage from catching but no apparent hopper effect. About a third of the fillets were undamaged (Grade 5) and 2% were rejected (Grade 2). There is a slight inconsistency between the proportions of grades 4 and 3, representing progressive damage to borderline condition.

Figure No. 14 overleaf shows the fillet damage to fish from half filled hoppers.

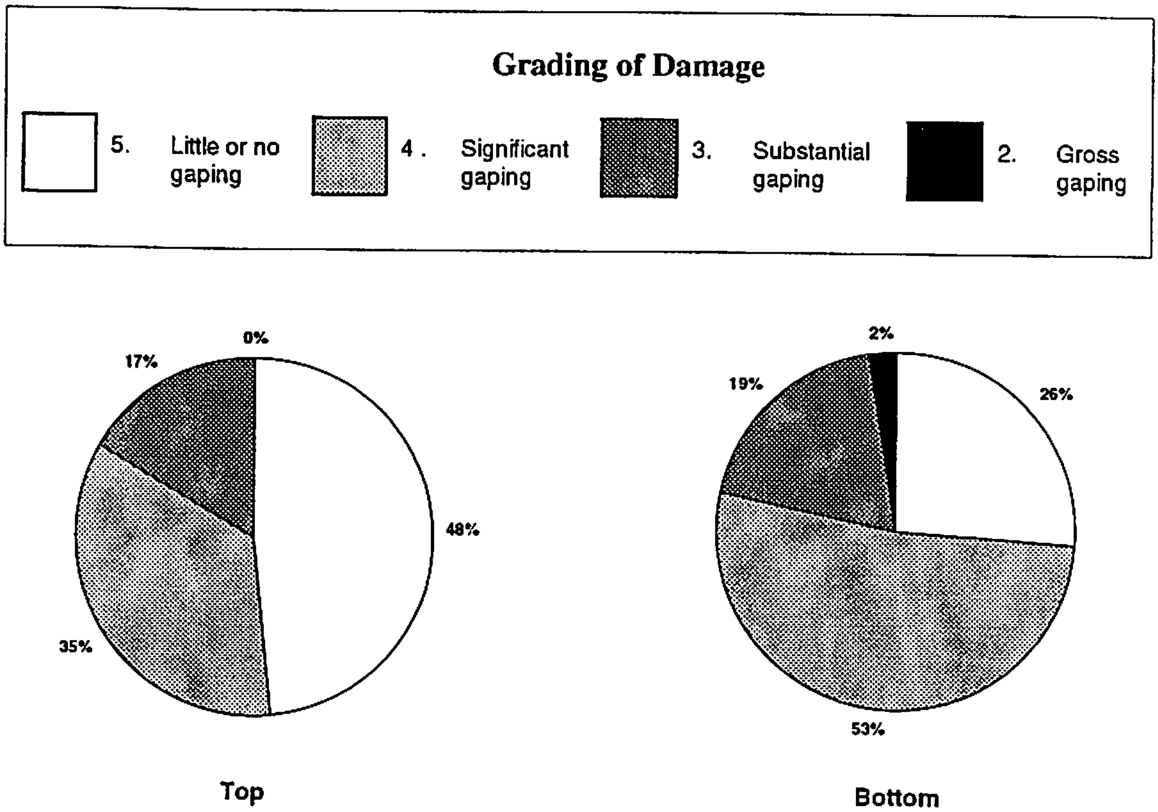


Figure 14 - Fillet damage to fish in half filled hoppers

A hopper effect was apparent with increased fillet damage and some rejection occurring to bottom fish. However, the sample size was small with only two boxes of top of hopper fish and three of bottom.

Figure Nos. 15, 16 and 17 overleaf breakdown the results for full hopper sampling into the different sizes of fish and their catching conditions.

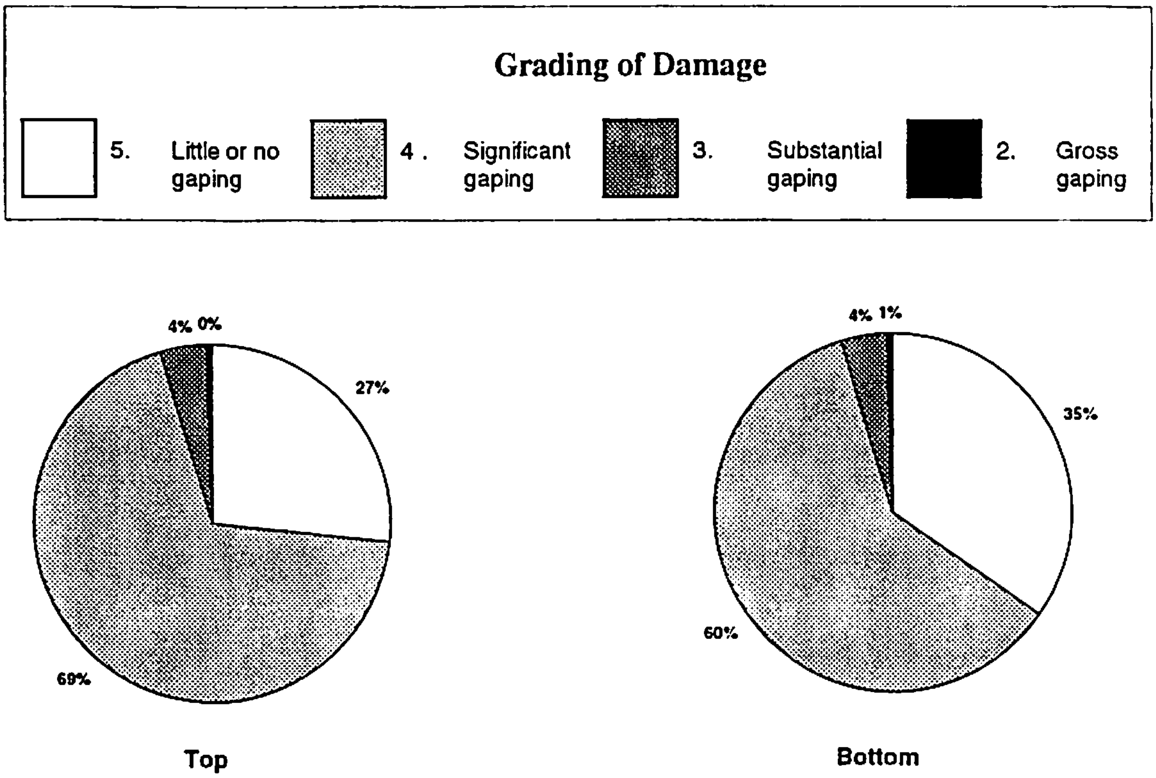


Figure No. 15 - Fillet damage to 2 hour tow medium sized fish in full hoppers

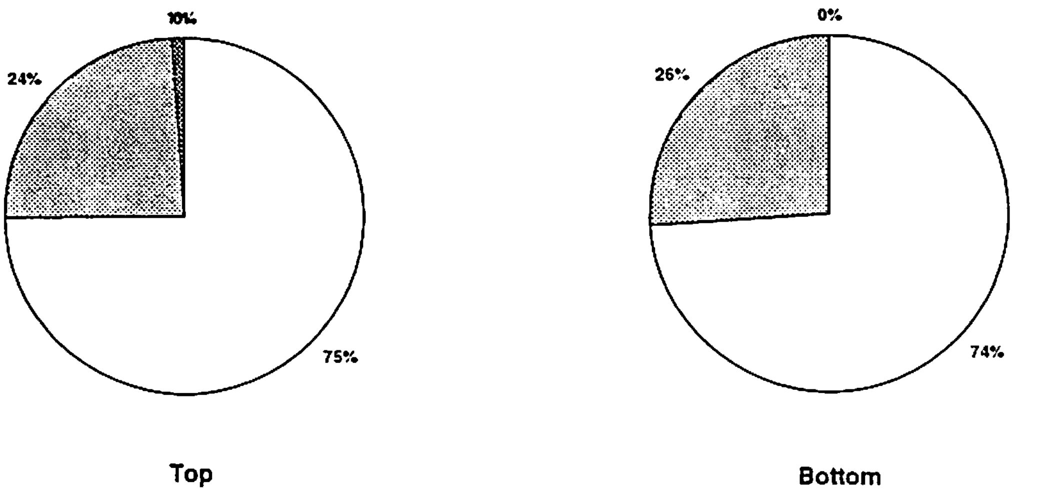


Figure 16 - Fillet damage to 2 hour tow small fish in full hoppers

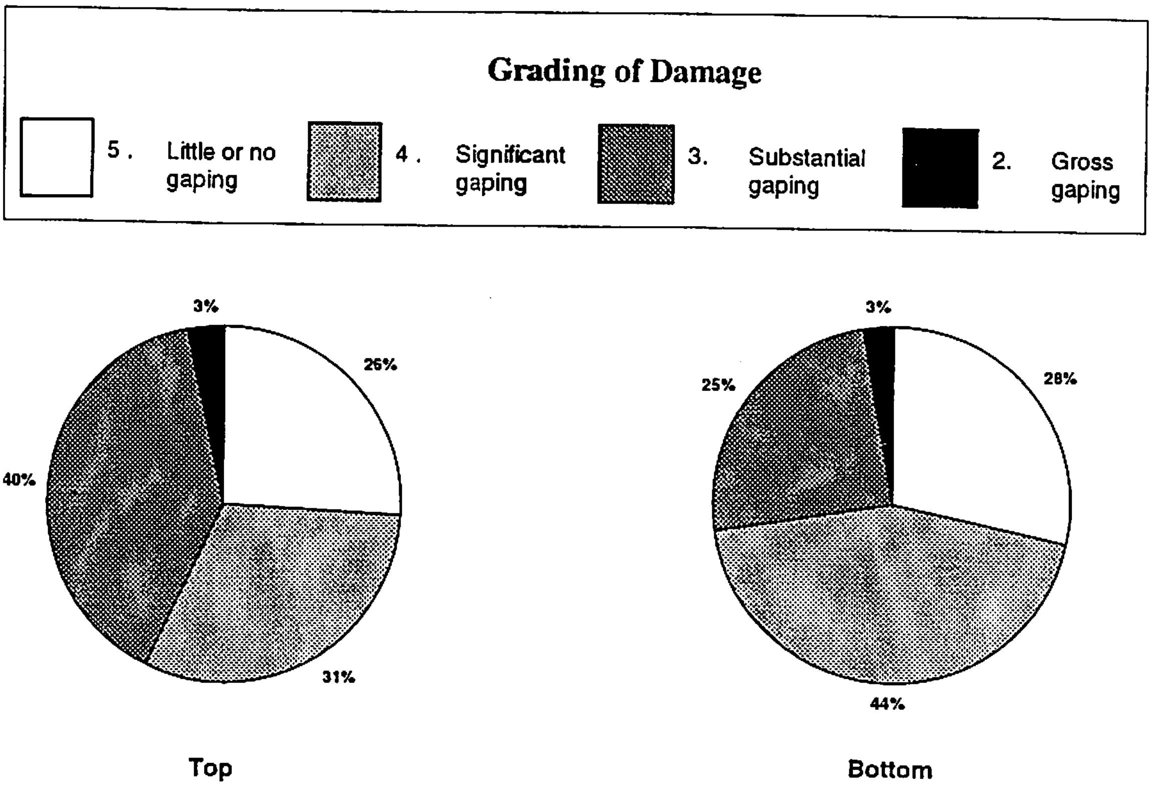


Figure 17 - Fillet damage to 4 - 5 hour tow small fish in full hoppers

Within the variability of the results, the only significant patterns of difference were that between small and medium sized fish and fish from short tows as opposed to those from long tows. The latter was marked with three quarters of the short tow small fish being undamaged with the reverse being the case for the long tow small fish where about three quarters were damaged. The short tow small fish suffered less damage than the medium ones and this would indicate, as with the whole damage results, that the medium fish were intrinsically softer than the small. Even so, the short tow fish had minimal borderline and rejected fillets whereas over 25% of the long tow fillets were borderline and 3% were rejected. The indications were that the more fish there were in the codend (up to 300 boxes), the more the damage.

Figure No. 18 below gives the gross and net (after any rejection) fillet yields by percentage weight of the whole (gutted) fish.

Figure 18 - Fillet yields (by percentage weight of whole gutted fish)

Batch	Hopper Conditions	Sampling Point	Number of Boxes	Fillet Type	Fillet Yield by % Weight of Whole Fish		
					Gross	Nett	Reject
1	FULL (160 boxes small haddock)	TOP	1	Single	56.1	53.7	2.4
		BOT	1	Single	56.1	56.1	0.0
			1	Butterfly	46.9	45.0	1.9
2	HALF FULL (80 boxes small haddock)	TOP	1	Single	56.1	56.1	0.0
		BOT	1	Single	56.1	55.0	1.1
			1	Butterfly	48.0	45.7	2.3
3	FULL (160 boxes small haddock)	TOP	1	Single	55.6	54.4	1.2
		BOT	1	Single	56.1	52.2	3.7
			1	Butterfly	48.0	48.0	0.0
4	FULL (70 boxes medium haddock)	TOP	1	Single	53.8	53.8	0.0
		BOT	1	Single	53.1	53.1	0.0
			1	Single	52.5	52.5	0.0
5	FULL (70 boxes medium haddock)	TOP	1	Single	53.7	53.2	0.5
		BOT	1	Single	52.6	52.6	0.0
			1	Single	52.1	50.9	1.2
6	FULL (70 boxes small haddock)	TOP	1	Butterfly	45.1	45.1	0.0
		BOT	1	Butterfly	43.8	43.8	0.0
7	HALF FULL (30 boxes small haddock)	TOP	1	Butterfly	45.5	45.5	0.0
		BOT	1	Butterfly	43.3	44.3	0.0

The fillet yields (by weight) were considered to be high by the processor and reflected careful handling onboard (in particular not over filling the boxes), the care taken by the filleter and the fact that no fillets needed to be trimmed to remove unacceptable blemishes.

The overall gross yield of single fillets from small haddock was 56% (butterfly fillets 45.8%) and the comparative figure for medium haddock was 53% for single fillets (no butterfly fillets). The lower gross yields of the medium size fish was probably due to their intrinsic condition. The gross yields before rejection for the long tow fish (batches 1, 2 and 3) were similar for the top and bottom of the hopper, whereas the gross yields for the short tows (batches 4-7) of the bottom fish were about one percentage point lower than the top fish.

Overall, the fillet rejection to top hopper fish and therefore due to catching only was 0.6% points. Comparatively, the rejection rate to the bottom hopper fish was 0.9% points. As this difference is small it does not indicate a significant hopper effect. Nearly all the reject, whether to the top or bottom, occurred with the long tow batches.

The fact that the long tow fish also had substantial proportions of grade 3, borderline fish (Figure No. 17), associated with the rejected fish was considered significant by the factory. This was because the cold smoking process involves mechanical handling and potentially, further damage to fragile fillets. In these circumstances a degree of further rejection due to gape at finished product inspection was likely. Additionally, machine filleting of such fish would be expected to lead to more rejection than with hand cutting.

Rejection from premium product represented a 50% loss of value for that fish which was diverted to a lower value outlet.

5.4 Whole Fish Freshness and Chilled Storage Life

Fish of TRS raw freshness 8 or above was required by the factory and the samples, at factory reception between 3 and 8 days after catching were acceptable. The TRS raw and cooked freshness assessment scores of samples over subsequent chilled storage life are given in Appendix III.

Although there was some variation, the overall pattern was of longer than typical useful chilled storage lives with no significant difference between top and bottom of hopper fish. The fish reached the limit of consumer acceptability (TRS 6) after about 15 days chilled storage, keeping about 4 days longer than would be normally expected. This may have resulted from the intrinsic condition of the fish and that they were correctly boxed.

5.5 Observations of Other Aspects of Mechanised Fish Handling

The operation of fish handling systems on both the trials vessels were observed from hopper to hold. This provided a contrast with the pair seiner's system being manual from gutting onwards, whilst the pair trawler's system was fully mechanised and used bins instead of boxes in the hold. Mechanisation clearly reduced labour but did not necessarily ensure good handling.

The hoppers discharged the fish without problem although there was clearly a heavy pressure of fish on the elevator on the pair seiner when starting up with a full hopper of 160 boxes of fish. Although hoppers were efficient for quantities up to their capacity, excess had to be run off into deck pounds or boxes with the result that the handling of fish in proper rotation was not guaranteed. Indeed, an instance of fish left in a pound for several hours before handling was the likely cause of a buyer reporting a bin with partly good quality fish and partly poor. The possible effects on fish quality of the time spent in the hopper before clearing fully, remains a concern – especially for large catches in warm conditions or rough weather.

Sorting and gutting the fish was made easier by the use of a gutting conveyor but the lack of a means for clearance of the guts meant that they were typically dropped on the conveyor. This contaminated fish which were yet to be handled. The compartment arrangements used in the fully mechanised system for holding the various selections of gutted fish enabled separate washing but was open to misuse by not clearing them if only partially full after each haul.

The 'U' shaped, tank, type fish washer integrated into the fully mechanised handling system with chute feed from the compartments and controlled elevator discharge, was at risk of overloading when the compartments were emptied and hence ineffective operation. In that sense it was as dependent on good practice as is the manually fed type of batch washer.

The arrangements for movement of fish from the mechanised washer to the chute into the fish hold suffered from the limited space available. Some fish tended to fall back down the elevator flights because of steepness but once over the top fell harshly, with a bang, onto the angled mouth to the chute. The plastic chute pipe was effective in enabling the fishermen to direct fish to where wanted in the fishroom – minimising handling before stowage. As the pipe was generally at a curve, the impact on the fish coming out the other end did not seem to be excessive, but if the drop was vertical onto a hard surface such as a sorting table or the deck, then this could be different.

The storage of fish in bins involved less work than with boxes. Part of this was due to less labour in handling ice as it had been loaded into a number of bins spread across the fish room and thus was nearer to point of application than with the typical ice pound arrangement. Chuting the fish directly into bins also reduced effort. Aligning the fish in the bins was still possible by straightening them during stage by stage filling. However, previous trials have indicated a 0.5 TRS point loss of freshness with depth in the 660 ltr bin typically used. Observations at the factory of 3 day old small fish stowed in these bins on the pair trawler showed some indications of effects with depth. It may be that another 3 or 4 days in stowage would have led to a similar quality loss to that previously found.

Boxing was clearly more laborious in comparison. However, typical boxing practice is harder work than need be as over filling requires particular attention to the packing of fish proud of the top of the box to reduce the likelihood of them dislodging. In terms of degree of damage and loss of quality that can occur to fish through movement or pressure against hard objects, poor drainage and poor chilling, the over filling of boxes has been shown in previous trials (Ref. 1) to be more destructive than the use of deep hoppers.

6. Overall Discussion

Overall it was found that fish removed from the bottom of fully filled hoppers showed some damage in the form of softening to the flesh. However there was no apparent effect on fish freshness or yield. The pressure on fish in the bottom of the hopper and the effect of pulling out by the elevator flights is thought to be the most likely cause of the softening but the effect could also be partly attributed to time since capture. Bottom of hopper fish, being first out of the codend, are likely to have been in the net longer. Fish from the bottom of half filled hoppers showed little or no increase in softening.

The biggest factor contributing to damage appears to be the catching process rather than the deep hoppers installed to accommodate the catches made as a result of these fishing practices. There was a significant difference between fish taken from a 4–5 hour tow as opposed to 2 hour tow. Not only did fish from the longer tow suffer from a marked increase in softening but also a higher level of fillet damage and rejection at processing. The indications are that the longer the hauls, the more the fish (up to 300 boxes with high discard rates), the more the damage. It may be that catching process can be a more significant cause of quality loss than is generally perceived. Long tows and large hauls lead to initial damage and to knock on effects, including the risks to quality in hoppers and in the longer time taken to handle and stow the fish, with the possibility of reduced care as crewing is tighter.

Although towing time appeared to have a greater effect on fish quality than that of current deep hopper/elevator systems, there is still a risk of damage from these systems which it may be possible to overcome by changes in design. At present, elevators are mounted within the hopper and pull the catch out through a tunnel with possible damage from the action of the elevator flights. If the fish could be directed from the bottom of the hopper to an elevator mounted outside then the risk of damage could be reduced. However, as this would probably involve some kind of opening or gate at which the fish may then jam and suffer damage and so it would need careful consideration before being put forward as an alternative. It may be that partially enclosing the elevator would enable the use of water to ease flow and reduce pressure the effects on the fish. In principle the shallow type of hopper, without an elevator, is preferable.

The hoppers and mechanical handling systems observed reduced handling but needed proper design and use to ensure that fish quality is maintained. Bins make fish stowage easier but further work is needed to indicate whether use of shallower versions are preferable and into a possible icing alternative – binary or slurry ice. Although the results indicated that catching is more likely to cause damage to fish than hoppers or associated mechanised handling systems the overfilling of boxes remains a major cause of damage and quality loss. The fact that the fish used in the trials were correctly boxed at sea and the comment made by the processor on the higher than normally be expected fillet yields is significant.

The trials set out to consider the effect of deep hopper/conveyor arrangements on fish quality and showed some likely effect, but towing time appears to be much more significant – albeit that the sampling was not extensive. Some further consideration should not only be made of hopper/conveyor design but also on the effect of fishing methods used, particularly the amount of time that the fish are held in the fishing gear before being brought aboard. Earlier trials on the use of set nets (Ref. 2) has shown the crucial effect of fishing practice on fish quality in that fishery.

7. Conclusions and Recommendations

- The catching process was found to cause significant damage to fish whereas there was a relatively small effect apparent with deep hoppers.

- The length of towing time of the fishing gear resulted in differences in fish quality. Fish from longer tows suffered an increase in softening, fillet gape and fillet rejection.

- Some fish taken from the bottom of deep hoppers with integral, flighted elevators suffered physical damage in the form of softening to the flesh. No reduction in fish freshness or fillet yield was apparent.

- The existing elevator approach to removing the catch from deep hoppers is not kindly to fish. It would be preferable for the fish to be fed to the elevator without being under pressure.

- Onboard mechanised fish handling systems need careful design and use to avoid risk to fish quality.

- Storage and handling of fish in 660 ltr pallet bins is easier than in boxes but needs further investigation of fish quality effects with depth and icing techniques – possibly using shallower bins and/or binary ice.

- Some further investigation of the effect of towing time on fish quality is merited as a difference of just 2-3 hours appeared to be quite significant.

- Some further work on hopper design is thought necessary.

8. Acknowledgements

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Skipper Alex Baird and crew
Skipper Ashley Goodbrand and crew
The management and staff at Norsea Foods Ltd.

9. References

1. WILSON, P (1983) An Investigation of the Effects of Over Filling Boxed at Sea Fish on Quality and Yield. Technical Report 229.

2. PROUT, P. (1993) The Effect of Soak Time on the Quality of Cod in Set Nets. Seafish Report No. 415.

Appendix I

Vessel Details
'PTARMIGAN' (BCK 26)
and
'STARLIGHT' (PD 150)

Vessel 1 - MFV 'PTARMIGAN' (BCK 26)

(Skipper Ashley Goodbrand and six crew)

Vessel Type:	Fly dragging seiner and pair seining for small haddock at the time of the trials
Length:	21.4 m
Tonnage:	49.68
Power:	Kelvin 495 h.p.
Construction:	Transom sterned, carvel built of wood with ¾ length aluminium shelter deck and after midships wheelhouse. The fish hold is fully insulated and wood lined to the bulkheads but not chilled. Capacity is about 500 boxes.
Layout:	Seine rope reels forward on working deck with the gutting conveyor, fish sorting and washing area in front of the wheelhouse and to the starboard side. The fish reception hopper, set into the shelterdeck alongside the starboard side of the wheelhouse, feeds the system via an elevator to the gutting conveyor. The fishing gear working is in the transom area aft of the shelterdeck with a net pound and power block. The hold is from midships forward with the engine room under the wheel house and crew accommodation aft.

Vessel 2: MFV 'STARLIGHT' (PD 150)

(Skipper Alex. Baird and seven crew)

Vessel Type: Pair Trawler

Length: 26 m

Tonnage: 75.4 tonnes

Power: Alpha 660 h.p.

Construction: Transom sterned, steel built with ¾ length aluminium shelter deck and after midships wheelhouse. The fish hold is partially insulated and wood/grp lined to the bulkheads, with chilling units fitted to the deck head. Fish stowage in 660 and 460 ltr pallet bins with a hold capacity of about 500 boxes equivalent

Layout: Trawl winches forward on working deck with the fish reception hopper set into the shelter deck on the starboard side, feeding the gutting and mechanised fish handling system via an elevator. The fish handling system consists of a gutting conveyor along the starboard side which faces selection compartments over a wide chute, for the gutted fish to pass into a 'U' configuration fish washer, with an elevator and chute feed to stowage in the fishroom. The fishing gear working is in the transom area aft of the shelterdeck with a net net drum and power block.

The hold is from midships forward with the engine room under the wheel house and crew accomodation aft.

Appendix II

Torry Research Station SensoryAssessment Scoring Sheets

SEAFISH

Freshness Score Sheet for Iced Cod* - Raw Fish

Score	Eyes	Skin	Texture and Effect of Rigor Mortis	Flesh and Belly Flaps	Kidney and Blood	Gills		Score
						Appearance	Odour	
10	Bulging, convex lens, black pupil, crystal-clear cornea.	Bright, well-differentiated odours, glossy, transparent slime.	Flesh firm and elastic. Body pre–rigor or in rigor.	Cut surface stained with blood. Bluish translucency around backbone. Fillet may have rough appearance due to rigor mortis contraction.	Bright red, blood flows readily.	Glossy, bright red or pink, clear mucus.	Initially very little odour increasing to sharp, iodine, starchy, metallic odours changing to less sharp seaweedy, shellfish odours.	10
9	Convex lens, black pupil with loss of initial clarity.		Flesh firm and elastic. Muscle blocks apparent. In or just passing through rigor.	White with bluish translucency, may be corrugated due to rigor mortis effect.	Bright red, blood does not flow.		Freshly cut grass. Seaweedy and shellfish odours just detectable.	9
8	Slight flattening or plane, loss of brilliance.	Loss of brilliance of colour.	Firm, elastic to the touch.	While flesh with some loss of bluish translucency. Slight yellowing of cut surfaces of belly flaps.	Slight loss of brightness of blood.	Loss of gloss and brightness, slight loss of colour.		8
7							Slight mousy, musty, milky or caprylic.	7
6	Slightly sunken, slightly grey pupil, slight opalescence of cornea.	Loss of differentiation and general fading of colours; overall greyness. Opaque and somewhat milky slime.	Softening of the flesh, finger indentations retained, some grittiness near tail.	Waxy appearance of the flesh, reddening around the kidney region. Cut surfaces of the belly flaps brown and discoloured.	Loss of brightness, some browning.	Some discolouration of the gills and cloudiness of the mucus.	Bready, malty, beery, yeasty.	6
5							Lactic acid, sour milk or oily.	5
4	Sunken, milky white pupil, opaque cornea.	Further loss of skin colour. Thick yellow knotted slime with bacterial discolouration. Wrinkling of skin on nose.	Softer, flesh, definite grittiness.	Some opacity reddening along backbone and brown discolouration of the belly flaps.	Brownish kidney blood.	Slight bleaching and brown discolouration with some yellow bacterial mucus.	Lower fatty acid odours (eg acetic or butyric acids), composted grass, 'old boots', slightly sweet, fruity or chloroform-like.	4
3							Stable cabbage water, stale turnips, 'sour sink', wet matches.	3

*Note: Score sheet used to assess haddock as they are similar to cod in respect of freshness changes.

Freshness Score Sheet for Iced Cod

- Cooked Fish

Score	Odour	Flavour	Texture, Mouth Feel and Appearance	Score
10	Initially wear odour of sweet, boiled milk, starchy followed by strengthening of these odours.	Watery, metallic, starchy. Initially no sweetness but meaty flavours with slight sweetness may develop.	Dry, crumbly with short tough fibres.	**10**
9	Shellfish, seaweed, boiled meat, raw green plant.	Sweet, meaty, creamy, green plant, characteristic.	Succulent, fibrous. Initially firm going softer with storage. Appearance originally white and opaque going yellowish and waxy on storage.	**9**
8	Loss of odour, neutral odour.	Sweet and characteristic flavours but reduced in intensity.		**8**
7	Woodshavings, woodsap, vanillin.	Neutral.		**7**
6	Condensed milk, caramel, toffee-like.	Insipid.		**6**
5	Milk jug odours, boiled potato, boiled clothes-like.	Slight sourness, trace of 'off ' flavours.		**5**
4	Lactic acid, sour milk, 'byre-like'.	Slight bitterness, sour, 'off ' flavours.		**4**
3	Lower fatty acids (e.g. acetic or butyric acids), composted grass, soapy, turnipy, tallowy.	Strong bitter, rubber, slight sulphide.		**3**

Appendix III

Raw and Cooked Freshness of Trial Samples over Chilled Storage Life on Ice

Sample Batch	Vessel/ Tow Time/ Hopper Condition	Hopper Position	T.R.S. Assess-ment	Freshness Scores over Chilled Storage Life (Days Post Capture)															
				3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Ptarmigan	Top	Raw				Factory 8.0			7.0				7.0			5.5		
	4 hours		Cooked							7.5				7.5			5.5		
	Full Hopper	Bottom	Raw				Factory 7.0			7.0				7.0			6.0		
			Cooked							8.0				7.0			6.0		
2	Ptarmigan	Top	Raw			Factory 7.5			7.5				7.0			6.5			
	4 hours		Cooked						7.0				7.0			5.5			
	Half Hopper	Bottom	Raw			Factory 8.0			8.0				6.5			6.0			
			Cooked						8.0				7.5			6.5			
3	Ptarmigan	Top	Raw			Factory 8.0			8.0				7.0			6.0			
	4 hours		Cooked						8.0				6.5			5.5			
	Full Hopper	Bottom	Raw			Factory 7.5			7.5				6.5			6.0			
			Cooked						9.0				7.0			6.0			
4	Starlight	Top	Raw						Factory 8.0				7.5				6.5		
	2 hours		Cooked										7.5				5.5		
	Full Hopper	Bottom	Raw						Factory 8.0				7.5				6.5		
			Cooked										8.0				6.0		
5	Starlight	Top	Raw						Factory 8.5				7.0				6.0		
	2 hours		Cooked										7.5				5.5		
	Full Hopper	Bottom	Raw						Factory 8.5				7.5				6.5		
			Cooked										7.5				5.0		
6	Starlight	Top	Raw		Factory 9.0				8.5				6.5						6.5
	2 hours		Cooked						7.5				6.5						5.5
	Full Hopper	Bottom	Raw		Factory 9.0				8.5				7.5						6.5
			Cooked						7.0				6.5						5.0
7	Starlight	Top	Raw	Factory 9.0				8.5				7.0							
	2 hours		Cooked					8.0				6.5							
	Half Hopper	Bottom	Raw	Factory 9.0				8.5				7.5							
			Cooked					7.5				6.0							