Further Trials to Enable the Icing of Fish on Small Inshore Vessels

MAFF Commission

Seafish Report No.370

March 1990 *(revised 1995)*

MAFF R&D Commission 1989-90

Sea Fish Industry Authority

Seafish Technology

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Summary

This project acknowledges the need for improvement in the quality of fish from inshore vessels, the majority of which are small and operate as day trip boats. The large fleet of inshore vessels under 16.5 m lands an estimated value of fish of at least £100 million per annum. However, the quality of a proportion of this catch is often far from what it could be due to lack of facilities and temperature control.

Earlier work identified the problems in more detail and demonstrated that it is possible to effectively ice fish on small inshore vessels. The icing techniques were based on using novel forms of insulation and draught proofing. This report covers the prototype development of these equipment concepts on commercial vessels during the summer months.

The portable insulative equipment, mainly based on boxed storage, varied in effectiveness but on average a fish to ice ratio of 2-2.5:1 was sufficient for chilling fish. This was on deck, in the warmer than average ambient summer temperatures ranging from 15 °C to near to 30 °C.

Icing aboard, in conjunction with continued chilling ashore, substantially improved the freshness of a variety of species. This was in comparison to the results from the normal practice of not using ice at sea and the generally slow rates of chilling ashore.

The types of insulated equipment are designed to be as practical as possible. The indications are that a 'mix and match' approach should maximise a vessel's chilling potential. However, space and the amount of ice taken remain as constraints. The hardware and techniques need further development and refinement.

The wider constraints to quality improvement appear to be lack of price incentive with priorities focused on catching quantity not quality. Apart from a general need to improve standards of care in handling it was noted that the static net fishing method affected quality. The lack of ice supply is a vital constraint in some localities.

It is recommended that refinement of the chilling equipment and fish handling techniques is carried out in a concentrated effort with a particular group of fishermen and their catch outlet. The aim would be to achieve a working model of alternative and beneficial commercial practice, which can be recommended to the industry. Additionally, it is recommended that the effect on fish quality of the static net fishing method is investigated.

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1. Introduction

This work follows the preliminary observations and trials of fish icing on small inshore fishing vessels (Seafish Report No. 461).

The majority of these vessels operate as day boats and may be as small as 5 m in length. The main physical problems found were lack of fish handling/storage space and facilities - both at sea and ashore. Some limited trials demonstrated that the typical lack of icing, especially at sea, results in substantial loss of freshness. This being despite the relatively short time periods involved. Trials with novel forms of insulative fish storage equipment showed that it is possible to effectively ice fish in on-deck storage on small vessels.

The main recommendation of this earlier work was to develop the insulative equipment concepts in the commercial fisheries to enable effective icing and quality improvement on small inshore vessels. It was decided therefore, to continue this work by collaborating with a number of vessels in a variety of conditions around the country. Development of the insulative equipment would further the insulated container and cover concepts to suit the needs of different types of vessels and operations.

These trials were carried out under MAFF Commission (QFC 16).

2. Objectives

- To continue the development of suitable insulated equipment to enable icing at sea on small inshore vessels.
- To obtain a measure of technical and practical performance of the equipment.
- To carry out the above in a variety of inshore fishing areas and locally demonstrate effectiveness.

3. Approach to Trials

The previous, mainly laboratory trials (Seafish Report No. 461) had demonstrated the effectiveness of icing fish in stacks of boxes, either under an insulated cover or in an insulated container. However, the two methods had not been compared in outdoor conditions. Further, it was also thought that the use of an insulated fish box which could be manhandled on and off the boat might usefully extend the stowage options. Similarly, it was considered that the use of lids on standard fish boxes might offer some improvement. Some initial laboratory trials were therefore considered necessary to evaluate the potential of these further types of equipment prior to field trials.

Concurrently, contact was made with a number of different inshore fishing localities around the United Kingdom to find suitable circumstances for observations and trials of the different equipment options. A pre-requisite to the choice of vessel was the willingness of the fishermen and buyers to collaborate freely. Icing effectiveness was to be measured by the monitoring of temperatures and ice loss. Assessment of the general potential for fish quality improvement was to be by making sensory comparisons of resultant freshness. Where possible, these being carried out with the buyers to demonstrate effective quality improvement.

Throughout the trials, other aspects of handling were to be considered to identify any further development needs.

4. Trials Equipment and Assessment

4.1 Fish Stowage Equipment

4.1.1 Laboratory trials

Four options were subject to limited trials. These were insulated lidded boxes; uninsulated lidded boxes; insulated covers and an insulated container containing boxes.

The insulated and uninsulated lidded boxes were of 30 litre capacity whilst uninsulated 70 litre fish boxes were used with the insulated covers and container. Details of the equipment are given in Appendix I.

4.1.2 Field trials

Seven equipment options were subjected to field trials and are shown in Table 1 below. Insulated covers were fabricated to fit over stacks of boxes like a 'cosy' and the insulated container had internal dimensions to suit the boxes.

Table 1 - Fish stowage options used

		Insulated cover		Insulated or uninsulated tarpaulin with uninsulated lidded box	Insulated lidded container	
Insulated lidded box	Uninsulated lidded box	With uninsulated lidded box	With uninsulated unlidded box		With uninsulated unlidded box	Fish not in boxes (slush ice)
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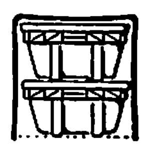
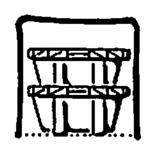
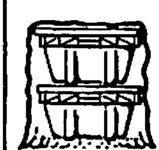
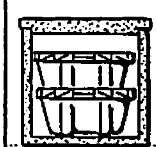
						

Details of the equipment options are given in Appendix I.

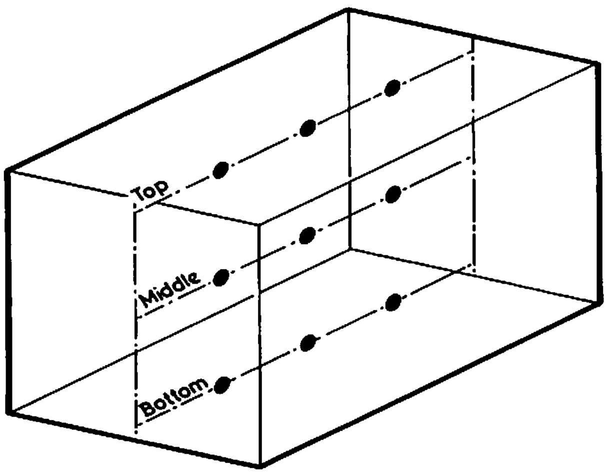
4.2 Icing

Ice usage was assessed by using scoops to measure initial and final amounts. The amounts of fish were normally judged by volume in the fish boxes with occasional check weighing at sea and ashore.

Standard icing procedure was top and bottom icing and the fish/ice mixtures used were in ratios of between 2:1 and 3:1 by weight.

4.3 Temperature Measurement

Ambient, sea and the associated fish temperatures were measured. Individual temperatures were taken using an electronic hand held thermometer, sometimes used in conjunction with a multi-channel junction box. Temperatures of normal and trials stowed fish were normally taken in the standardised positions as shown below.



Thermocouple Positions

Note: The top and bottom temperatures were taken of fish inset about 20 mm in from the top and bottom layers of ice

4.4 Quality Assessment Procedure

Trials chilled samples were compared against those held at prevailing temperatures in the conventional way. Any quality differences therefore reflected changed icing and stowage practices.

Assessment of freshness quality was either by inspection of the fish, with the buyer/processing staff/fishermen or by more detailed sensory assessment. The latter was of external appearance, raw odour and cooked odour/flavour over an extended period of subsequent storage on ice (generally in the Seafish Laboratory at Hull).

4.5 Involvement of Local Fishermen, Buyers, Processors

Visits were made to different inshore fishing localities with a view to obtaining a variety of field experience. The minimum requirement was the interest of the crew, as vessels were not chartered. In most cases there was also buyer interest and this helped to identify and demonstrate quality improvement. Commercial involvement also helped in obtaining feedback on practicalities as well as achieving some local demonstration.

5. Summary Schedule of Trials and Observation Visits

Trials and observation visits took place between July and October at several ports/landing places around the UK. Details are given in Table 2 below.

Table 2 - Summary schedule of trials and observation visits

(Dates)	Place	Vessels	Observation/Trials
14–18 August	Maryport	10.5 m trawler	Trials of boxes in an insulated container (Option F)
25–28 July and 11–12 October	Hastings	6.5 m and 8.5 m netting vessels	Observations of lidded boxes under insulated covers and insulated boxes (Options A+C)
1–4 August, 8–11 August, 21–22 August and 18–26 September	Rye	10 m and 11 m trawlers, 10 m netter	Trial comparisons of different types of insulated equipment and attempts to ice all of catches (Options E+G)
14 August to 16 September	St. Ives	5 m and 6 m mackerel jigging vessels	Observations of slush ice chilling ashore (Options G)
14–19 August and 16–19 October	Looe	6.5 m netter, 11 m trawler, 9 m mackerel jigger	Trial comparisons of different types of insulative equipment. Monitoring of commercial use of insulated box on netter (Options A,B,C, D and G)
12 July, 6–7 September and 25 October	Bridlington	10 m netter, 15 m trawler	Observations and trial comparisons of different types of insulated equipment (Options A+D)
18–21 September	Port Appin (Loch Linnie)	6.5 m Nephrop creeler	Observatory trial of uninsulated lidded boxes and insulated covers to protect Nephrops (Options B+C)

6. Trials Conditions and Results

The conditions under which most of the trials were undertaken were warm and occasionally hot. Ambient temperatures were mostly above those of the sea surface at 14-18 °C and were up to 25 °C during some trials. More information on the fish temperatures found in inshore industry handling is given in Section 6.3.

6.1 Laboratory Trials of Insulated Equipment

In earlier trials (Ref: Seafish Report No 461) insulated containers and covers had not been compared in outdoor conditions. Similarly an insulated fish box capable of being manhandled on and off the boat or the use of lidded boxes had not been considered.

6.1.1 Trials description

Four separate trials were carried out at the Seafish laboratory in Hull. Trials 1 and 2 were completed outside whilst Trials 3 and 4 were inside. The trials were as follows:-

1. An ice meltage comparison in outdoor conditions between fish boxes under an insulated cover and fish boxes within an insulated container (boxes filled with ice only).

2. An ice meltage/fish chilling comparison between the above equipment types in similar outdoor conditions.

3. A fish chilling trial in the laboratory comparing an uninsulated, lidded draught proof fish box (30 litre) with an insulated air freight box. An air-draught was induced around the boxes by an electric fan.

4. A fish chilling trial under similar air-draught conditions to above but using improvised insulation made of 25 mm expanded polystyrene on a standard 70 litre fish box, in comparison to a box without. Both the 70 litre boxes had lids.

6.1.2 Results

Insulated container V insulated cover (Trials 1 and 2):

The insulated container with its all-round thermal protection retained between 12% and 18% more ice than the insulated cover where the ice loss in the bottom box was marked. The fish chilled to less than 5 °C average within 5 hours in both types of equipment. During the trials it was noted that when there were sunny periods, the light blue surface of the insulated container was up to 9 °C warmer that the white surface of the insulated cover.

Insulated lidded boxes V uninsulated lidded boxes (Trials 3 and 4):

During trial 3 the insulated air freight box retained 70% of the original ice as compared with 14% for the uninsulated version. The fish cooled to less than 1 °C average in both cases. The ratio of fish to ice was 2.1:1. In Trial 4 the insulated version of an ordinary fish box retained 20% of the ice compared with 8% for the uninsulated box and the average fish temperatures were 3.2 °C and 6.4 °C respectively. The ratio of fish to ice was 3.2:1 Control fish temperatures, i.e. uniced, remained at about 17 °C.

The ice meltage/fish chilling results showed that the insulated container provided more thermal protection than the insulated cover and that insulated boxes also were potentially effective. As a result of this work the range of insulative equipment for field trials was therefore expanded to include a lidded insulated fish box of a size that was manhandable, unlike the larger container which would not be portable on and off the vessel. The use of a light external colour and ways of minimising the air draughts over the fish and ice were also considered important.

6.2 Trials on Commercial Vessels

6.2.1 Icing trials conditions and results

Table 3 summarises the trial conditions and results for the seven stowage equipment Options A to G, and Fig. 1 compares the chilling performance of Options A-D. The trials of A-D are not directly comparable to E-G because of differences in trial durations and/or icing. The trials measurements were of initial and final fish temperatures and quantities of ice. Individual trials data are given in Appendix II.

6.2.2 Trials fish quality assessment and results

Assessments were made of fish from several of the icing at sea trials, the comparison being between the trials iced fish and that uniced as normal on the vessel.

Table 4 summarises the trials conditions, nature of assessment and the results. The fish were initially assessed 24 hours after capture and in some cases were re-assessed during subsequent storage on ice at the laboratory.

A major point that arose as a result of trial observations was the variation of initial quality of static netted fish. In particular some cod were observed (and smelt) to have lost their sea fresh condition as a result of the nets remaining in the sea for periods (soak times)of about 24 hours between hauls. After their death, these fish appeared to be subject to rapid loss of freshness as a result of warm water temperatures. Additionally, some of the cod were damaged as a result of marking from the nets and attack by predators such as crabs and starfish.

Table 3 - Summary of icing trial conditions and temperatures

Conditions	Stowage Equipment Options						
			Insulated cover			Insulated container	
	Insulated lidded box	Un-insulated lidded box	With uninsulated lidded box	With uninsulated unlidded box	Tarpaulin with un-insulated lidded box	With un-insulated unlidded box	With fish not in boxes (slush ice)
	A	**B**	**C**	**D**	**E**	**F**	**G**
No. of trials	4	3	2	6	4	1	2
Total number of boxes monitored	6	6	4	12	8	1	2 (containers)
Average fish:ice (by weight)	2.3:1	2.3:1	2.3:1	2.2:1	2.0–2.5:1	2.2:1	2.9:1 (+sufficient sea water)
Trials duration (hrs) Average - Range -	8.7 7–10	8.3 7–10	8.0 7–9	8.3 7–10	8.0 7–9	6.5 ---	2.0 1.3
Ambient (°C) Range	15.5–25	17.2–25	17.2–25	15.5–25	15.2–25.5	18.5–21.6	17.4–21.6
Initial temps of fish (°C) Average Range	15.8 14.4–17.9	15.7 13.8–17.8	16.0 13.8–17.9	15.5 13.8–19.6	17.2 16–18.4	18.0 17.8–18.6	17.1 15.6–18.3
Final temps of fish (°C) Average - Range -	2.4 0.2–7.4	7.5 1.1–14.3	2.7 0.6–6.2	2.8 0.0–10.6	4.8 0.7–11.7	2.7 1.5–4.3	1.8 0.3–6.4
Proportion of ice remaining Average - Range -	38% 30–45%	4% 0–10%	24% 15–30%	20% 10–30%	13% 5–25%	Not measured	Very little remaining

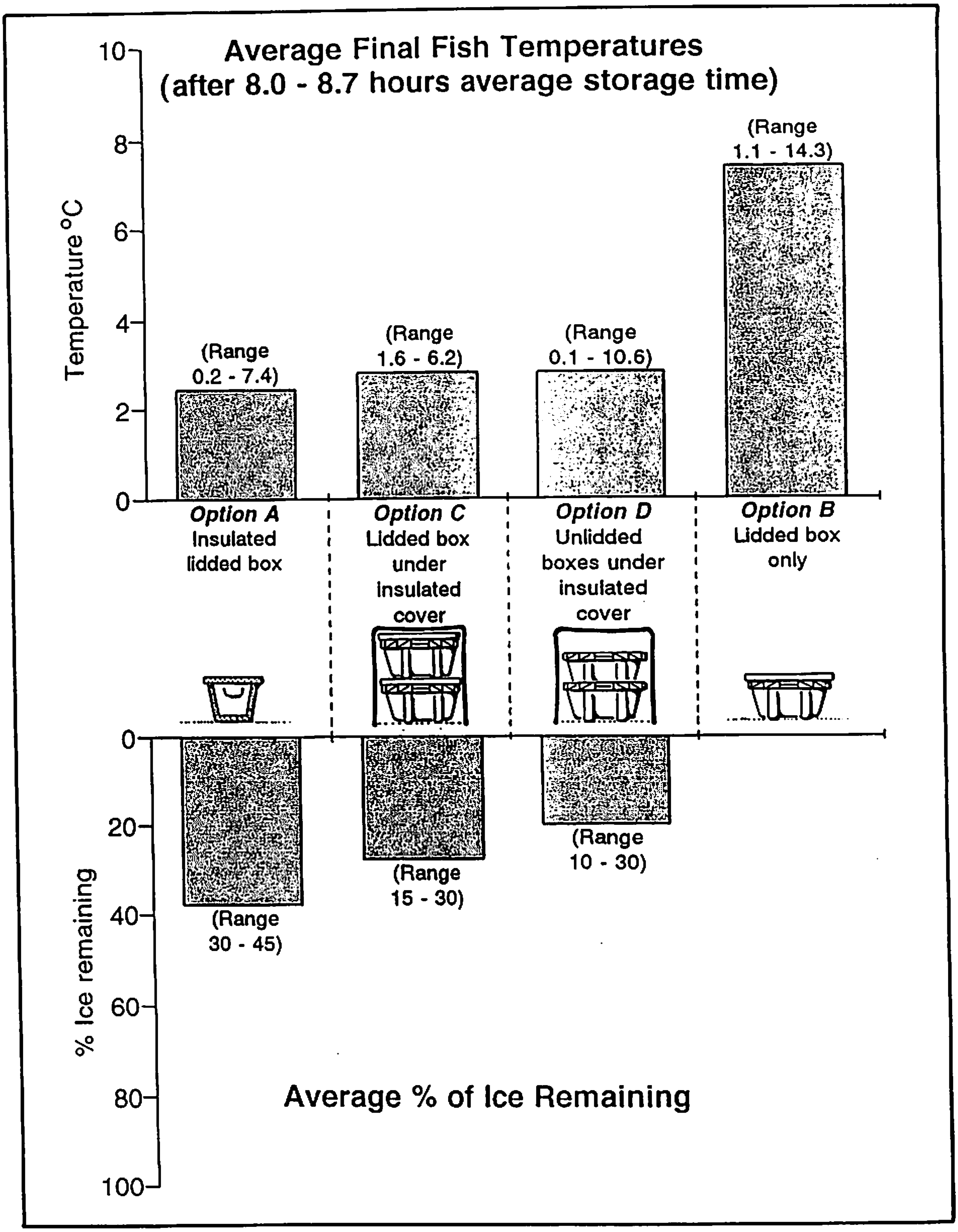


Figure 1 - Chilling performance of insulated lidded and ordinary fish boxes: with and without insulated covers (average final fish temperatures and remaining ice)

Table 4 - Summary of freshness quality trials conditions and results

Date	Source of Samples	Temperature Control	Nature of Assessment	Freshness Quality Results
2 Aug	10 m trawler (boxed plaice)	Iced at sea compared to uniced for 14 hours at 17°C before slow chilling	Raw assessment in conjunction with staff at port buyers premises	Uniced at sea plaice had lost seafresh gill appearance within 24 hours. Buyer's staff considered that iced at sea fish would keep 2 days longer on ice
7 Sept	15 m trawler (boxed cod)	Iced at sea compared to uniced for 11 hrs at 15°C before chilling overnight to 3°C	Full organoleptic assessment by panel of 2/3 people at laboratory	Uniced at sea cod had lost all its desirable characteristic and sweet flavours (to TRS 7) within 3 days of capture, whereas the iced at sea fish took nearly 6 days to reach that point
16 Sept	5 m hand line boat (boxed mackerel)	Iced at sea (chilled to 1°C within 3 hours) compared to uniced for 8 hrs at 18°C before rapid chilling	General freshness assessment with fishmonger in Cornwall and London	After 24 hrs the uniced at sea mackerel were slightly softer and duller than the iced at sea fish. The fishmonger considered that there was an overall loss of storage life on ice of about 1 day as a result of not icing at sea
18 Sept	10 m trawler (boxed plaice)	Iced at sea compared to uniced for 10 hrs at 17°C before chilling overnight	General freshness assessment with fishmonger at London	The uniced at sea fish had lost its sea fresh appearance within 48 hrs of capture. The iced at sea fish was remained sweet and characteristic at that point
19 Sept	10 m trawler (boxed lemon and dover sole)	Iced at sea compared to uniced for 10 hrs at 17°C before chilling overnight	General freshness assessment with fishmonger at London	Uniced at sea fish were of slightly less fresh appearance after 24 hrs and lost their desirable sweet and characteristics flavours within 7 days of capture. At this point the iced at sea fish still had some characteristic flavour
26 Sept	10 m netter (slush iced cod)	Iced at sea (to 1.0°C within 3 hrs) compared to uniced for 10 hrs at 16°C before overnight chilling to 2°C.	Full organoleptic assessment by a panel of 2-3 people at laboratory	After 24 hrs uniced at sea fish significantly less fresh at TRS 7-8 (raw and cooked) than the iced at sea fish at TRS 8-9. The uniced at sea fish were stale after 7 days whereas the iced fish had some remaining freshness
18 Oct	9 m handline boat (slush iced cod)	Iced at sea (to 3°C within 3 hrs) compared to uniced for 7 hrs at 14°C before chilling overnight	General assessment of condition at laboratory	The uniced at sea fish had lost all their desirable, sweet flavours within 24 hrs of capture. They were also duller and softer than the iced at sea fish

6.3 Observed Industry Approach to Temperature Control during the Trials Period

6.3.1 Handling periods

The periods of custody of the inshore catch on the part of the fishermen and shore handlers were generally less than 48 hours. The fishing trips varied between 3 and 36 hours (mostly 8–14 hours), whilst the associated periods ashore prior to auction or despatch were usually between 2 and 16 hours.

6.3.2 Uniced fish temperatures

The conditions under which most of the observations and trials were undertaken were warm to hot. Fish temperatures out of the sea were high. i.e. between 14 °C and 18 °C. The ambient temperatures rarely fell below those of the sea surfaces at 14 °C–18 °C and reached a maximum approaching 30 °C. During the summer the exposed fish tended to warm by at least a degree or two and were as high as 20 °C on deck and at landing. Details are shown in Table 5.

Table 5 - Ambient and uniced fish temperatures aboard

Date	Place and Vessel Type	Ambient Range (°C)	Sea Surface (°C)	Initial Fish Temps (°C)	Fish Temperature Changes (°C)
13 July	Bridlington 10 m coble	16.5–19.5	15.0	15.1	Fish at 16°–17° on landing (after 5 hrs)
21 July	Maryport 10 m trawler	16.3–18.5	15.7	16.0	Fish warmed by 1.5° over 2 hrs prior to chilling trials
27 July	Hastings 8 m netter	15.7–22.4	17.5	17.5	Fish warmed by 1.5°–3° over 4 hrs prior to landing
3/4 August	Rye 10 m trawler	17.0–18.5	17.5	16.9	Fish warmed by at least 1.5° over 6 hrs
10 August	Rye 10 m netter	17.2–19.4	17.5	17.2–4	Fish warmed by 0.7°–2.9° over 3 hrs
14 August	St. Ives 5 m hand liner	14.0–20.5	15.7–16.3	16.7	Difficult to detect general warming but instances of fish as warm as 19.1° after 2 hrs
16 August	Looe 10 m trawler	17.1–23.4	17.0	16.2–9	Warming of up to 1.2° prior to boxing
7 September	Bridlington 15 m trawler	15.5–17.8	14.2–15.3	13.9–14.2	Fish warmed by about 2° on deck
11 October	Looe 6 m netter	15.3–16.3	15.8	15.8–15.9	No warming
13 October	Hastings 8 m netter	14.3–16.3	15.7	15.6–16.1	No warming

6.3.3 The use of ice

Looe, Maryport and Bridlington were the only places where ice was observed to be routinely taken to sea and this was by trawling vessels with holds. It was clear that the chilling these vessels achieved in practice was limited by ice loss. The reasons for this were time, uninsulated fish holds and lack of alternative thermal protection. More details of deck structure and hold temperatures are given in Appendix III.

Temperature control practices ashore varied widely. This depended on provision of ice and storage facilities but was coupled to handling arrangements and practice. The best control was where the fishermen had ready access to ice and were able to land top iced fish from the boat, weigh, re-ice and place the catch directly into a modern quayside/market chill. The worst control tended to occur where the landing of the uniced catch required transport to a point away from the quay, where it was put into a buyer's chill with little or no icing and hence slow cooling. These were the sort of circumstances where delays could easily occur with the fish remaining unprotected at the landing point before transport.

Observations showed that exposure of trials iced at sea fish as a part of shore handling could cause significant loss of temperature control. An instance of delays at the quayside in exposed sunny conditions warmed trials fish by up to 7.6 °C within an hour. Details of temperature control observed at some of the landing places are given in Appendix IV.

Overall, the normal practices encountered ashore had usually cooled the fish down to between 12 °C and 4 °C within 24 hours of capture.

7. Discussion

7.1 Chilling Effectiveness of the Fish Stowage Options Used

The results showed that effective cooling of fish was achievable on the deck of small day boats in summer conditions. This was typically with one box of ice to make two boxes of iced fish i.e. a ratio of about 1:2.3 by weight (perhaps slightly heavier icing than what was good practice on trip vessels with proper holds for boxing). As a guide, in theory about 40% of this ice would have been needed to cool the fish typically at 16 °C average down to 3 °C average in totally insulated conditions.

Insulated lidded box (Option A):
This option performed the best over the typical trials period of about 8.5 hours with the fish cooled to 2.4 °C average and about 40% average ice remaining. A one off trial which mixed ice through the fish, instead of top and bottom only, more uniformly chilled the fish to between 0.2 °C and 1 °C, but appeared to use slightly more ice. This was reflected in the extra cooling achieved. That there was little difference to the pattern of ice remaining in the boxes indicated that the all-round insulation and drought proofing was beneficial and potentially less ice could have been used or the fish stored longer.

Uninsulated lidded box (Option B):
This option was ineffective as the final temperatures ranged between 1.1 °C and 14.3 °C (7.5 °C average). The ice loss was practically total whereas the other options retained significant amounts. From the patterns of temperatures it is clear that once the protective top and bottom ice had been lost the outer fish rapidly warmed because of the lack of insulation from the deck and ambient heat (the centre fish were in fact cooler). Considering the practical effort and cost of getting the ice to the point of use, uninsulated boxes were too wasteful and when used alone are probably at best only suitable for very temporary iced stowage.

Insulated covers with boxes (Options C and D):
Icing in uninsulated boxes under insulated covers cooled fish well to about 2.7 °C average, although only about 22% average of ice remained, compared with about 40% with the insulated lidded boxes. The indications were that uninsulated lidded boxes (Option C) retained slightly more ice than unlidded equivalents (Option D) and gave marginally better and more uniform cooling. Overall, the top and bottom parts of the stacks of boxes lost the most ice - even to the point where fish were warming. A one off trial indicated that slightly raising the bottom box off the deck improved the retention of ice and hence thermal protection. A further one off trial of periodically removing the cover to simulate stowage in unlidded boxes of more fish as catching progressed gave similar cooling to the control stack where the cover remained undisturbed but with only 10% ice remaining compared with 20% for the control. The close fitting nature of the covers to the boxes and deck appeared to enhance drought proofing but the lesser thickness of insulation and lack of all-round thermal protection compared with the insulated box inevitably causes ice loss and restricts storage times. However this relative inefficiency may not matter if the fish are landed sooner rather than later.

Tarpaulin with uninsulated lidded boxes (Option E):
The results of trials of tarpaulins were not directly comparable to those of options A to D because of differences in duration, disturbance and amount of ice (2:1 compared to 2.3:1 by weight for A to D). The insulated tarpaulin retained some ice on the fish (5-25%) after about eight hours whereas insignificant amounts remained with the uninsulated version. Comparatively the fish temperature reductions (to 2.8 °C - 6.1 °C averaged)were about 2 °C better than for the uninsulated tarpaulin but in both cases the associated temperature ranges could be quite wide with fish possibly up to 10-12 °C. The general indications are that the use of tarpaulins over uninsulated lidded boxes (Option B) are of some benefit but because of their somewhat open nature and relative lack of drought proofing are ineffective compared with insulated covers (Options C and D).

Insulated container (Options F and G):
The one off trial of Option F (uninsulated boxes within insulated lidded container), although of a slightly shorter duration than for A-D, indicated that this option is as thermally effective as icing in insulated lidded boxes. The two trials of option G (stowing without boxes in a suspension of ice and water - termed slush icing) were not directly comparable to the main trials due to the lower icing ratios and shorter durations. However the method demonstrated rapid and potentially uniform chilling to 1 °C - 2.5 °C average within one to three hours. Albeit with little ice remaining. However this would have been mainly due to less initial ice, extra cooling requirement due to seawater used and the scale of temperature reductions achieved. It appears that the insulated, lidded, container used was thermally effective and slush icing is a potentially useful technique.

7.2 Practical Consideration of Equipment in Commercial Conditions
Observations indicated that lack of draught proofing and thermal protection from the deck structures were direct influences on the efficient use of ice. Thus the cooling efficiency of all the forms of equipment in working conditions is likely to be somewhat lower than in the trials because of removal of lids/covers and deck effects such surface water. In practice sensible measures to minimise these aspects and slightly more ice should help balance out the possible effects of working conditions.

The equipment types have different practical and thermal pros and cons. In principle boxes are versatile and manageable for stowing, landing etc. Insulated boxes retain some of that flexibility but because of the thick walls lose some capacity compared with ordinary boxes. Ordinary boxes however require the thermal protection of insulated covers or containers. Uninsulated lidded boxes and/or tarpaulins (insulated or not) are not thermally adequate. Insulated covers are a compromise in terms of thermal protection but have the important practical advantages of folding for storage, tailoring to particular box and stack requirements and versatility i.e. can be used to prevent exposure in landing and or transport. Containers confer better thermal protection but are likely not to be portable enough to land the fish in and possibly being awkward on deck. Part of their thermal protection advantage is in the insulated thickness of the walls, but this is a practical play off against their capacity and bulkiness.

The insulated containers/boxes are likely to be the most expensive stowage options. Uninsulated lidded boxes are expensive compared with ordinary boxes and therefore the extra investment would probably be better put to insulated covers or containers/boxes.

It seems that a 'mix or match' combination of equipment, tailored to the individual boat will be needed to maximise chilling. Depending on the port facilities the ice may need protection in delivery to the vessel as well as in storage aboard. Space on the vessel will also require practical choices. Catch protection ashore may also be a factor. Fitted containers or insulation to spaces below deck may help. Ideally this matter needs to be taken into account in the design and construction of the boat.

As the approach is one of developing equipment and techniques to be as practical as can be, the maximisation of potential will come from technical and practical refinement in commercial conditions. In the end, the chilling capacity will be limited by the amount of ice taken and its effective usage.

7.3 Specification of Equipment

The general principles of design in respect of thermal protection are adequate insulation, draught proofing and light or preferably white external colour. The parallel considerations in respect of hygiene are suitable drainage, impervious construction and ease of cleaning.

7.3.1 Insulated lidded boxes and containers

A basic requirement of a box is that it is light enough, when full, to allow one, or possibly two, persons to manhandle it. Overall weights of more than 50-60 kg are excessive in most circumstances. The hand holds should enable a secure grip and be draught proof. The boxes should also locate securely on one another.

The prototype insulated box/container construction of laminated 2-3 mm G.R.P.skins over 25 mm polyurethane foam is probably a reasonable compromise between practicality and insulative capability. The prototypes used the 'hatch' principle, i.e. a downturned rim on the lid, which fitted closely to the sides of the base and provided effective draught proofing.

7.3.2 Insulated covers

A basic requirement of suitable materials for construction is that it is fabricable into different configurations and remains flexible enough to fold.

The prototype construction consisted of PVC sheet skins over 8 mm air bubble material and appeared to be a reasonable compromise between insulative capability and practicalities. The layers were not bonded and the seams need to be sealed to prevent ingress and enable effective cleaning. A snug fit of the cover to the deck and boxes is required. An allowance of 25 mm on length, breadth and depth is reasonable to enable fitting whilst retaining draught proofing.

7.3.3 Uninsulated boxes
Standard fish boxes are available, some with lids.

7.3.4 Materials and commercial availability
The prototype materials and constructions for insulated boxes/containers are considered suitable for commercial use. The materials lend themselves to tailored requirements. Containers can be readily fabricated by local G.R.P. boatbuilders. Some rotationally moulded polyurethane skin and injected foam sandwich containers are commercially available but are too bulky for many small vessels. There are no suitable insulated box equivalents commercially manufactured. The potential demand for the commercial production of insulated boxes/containers has to justify tooling costs and factory production.

Insulated covers could be made available locally if fabricated by competent tarpaulin/sail makers. Suitable ready made skinned insulation material is not thought to be available and so has to be made up.

7.4 Quality

7.4.1 Effects of improved chilling
The quality work was supplementary to the chilling trials and the results give a general indication. Trials chilling to below 4 °C at sea prevented premature loss of freshness. In comparison the uniced fish at 14 °C–17 °C for 10–14 hours before slow chilling ashore, had lost some or all the valuable prime condition within 24 hours of capture.

Pattern of loss of freshness flavours

Sweet and characteristic flavour	Loss of flavour	No flavour	Off flavours developing
Prime condition	Little or no freshness		Staleness

Normal limit of consumer acceptability (TRS 6)

This pattern of loss of freshness over storage on ice is typical. The storage life for well iced cod till off flavours develop is typically about 11 days. Cod kept at 15 °C after capture can only be expected to have maximum useful storage life of only 1–2 days.

With respect to condition on landing; fish uniced at sea can look sea-fresh if well gutted, washed and kept moist and therefore the quality ill effects may not generally be apparent to the fishermen. Where the fish were reassessed over further storage on ice, it became clear that delayed cooling made uniced day trip fish no better than well iced fish from trips of a good few days. Thereby losing the advantage that day trip fish should be - the best. One buyer of trials fish intimated that they could be kept longer than normally would have been dared, enabling alternative outlets to be found. It seemed likely that this quality advantage was not passed on. It is known from previous observations and trials, that species such as Nephrops, cod, mackerel etc., can deteriorate to the point of rejection within 24 hours of capture, if not protected from high temperatures. Icing at sea has been shown to be needed to assure quality and is essential to retain freshness in the summer time.

7.4.2 Effects of catching and working practices

A major point which arose as a result of the observations is variation in quality of gill/tangle netted fish. In particular some gill netted cod were observed (and smelt) to have lost their freshness on removal from the nets. Additionally, some cod were damaged as a result of net marking and attack by predators such as crabs. This spoilage and damage was a result of the nets being left in the warm seawater for about 24 hours - the normal day trip vessel cycle of net hauling operations. As static (set) netting is a widespread inshore fishing method, some investigation of soak time effects on quality is probably needed.

The working of the fishing gear dictates priorities on these small vessels. Trawling is normally a regular activity which enables a timely and routine approach to fish handling. Static netting requires more gear handling and can command all possible time and deck space. It is with this gear working pressure that fish quality loss is more likely i.e. roughness in handling and exposure on deck with the likelihood of bruising, drying etc.

7.5 Overall Constraints to Development and Improvement

Apart from the constraints of space, time and facilities (there may not even be a deck wash fitted) standards of care in handling and treatment depend on training, pride and incentive on the part of the fishermen. It was observed that poorly handled, gutted and washed fish often made as much money as well handled fish.

It is clear that there is a general lack of incentive to improve quality and that the overriding constraint is industrial - not technical. Although it may be said that a lack of positive relationship between price and quality is a longstanding industrial problem, it is a particular case in many inshore localities. The practice of buyers mixing the fish from poorly and well handled sources results in little chance of a lift in quality to eventual markets. This in turn inhibits value improvement.

By its nature the inshore small boat sector is diverse, fragmented, remote and poorly linked to market. A basic and common deficiency is inadequate availability of ice.

The inshore fishermen and fish handler tends not to have a correct grasp of quality control because of traditional beliefs, lack of effective feedback from markets and insufficient training. Thus awareness and incentive are commonly missing. Fishermen tend to see the way forward in terms of intensification of fishing effort, not quality improvement. This lowers the priority on careful handling.

There is a need to develop the project by concentrating efforts on a particular group of fishermen and their catch outlet to see through a price/quality incentive as a result of improved practice. Although this will be a difficult feat to achieve because of prevalent negative practices it is necessary to try in order to demonstrate to industry a model of alternative and beneficial practice. An integrated approach with fishermen and buyers will be needed to develop improved practices and value it therefore follows that collaboration with other groups within Seafish may help.

8. Conclusions and Recommendations

8.1 Conclusions

- Effective icing at sea on small inshore vessels has been shown to be feasible.
- The types of insulated equipment tested: insulated covers over boxes, insulated boxes and insulated containers; have been shown to be practical and effective.
- With a fish to ice ratio of 2-2.5:1 by weight, cooling at sea to less than 3 °C (average) within 2-9 hours was achieved with this equipment.
- Effective icing at sea prevented the freshness losses that are typical of uniced day trip fish.
- The physical constraints of lack of space on small vessels, lack of ice supply and arduous conditions remain.
- The further constraints to quality improvement i.e. lack of knowledge, feedback from markets and price incentive remain also.
- Additionally, the deterioration suffered by static net caught fish could be a significant problem.

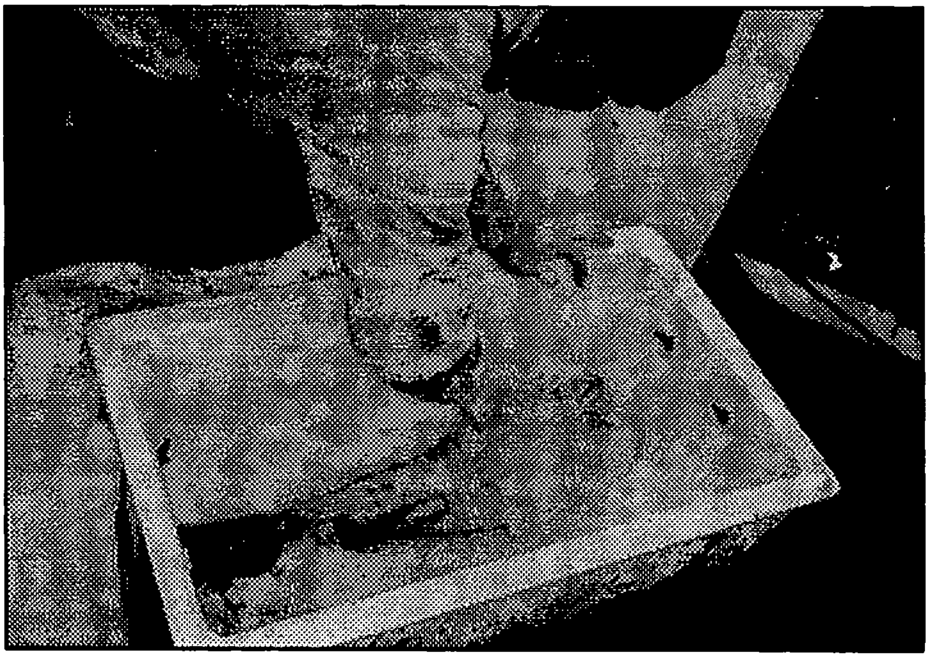
8.2 Recommendations

- The refinement of the icing equipment and techniques should be carried out with a particular group of fishermen and catch outlet in order to demonstrate commercial benefit.
- The effect of soak time on the quality of inshore caught static net fish should be investigated.

Appendix I

Details of Equipment Options Used in Fish Stowage Trials

A - Insulated Lidded Box



Dimensions (ext) - 0.83 m x 0.48 m x 0.33 m

Capacity - 70 litre

Construction - 3 mm GRP skins laminated over 20mm foam

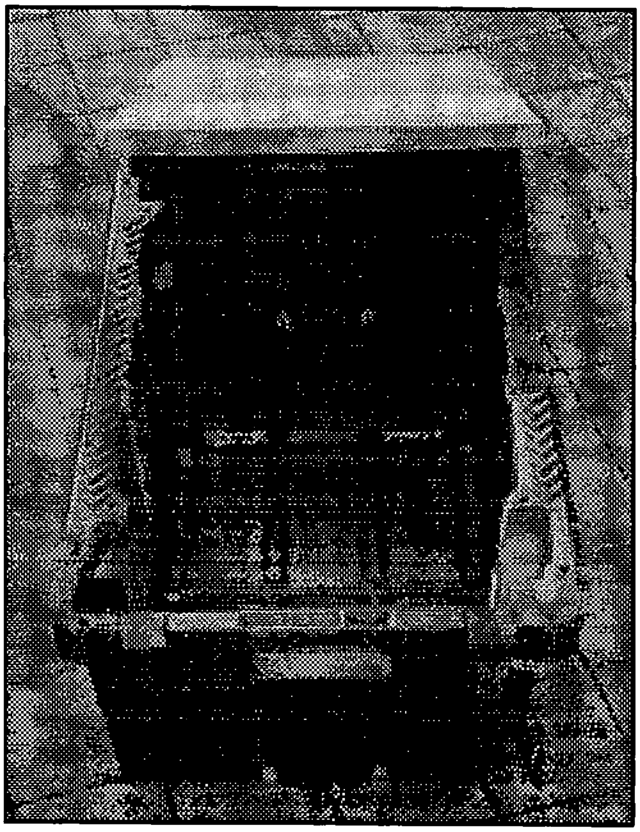
B - Uninsulated Lidded Boxes

G.P.G. Stack Nest Box Type C1519 with Specially Fabricated G.R.P. Lids

Dimensions (Ext) - 0.82 m x 0.48 m x 0.30 m

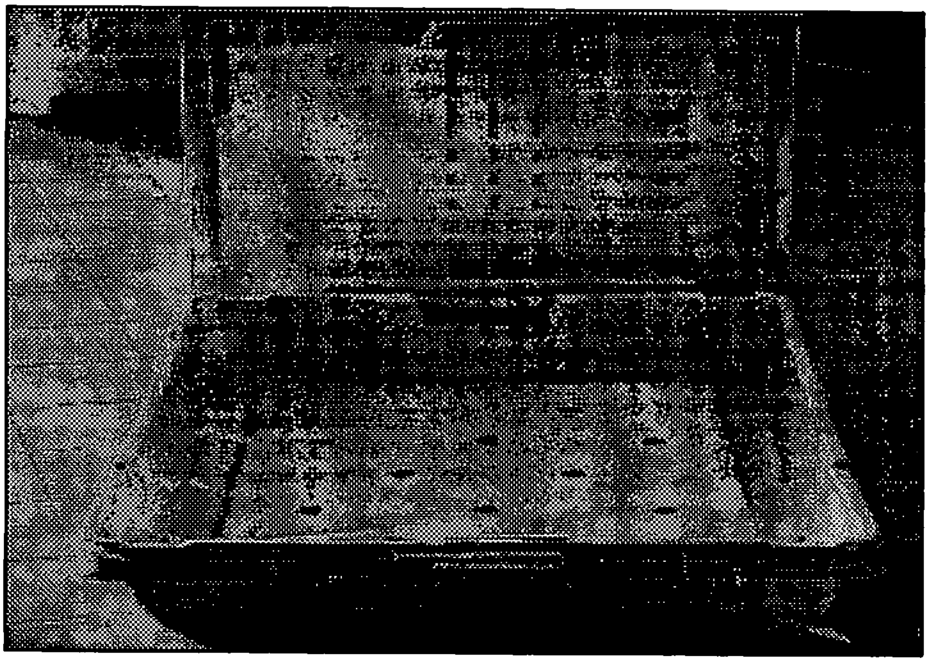
Capacity - 70 litres

Construction - Moulded plastic/3 mm G.R.P. lid

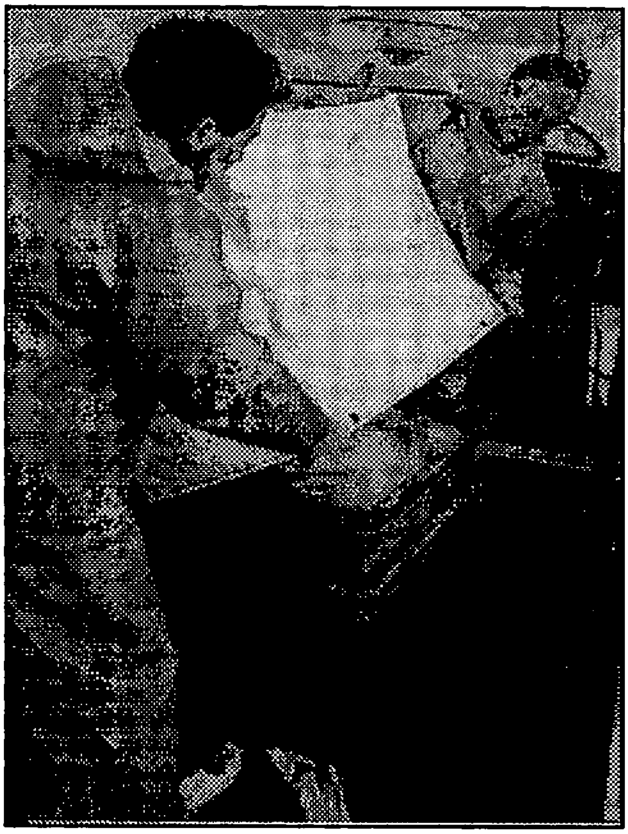


Allibert Slack Nest Lidded Box Type 39070:

Dimensions (Ext)	-	0.80 m x 0.60 m x 0.23 m
Capacity	-	70 litres
Construction	-	Moulded plastic



C/D – Insulated Cover

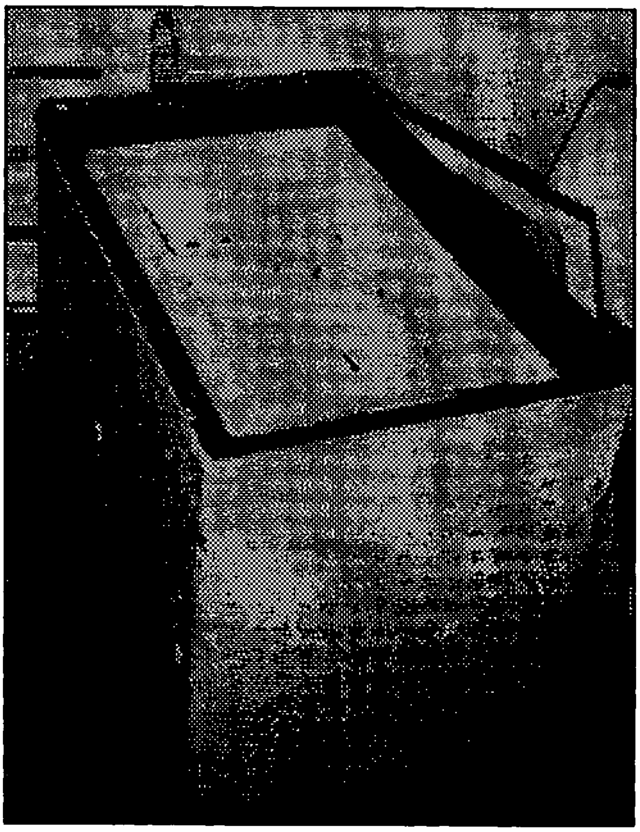


Dimensions	-	To suit particular boxes and stack heights
Capacity	-	Two or three high stacks of boxes
Construction	-	Loose sandwich of reinforced PVC skins over 8 mm thick insulated bubble material. The joins/edges were formed by stitching

E – Insulated Tarpaulin

\- Same construction as insulated covers

F/G – Insulated Container



Custom Made Container:

Dimensions (Ext)	-	0.94 m X 0.62 m X 0.8 m
Capacity	-	300 Litres
Construction	-	3 mm G.R.P. skins over 25 mm foam

Appendix II

Trials Data Obtained for Insulative Equipment A-G

List of Tables

Table 1 - Option A: Chilling in insulated lidded box - initial and final measurements

Port and date	Trial	Initial fish: ice ratio (by weight)	Initial and final ambient temps °C	Initial fish temps (average and range) °C	Storage time (hours)	Final fish temps (average and range) °C	% Ice left (by weight)	Comments
Looe 15 August	One insulated lidded box on deck	Top and bottom iced 2.3:1	19.8 and 18.1 (max. 24)	16.3 average Range: 15.2–17.9	7	3.7 average Range:2.5–7.4	35	Top fish of the box were coolest
Looe 17 August	Two insulated lidded boxes in a stack	Top and bottom iced 2.3:1	17.2 and 18.7 (max. 25)	15.1 average Range: 13.8–16.0	9	Top box 2.4 average Range:1.2–4.2 Bottom box 2.6 average Range:1.0–4.1	45	No particular pattern to temperatures
Looe 18 August	Two insulated lidded boxes in a stack	Top and bottom iced 2.3:1	18.9 and 18.8 (max. 19.2)	15.0 average Range: 14.5–16.0	10	Top box 1.9 average Range: 0.8–3.3	30	No particular pattern to temperatures or remaining ice
		Ice mixed through 2.3:1				Bottom box 0.6 average Range:0.2–1.9		The warmest temperatures were at the centre of the box
Bridlington 7 September	One insulated lidded box	Top and bottom iced 2.1:1	17.0 and 15.5 (max 17.8)	14.8 average Range: 14.4–15.1	7	3.0 average Range:1.4–4.0	40	No particular pattern to temperatures although least ice remained at the top

Table II - Option B: Chilling in uninsulated lidded boxes - initial and final measurements

Port and date	Trial	Initial fish:ice ratio (by weight)	Initial and final ambient temps °C	Initial fish temps (average and range) °C	Storage time (hours)	Final fish temps (average and range) °C	% Ice left (by weight)	Comments
Looe 15 Aug	Stack of two lidded boxes	Top and bottom iced 2.3:1	19.8 and 18.1 (max 24.8)	16.9 average Range: 15.2–17.8	7	6.8 average Range:1.1–10.5	7	The top and bottom most fish of the stack were the warmest
						6.4 average Range: 2.2–11.7	10	
Looe 17 Aug	Stack of two lidded boxes	Top and bottom iced 2.3:1	17.2 and 18.7 (max. 25)	15.1 average Range: 13.8–16.0	9	Top box 6.3 average Range: 2.7–10.4	5	The lowest temperatures were in the middle of each box. The warmest fish were at the bottom of the stack
						Bottom box 4.7 average Range:3.0–8.2	Very little	
Looe 18 Aug	Stack of two lidded boxes	Top and bottom iced 2.3:1	18.9 and 18.8 (max. 19.2)	15 average Range: 14.5–16.0	10	Top box 8.8 average Range:3.8–11.7	None	The highest temperatures were at the top and bottom of the stack
						Bottom box 11.7 average Range:6.3–14.3	None	

Table III - Option C: Chilling under insulated cover (using lidded boxes) - initial and final measurements

Port and date	Trial	Initial fish:ice ratio (by weight)	Initial and final ambient temps °C	Initial fish temps (average and range) °C	Storage time (hours)	Final fish temps (average and range) °C	% Ice left (by weight)	Comments
Looe 15 Aug	Stack of two lidded boxes under insulated cover	Top and bottom iced 2.3:1	19.8 and 18.1 (max. 24.8)	16.9 average Range:15.2–17.9	7	Top box 3.7 average Range:1.6–6.2	25	No particular pattern to range of temperatures but least ice left at top and bottom of stack
						Bottom box 3.1 average Range: 1.8–6.2	15	
Looe 17 Aug	Stack of two lidded boxes under insulated cover	Top and bottom iced 2.3:1	17.2 and 18.7 (max. 25)	15.1 average Range:13.8–16.0	9	Top box 2.0 average Range: 0.9–2.8	25	Same as above
						Bottom box 2.0 average Range: 0.6–4.0	30	

Table IV - Option D: Chilling under insulated cover (using unlidded boxes) - initial and final measurements

Port and date	Trial	Initial fish: ice ratio (by weight)	Initial and final ambient temps ° C	Initial fish temps (average and range) ° C	Storage time (hours)	Final fish temps (average and range) ° C	% ice left (by weight)	Comments
Looe 15 Aug	Stack of two unlidded boxes under insulated cover	Top and bottom iced 2.3:1	19.8 and 18.1 (max. 24.8)	18.1 average Range:16.8–19.6	7	Top box 3.4 average Range:2.0–4.8	15	No particular pattern to range of temperatures. Least ice remaining at top and bottom stack
						Bottom box 3.7 average Range:1.8–4.2	20	
Looe 17 Aug	Stack of two unlidded boxes under insulated cover	Top and bottom iced 2.3:1	17.2 and 18.5 (max. 25)	15.1 average Range:13.8–16.0	9	Top box 3.1 average Range:1.0–7.0	20	The highest temperatures were in the bottom of the boxes and the least ice remained at the bottom of the stack
						Bottom box 3.2 average Range:0.1–7.0	15	
Looe 18 Aug	Stack of two unlidded boxes under insulated cover	Top and bottom iced 2.3:1	18.9 and 18.8 (max 19.2)	15.0 average Range:14.5–16.0	10	Top box 3.8 average Range:1.9–10.6	25	The highest temperatures and least ice were at the top and bottom of the stack
						Bottom box 3.2 average Range:1.4–5.8	20	
	Same as above but the cover was removed for 5 minutes in each hour					Top box 5.0 average Range:1.6–10.0	10	No ice left at the top of the stack where the temperatures were highest
						Bottom box 2.4 average Range 1.4–5.8	10	
Bridlington 7 Sept	Stack of two unlidded boxes under insulated cover	Top and bottom iced 2.1:1	15.5 and 15.5 (max. 17.6)	14.8 average Range:14.4–15.1	7	Top box 2.4 average Range:0.1–8.2	20	Separating the iced fish from the deck appeared to improve ice retention
						Bottom box 1.4 average Range:0.0–3.6	20	
	Same as as above but bottom box rested in empty box i.e. separated from deck					Top box 0.6 average Range:0.1–2.6	30	
						Bottom box 1.5 average Range:0.5–3.0	30	

Table V - Option E: Chilling under tarpaulins - initial and final measurements

Port and date	Ambient range °C	Initial fish: ice ratio (by weight)	Initial fish temps °C	Tarpaulin type	No boxes monitored, storage times, final fish temps (°C and remaining ice *		
Rye 18 Sept	15.2–20.8 over 12 hour trip	Top and bottom iced 2.0:1	17.4–18.1	Ordinary	1 box after 4 hours 7.2 average Range: 2.7–10.6 Very little ice left	1 box after 6 hours 4.9 average Range: 1.9–8.3 ,5% ice left	1 box after 8 hours 7.6 average Range: 6.7–10.1 5% ice left
			17.4–18.1	Insulated	1 box after 2 hours 8.9 average Range:8.5–9.2 Ice not measured	1 box after 6 hours 6.7 average Range: 3.0–10.2 15% ice left	1 box after 8 hours 6.1 average Range: 4.1–9.5 5% ice left
Rye 20 Sept	16.2–25.5 over 14 hour trip	Top and bottom iced 2.0:1	17.5–18.4	Ordinary	1 box after 2 hours 8.9 average Range: 8.5–9.2 Ice not measured	2 boxes after 5.5 hours 7.1 average Range: 2.5–12.2 Ice not measured	2 boxes after 8 hours 6.1 average Range: 2.1–7.0 5% ice left
			17.5–18.4	Insulated	2 boxes after 2 hours 4.2 average Range:2.1–6.9 Ice not measured	1 box after 5.5 hours 5.0 average Range: 2.5–7.0 Ice not measured	1 box after 8 hours 3.9 average Range:2.3–5.2 Ice not measured
Rye 21 Sept	17.4–22 over 12 hour trip	Top and bottom iced 2.0:1	About 18.3	Ordinary	2 boxes after 3 hrs 6.4 average Range: 3.5–11.1 10% ice left	2 boxes after 4.5 hrs 5.9 average Range:3.9–15.4 5% ice left	4 boxes after 7 hrs 7.0 average Range:1.6–11 Very little ice left
			About 18.3	Insulated	2 boxes after 3 hrs 8.2 average Range: 2.3–13.3 10% ice left	2 boxes after 4.5 hrs 6.2 average Range:2.1–11.3 15% ice left	3 boxes after 7 hrs 5.1 average Range: 1.2–10.4 10% ice left
Rye 24 Sept	15.4–18.5 over 11 hr trip	Top and bottom iced 2.0:1	About 16	Ordinary		-	3 boxes after 9 hrs 5.0 average Range:0.7–11.7 5% ice left
			About 16	Insulated		-	3 boxes after 9 hrs 2.8 average Range:0.7-6.3 25% ice left

* Note the amounts of ice remaining were visually estimated and not measured - either initially or finally

Table VI - Options F and G: Chilling in insulated container - initial and final measurements

Port and date	Trial	Initial fish:ice ratio (by weight)	Initial and final ambient temps °C	Initial fish temps (average and range) °C	Storage time (hours)	Final fish temps (average and range) °C	% ice left (by weight)	Comments
Maryport 19 July	**Option F** Temperatures taken of bottom box of two stowed in the container	Top and bottom iced 2.2:1	18.5 and 21.0 (21.6 max)	18.0 average Range: 17.8–18.6	6.5 hours	2.7 average Range:1.5—4.3	Amount remaining not recorded	No particular pattern to temperature
Rye 26 Sept	**Option G** Slush icing of fish into container i.e. fish suspended in ice and added water	Fish:Ice 2.7:1 Fish:Water 10:1	17.8 and17.4	18.2 average Range: 18.0–8.3	3 hours	1.0 average Range: 0.7–1.3	Very little	This trial was slightly different because fish were added over the period. The results were after 3 hours cooling to the fish measured
Looe 18 Oct	**Option G** Slush icing Fish/ice/water	Fish:Ice 3:1	14.7	16.0 average Range: 15.6–16.5	1 hour	2.5 average Range: 0.3–6.4	Very little	Container only half filled as ice ran out

Appendix III

Temperatures of Hold and Deck Structures

Table I - Temperatures of hold and deck structures

Date and port	Conditions	Temperatures
Maryport **19 and 27 July**	Uninsulated wooden hold where ice being used. Sea temperature 16 °C. Outside ambients ranged 16.3 °C–18.5 °C during daylight hours	Temperature ranges over 24 hours (affixed thermocouples): Inner hull side 14.8 °C–18 °C; Deckhead 13.6 °C–23.4 °C; Engine room bulkhead 14 °C–17.2 °C; Centre hold air mass 9 °C–13 °C
Rye **3 August**	Uninsulated G.R.P. lined hold. Sea temperature 16 °C. No ice in use. Outside ambients ranged between 17.7 °C and 20.7 °C	Temperature ranges over 11 hours: Deckhead 15.5 °C–22.3 °C; Engine room bulkhead 20.6 °C–30.6 °C
Rye **18 August**	Wooden deck surrounding metal 'dry' exhaust pipe. The ambients on trip ranged between 15.5 °C and 19.4 °C	The deck temperatures (thermocouple proble point) at: 25 cm radius were 32.5 °C 50 cm radius were 28.1 °C 75 cm radius were 27.2 °C 100 cm radius were 22.2 °C 125 cm radius were 19.5 °C 150 cm radius were 20.2 °C
St. Ives **14 August**	Wooden deck, engine box and G.R.P. hull. Metal 'dry' exhaust pipe at from of engine box. Ambients 14 °C–17.9 °C	Surface temperatures: Front of engine box 15 °C–20 °C; Brown paintwork 18.5 °C; Blue paintwork 18.4 °C; White paintwork 17.4 °C
Looe **16 August**	Sunny day - brown wooden deck in dry condition	Point temperatures of deck surface about 20 °C

Appendix IV

Features of Fish Temperature Control Ashore

Table I - Features of fish temperature control ashore

Day and month	Place and operations	Conditions and temperature changes
22 July	Maryport: Delayed landing of catch	Mid morning with sunny and mid 20's ambient temps. Trials chilled fish left exposed at quayside warmed by up to 7.6 °C(2 °C average increase) within an hour
27 July	Hastings: Storage on market overnight	Box of iced-at-sea fish re-iced under insulated cover in comparison with normal practice of top icing on market and storage under a blanket-type cover. At 04.30 hours the insulated covered fish was at 6 °C average with some remaining ice. The fish under the blanket was at 8 °C with no ice remaining
14 August	St. Ives: landing mackerel into transport for Newlyn	Uncooled mackerel landed after 5 hour sea trip were at 15.8 °C-16.9 °C (after washing in harbour). Ambient at landing 17.9 °C. On this occasion there was no ice available.
18 August	Looe: Fish landed previous day and iced into chill overnight	Fish temperatures on landing between 4 °C–8.5 °C after top icing in the hold. The catch was sorted, weighed and iced into market chill overnight. Fish temperatues prior to auction the next day were 0.5 °C–3.1 °C