SEA FISH INDUSTRY AUTHORITY

Seafish Technology

IMPROVING THE POST HARVEST CARE OF SMALL SHRIMP

Crangon crangon *Pandalus montagui*

Internal Report No. 1422

H Teepsoo
M Boulter
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SUMMARY

Initial investigations have shown that it is **possible** for shrimp cooked at sea to meet the temperature requirements of both the Food Hygiene (Amendment) Regulations for cooked products and the E.C. Fishery Products Directive, which will come into force in January 1993. This is by the use of direct and indirect icing and insulated fish boxes to hold the cooked shrimp, on board vessel. Icing the cooked shrimp at sea also significantly extends the subsequent storage life of the product. It has also been shown possible to hold uncooked brown shrimp (*Crangon crangon*), in ice onboard and then transfer the cooking operation ashore and produce a satisfactory product. However, during these initial trials this practice was not found to be satisfactory with pink shrimp (*Pandalus montagui*).

These trials have examined a number of ways in which the post harvest care of small brown and pink shrimp can be improved to meet new legislation whilst retaining the characteristic acceptable flavours required by the trade. The work relates to the handling on small vessels in the Wash fishery which, because of their size, present limited opportunity for major changes in practices or equipment.

The work however is only partially complete because of funding limitations and there is a need to reinforce the findings and at a commercial scale.

Prior to the trials a sensory assessment score sheet was formulated by Seafish to enable analysis of the trials results, as the existing score system were found to be inadequate.

The report describes in detail the practices on board small shrimp vessels in the Wash fishery.

This report covers the initial investigations. In view of the current handling practices of shrimp on board vessel such as uncontrolled cooking, slow cooling in the open air or by direct contact with raw seawater of dubious quality, further work is recommended.

The work was carried out by Seafish during the summer months of 1990 in the Wash fishery.

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1. INTRODUCTION

Small brown shrimp (*Crangon crangon*) and pink shrimp (*Pandalus montagui*) are traditionally cooked at sea as they spoil rapidly in the fresh state. With a few exceptions this is carried out in the UK on small and aged fishing vessels with very limited facilities. There is little control of the cooking process, the cooked shrimp are generally cooled in the open air or by seawater and usually there is no further chilling.

From April 1991 the Food Hygiene (Amendment) Regulations 1990 require cooked products including shellfish to be rapidly chilled and kept below 8°C. From April 1993 this becomes 5° C. The purpose of this legislation is to prevent the growth of harmful bacteria in these relatively high risk pre-cooked products. However, the wording of that legislation precludes its application to shrimp vessels as they are neither catering businesses nor 'premises'. Nevertheless, from January 1993 the EC Fishery Products Directive requires that on these vessels the shrimp must be rapidly cooled after cooking to a temperature approaching that of melting ice and that there must be microbiological checks of the products.

It was thought unlikely that the small shrimp vessels could comply with these requirements. It was therefore necessary to consider alternative means of handling the shrimp.

In their published guidelines Seafish recommend that cooked products be chilled and be

handled carefully to avoid contamination. Although the vessels do not have to comply with the Food Hygiene (Amendment) Regulations they are required to use all 'due diligence' in producing a food which is safe for human consumption, under the Food Safety Act 1990.

Shrimp spoil rapidly once caught and cooking is the traditional means of preservation. If the shrimp does not curl this is traditionally taken as an indicator that they have been allowed to spoil. Chilling at sea followed by cooking ashore has been thought to be impractical because there is no easy access to ice and there is usually no chilled fish hold facilities on board. However, Seafish have already developed techniques of chilling using insulated fish boxes for use on inshore vessels and this technology could be implemented.

Trials were planned to investigate the possibility of chilling raw shrimp and transferring the cooking operation ashore and alternatively the rapid chilling of shrimp cooked on board.

Application for funding was made to MAFF and the work was started because of seasonal and staffing timescale factors. However, funding was ultimately provided by MAFF to Torry Research Station for shrimp work and so the Seafish work was curtailed. This report describes the preliminary work funded by Seafish and the results described here can only be taken as indicative. More work is recommended.

2. OBJECTIVES

The general aim was to gain a better understanding on the traditional practices of post harvest care of small shrimp and how these practices could be adapted to conform to new legislation.

More specifically the objectives were:

2.1. To investigate the possibility of rapid chilling raw brown and pink shrimps (*Crangon crangon* and *Pandalus montagui*) and cooking ashore.

2.2. To investigate rapid chilling of brown and pink shrimp (*Crangon crangon* and *Pandalus montagui*) which have been cooked on board vessel.

3. CURRENT HANDLING METHODS

3.1 Fishing Vessels and Methods

The Wash shrimp fishery is carried out by various types of fishing vessels. A description of these vessels is given in Appendix I and figures 1, 2 and 3 which for convenience are classified as Classes I, II & III.

Most of the vessels fishing for shrimps use a beam trawl of one type or another. The older vessels work a single beam, usually of wooden construction, worked off the side of the vessel. The more modern vessels use a twin beaming method with the beams supported on two derricks, one on either side of the vessel. These beams are made of steel. The shrimp beam trawls use a fine nylon net of 20mm mesh. Most of the more modern vessels are ex-Dutch beam trawlers.

The vessels usually tow their fishing gear for two to three hours between each hauling of the nets.

3.2 Cooking the Shrimp

Pink and brown shrimp are handled in the same way on board, although methods do vary from vessel to vessel and each vessel will have its own standard practice. At present all shrimps are cooked on board vessel with little control of the cooking process. The handling of the catch is described below.

On the older traditional wooden shrimpers the catch is landed onto the deck (See Figure 5) and immediately hand shovelled onto a riddle. On many larger, more modern vessels the catch is landed directly into a hopper on deck and conveyed onto a riddle (see Figures 4 and 6). A double vibratory riddle separates the shrimp from any unwanted fish, crabs, weeds and any small shrimps, which fall through the bars and are washed back overboard. Sizeable shrimp then vibrate along the second set of bars and fall into a box (see Figures 7, 8 and 9).

The boilers on board (called coppers) vary in size on each vessel (see figure 10). The boiler is filled with seawater. The small boilers hold around 45 litres (10 gallons) and a scoop or handful of salt is added to the water. Salt is not added to the seawater if pink shrimp are to be hand peeled, to allow easier peeling. The amount of salt may vary from vessel to vessel and it is not weighed. It is estimated that the amount of salt could be 1 to 5Kg. Salinity of the boiling medium is estimated to range from 3 to 10%.

Shrimps are cooked as soon as possible but time between handling and cooking could vary between 5 minutes and 1.5 hours if a large catch is made. How long the shrimps stay alive depends on the ambient temperatures, but on a hot day with a large catch the majority would be dead before cooking. Brown shrimp stay alive longer than pinks.

The amount of shrimps added to the boiling salt solution may vary considerably. Each vessel has its own rough method of a volumetric standard batch, such as 'a fish pad full' or 'half a fish box'.

Cooking is not timed but after being immersed in boiling brine, the water re-boils after about two minutes and the shrimps rise to the surface. The shrimps are then usually stirred using a mesh scoop and when the water boils again it is taken that the shrimps are cooked. Total cooking time is two or three minutes.

More modern vessels may have a boiler with a built in sieve to lift out the cooked shrimp but most vessels will add cold seawater to the boiling brine to prevent the water boiling over and to allow removal of the shrimp with a mesh scoop. Once removed from the boiling medium the shrimp are riddled again on a different double vibratory riddle to remove any unwanted pieces of crab or fish which may have broken up during cooking or any remaining small shrimp. This riddle usually has a water flow and the shrimp are cooled with seawater (see Figure 11). Older, smaller vessels only have one riddle and hence cooked shrimp are re-riddled on the same equipment as the raw shrimp (see Figure 9).

The more traditional way of cooling the shrimp is to cool by air which is thought to produce a crispier and firmer product. A few traditional skippers cool the shrimp this way even though they may have a modern vessel.

Once cooled any remaining, unwanted particles of weed, fish etc are picked out by hand. (See Figures 12 and 13).

Air cooled shrimp are usually measured by volume into net bags and stored in the open air on the deck at the stern. Seawater cooled shrimp are also hand picked and are stored in mesh fish boxes and again stacked on the deck at the stern in the open air, for the duration of the trip (see Figure 14).

This open air stowage may be from 3 to 48 hours. Some vessels have fish holds with air blast chillers but they are only used on the longer duration trips. In the holds the shrimp are stacked, openly in mesh fish boxes.

4. DEVELOPMENT OF SENSORY ASSESSMENT SYSTEM FOR SHRIMP

To assess the effect of the trial variables, a method of scoring was needed to distinguish between differences in quality on an objective basis.

In previous work by Humber Laboratory (ref 1) a score sheet was developed for raw and cooked shrimp combining *Pandalus montagui* and *Crangon crangon* (pinks and browns). This existing scoring system was developed from shrimp that had been steamed for an additional twenty minutes to ensure food safety. This produced acid, smoky odours and flavours which masked the normal flavours of non-reheated shrimp and was consequently un-realistic for these trials. It was agreed that in these trials the shrimp would not be reheated.

In addition to this the initial assessments of samples indicated differences between the two species of shrimp in quality factors during deterioration in storage which had not been differentiated in the previous work.

Therefore individual sensory score sheets for non-reheated pinks and browns were required. Cooked shrimp only were to be assessed, so a sensory scoring system for cooked pinks and browns was developed prior to starting the handling trials.

Five batches of *Crangon crangon* and four batches of *Pandalus montagui* were examined, noting changes during deterioration in chilled storage from absolute freshness to putridity.

Absolute freshness was difficult to attain because of the time delay in collecting samples from Kings Lynn and some of the commercial samples had not been chilled on the vessel. Samples of *Crangon crangon* available locally were caught by beach seining to keep the shrimps alive but the majority of them were dead on arrival a couple of hours later at the Seafish fish laboratory in Hull, where they were cooked to assess any differences in shelf-life and any organoleptic differences that may occur in varying salinity.

Different batches were boiled in 3%, 6% and 9% solutions of salt water for 3 minutes and assessed immediately.

Pandalus montagui were unavailable locally but commercial samples were obtained from Kings Lynn, which had been cooked then iced on board some with and some without added salt in the cooking medium, to assess any differences in shrimp from the different cooking methods.

Samples were presented to an informal taste panel of two to six staff who commented on the appearance, odour, texture and flavour of the cooked product. A number of descriptive

terms were agreed upon over a storage period of 15 days indirectly iced for both species. The system was refined further during the subsequent shrimp handling trails.

Appendix III contains the score sheets devised. The scoring systems are based on parameters of cooked shrimp: the general appearance and odours of the whole shrimp, the flavours and texture of the shrimp meats.

The scoring systems were developed using shrimp from the Wash during the summer months, and they may not be suitable for shrimp from elsewhere as regional and seasonal variations of shrimp are not known although samples of brown shrimps taken from the Humber proved to have a notable flavour of hydrocarbons. The shelf life of the shrimp was taken as the time which elapsed before the shrimp dropped below a sensory score of 3 after which unpleasant off-flavours developed that would clearly make the product un-acceptable.

The score sheets have not been statistically checked for their reliability or repeatability but Seafish are confident of their validity.

5. OUTLINE OF TRIALS PROCEDURES

The following variables were investigated during the trials;

5.1 Species

Trials were carried out with pink and brown shrimp to identify any differences between the species in storage life and organoleptic qualities including any differences after icing, cooking at sea and cooking ashore.

5.2 Cooking Method

Shrimp cooked on board the vessel in the traditional way were compared in terms of shelf-life and organoleptic qualities with shrimp that were held raw and cooked ashore.

5.2.1 Samples were cooked on board vessel as in the normal commercial practices. This is described in section 3.2. Some samples were cooked without any extra salt added to the boiling water.

5.2.2 Samples were held raw on board vessel and cooked ashore. The time delay from capture to cooking varied from 6 to 21 hours depending upon circumstances but not in a controlled fashion. On landing, the samples were placed into a standard shrimp vessel type boiler in a factory. The water temperature was brought up to boiling point and the shrimps then placed in it for 3 minutes. The shrimps were then removed by use of a mesh scoop. After allowing them to cool for 2 -3 minutes the shrimp were placed in plastic bags and iced. To assess any differences in shelf-life that may occur through varying salinity, different batches were boiled in 3%, 6% and 9% solutions of salt water.

5.3 Storage Method

Different ways of storing the shrimp on board vessel were investigated and how they affected the temperature of shrimp. The effect of each storage method on the shelf-life on the shrimp was also studied. Direct icing was thought to be harmful to the shrimp and so indirect icing methods were used for comparison. To keep the temperatures low all the samples were held in insulated boxes as described in Appendix II. Detailed descriptions of the different storage methods used are given below.

5.3.1 No Ice

These were control samples taken. Shrimp were left on the deck in mesh fish boxes after cooking on board. This is normal commercial practice.

5.3.2 Direct Icing
Shrimps were held in an insulated fish box in direct contact with ice.

5.3.3 Indirect Icing
Shrimps were held in plastic bags in an insulated fish box, and the bags surrounded by ice so avoiding direct contact with ice.

5.3.4 Fish Hold
Shrimp were held without any ice in open boxes in the refrigerated fish hold of the vessel.

5.3.5 In Sea Water
To keep shrimp alive before cooking ashore, shrimp were placed in sea water in insulated containers immediately after catching. The sea water was changed every 2 hours, to help keep the shrimp alive. The sea water was not iced and so as ambient temperatures were high, the temperature of the sea water increased.

5.4 Location
The shrimp fleet at Kings Lynn is by far the largest in the UK, fishing for *Crangon crangon* and *Pandalus montagui* and so the main part of the trials were carried out there. Trials took place over a 6 week period during July and August 1990.

5.5 Sea Trips
A total of 8 sea trips were conducted. The trips can be divided into 2 groups;

5.5.1 Three initial trips were made to assess the present operations of the vessels and to gain a knowledge of shrimp quality and rate of deterioration for score sheet formulation. Spot temperatures were taken of the shrimps at various points in the processing operation on board vessel.

5.5.2 A further 5 trips investigated the feasibility of storing and cooking shrimps in various ways and the effect on shrimp quality.

Further details of the sea trips and the temperature data collected during the first group are shown in Table 1.

TABLE 1

Sea Trip	Vessel Name	Class of Vessel
1	CORINA II	CLASS II
2	WASH PRINCESS	CLASS II
3	ANTARES	CLASS I
4	CORINA II	CLASS II
5	AUDREY PATRICIA	CLASS I
6	AUDREY PATRICIA	CLASS I
7	EIDER	CLASS III
8	ANTARES	CLASS I

See Appendix I for vessel classification

Sea Trips 1, 2 and 3 Temperatures

	Trip 1	Trip 2	Trip 3
	'CORINA II'	'WASH PRINCESS'	'ANTARES'
	TEMPERATURES (°C)		
Air	12.5°C	14°C	14.8°C
Seawater	11.6°C	12°C	13.2°C
Pre-Cooked Shrimp	11.8-12.4°C	-	-
Boiling Medium	103.4°C	102°C	102°C
Cooled Shrimp[1]	14.2-16.3°C	15-18°C	15-17°C
Fish Hold Air Temp	n/a	n/a	0.5°C
Shrimp in Fish Hold after 2 hours	n/a	n/a	0-1.6°C

5.6 Equipment

Details of the equipment used in these trials are shown in Appendix II.

[1] The shrimp were cooled in different ways on each trip:
Trip 1 - on air racks; Trip 2 - by sea water; Trip 3 - sea water and refrigerated fish hold

6. TRIALS PROCEDURE

During seatrips 4-8 samples of shrimps were held under 11 different cooking and temperature control regimes to enable measurement of temperature and assessment of subsequent quality differences.

During these 5 seatrips samples of brown shrimps were caught four times and samples of pink shrimps caught three times.

The different cooking and temperature control methods used were:

1) Cooked onboard vessel with no added salt in the boiling medium and stored on deck with no form of chilling.

2) Cooked on board vessel with added salt in the boiling medium and stored on deck with no form of chilling.

3) Cooked on board with added salt and then indirectly iced, by placing the shrimps in a plastic bag, on a bed of ice, in an insulated box.

4) Cooked on board with added salt and then directly iced on a bed of ice, in an insulated box.

5) Cooked on board with no added salt. Then indirectly iced by placing the shrimps in a plastic bag, on a bed of ice in an insulated box.

6) Cooked onboard with added salt then placed in mesh boxes in a refrigerated fish hold.

7) Kept raw on vessel and indirectly iced by placing the shrimps in a plastic bag, on a bed of ice, then cooked ashore after landing in a 6% salt solution for 3 minutes.

8) Kept raw on vessel and directly iced then cooked ashore after landing in a 6% salt solution for 3 minutes.

9) Held in a seawater tank whilst at sea then cooked ashore in a 3% salt concentration.

10) Held in a seawater tank whilst at sea then cooked ashore in a 6% salt concentration.

11) Held in a seawater tank whilst at sea then cooked ashore in a 9% salt concentration.

For details of which methods were used on each seatrip see Table 2.

TABLE 2
PINK AND BROWN SHRIMP SEATRIPS

		PINK SHRIMP			BROWN SHRIMP			
		Sea trip			Sea trip			
Key No	COOKING & STORAGE METHOD	4	5	6	4	5	7	8
1	Cooked onboard with no added salt/not iced	✓	✓					
2	Cooked onboard, with added salt/not iced	✓	✓			✓	✓	✓
3	Cooked onboard with added salt/indirect icing		✓	✓		✓	✓	✓
4	Cooked onboard with added salt/direct icing		✓	✓		✓	✓	
5	Cooked onboard with no added salt/indirect icing			✓				
6	Cooked onboard with added salt/chilled in fish hold							✓
7	Cooked ashore/indirect icing		✓	✓		✓	✓	✓
8	Cooked ashore/direct icing	✓	✓	✓	✓	✓	✓	
9	Kept alive in seawater tank/Cooked ashore in 3% salt solution.				✓			
10	Kept alive in seawater tank/Cooked ashore in 6% salt solution.				✓			
11	Kept alive in seawater tank/Cooked ashore in 9% salt solution.				✓			

6.1 SEATRIP 4

Seatrip 4 was on the 'Corina II'. Brown shrimps were held using methods 8,9,10 and 11. Most of the shrimps held in the seawater tank (methods 9,10 & 11) died before being cooked ashore, probably due to the water temperature, as it rose to 16° C before landing. Thus these methods were not repeated. The shrimps held by method 8 were mostly still alive before cooking. The shrimps had been held for approximately 6 hours before landing.

Pink shrimps were held using methods 1,2 and 8. The pink shrimp samples were held for approximately 12 hours before landing. Unfortunately on this seatrip no temperature recordings were possible due to equipment failure.

6.2 SEATRIP 5

On seatrip 5, six samples of pink shrimp were collected and five samples of brown shrimp. The pink shrimp were held before landing for 11 hours. The pink shrimp were held in the following methods: 1,2,3,4,7 and 8.

All these samples were monitored for temperature change on the vessel by a data logger. Upon landing, temperature measurements of ten shrimp within each sample were conducted to give a mean temperature on landing.

The five samples of brown shrimp were held before landing for 8½ hours by methods 2,3,4,7 and 8. Temperature measurement was done manually a few times during the trip and on ten shrimp within each sample upon landing.

6.3 SEATRIP 6

On this seatrip five samples of pink shrimp were collected and stored using methods 3,4,5,7 and 8. The temperatures were measured by data logger for all 5 methods of storage. Shrimp were in storage on the vessel for up to 8 hours before landing. On landing, manual temperature measurements of ten shrimp in each sample was conducted.

6.4 SEATRIP 7

On this seatrip five samples of brown shrimp were collected and stored using methods 2,3,4,7 and 8. The temperatures were measured by data logger for all five methods of storage. The shrimp were in storage on the vessel for 7 hours before landing.

6.5 SEATRIP 8

On this seatrip four samples of brown shrimp were collected and stored using methods 2,3,6 and 7. The shrimp stored using methods 2,3 and 7 were stored on deck and temperature measurement was by data logger. The shrimp were held in storage for 18 hours, until landing.

The shrimp held using method 6 were in the fish hold and temperature measurement was by manual means on three occasions. However, as was usual practice on this vessel, the boxes of shrimp were placed at the front of the fish hold near to the chillers when initially put into the hold, then moved further away, to allow for the input of the next haul of shrimp during the trip.

Therefore it was not possible to trace haul from which each batch originated. So on three occasions a measurement of temperature of each box of shrimp in the fish hold was made to give an assessment of overall temperature. The cooler boxes, probably relate to the boxes from the earlier hauls, which are comparable to the shrimp put into storage trials on the deck. (See table 3).

6.6 Sensory Assessment

All trial samples were assessed to determine the effect of each trial variable.

All batches of shrimp upon landing or cooking ashore were placed in plastic bags, immersed in ice and transferred back to the Fish Laboratory facilities in Hull. Batches were assessed by a panel of 2 to 6 staff. Notes were made of the general appearance and odours of the whole shrimps, the flavours and texture of the meats, over a period of 15 days. The descriptions were used to score the samples using the developed score sheet in Appendix III.

7. RESULTS AND DISCUSSIONS

7.1 Temperature During Different Storage Methods

Changes in temperature over time from stowage on the vessel to landing are shown in figures 15-19.

In all trials the samples which were directly or indirectly iced reduced in temperature to less than 5°C before the vessel landed. In all trials the uniced sample, handled according to commercial practice, did not drop much below the ambient temperature of 15-20°C during the sea trip.

Direct icing gave more rapid chilling than indirect icing although both methods gave ultimate temperatures close to zero within a few hours.

On seatrip 8, where shrimp were chilled in the vessel's hold, the results show that the shrimp mean temperature dropped to just below 5°C by the end of the sea trip. The data from this trial is somewhat confusing as the boxes were moved around in the fish hold as more shrimp were caught. The temperature of the shrimp in every box in the hold was measured 7 hours, 13 hours and 18 hours after the first boxes were put in the hold, but on each occassion some of the boxes had only been in the fish hold for a short period of time. In the other trials the sample shrimp all came from the first haul.

TABLE 3
Brown shrimp temperatures from individual fish boxes held in a refrigerated fish hold on Seatrip 8

Shrimp temperatures (°C) at time periods after first boxes stowed			
7 Hours	13 Hours	18 Hours	
1.7	1.8	2.5	6.7
3.4	7.4	2.2	11.6
13.0	3.0	4.3	5.2
3.0	10.9	2.7	6.7
8.4	3.2	3.6	6.7
2.7	0.9	6.6	5.0
1.4	6.3	3.7	2.2
14.3	13.3	2.8	2.0
9.7	6.5	4.4	2.0
11.8	7.2	9.2	2.1
12.3	4.3		0.5
	10.2		1.0
Mean Temp.			
7.4	5.85		4.23

7.2 The Effect on Quality of Chilling Shrimp Cooked at Sea

Changes in sensory scores over time are shown in Figures 20-27.

Both direct and indirect icing of the cooked brown shrimp on board vessels extended the shelf life by 2-3 days compared to the non-iced shrimp. Storing in a chilled fish hold did not result in a simarlarly increased shelf life.

Cooked pink shrimp which were indirectly iced had a shelf life of 1 to 2 days longer than non-iced shrimp. Directly iced cooked pink shrimp had a shelf life similar to non-iced shrimp.

Temperature data of the shrimp storage show that the direct and indirect icing methods dropped the temperature of the shrimps quickly and this is reflected in the extension in shelf life of the brown shrimp. Although indirect icing did take longer to drop the shrimp temperature than direct icing there was no indication of the different storage methods in the shrimp quality and both these methods of chilling were successful in extending shelf life.

Chilling the shrimp in the fish hold gave no extension of shrimp shelf life. However this storage method was only carried out once during the trials and so the results are limited.

Cooked brown shrimp which were directly iced had an extention to shelf life of around 2 to 3 days, whereas directly iced cooked pink shrimp had a similar shelf life to non-iced cooked shrimp. This is not easily explained. However, water uptake from the ice was noted at the time of tasting pink shrimp, with excessive wateriness under the shells on peeling. This may have washed away sweet characteristic flavours resulting in a lower sensory score. The pink shrimp are obviously much more sensitive to changes than brown shrimp.

7.3 The Effect on Quality of Cooking Shrimp Ashore

Attempts to keep the shrimp alive at sea by holding them in water largely failed and resulted in poor products.

All the shrimp which was directly iced at sea and cooked ashore had high sensory scores at the initial tasting immediately after cooking. These scores were similar to the commercial samples which were cooked at sea but not iced at sea.

For brown shrimp, directly iced at sea and cooked ashore samples had a consistently long shelf life of around 7 to 8 days whereas indirectly iced at sea and cooked ashore samples had a shelf life of around 5 to 6 days and had consistently poorer initial

sensory scores. Commercial cooked at sea but not iced at sea shrimp had a shelf life of 4 to 5 days.

Icing raw pink shrimp at sea and cooking ashore did not produce a satisfactory product. The shrimp were pale and had white patches on the heads. There was a distinct lack of sweetness with unpleasant, lard type flavours.

Temperature data taken, shown in Figures 15-18, show that the indirect icing method took longer to lower the temperature of the shrimp than the directly iced shrimp. The differences in quality between the directly iced and indirectly iced samples, reflected by higher initial sensory scores and a longer shelf life, suggest that the difference in temperature for the first few hours after the shrimp are caught affects the long-term quality of the shrimp. There was insufficient data to determine the expected effects of storage delay prior to cooking.

The pink shrimp were chilled and cooked in a similar way to the brown shrimp and so the difference in quality may be explained by a more rapid deterioration from capture to cooking in the pink species.

Shrimp cooked ashore were noted as having a slightly paler colour compared to shrimp cooked on the vessel. It had been believed that if the shrimp were not cooked alive immediately on board vessel they would not curl but no evidence was found to support this. The majority of shrimp curled tightly with no apparent differences to shrimp cooked on board vessel.

7.4 Effect of Salt Concentration in the Boiling Medium on Shrimp Quality

Brown shrimp, on seatrip 4 and the score sheet formulation samples cannot be compared with other batches as all these shrimps were held in sea water, with no ice, in an attempt to keep them alive. Significant deterioration may well have occurred prior to cooking as most of the shrimp were dead at the time of cooking.

The results are limited and it was not possible to control the time delay between capture and cooking, and other factors.

The results do not indicate the expected pattern of increased shelf life with increased salt concentrations.

9% salt concentration led to excessively strong salt flavours which masked the characteristic flavours.

8. CONCLUSIONS

Only tentative conclusions can be drawn from these initial trials in which all the relevant variables were not fully investigated.

8.1 Indirect icing at sea of shrimp cooked at sea can successfully bring the product temperature down below 5°C using insulated fish boxes.

8.2 Sensory scores of cooked then indirectly iced at sea brown shrimp indicate an extension to the shelf life of 2 to 3 days in subsequent chilled storage compared to shrimp not iced at sea.

8.3 Sensory scores of cooked then indirectly iced at sea pink shrimp indicate an extension of the shelf life by 1 to 2 days in subsequent chilled storage compared to shrimp not iced at sea.

8.4 Direct icing at sea after cooking at sea also gave good results for brown shrimp but resulted in a poor quality pink shrimp product.

8.5 Brown shrimp that was iced at sea, then cooked ashore produced a satisfactory product.

8.6 Pink shrimp that was iced at sea, then cooked ashore did not produce a satisfactory product.

9. RECOMMENDATIONS

The work has identified current practices on the smaller class of shrimp trawler found in the Wash, fishery but time and funding only permitted some lited scale trials of the factors affecting quality loss. It is recommended:

9.1 Further, more extensive investigations are conducted, repeating and extending this work under controlled conditions and on a larger scale.

9.2 Further work is conducted to investigate the microbiological safety of the product, particularly shrimp which are cooled by sea water.

9.3 Investigations are required on intrinsic seasonal differences in the 2 species and effects on cooked and chilled products.

9.4 Further work is conducted to investigate the importance of the time period of storage in the raw state prior to cooking.

9.5 Further work is conducted into equipment used during indirect icing, in particular with sealable plastic bags to prevent shrimps having direct contact with ice.

9.6 Consideration is given to the equipment required on board vessel if the shrimps are to be hygienically cooked and handled at sea.

9.7 The effects of chilling and cooking on the peeling characteristics requires investigation, particularly in relation to the possibilities of mechanised peeling.

9.8 That the sensory score sheet which was formulated for the purposes of this work, if used with further work, it's accuracy is investigated statistically and the system revised if necessary.

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4. **HOPPER, TUMILTY, PELL, MACMULLEN (1987)** 'Estuary Profile The Wash'. Seafish Internal Report No.

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FIGURES

Figure 1 - Class I type vessel

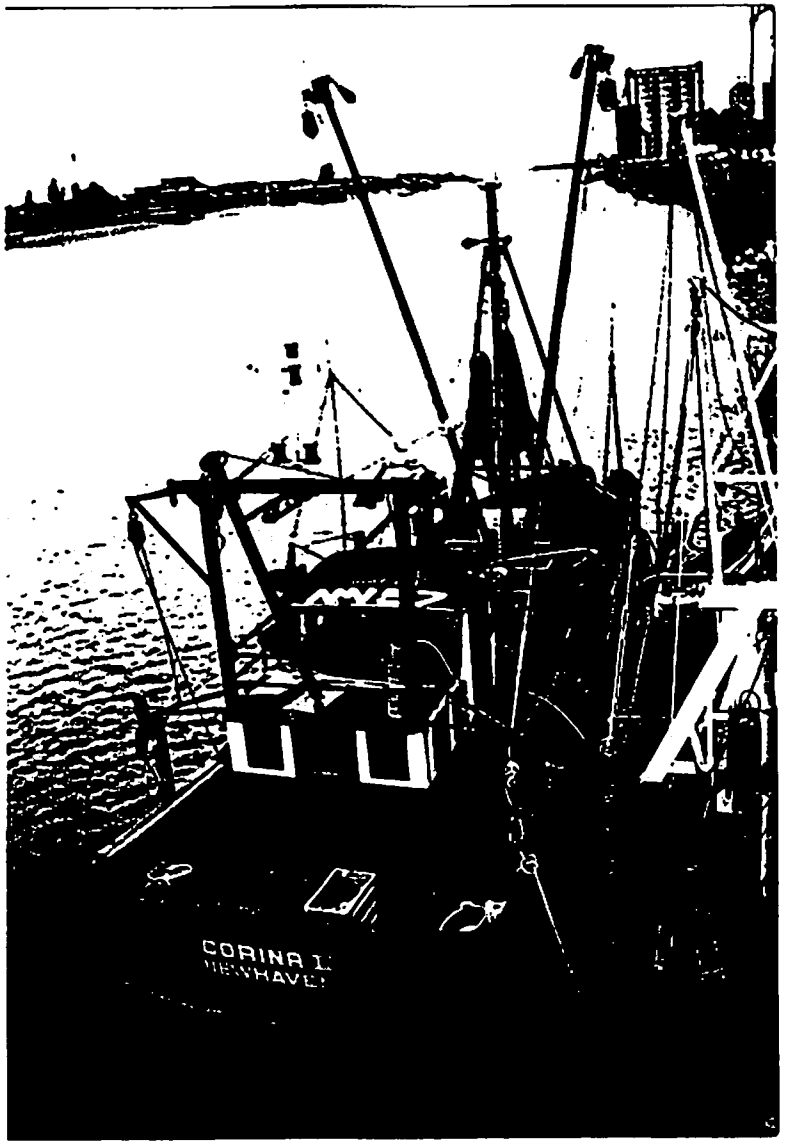


Figure 2 - Class II type vessel

Figure 3 - Traditional wooden shrimpers, Class III type vessels at Kings Lynn

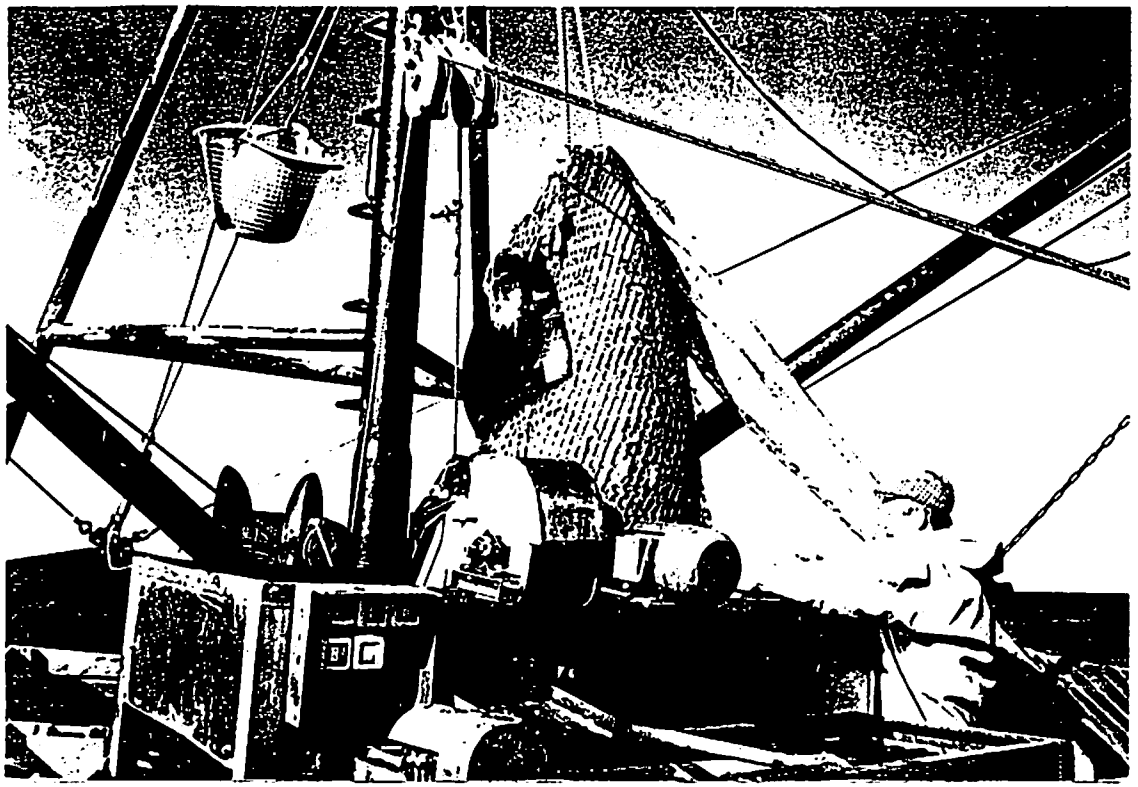


Figure 4 - Landing catch onto Class II type vessel

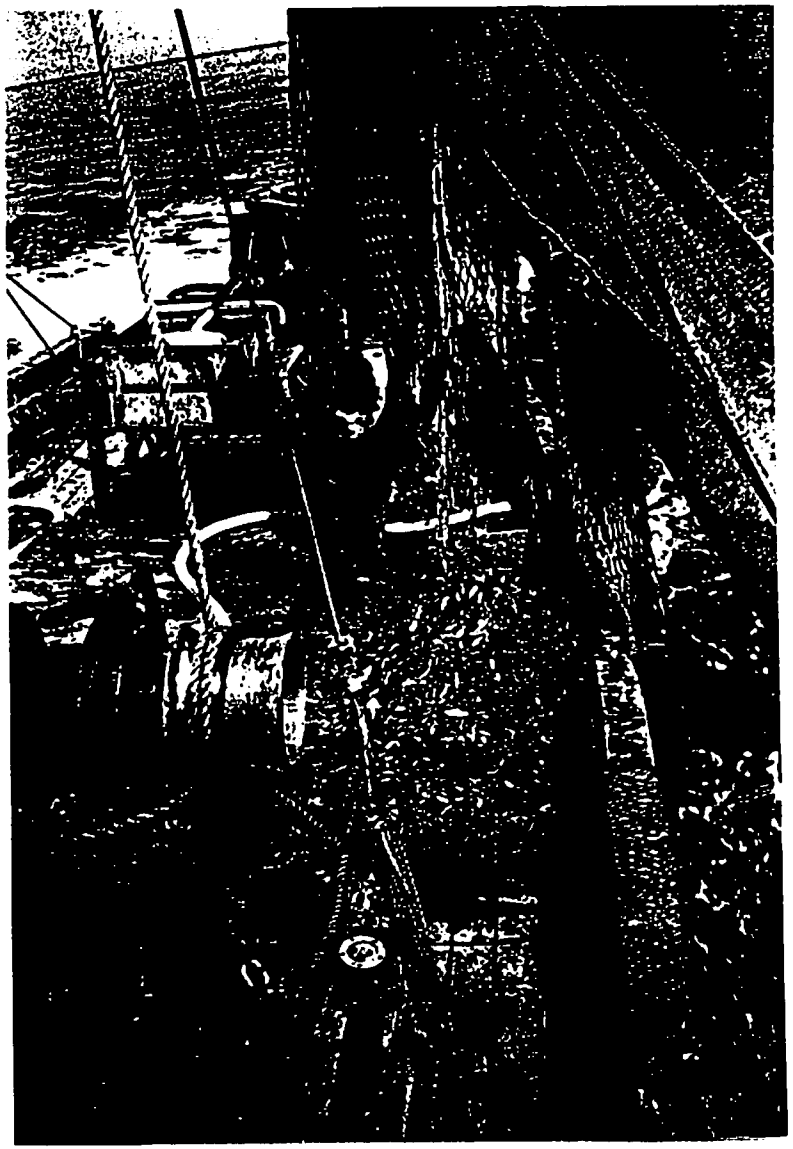


Figure 5 - The landed catch on Class III type vessel

Figure 6 - Catch conveyed from hopper to riddle for cooking, on Class I type vessel

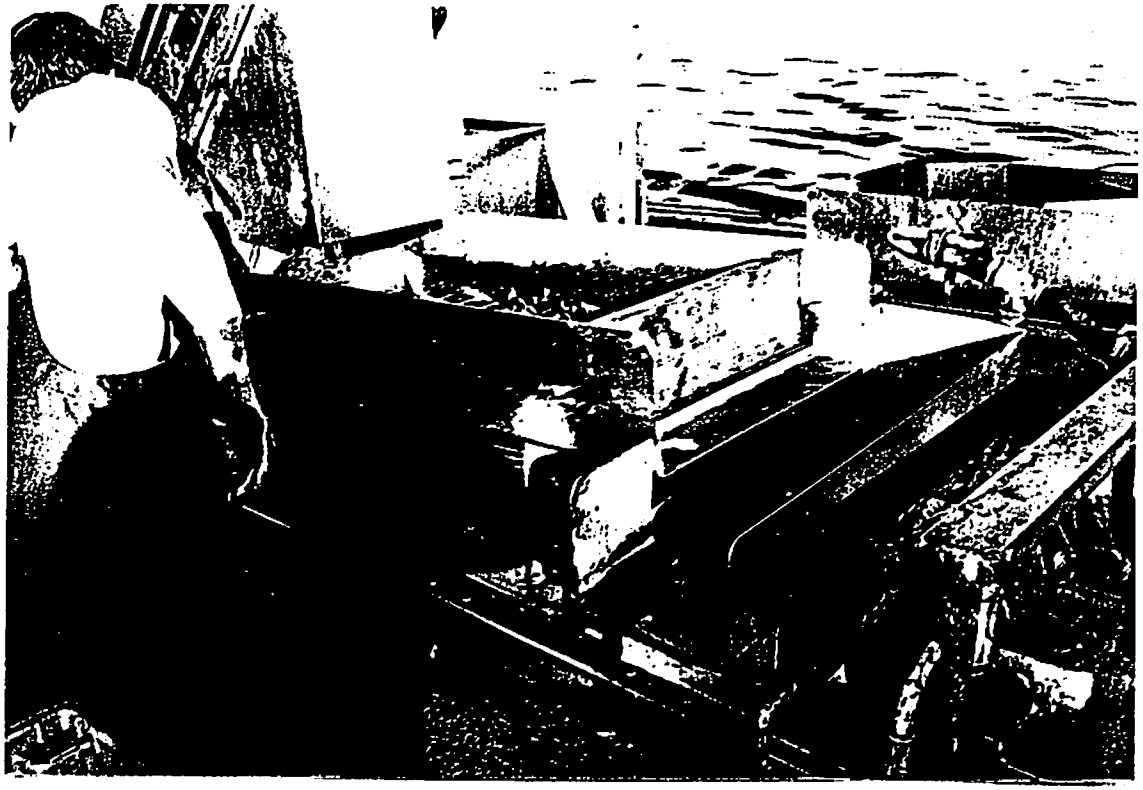


Figure 7 - Double layer vibratory riddle on Class I type vessel

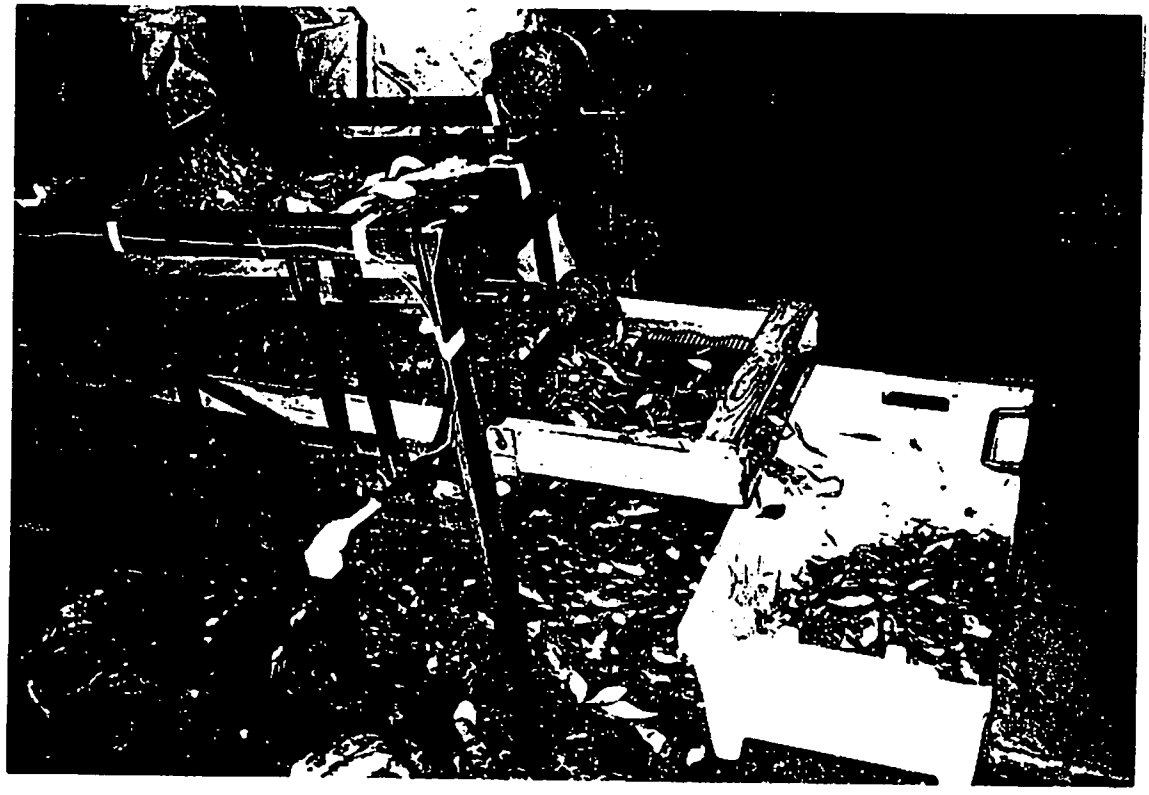


Figure 8 - Pre-cooking, double layer vibratory riddle on a Class II type vessel.

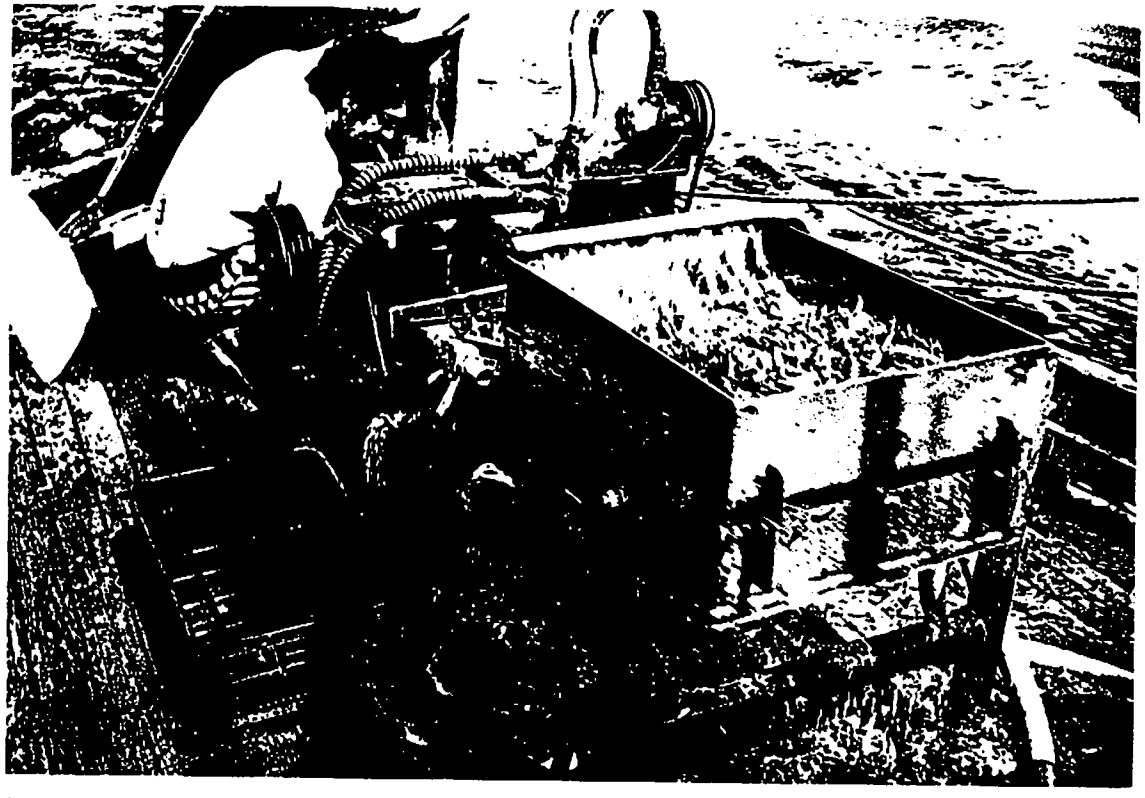


Figure 9 - Pre-cooking, double layer vibratory riddle on Class III type vessel

Figure 10 - Shrimp boiled on a Class II type vessel

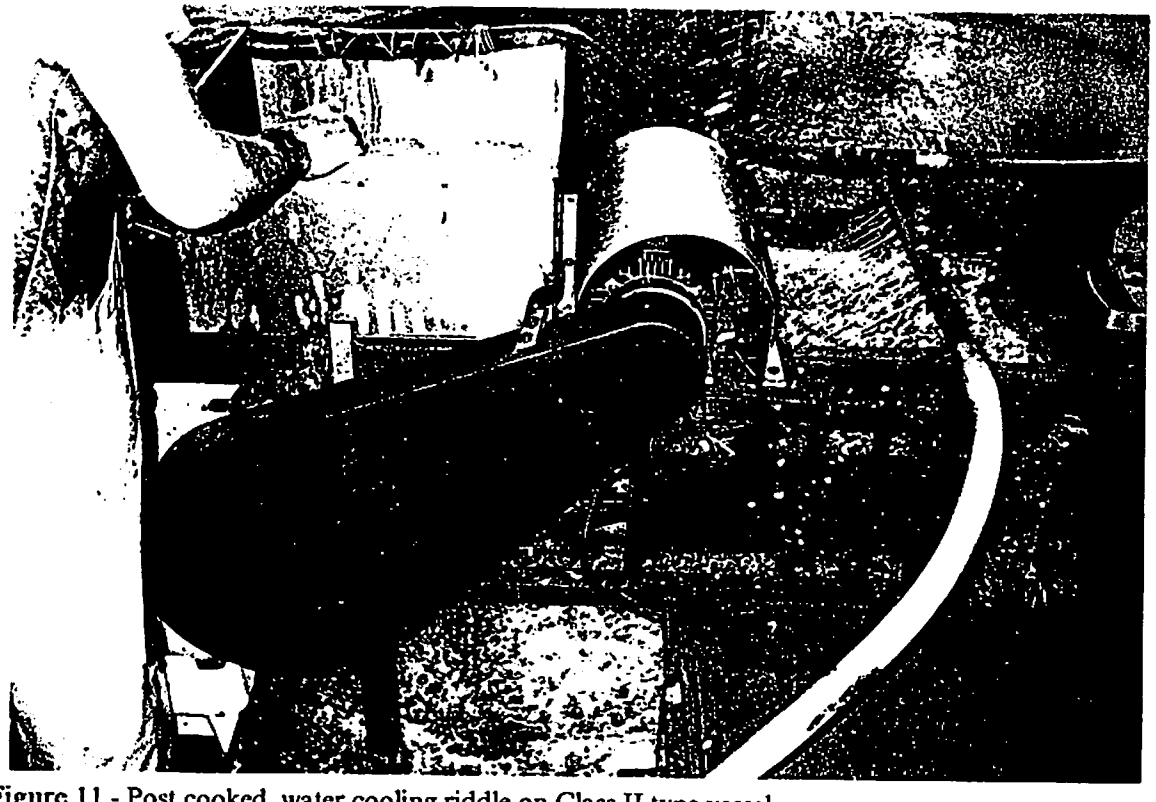


Figure 11 - Post cooked, water cooling riddle on Class II type vessel

Figure 12 - Hand picking any unwanted fish particles, crab etc. from cooked pink shrimp, from an air drying rack

Figure 13 - Hand picking out any unwanted fish, crab etc. from cooked shrimp on a Class II type vessel

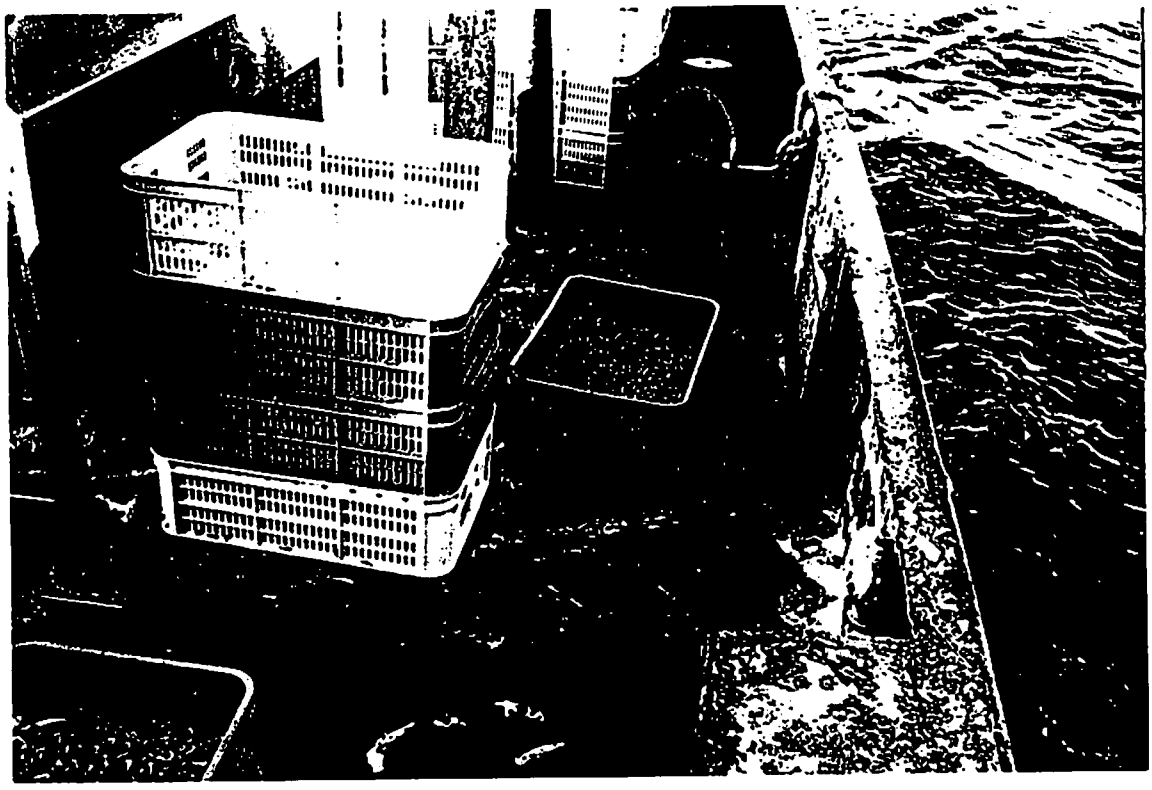


Figure 14 - Boxes used to store cooked shrimp on the deck, until landing

Fig. 15. Temp. profile of Pink shrimp in storage on seatrip 5.

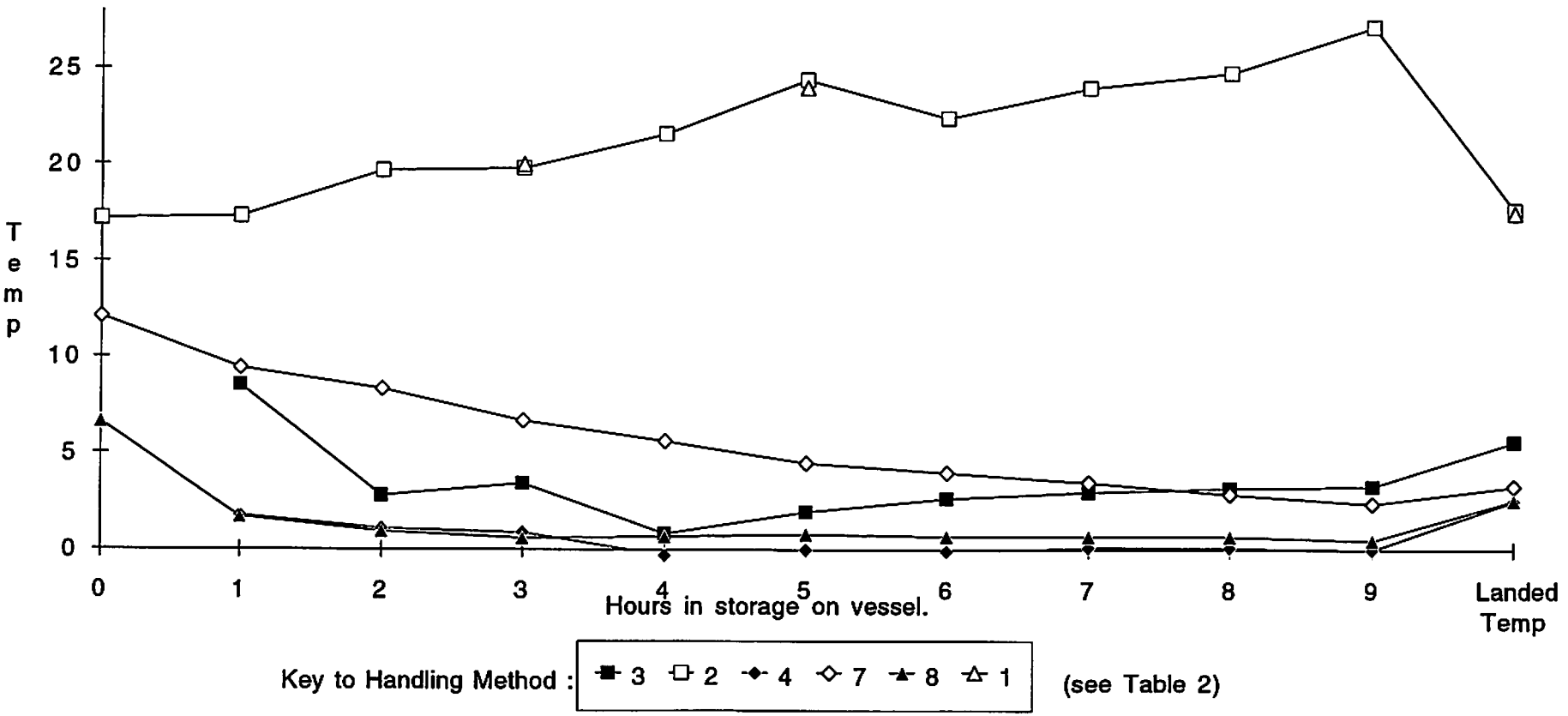


Fig. 16 Temp. Profile of Pink Shrimp in storage on seatrip 6.

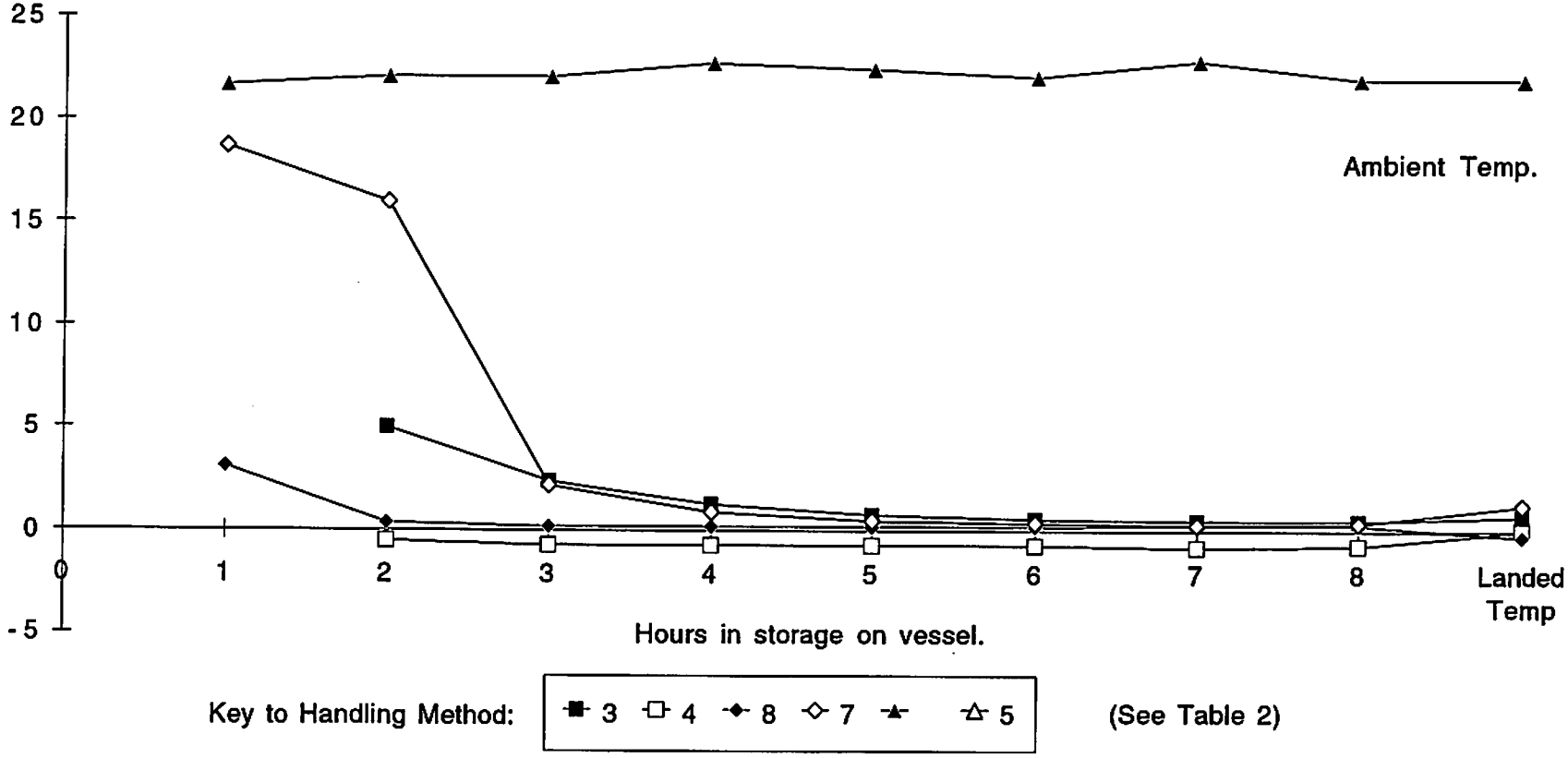


Fig. 17 Temp. Profile of Brown shrimp in storage on seatrip 7.

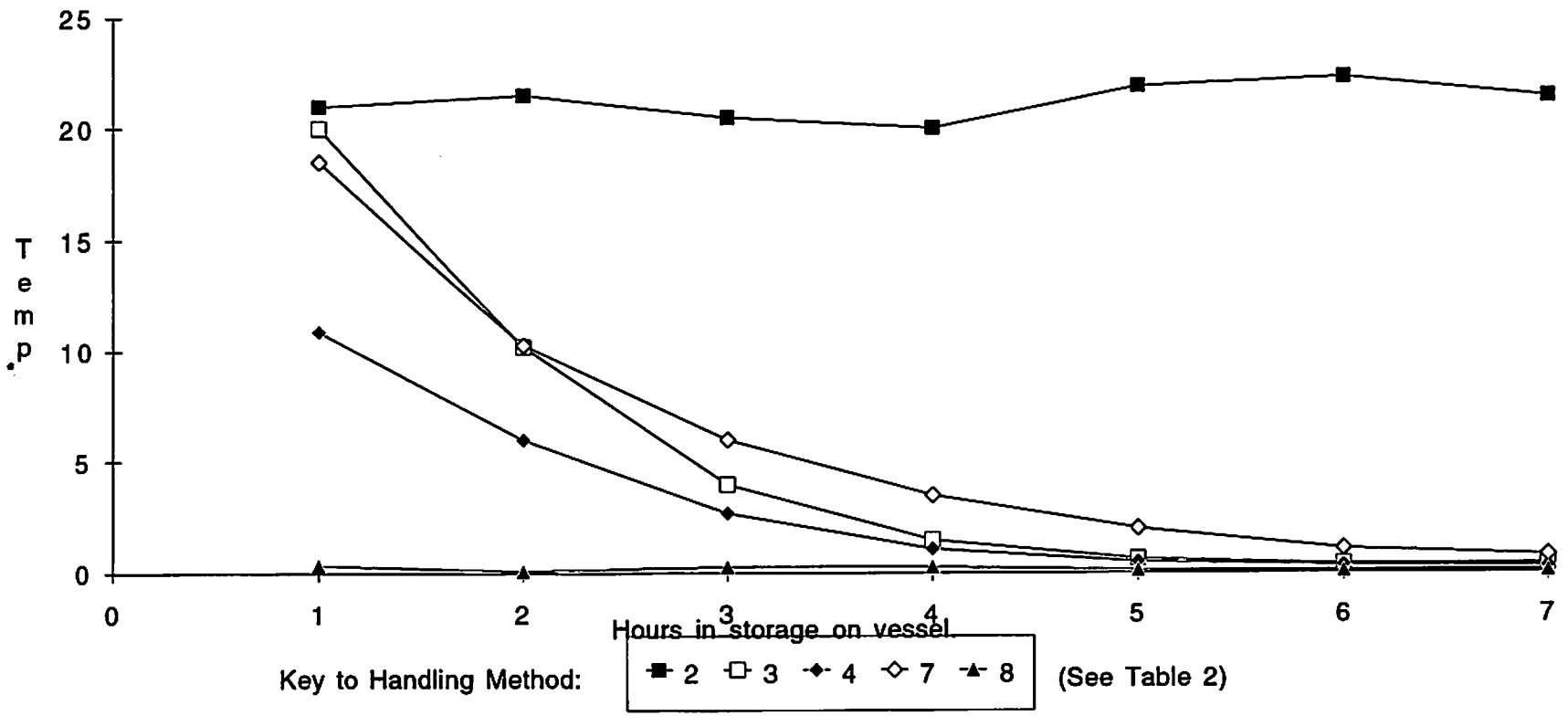


Fig. 18 Temp. Profile of Brown shrimp in storage on seatrip 8.

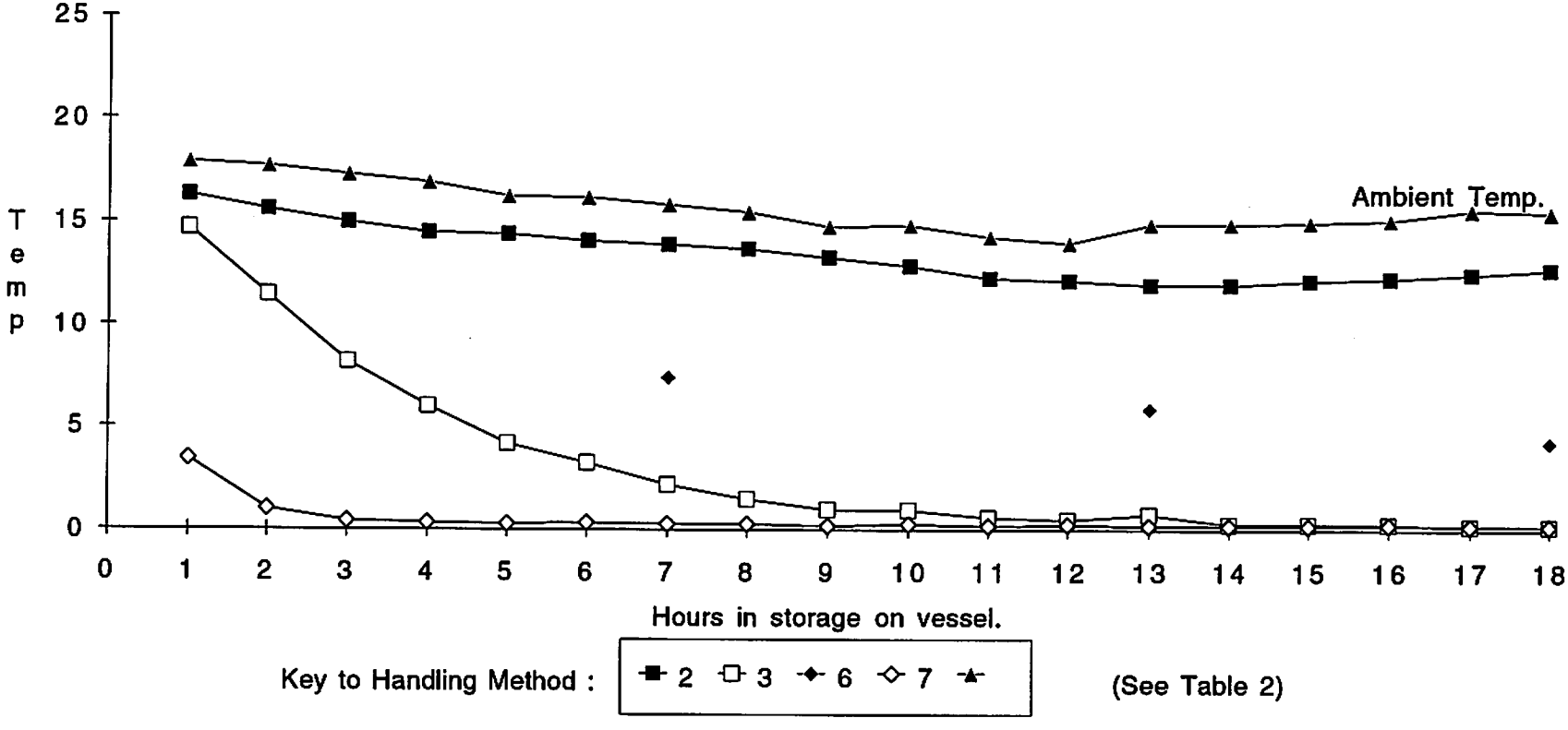


Fig. 19 Temp. of individual boxes of brown shrimp held in refrigerated fish hold in trial 8. (See Tables 2 & 3.)

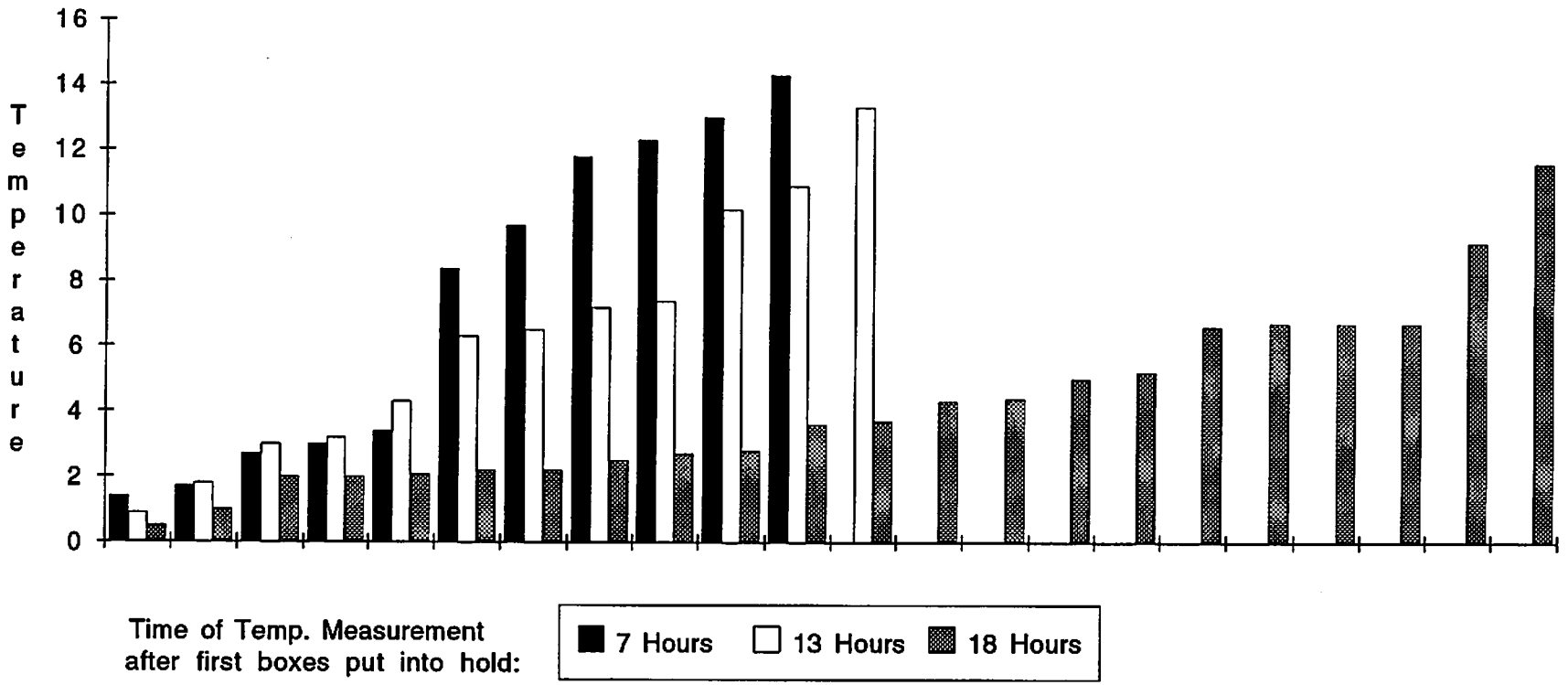


Fig 20 Quality assessment of Brown shrimp from seatrip 4

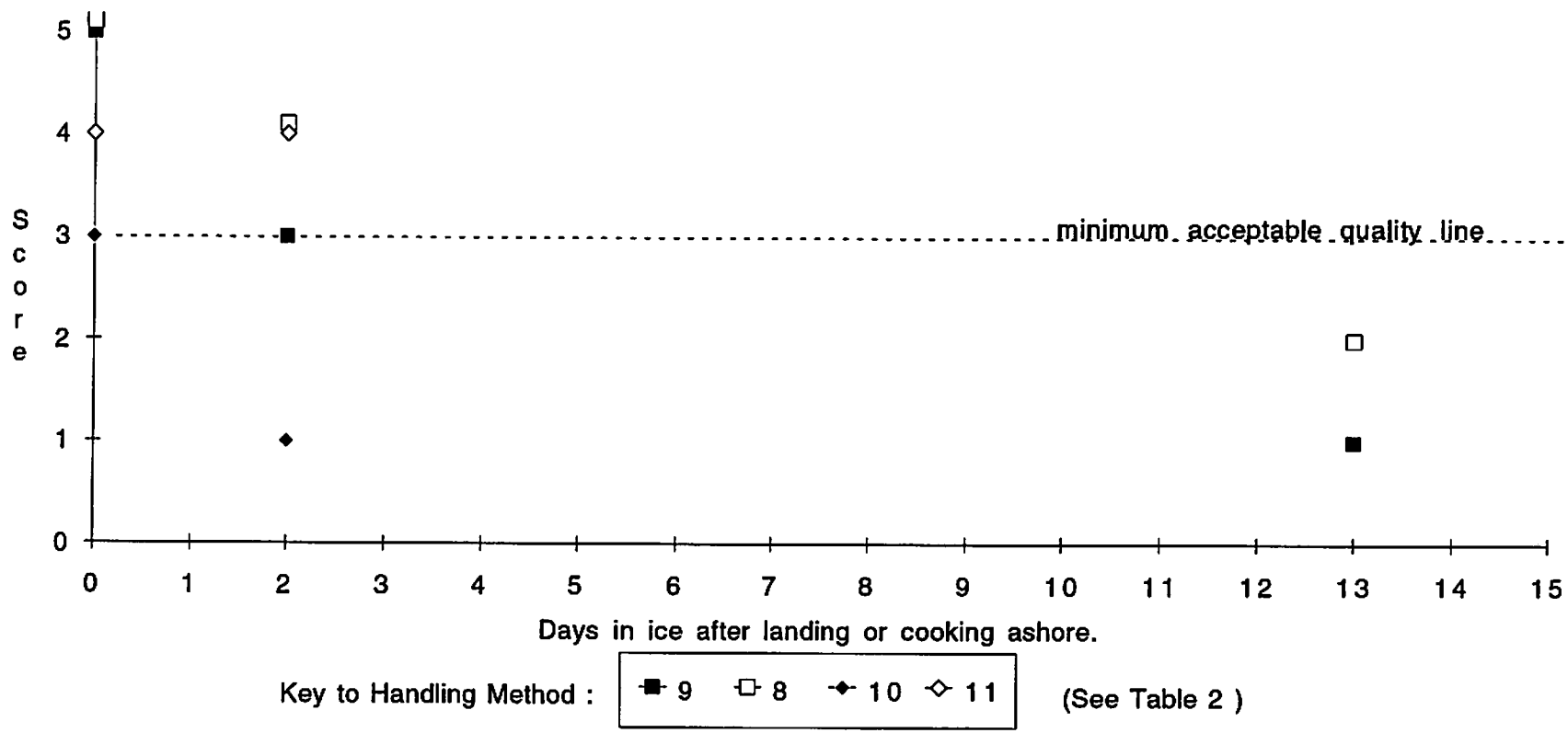


Fig. 21 Quality assessment of Brown shrimp from seatrip 5

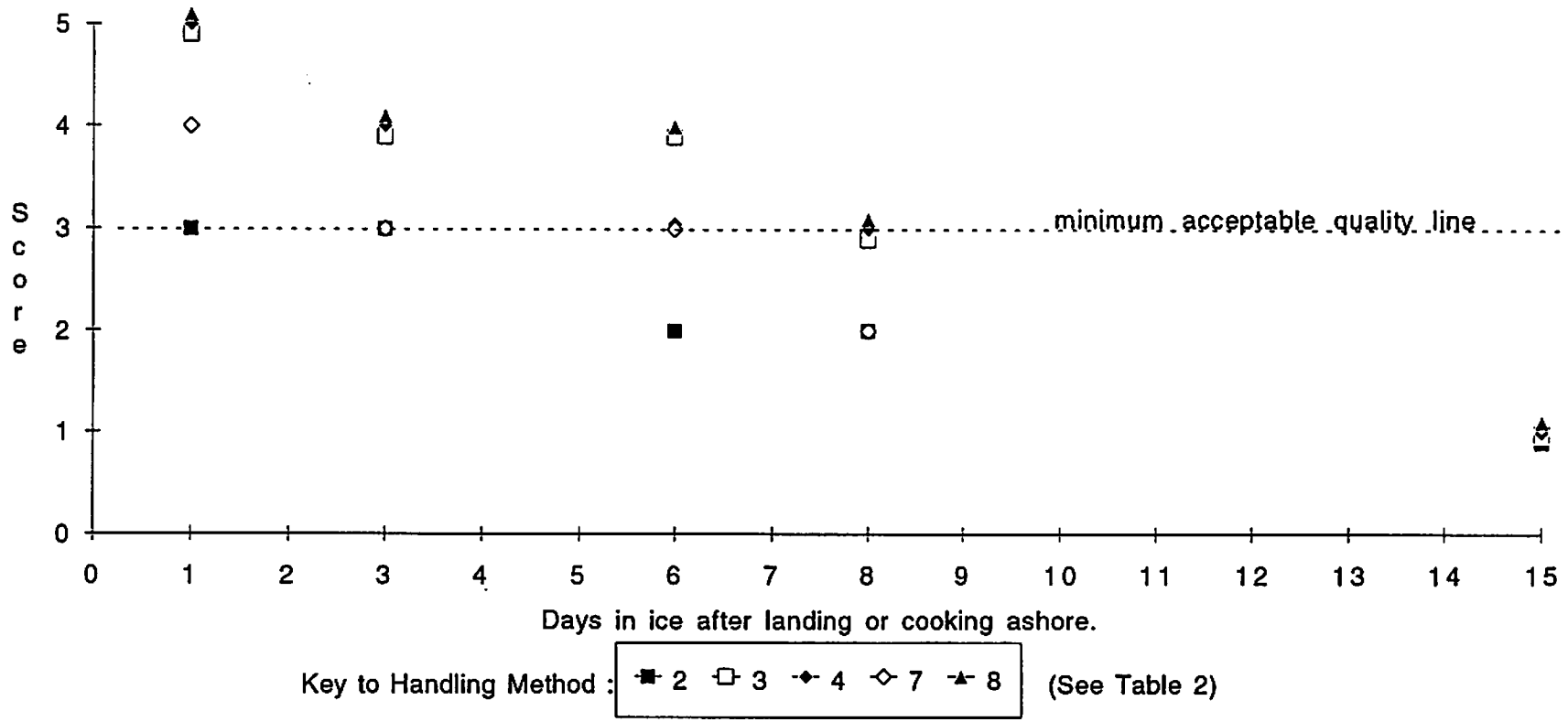


Fig 22 Quality assessment of Brown shrimp from seatrip 7

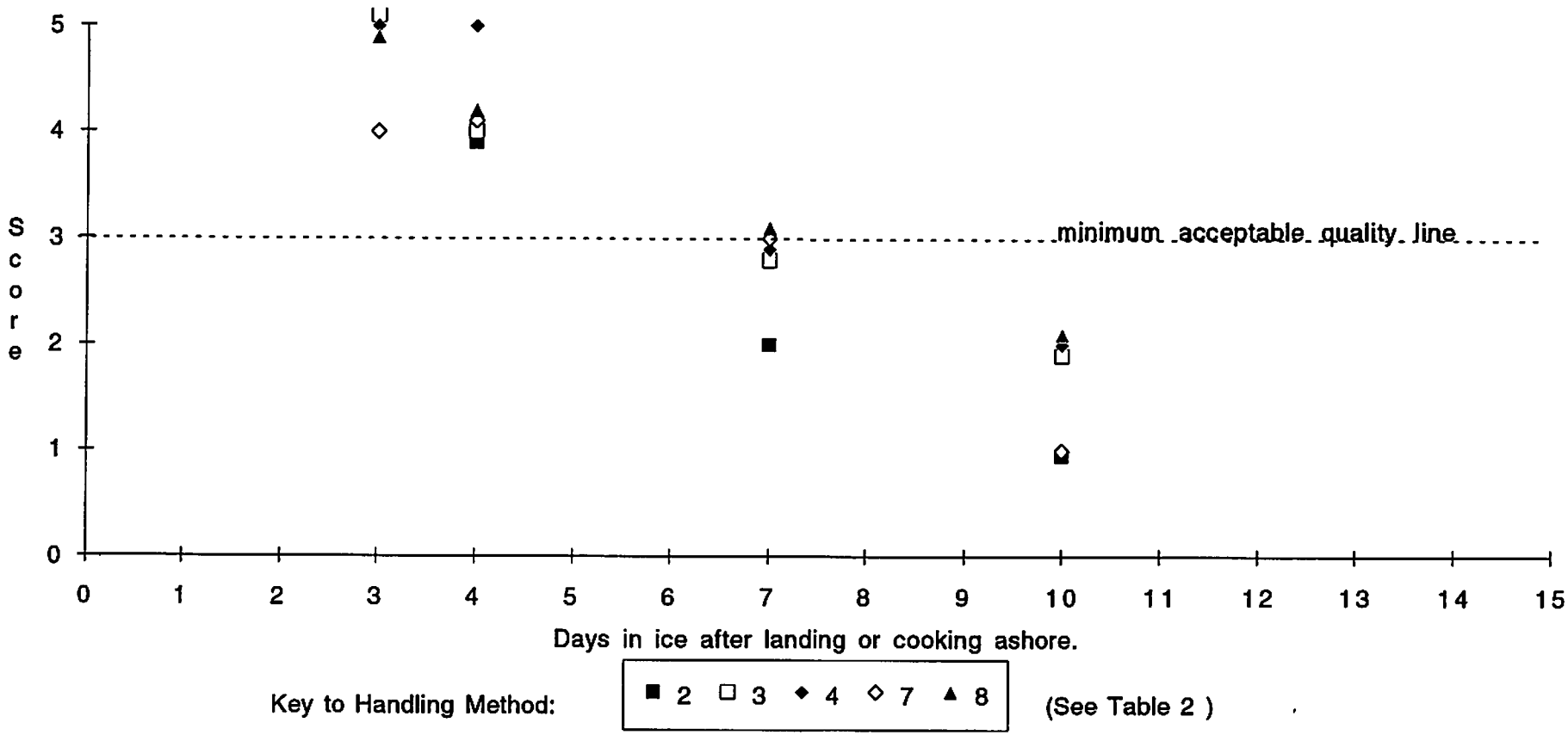


Fig 23 Quality assessment of Brown shrimp from seatrip 8

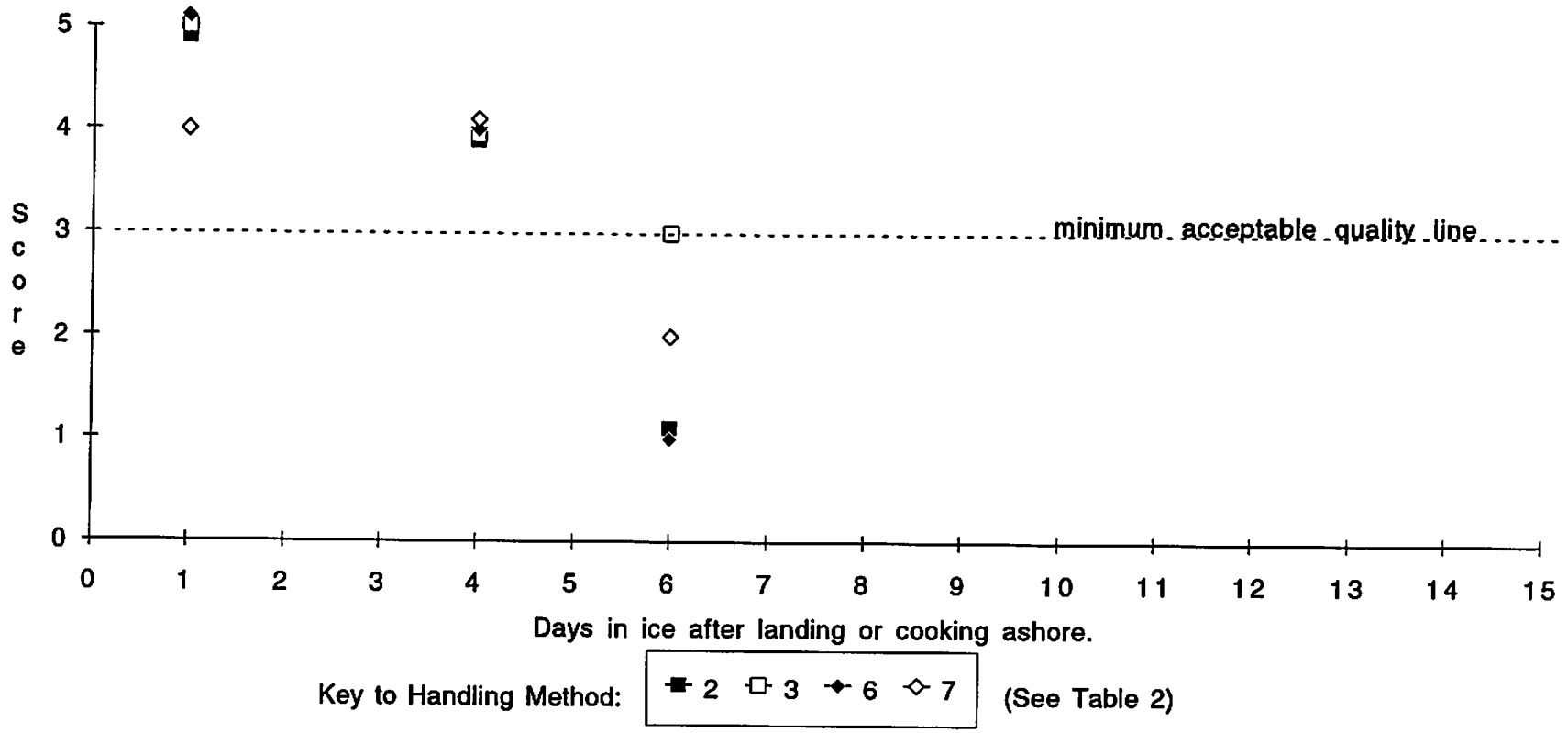


Fig 24 Quality assessment of Brown shrimp for score sheet formulation

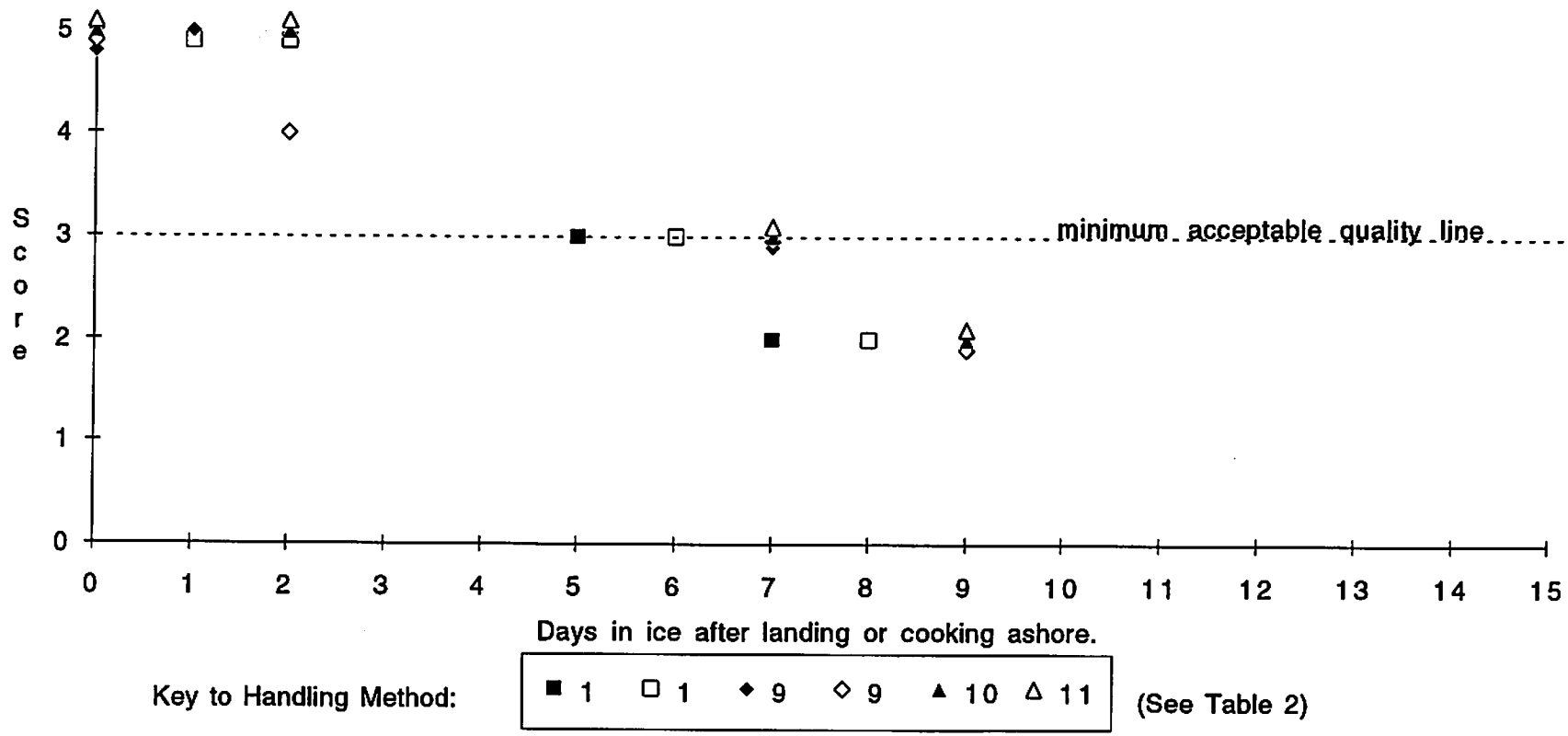


Fig. 25 Quality assessment of Pink shrimp from seatrip 4.

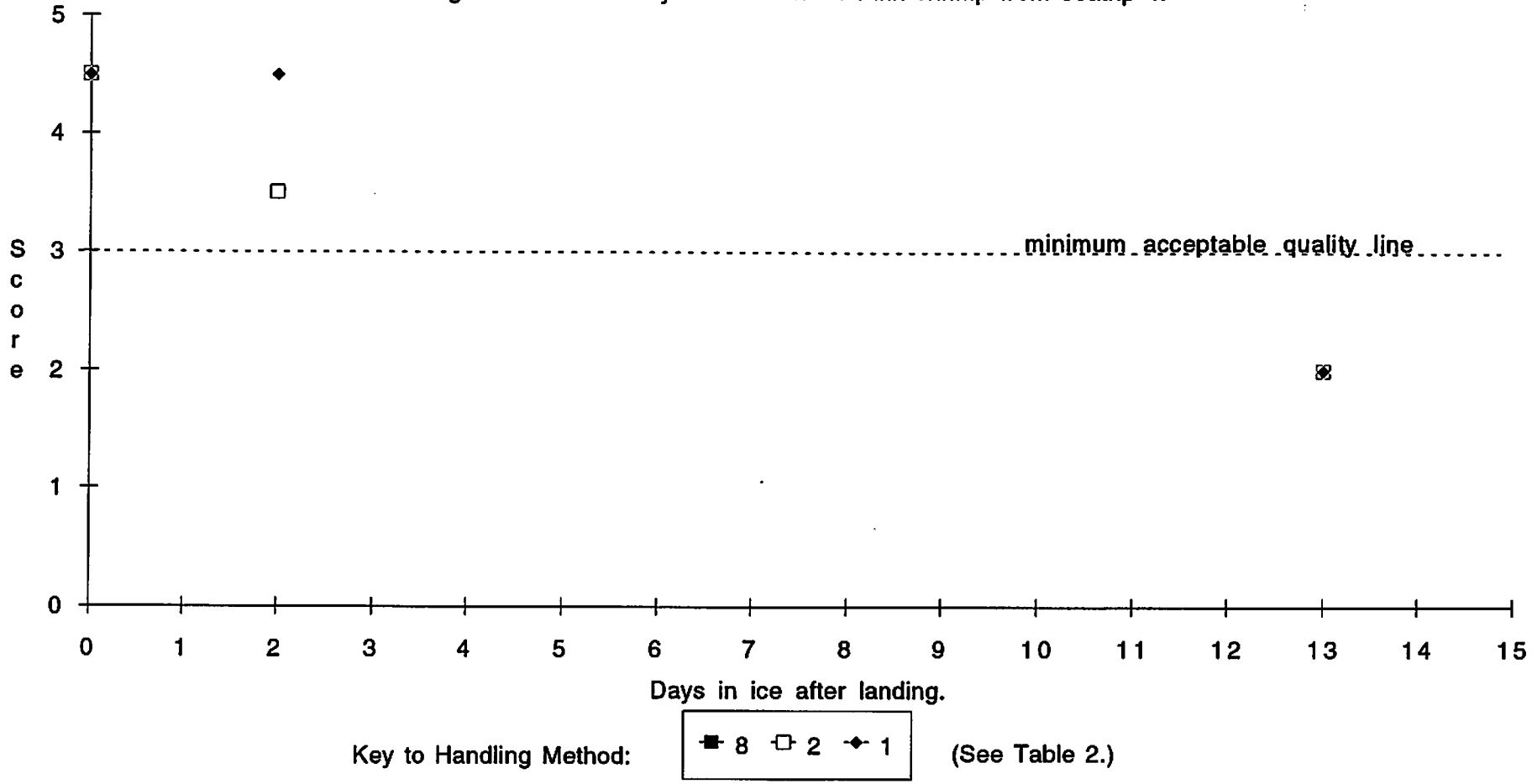


Fig 26 Quality assessment of Pink shrimp from seatrip 5.

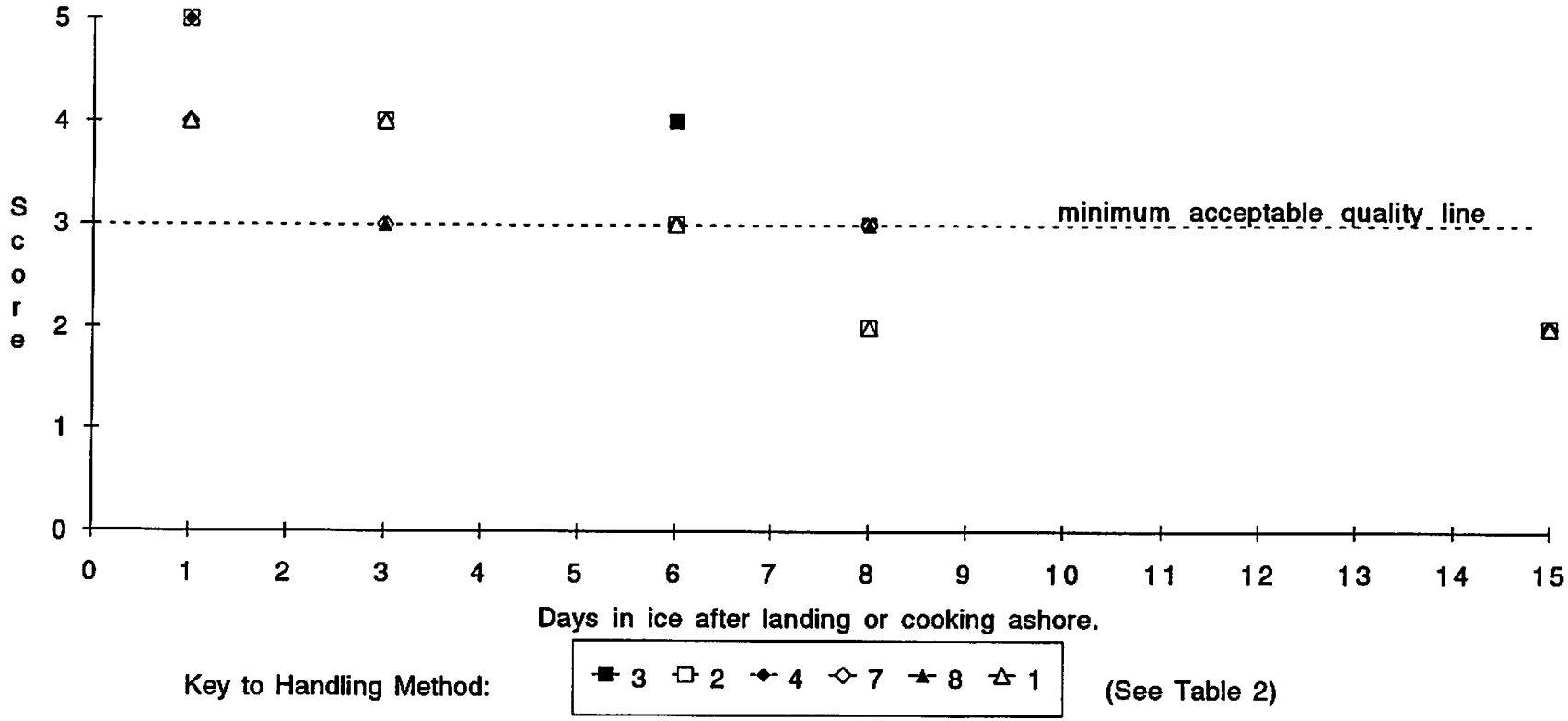
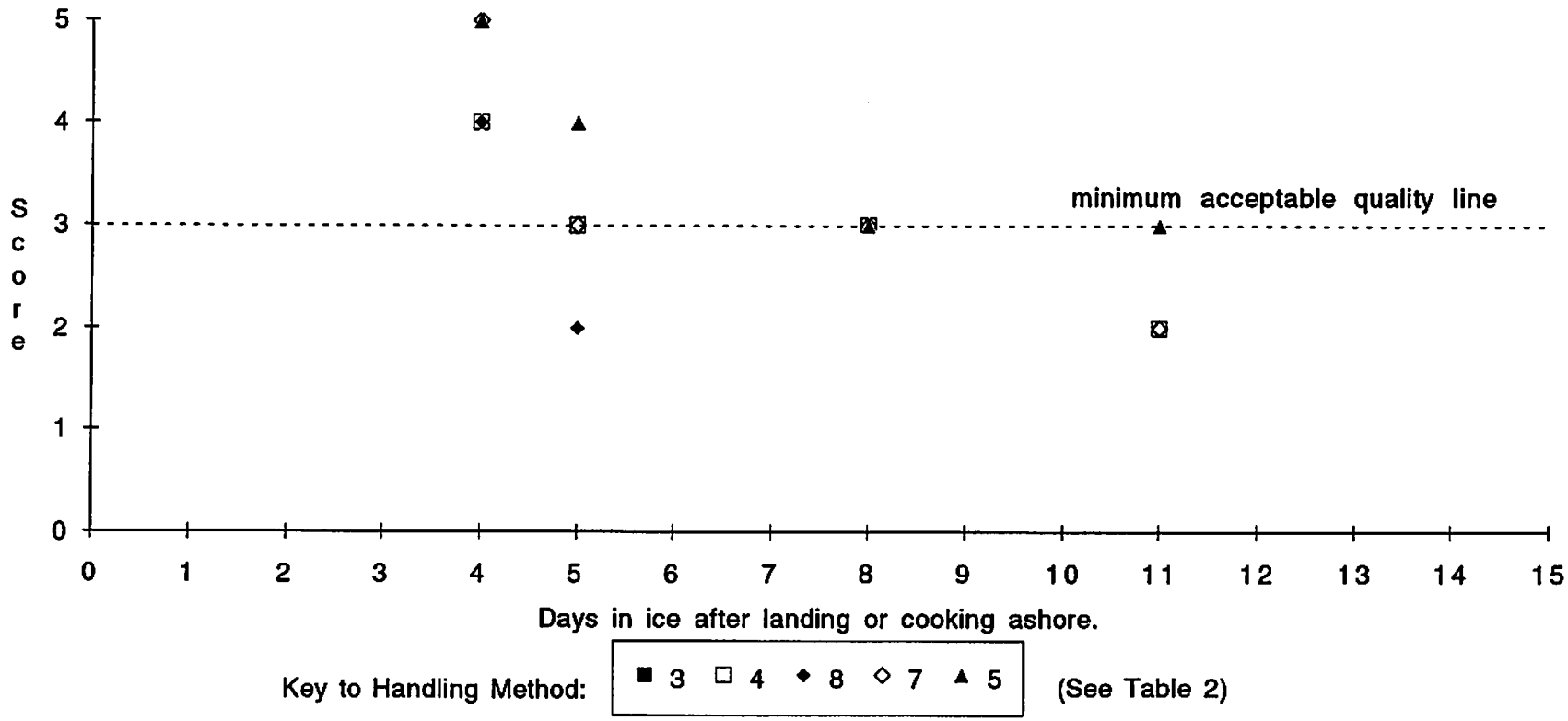


Fig 27 Quality assessment of Pink shrimp from seatrip 6.



APPENDIX I

TYPES OF VESSELS IN THE WASH SHRIMP FISHERY

Kings Lynn has by far the largest fleet of vessels fishing for *Crangon crangon* and *Pandalus montagui* in the UK. Other vessels are shrimping from Grimsby and from parts of the Norfolk coast but their number and value of their landings is unknown although likely to be much smaller.

The present Wash shrimp fleet (Boston and Kings Lynn) consists of approximately 50 vessels. These can be split into 3 different classes. Boats from other parts of the coast will also fit into the same categories.

Class 1: Modern 12 to 18 Metre Vessels

The most sophisticated class of vessels are the newer vessels of steel construction which use stainless steel handling and cooking equipment (See Figure 1). They have 3 crew and usually fish for 12 to 48 hours. There are approximately 4 of this class of vessel in the Wash.

The deck equipment is of Dutch origin. It is similar to the older vessels in classes 2 and 3 but is better designed with more control of the water flow and speed of the conveyors and riddles.

All of these vessels have fish holds and two vessels in the Wash fleet have a refrigerated facility for the storage of shrimps.

Class 2: Older 12 to 18 Metre Vessels

This class of vessels are mainly of steel construction and use 'rough and ready' handling and cooking equipment (See Figure 2). These are mainly ex-Dutch shrimp vessels. These vessels usually operate with 3 crew and fish for 12 to 48 hours. There are approximately 18 of these vessels. A few of this class of vessels have fish hold facilities but they are rarely used.

Class 3: Traditional Wooden Shrimpers

The most basic class of vessel is the 9 to 11 metre (30 to 45 feet) wooden traditional shrimper (see Figure 3). Most of these vessels are worked single handed and only work on a part-time basis. They usually work a single tide (12 hours). There are approxmately 28 of these vessels in the Wash.

APPENDIX II

Trials Equipment

Shrimp Storage

A number of polyurethane, and cavity foam filled, insulated, lidded fish boxes were used. These boxes were under development by Seafish for use by the inshore vessel sector for the cooling and maintenance of quality of wet fish. The boxes have a capacity of 60 litres. They were used to hold both ice and shrimp in these trials.

An insulated container, Allibert 15002, was also used to store live shrimp.

Heavy duty clear plastic bags were used for the storage of shrimps when indirectly icing, to avoid contact with the ice.

Monitoring Temperature

A Comark 9101 temperature monitor and probe.

A Grant squirrel 1200 series temperature logger with 8 temperature sensors, housed in a sealable waterproof box. IBM computer used to retrieve temperature information.

APPENDIX III

SENSORY ASSESSMENT SCORE SHEETS
Brown shrimp: *Crangon crangon* From The Wash
Shrimp indirectly iced in chill room

Score	General Appearance	Odours	Flavours of Meat	Texture of Meat
5	Shiny and glossy with pink hues on shell body	Empty crabshells Marine Seaspray Creamy Cardboard Woody Boiled potatoes	Milky Sweet Characteristic shrimp	Chewy firm mouth feel
4	Loss of gloss but retaining pink hues	Seaweed faint ammonia sweaty		
3	Loss of pink hues Yellow colours appearing Yellow legs	Ammoniacal Sulphides Rotting vegetables Compost Rotten seaweed	No sweetness Slight sour Burnt milk Meat Fat Cottage cheese	Gritty feel to shell on peeling. Sticky meats. Very chewy Dry mouth feel
2	Dull loss of colours Slight slime			
1	Green and yellow colours	Faecal strong ammoniacal compost	Mature cheese Strong Sickly aftertaste	

Pink shrimp: *Pandalus montagui* from The Wash

Shrimp indirectly iced in chill room

Score	General Appearance	Odours	Flavours of Meat	Texture of Meat
5	Distinct colours glossy Shiny pink bright	Milky Sweet Ice-cream Marine	Sweet milky Creamy Condensed milk Characteristic shrimp	Chewy Meaty mouth feel
4	Orange/red colours Pink colours Loss of gloss shine	Marine wet Pebbles Wet pastry	Loss of characteristics Little sweetness Raw pastry/lard	
3		Weak ammonia Dried old seaweed Wood shavings Fatty Meat Burnt milk	No sweetness Musty Muddy Cardboard Soap Spearmint Liquorice Aftertaste No characteristic shrimp	
2	Loss of bright colours Yellow colours	Compost Manure Mousey Burnt milk Ammonia Faecal Chlorine	Green vegetables, Soap Spearmint Liquorice Aftertaste	Gritty feel to shell on peeling Sticky feel to meats Very chewy Greasy mouthfeel