Scallop Purification

Initial Trials at Ardtoe
September 1992

Seafish Report No. 418

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Sea Fish Industry Authority

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Summary

Under the Food Safety (Live Bivalve Molluscs and Other Shellfish) Regulations 1992, farmed scallops for human consumption may only be harvested from classified waters. Provisional classifications indicated that some areas where scallops were currently farmed would require purification. As far as the author was aware no attempt had been made to purify scallops before, and due to physiological differences between them and other bivalve molluscs normally purified, a short trial was carried out by Seafish at their Marine Farming Unit at Ardtoe to investigate.

The inability of scallops to retain shell liquor when removed from seawater was considered to be a major potential problem and so the trial was aimed at the effect of delay between harvest and re-immersion. The effect of physical shock and storage conditions prior to re-immersion were also considered.

Scallop activity when immersed was used as an indicator of their ability to purify, on the basis that molluscs must be in good physical condition for effective purification, and an assessment score sheet was developed for the trial.

Results demonstrated that both king and queen scallops could be stored at ambient temperatures of 11.0 - 13.0°C for 9 hours without apparent ill effect but that after 24 hours storage they were weakened. Storage both directly and indirectly in ice was found to cause considerable weakening at 9 hours and mortality at 24 hours probably caused by thermal shock. Scallops held in re-circulated seawater were also found to be less active after 24 hours immersion. Those subjected to some physical shock were weakened. It was also observed during the trial that queen scallops were quite active when immersed and occasionally free swimming which would make it difficult to purify them as a result of the water disturbance.

Overall it was concluded that the purification of scallops would be difficult to achieve but further investigative work would be required to confirm this.

1. Introduction

The Food Safety (Live Bivalve Molluscs and Other Shellfish) Regulations 1992, that came into force from January 1993, require bivalve molluscs that are to go for human consumption to be harvested only from waters that have been classified as A,B or C. The category determines whether molluscs can go directly to market or first have to undergo purification or relaying. Wild caught scallops are exempt from the need for area classification but not those that have been grown by marine farming.

Provisional area classifications in Scotland during the Summer of 1992 indicated that some sites used for farming scallops could ultimately be in B areas. This would require scallops to be purified or relayed before going to market. Given this circumstance the most practical option would probably be to purify in shore based tanks, as with other bivalve molluscs, but it was considered there may be problems in achieving this due to physiological differences between scallops and other bivalve molluscs. No published work could be found of any previous study of scallop purification and so it was decided that a short investigative trial be carried out by Seafish at their Ardtoe site to determine the possibility of such.

This work was undertaken by Fish Technologists from the Seafish Technology Unit at Hull as part of their programme of work to investigate the purification requirements of selected bivalve molluscs. The work was part funded by the MAFF R & D Commission.

2. Trials Purpose

To carry out initial investigation into the feasability of purifying both King (*Pecten maximus*) and Queen (*Chlamys opercularis*) scallops.

3. Trials Scope

Unlike most bivalve molluscs, scallops are unable to fully close their shells when taken out of seawater and retain shell liquor. It is therefore unlikely that they will be able to withstand long periods out of seawater and remain in a fit condition for purification. An investigation of the effect of delay between harvesting and purification was therefore considered to be the main purpose of the trial with some investigation of the effect of physical shock, storage temperature and storage method. No microbiological testing was carried out.

Seawater temperature, salinity and dissolved oxygen were to be kept at set levels and scallops kept in seawater at low densities.

4. Equipment

4.1 Holding Tank: An existing indoor holding tank at the Ardtoe site was made available for the trial. This is made in fibreglass and is approximately 5 metres in length, 1 metre wide and held seawater at a depth of 300 millimetres. The tank was continuously fed with fresh seawater and not re-circulated.

4.2 Model Depuration Plant (MDP): A portable purification tank used by Seafish in many of their mollusc purification trials with external dimensions of 1000 x 600 x 530mm and a capacity of 200 litres. The tank operates a seawater re-circulation system.

4.3 Hand held electronic thermometer and dissolved oxygen meter were used.

5. Trials Record

The trials were carried out at the Seafish Marine Farming Unit based on the Ardnamurchan Peninsular on the West Coast of Scotland during the period September 23rd - 25th 1992.

5.1 Approximately 100 each of king and queen scallops were taken from the growing site at Ardtoe and stored either in tightly closed net bags at ambient temperature or in bags either indirectly or directly in ice in insulated containers. The queen scallops were 3 year old stock whereas the king scallops were five years old. The king scallops were heavily encrusted with marine fouling, much of which was removed by hand.

5.2 Shortly after harvest some scallops held at ambient were dropped in a bag from a height of one metre for five consecutive drops to simulate rough handling. The king scallops onto a concrete surface, the queen scallops onto a wooden surface.

5.3 Six of each species from each holding and handling method were immersed at set time intervals from capture of between 2 and 43 hours in either the MDP, with re-circulating seawater, or holding tank, with single use seawater. The scallops were held in mesh trays in a single layer. Some slight overlapping of king scallops occurred due to limitations of tray size. Some variation in sample size occurred due to damage or surplus sample stock.

5.4 Samples were assessed on their condition at intervals over a period of 48 hours from harvesting and given a condition score of 1 to 5 as shown in Table 4.

5.5 During trials some assessment was made of the effect of water disturbance from direct aeration by air stone or water cascade and the effect of changes in light and shadow on a small number of scallops in a part of the holding tank away from other scallops.

5.6 During the trials some assessment was made of the effect of reduced dissolved oxygen level on the activity of scallops by placing individuals in a plastic container of seawater.

6. Results

6.1 Summary of temperature, salinity and dissolved oxygen levels are given below in Table 1.

Table 1

Ambient daytime air temperature in building	11.0-13.0°C
Fresh seawater supplied for flow through	13.2-13.5°C
Re-circulated seawater (gradual rise)	14.6 to 17.8°C
Seawater salinity (parts per thousand)	30.5‰
Dissolved oxygen level percentage saturation in	
Fresh seawater	91-94%
Re-circulated seawater	91-94%

6.2 The effect of external disturbance is shown below in Table 2.

Table 2

	Disturbance	Observed Effect
1	Direct airation beneath scallop	Both shells remain open but withdraw filaments
2	Airation to one side	Filaments slightly withdrawn
3	Water cascade directly above scallops in 100mm water	King tend to close, withdraw filaments. Queen appear unaffected
4	Passing shadow over water	King no effect. Queen sometimes move

6.3 The effect of reduced seawater dissolved oxygen levels is shown below in Table 3.

Table 3

Dissolved Oxygene % Saturation	Observed Effect
94%	King and Queen shells open and filaments extended
60% (after 2 hours)	King shell closed slightly and filaments part withdrawn. Queen shell closed slightly
94%	Both quickly return to full shell opening and filament length when returned to fully oxygenated water

6.4 The observed scallop condition scores (based on the assessment system shown in Table 4) are given for queen scallops in Table 5 and king scallops in Table 6. Scallops were not removed from the seawater after immersion in the tanks and so activity level out of water was not included in the assessments during this period.

Table 4
Scallop Assessment (King and Queen) of Condition

Score	Condition
1	Shell open (usually 1.0 to 3.0cm) Full mantle, outward bulge Filaments straight and extended Active shell movement when removed from seawater
2	Shell partly open (up to 1.0cm) Mantle slightly recessed Filaments less extended, possibly curled Only slight shell movement out of seawater
3	Shell open but mantle recessed exposing inside lip of shell Filaments not extended Very slight or no activity when removed from seawater
4	Shell shut Very slight or no activity when removed from seawater
5	Dead Shell gaping Mantle totally recessed and detaching from shell No activity out of seawater

Table 5
Immersed Trial Condition Scores for Queen Scallops

Storage and Handling Conditions	Ambient Storage						Indirectly Iced Storage				Directly Iced Storage		Ambient Storage and Subjected to Drops	
Storage delay prior to immersion	3	6	9	24	43	2	3	6	9	24	2	24	3	9
Single use (s) or recirculated (R) seawater	S	S	S	S	S	R	S	S	S	S	R	S	R	S
Trial Code No	1A	1B	1C	1D	1E	4	2A	2B	2C	2D	3A	3B	5A	5B
Hours from Harvest	Assessment of Sample Condition (1st figure in brackets (no. of scallops) 2nd figure condition of scallops)													
3						(6)1					(6)1			
6						1					1		(9)2	
9	(6)1	(6)1				1	(6)1	(6)1			(1) (5)2		2	
20	1	1	(6)1			1	1	1	(4)1 (2)4		1		2	(6)2 (1)3
24	1	1	1			1	1	1	(1)1 (3)3 (2)4		1		(8)2 (1)5	(6)2 (1)5
27	1	1	1	(2)2 (4)3		1	1	1	(1)2 (3)3 (2)4	(6)5	1	(10)5	2	2
43	1	1	1	2		2	1	1	(1)1 (2)2 (3)5		2		2	(5)2 (1)5
48	1	1	1	2	(2)5	2	1	1	(1)2 (2)5					2

Table 6
Immersed Trial Condition Scores for King Scallops

Storage and Handling Conditions	Ambient Storage					Indirectly Iced Storage				Directly Iced Storage		Ambient Storage and Subjected to Drops	
Storage delay prior to immersion	2	6	9	24	43	2	6	9	24	3	24	3	9
Single use (s) or recirculated (R) seawater	R	S	S	S	S	R	S	S	S	S	S	R	S
Trial Code No	6A	6B	6C	6D	6E	7A	7B	7C	7D	8A	8B	9A	9B
Hours from Harvest	Assessment of Sample Condition (1st figure in brackets (no. of scallops) 2nd figure condition of scallops)												
3	(6)1					(5)2							
6	1					2						(3)1 (2)2	
9	1	(6)2				2	(6)2			(20)1		1	
20	2	1	(2)1 (4)2			2	2	(5)2 (1)5		1		1	(6)2
24	2	1	1			2	2	(3)2 (2)3		1		1	2
27	(3)1 (3)2	1	1	(6)2		2	2	(4)3 (1)5	(1)3 (5)4	1	(6)4	2	2
43	2	1	(4)1 (2)2	2		2	(4)2 (2)3	(3)3 (1)5	(1)3 (1)4 (4)5	1	5	2	2
48		1	(4)1 (2)2	(4)2 (1)3 (1)4	(2)4		(4)2 (1)3 (1)4	(2)3 (1)5	.(2)3	1			2

7. Discussion

7.1 Assessment of Scallop Condition (Table 4)

For any bivalve mollusc to purify satisfactorily it must be in good physical condition such that when placed in suitable seawater conditions it will quickly resume filter feeding activity. For the purposes of these trials therefore it was considered that by observing the degree of scallop activity when immersed in seawater an assessment of their condition would indicate the likelihood of them being able to purify. The scoring system, shown in Table 4, was therefore devised to cover activity from good condition to death and was formulated by discussion with Ardtoe site staff and observation. With regard to the ability of the scallops to purify, this can only be finally determined by microbiological analysis, but for the purpose of this trial it is considered that a score of 1 is required during most of the purification period. At present there is no indication of how long that period should be.

7.2. Dry Storage Delay at Ambient (Trials 1 and 6)

Delays at ambient temperatures of 11.0-13.0°C did not appear to have any detrimental affect on queen scallops for up to 9 hours dry storage, but there were some signs of weakening with king scallops. In fact often both 6 and 9 hours delay king scallops appeared to go through a short recovery period before becoming fully active. At 24 hours delay both species were showing positive signs of weakness. The effect of holding scallops at higher ambient temperatures must clearly be taken into consideration and would require further work but would no doubt reduce allowable delay times further. Consideration must also be given to differences in storage and seawater temperatures which may result in thermal shock as discussed in 7.3.

Results from king scallop trial 6A showed signs of stress toward the end of the trial but this is considered to be a result of the use of re-circulated seawater as discussed in Section 7.5, not of storage delay.

7.3 Indirect Dry Storage in Ice (Trials 2 and 7)

For queen scallops the storage at 0°C appears to have no effect after six hours delay but after nine hours the effect is quite dramatic with little activity and ultimate mortality. King scallops appeared less happy, even after two and six hour delays, but after nine hours there is a sudden reduction in activity. The use of re-circulated seawater (Section 7.5) in trial 7A is considered less significant here as there is little king scallop activity after immersion.

One possible reason for this apparent sudden effect at 9 hours storage is that as scallops are not naturally subject to temperatures of 0°C this low temperature is effectively

killing them. This may account for the sudden fall in activity between six and nine hours storage as it would have taken some time for the indirectly iced scallops to reduce in temperature. A second possibility is that of the thermal shock when re-immersed in seawater with a temperature differential of up to 13.0°C which again is something that scallops would not encounter in their natural environment. As some scallops were nearer to the ice in storage than others, individuals would have experienced different cooling rates and this may reflect the varied activity levels of individuals at nine hours storage.

On the basis of this trial scallops should not be stored at ice temperatures if they are to be re-immersed for purification although storage for consumption as a fresh product or for processing at this temperature would no doubt be beneficial to the finished product. The effect of thermal shock requires further investigation and may well apply to both sudden increases and decreases in temperature when re-immersed.

7.4 Direct Storage in Ice (Trials 3 and 8)

Although only two delays were used with this trial the first delay of 3 hours for king scallops appeared to have no effect and that at 2 hours for queen scallops little either, bearing in mind that this particular trial was with re-cycled seawater (7.5). After 24 hours delay both batches were effectively dead as were the corresponding samples that had been indirectly iced. It would appear therefore that there is little effect from ice meltwater over a few hours storage. Overall this is of little significance as the effects of low temperature and thermal shock still apply as discussed in 7.3.

7.5. Seawater Re-circulation (Trials 1A and 4)

Only one trial was carried out to compare directly the use of re-circulated single use seawater. This was with queen scallops and after 40 hours of immersion those in re-circulated seawater were showing less activity. In all other trials where seawater was re-circulated (3A, 5A,6A, 7A and 9A) there are complicating factors although it is noticeable that in all of these the scallops are showing less activity after long immersion. This could in some cases be attributed to the particular trial condition but a comparison of trials 6A and 6B for king scallops indicates the shorter time delay sample with less activity after a 20 hour period.

Other species of bivalve mollusc currently purified are estuarine and no doubt more able to cope with variable levels of waste by-product (such as ammonium) in the seawater. Scallops are not and may well be reacting to a gradual build up of waste in the re-circulated seawater system used. It would appear therefore that a constant flow of fresh seawater is required although this can by no means be taken as conclusive from the limited evidence of this trial.

A further possibility is that the flow through seawater is presenting the scallops with a food source and thereby some stimulus to activity by feeding. In the re-circulating system the food source depletes with time and may be responsible for the reduced activity.

7.6 Mishandling (Trials 5 and 9)

For queen scallops a direct comparison can be made between trials 5A and 4 as both were with re-circulated seawater and clearly indicate that the five, one metre drops have stressed them. A comparison with in addition, further delayed storage is made between 1C and 5B where a greater effect can be seen.

For king scallops a comparison of trials 6A and 9A shows dropping causing some initial shock with recovery whereas comparison of trials 6B and 9B with in addition, further delayed storage show them to be stressed.

The effect of mishandling is clear and indicates that if scallops were to be purified a great deal of care would be needed from harvest to purification system.

7.7 External Disturbance when Immersed (Table 2)

It is clear from the observations made that scallops are susceptible to water disturbance, as with other species, and this needs consideration when operating a purification system.

7.8 Dissolved Oxygen in Seawater (Table 3)

The current minimum dissolved oxygen level requirement in purification systems is 50% saturation. This small trial, although only conducted with a few scallops showed that at a level of 60% the king scallops were under stress. As discussed in 7.5 scallops are not estuarine and therefore used to the relatively high levels of dissolved oxygen present in natural seawater. This would need further work to establish what the required minimum dissolved oxygen levels should be.

7.9 Loading Density

During the trials scallops were put into trays in a single layer. It was observed that movement occurred within the trays and on occasion within the tank. King scallops placed the wrong way up (flat shell should be uppermost) tended initially to try and re-orientate themselves whilst queen scallops, for reasons not understood, often would simply swim off. In both cases water disturbance occurs and can re-suspend material in the immediate vicinity. This can potentially cause re-contamination and must be avoided. With king scallops movement would not matter provided disturbance was limited to a short period after immersion but for queen scallops it would be difficult to prevent them swimming without preventing them from filter feeding. Again this is a fundamental difference between scallops and other bivalve molluscs currently purified which if they move at all, move slowly. Further investigation is required.

7.10 Other Factors Effecting Purification of Scallops

Seawater salinity, maximum and minimum seawater temperatures, required purification time and microbiological testing of scallops would all require investigation, in addition to further work already recommended in the previous discussion, before allowing scallops to be purified.

When removed from seawater scallops snap their shells open and shut and may sometimes 'snap' shut on others. This 'biting' effect can damage the mantle of the scallop and may reduce effective filtration. Again this would require further investigation.

8. Conclusions

8.1 On the basis of these preliminary trials the indications are that the fundamental differences between scallops and other bivalve molluscs currently purified in the U.K. would make their purification difficult to achieve.

8.2 A problem exists with the natural swimming movement of both species disturbing the tank although this is probably more acute with queen scallops.

8.3 Both species were kept in dry storage at ambient tempertures of 11-13°C for a period of 9 hours without apparent effect on their ability to filter feed when re-immersed. This could not be achieved after 24 hours storage.

8.4 The effect of dry storage at higher ambient temperatures would require investigation.

8.5 The storage of both species at 0°C causes apparent stress and reduces the allowable delay between harvest and re-immersion compared to ambient storage.

8.6 Scallops appear to be susceptible to thermal shock when put into seawater with a temperature differential of up to 13°C from that of storage. Desirable temperature ranges and rates of acclimatisation would require investigation.

8.7 There is little difference between direct and indirect storage in ice over a period of 3 hours.

8.8 A continuous flow of fresh seawater results in greater activity. Scallops may become stressed when left in re-circulating seawater but this would require further investigation.

8.9 As with other bivalve molluscs, scallops are weakened by physical shock and must be handled carefully if they are to be re-immersed.

8.10 The current minimum dissolved oxygene requirement of 50% saturation in purification system seawater may not be adequate for scallops and would require further investigation.

8.11 Other factors such as salinity, maximum and minimum seawater temperture purification time required and microbiological testing of scallops would all require investigation.