Sea Fish Industry Authority
Seafish Technology

Evaluation of Good Handling Practice for Razor Clams

Supported by: Highland Council and Highlands & Island Enterprise

Seafish Report No. SR548

M. Pyke
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SUMMARY

High-quality razor clams (Ensis spp.) are currently exported via airfreight to the Far East where they command a high price; there are believed to be substantial under-utilised stocks around the UK.

To assist in the possible development of this fishery, different methods of capture and post-harvest handling of razor clams were investigated to examine the conditions of capture and storage most likely to produce and maintain high quality and viable live animals. The razors used in the study had been either diver-caught or harvested using a commercial fluidised-bed towed razor clam dredge.

Handling and storage regimes included combinations of iced, ambient, wrapped and immersed storage, with samples analysed organoleptically, microbiologically and visually.

For diver-caught and dredged animals it was found that ambient storage causes high levels of stress to the razor clams, with associated high levels of mortality, as does storage in ice melt-water. Non-contact chilling of the live animals maintains quality the longest.

Razor clams caught by divers were, in general, of substantially higher quality and survived better than those caught by the dredge used in this trial.

Some further work is suggested, However, recommendations based on current knowledge are made for good handling practice which will be beneficial to product storage life and quality.

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1 INTRODUCTION

The fishing industry is becoming interested in exploiting the razor clam stocks present around the UK coast. Their beds are accessible, equipment and fishing techniques have some similarities to other existing fisheries and they have not been subject to intensive fishing effort. Market demand, mostly overseas, is large, due mainly to stock over-exploitation in other countries.

Little work appears to have been carried out or published to determine the correct way to handle the animal post harvest and/or depuration in order to ensure a good quality product with a long shelf life. Various companies are trying to find the optimum handling criteria for transportation to the end customer, with varying levels of success, either stored in vivier tanks[1], iced or chilled.

This report describes part of a broad programme of work being carried out by Seafish and others to investigate razor clams.

The aim of this study was to investigate the impact of different methods of handling these animals, in order to identify which give the best quality live product when assessed organoleptically, microbiologically and visually. Assessments were made on razor clams kept in ambient conditions, chilled, iced and depurated[2] then subsequently stored chilled. All treatments were assessed with bundles of razor clams, either wrapped in paper to create a moist microclimate or unwrapped. The study evaluated quality and mortality issues for both diver and dredge caught animals.

This study did not investigate the effects of seasonal variation or of shucking and transportation of the dead animal (in comparison with live storage),or if there was any difference by species or region, however, these factors could be the subject of future work. The bulk of the work was carried out with Ensis siliqua although some trials involved the use of Ensis arcuatus.

1. Vivier transportation is a means of transporting live shellfish in aerated seawater to extend the life of the animals so they can reach distant markets alive and hence fetch the best prices. This method of holding marine animals is commonly used to transport crustaceans and also scallop spat. A drawback to such systems can be a build up of ammonia as the animals effectively sit in an enclosed body of water which over time, accumulates the animals' own waste products. This system is similar to a closed circuit re-circulating depuration system but does not normally have an ultra violet sterilisation unit as part of the system.

2. Depuration is the process by which bivalve molluscs are cleansed of any bacteria that is harmful to human health. This takes place by holding the animals in tanks of clean water for a period of time, at least 42 hours in the UK. It has been found that species suitable for depuration cleanse themselves of any harmful bacteria, given the correct environmental conditions. Any harmful bacteria that pass into the water, or are excreted by the molluscs, either settle to the base of the tank in the detritus or are neutralised by ultra violet light (UV). This UV process disrupts and damages the DNA molecules of the bacteria, preventing replication. A further understanding of the processes involved can be gained by referring to Seafish Technical Report SR520.

2 THE RAZOR CLAMS

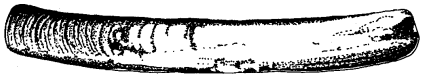
2.1 Biology and Habitat

Razor clams are found in inter-tidal and sub-tidal habitats. Many sub-tidal habitats are expected to support commercially exploitable stocks. *Ensis sp*. are found down to a depth of about 40 m. *Ensis siliqua* inhabits fine sands in a wide range of latitudes from the Norwegian Sea and the Baltic, south to the Iberian Peninsula, into the Mediterranean and along the Atlantic coast of Morocco (Tebble 1996)[(i)]. Sampling of eleven separate sites by Aqua–Fact in Southern Ireland revealed densities of 7.9 *Ensis siliqua* and 16 *Ensis arcuatus* per m^2. Localised high densities of 20 animals per m^2 were found. However, an investigation of the large, commercially exploited bed of *Ensis sp*., at Gormanstown, Co Meath, Eire found an overall density of only 1.45 – 1.52 animals per m^2. (Aqua-Fact International Services Ltd) [(ii)]

Personal contact with various harvesters has revealed that divers can gather 200 – 500 kg per day and fluidised bed dredges are able to catch from 400 kg to 1500 kg per day.

The following species of Ensis are commercially exploited and native to the British Isles: *E. ensis, E. siliqua and E. arcuatus*. *E. siliqua* and *E. arcuatus* are quite similar in shape. *E. ensis* is markedly smaller in comparison and has a more pronounced curve to the shell as the drawing below indicates.

Ensis siliqua
(up to 20 cm long)



Ensis arcuatus
(up to 15 cm long)

Ensis ensis
(up to 12.5 cm long)

Figure 1 - Commercial Species in UK (not drawn to scale)

Ensis siliqua has a round shape to the shell and body when viewed end on, *Ensis arcuatus* is more oval in comparison as shown below.

Figure 2 - *Ensis siliqua*

Figure 3 – *Ensis arcuatus*

Some authors have noted a difference in the colour of the foot. Holme (1951)[iii] states that *Ensis siliqua* and *Ensis arcuatus* are creamy white in colour, reticulated with fine brown lines and that *E. ensis* has a pale reddish brown foot. He also uses the papillae in the fourth aperture as a distinguishing characteristic.

It has been found that *Ensis siliqua* grows more slowly in North Wales than in Southern Portugal. However, the animals from Wales achieved a greater maximum length. It is not known whether there is any growth differential or maximum size, between animals taken from the South Coast of England and the North of Scotland, or if there are any implications in terms of respiration, that may influence any of the factors being investigated. The diagram overleaf taken from Seafish Field Report No. 989 illustrates the anatomy of the animal.

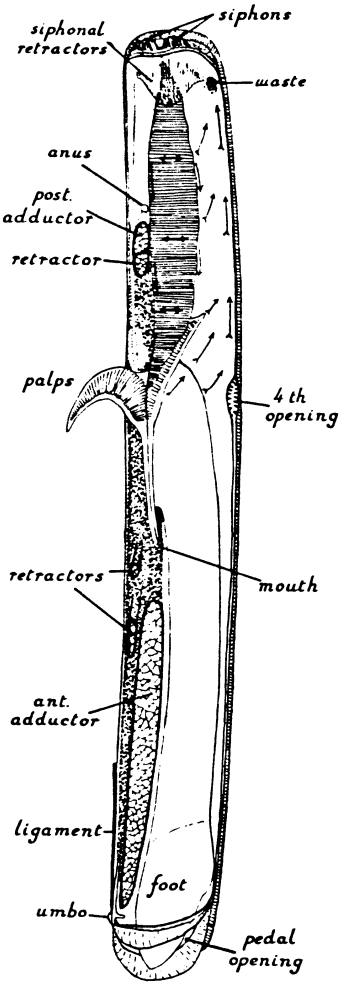


Figure 4 - Generalised Anatomy of *Ensis sp*.

Figure 5 - Open *Ensis siliqua* showing foot

Unfamiliarity with the animals can lead to problems in identification and mixing of the species (Seafish has observed juveniles of two different species mixed together for sale on a multiple retailer's fresh fish counter). It was necessary to confidently identify the species under investigation, as there may be differences in their ability to withstand different forms of handling and subsequently their shelf life.

A fourth species of razor clam *E. directus* has been found in European waters and has been reported to be resident in the Wash. (*pers. com*. C. Amos). This animal was observed for the first time in Europe, in waters of the German Bight, in 1979 (Van Urk 1987)[iv]. It now occurs along the North Sea coasts from northern Denmark to northern France. It tolerates relatively low salinity, occurring in marine and estuarine areas.

E. directus exhibits a fast rate of growth during the first two years of life, and is capable of reproducing as early as two years old. An illustration of *E.directus* (Tjarno Marinebiologiska Laboratorium, Stromstad 1998) is shown below. When compared with the previous diagrams this reinforces the point that it is difficult to separate these animals on shape of shell alone.

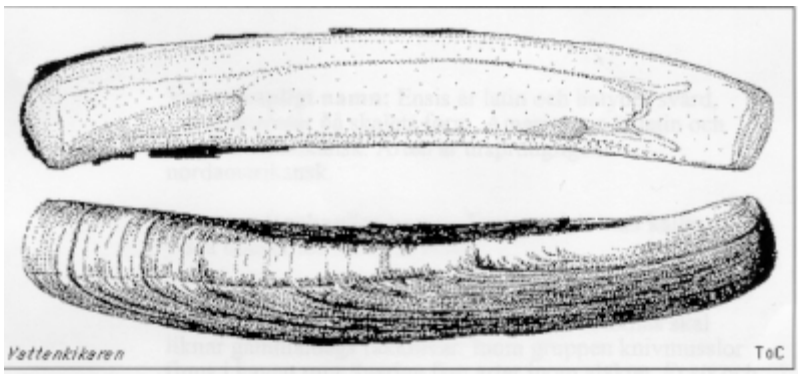


Figure 6 - *Ensis directus*

It is reported that these animals, which are native of the Eastern Seaboard of America, were transported to this side of the Atlantic as larvae in ships' ballast water. Carlton (1995)[v] noted that "No introduced marine organism, once established, has ever been successfully removed or contained, or the spread successfully slowed".

It has been reported that after the collapse of the Wadden Sea mussel fishery in the early 1980s a survey in 1990-94 found that larvae of *Ensis directus* exceeded those of *Mytilus edulis.*

Seafish has observed and filmed razor clams jetting themselves around on the seabed and in depuration tanks. *Ensis arcuatus* have been observed to move swiftly, along the bottom of the seabed. They have done this by coming out of their burrows, falling on their sides and propelling themselves by a combination of flicking the foot and jetting water out of the pedal opening at the same time. This allows them to move forward very quickly, some 3 – 5 metres at a time, before they recess.

2.2 Harvesting Techniques

Currently there are 5 methods used to harvest these animals in the United Kingdom. These are:-

1. **Walking backwards on a beach at low water springs to observe the disturbed animal's reaction.**
   The pressure of a person's foot can result in a "spout" of water being ejected from a hole, disclosing the animal's whereabouts. A knife or other tool is then pushed down the hole and the animal jammed against the side of the burrow allowing the animal to be dug out.

2. **Salting a beach**
   Salt is broadcast on the beach and in the area of the burrow entrances. The animals then leave the burrows and are picked up from the sand.

3. **Divers picking the animals out of the seabed**
   Having found the keyhole depressions in the seabed or seeing the siphons projecting above the surface, the thumb and fore finger are quickly pushed into the silt/sand and the animals are grasped and pulled from the seabed with a twisting action to ensure the foot is not left behind.

Figure 7 - Siphons of *Ensis* creating keyhole depression in sand

4. **Divers salting a bed**
   Divers broadcast salt from a bottle or watering can, onto a previously identified bed of animals. The brine solution, being denser than seawater, settles into the burrows. The animals then leave the burrows and are picked up from the sand.

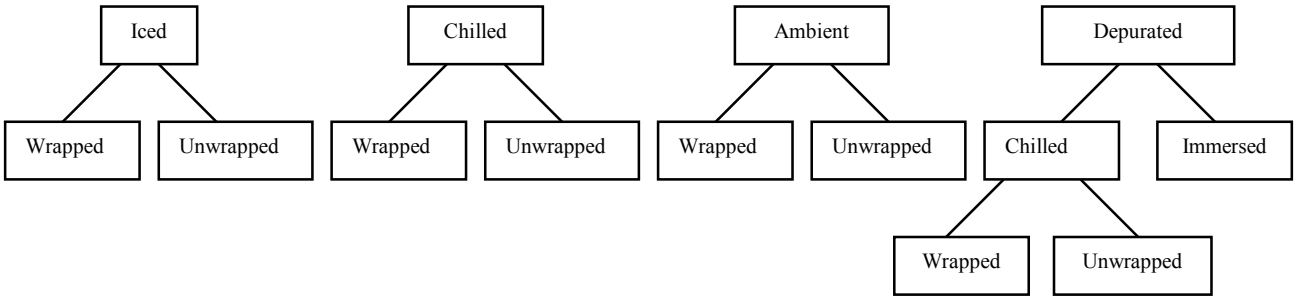
5. **Fluidised bed dredges towed by vessels**
   These dredges inject water under pressure into the seabed to fluidise it, any animals rise above the seabed and are collected in the dredge. The newer designs create a shallow trench from which the animals are blown into the dredge. Fluidised bed dredgers are usually limited to nine fathoms depth due to the physics of pumping water down to the seabed.

3 GENERAL METHODOLOGY AND EQUIPMENT

These trials were carried out with *Ensis siliqua* except where an alternative species is stated.

The first two trials were carried out with animals that were caught by divers, and a third trial was conducted with razor clams that were harvested by a fluidised bed dredge. The first two trials were carried out in Weymouth, Dorset and the third trial in the Western Isles of Scotland.

In all three trials the animals were held in nine different treatments after the start of the trials. They were stored, wrapped or unwrapped, in four different temperature/holding conditions: iced, chilled, ambient temperature and immersed in water.



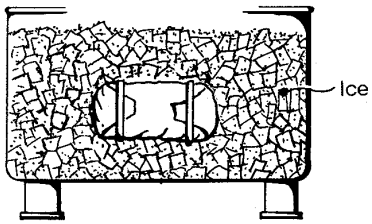
3.1 General Methodology

The animals were held either banded and unwrapped or banded and wrapped after capture and/or depuration. This entailed discarding any damaged animals, grading to ensure that the animals were grouped in approximate size groups and orientating with all the siphons all pointing the same way. Groups of ten animals were then held together by two elastic bands, one at either end of the bundle.

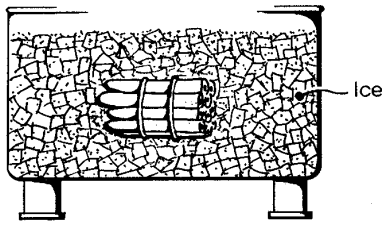
The animals were banded as a result of an earlier trial (CEFAS 1999)[vi] carried out by Seafish. This showed that banded animals that were depurated (wet stored) and held vertically could give the best results. However, two problems were encountered when storing animals this way. One was that some would escape from the bundles and then die. Secondly, it is easy to get animals in the bundles the wrong way up. Animals in the upside down orientation showed signs of stress. Those animals that were depurated (wet stored) and held banded and horizontal produced the second best results. This orientation would probably fit best with existing techniques used to wet store or depurate bivalves. Little difference was seen in the quality scores for animals that were dry stored either horizontally or vertically. Hence storing animals horizontal, which is easier to achieve, can be carried out without being significantly detrimental to product quality. Banding was clearly beneficial.

For the trials detailed in this report, some bundles were subsequently wrapped in greaseproof paper and then banded again, or taped to keep the paper tightly wound around the bundle. Ten bundles (either wrapped or unwrapped) were then treated in each of the conditions shown in the following schematic diagrams.

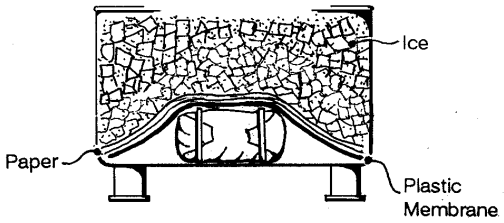
(a) Wrapped in greaseproof paper and banded or sealed with tape, then **held in flake ice**.



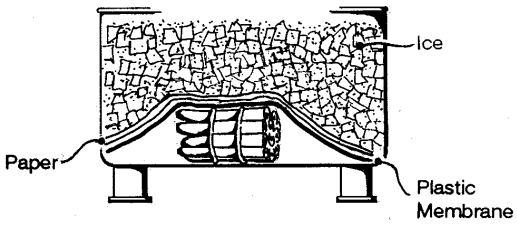
(b) Not wrapped at all, left banded and **held in flake ice**.



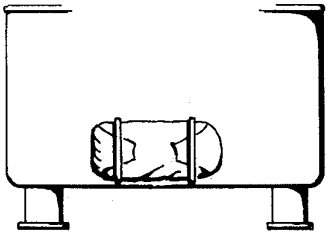
(c) Wrapped in greaseproof paper and sealed with tape, **held in a chilled environment** by covering with a plastic membrane and topping with paper and then ice.



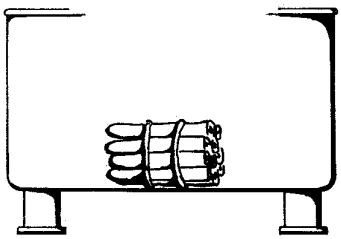
(d) Not wrapped at all, left banded and **held in a chilled environment** by covering with a plastic membrane and topping with paper and then ice.



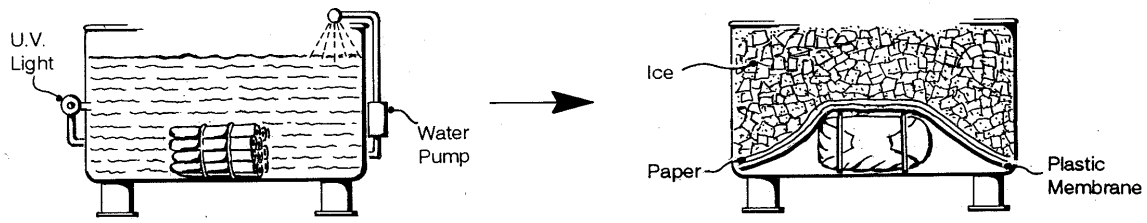
(e) Wrapped in greaseproof paper and sealed with tape, then **held in an ambient condition** without any chilling or icing.



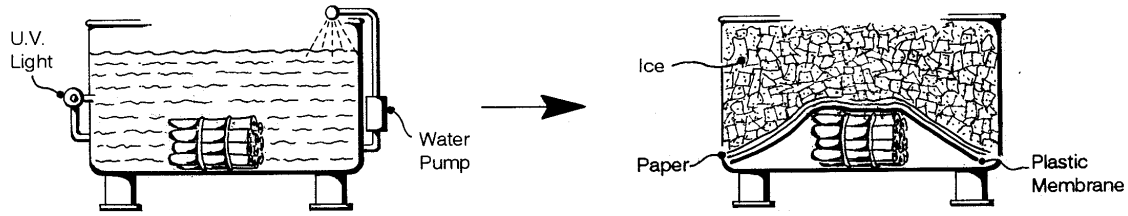
(f) Not wrapped at all, left banded and then **held in an ambient condition** without any chilling or icing.



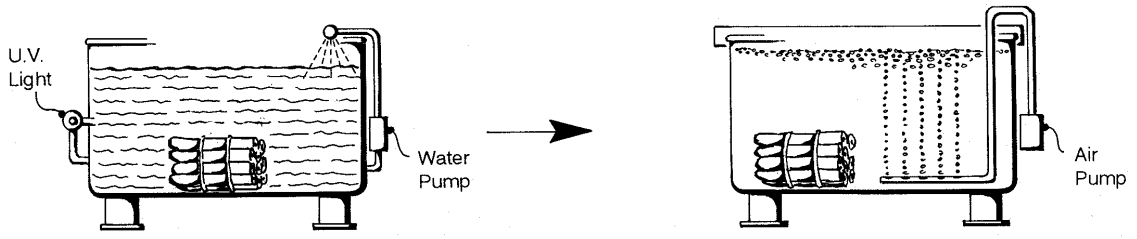
(g) Depurated for 42hrs then **wrapped** in greaseproof paper and sealed with tape, **held in a chilled environment** by covering with a plastic membrane and topping with paper and then ice.



(h) Depurated for 42hrs then **not wrapped** at all, left banded and **held in a chilled environment** by covering with a plastic membrane and topping with paper and then ice.



(i) Depurated for 42 hrs then held in a vivier tank



3.2 Equipment

The Seafish designed small-scale purification tanks were used for the first two trials to simulate depuration followed by wet storage. These are based on a 650 litre Allibert Type 21626 plastic pallet box used as the tank. In the third trial, four identical Seafish-designed, 300 litre laboratory-scale depuration tanks were used for depuration measurement. Each 300 litre tank would contain 150 litres of seawater prior to the start of any trial. This would normally ensure that there was about 10 cm of water above the siphons of mature *Ensis siliqua* when held vertically. This would give an average shellfish mass to water volume ratio of 1:30.

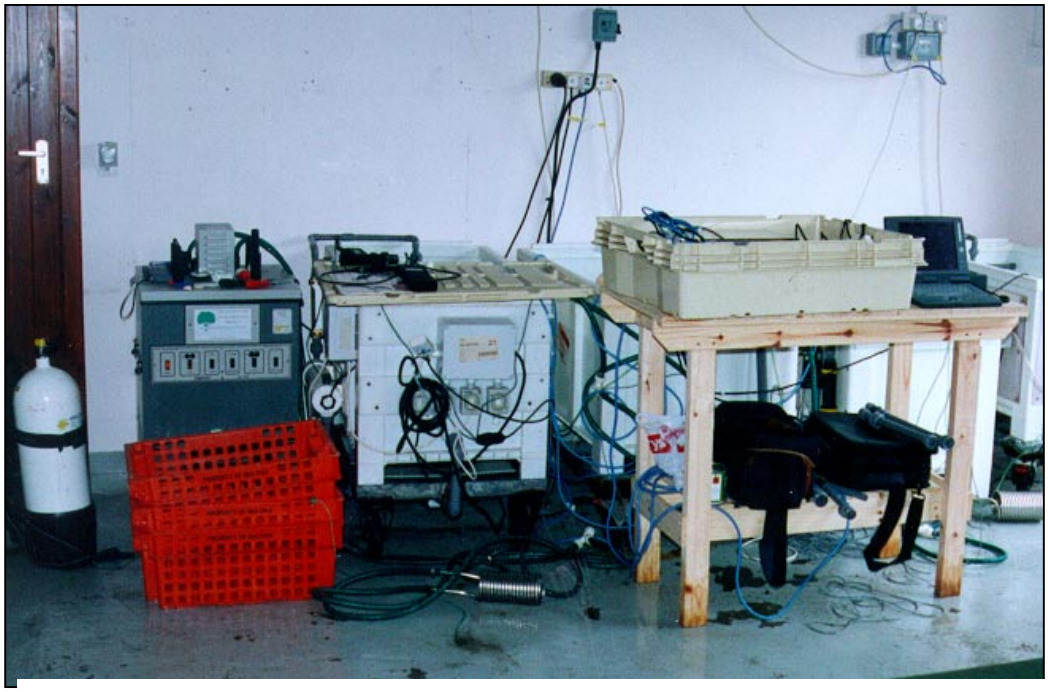


Figure 8 - Trial Tanks and Monitoring Equipment

Water was circulated around the closed circuit system at 10 litres per minute ensuring that the water passed through the 30W UV chamber, on average four times an hour.

A thermostatically controlled chiller coil was placed in each tank to control temperature. Temperature data were collected electronically using a Grant 1200 Series Squirrel data logger, with one thermocouple placed in the bottom of each tank.

Salinity was monitored using a WTW LF 320 conductivity meter or with the use of a refractometer and hydrometer.

Ammonium (NH4-n) and Nitrite (NO_2) levels were measured using a Dr Lange “Lasa 20” sensory array photometer.

A number of 28 litre insulated cool boxes were used to hold the samples in the ambient, iced or chilled conditions.

Oxygen was monitored using an 'Oxyguard PLC' dissolved oxygen meter connected to the unit. Two probes were placed in each tank.

3.3 Analysis Methods

3.3.1 Microbiological Analysis

The microflora of molluscan shellfish reflects the environment from which they are harvested. As molluscan shellfish are filter feeders, they accumulate both pathogenic and non-pathogenic micro-organisms from the water. Benthic shellfish dwelling on the bottom or burrowed in marine sediment are especially vulnerable.

Analysis was carried out by the Hull Public Health Laboratory Service (PHLS) and by the Environmental Hygiene Laboratory at Raigmore Hospital, Inverness. Analysis comprised assessment for Total aerobic bacterial count, Total coliforms bacilli, *E. coli* and *Pseudomonas*. Three animals were shucked for each sample submitted.

3.3.1.1 Total Viable Count (TVC)

This measurement gives an indication of the total viable number of bacterial colonies present in the sample, however, it makes no attempt to classify the types of bacteria. The common term used to describe the above is TVC or Total Viable Count.

3.3.1.2 Total Coliforms

Coliform bacteria are a natural part of the microbiology of the intestinal tract of warm-blooded mammals, including man. Coliform bacteria can also be found in soil, other animals and insects. Some types are pathogenic. If large numbers of coliforms are found, there is a probability that other pathogenic bacteria may also be present. This may also highlight poor hygiene practices. The micro-organisms detected within this family include *Escherichia coli*.

3.3.1.3 Escherichia coli (E. coli)

E. coli occurs almost exclusively and in huge numbers in human and warm blooded mammals and in their faeces. *E. coli* is used officially as an indicator of faecal pollution. Some strains can themselves cause food poisoning. It is also a crude indicator of enteric viral contamination.

The regulations governing the harvesting and placing of shellfish on the market require that all bivalve mollusc “production areas” are designated and categorised by the relevant government dept/agency as either 'A', 'B', or 'C' depending on the degree of contamination of the shellfish. These classifications are based on the level of faecal contamination detected by testing for *E. coli*. Shellfish growing areas with levels less than 230 colony forming units (CFU) per 100 grams are classified 'A' and the molluscs may be marketed without being further treated. Class 'B' is between 230 and 4,600 CFU and the molluscs must be purified by depuration or be relayed or heat-treated. Any shellfish growing areas with between 4,600 and 46,000 CFU per 100 grams are classified as category 'C' and the molluscs must be relayed for an extended period or heat treated by an approved process in an approved establishment.

3.3.1.4 Pseudomonas species

Pseudomonas species can grow well at relatively low temperatures and cause spoilage of a large range of foodstuffs. The typical 'off' odours and flavours are produced by members of the genus *Pseudomonas*. These bacteria can produce spoilage at 0ºC and will quickly proliferate if the temperature increases, and decomposition will continue. Any significant increase in *Pseudomonas sp*. found may indicate that a particular holding condition is unsuitable for handling *Ensis sp*.

3.3.2 Quality Assessment

3.3.2.1 Assessment of Eating Quality

Sensory evaluation is the most common method used for freshness evaluation in the fish sector. A measurement scale for fish freshness and hence consumer acceptability was devised by the now closed Torry Research Station. Separate descriptive scales have been developed for different species, using the senses of sight, smell, touch and taste. To assess the cooked odour, flavour and texture of razor clams, the Torry Sensory Score Sheet developed for scallops was used.

Samples of freshly shucked razor clam meat were placed in boilable plastic bags with 100 ml of one percent sodium chloride solution. The bags were suspended in boiling water and when the water returned to the boil cooking continued for a further five minutes.

Odour, flavour and texture were marked out of 5, with 5 being the best condition and 0 being the worst possible cooked product. This is outlined in Table 1 overleaf.

The score for texture was not included in the compilation of a final score for each sample as, unlike scallops, the tip of the razor clam's foot was always found to be tougher than the rest of the body. Hence texture could vary even within the animal being tested.

The assessors had no knowledge of the source or trials treatment of the samples being assessed.

Table 1 - Organoleptic Assessment Scales (texture not used)

Cooked Odour		Cooked Flavour		Cooked Texture	
5	Sweet milky; condensed milk	**5**	Intensely sweet; cloying	**5**	Chewy; fibrous; rubbery
4	Slight milky; seaweed	**4**	Less sweet, milky	**4**	Slight chewy; slight soft
3	Neutral; musty	**3**	Neutral; slightly musty; some residual sweetness		
2	Slight sour	**2**	Slight sour; musty; some residual sweetness	**2**	Soft; gelatinous; sticky
1	Sour; sweaty; ammonical	**1**	Sour; bitter; off; some sweetness may still be detectable		

3.3.2.2 Whole Animal Assessment

As part of an earlier study with (CEFAS 1999)[vi], a visual method of assessing the condition of live razor clams, called the **'Consolidated Condition Score',** was developed. This looks at four indicators of condition which were:

i) Split – Any splitting of the membrane from the pedal opening to the 4th opening scored as 0 (no splitting) or 1 (splitting);

ii) Gaping – Membrane totally split from pedal opening to 4th opening, foot can be observed inside sheath and animal has lost the ability to hold the shell together – scored as 0 (no gaping) or 1 (gaping);

iii) Colour – As assessed on the foot, membrane around the pedal opening and the colour of the flesh as it changed from white through yellow to a brown colouration from the time of harvest and during depuration and subsequent storage – scored as 0 (white), 0.5 (yellow) or 1 (brown tinge). This change of colour is believed to be associated with the physiological deterioration of the animal;

iv) Response – Assessed by observing the movement of the foot through the bottom of the complete, split or gaping pedal opening. The ability and speed at which the animal may retract its foot, and close or retract its siphons upon touching – scored as 0 (fast), 0.33 (slow), 0.66 (slight) or 1 (dead).

All of these observations, although subjective to some extent, were almost always made by the same worker therefore the consistency of approach and assessment was maximised. The quality assessment system has been developed and adapted for the unique characteristics of razor clams.

The 'Consolidated Condition Score' is the average of the four indicators.

4 OUTLINE OF TRIALS SEQUENCE

4.1 Diver Caught – Trial 1

Divers obtained razor clams from a category 'B' bed in Weymouth Bay taken from a depth of 3 – 5 m on Saturday 30/01/99. After returning to the vessel, the divers sorted and banded the animals. The bundles of razor clams were then placed horizontally into a plastic keep box and lowered back into the sea for storage.

On Monday morning the animals were retrieved and delivered to the CEFAS laboratory at Weymouth - a journey time of less than one hour. Upon arrival at the laboratory the animals were checked to ensure that there were no damaged ones and to confirm that there were 10 animals in each bundle and that they were all orientated the same way.. They were then placed into a Seafish small-scale standard design depuration tank for holding until the Tuesday. The initial water temperature in the tank was 13°C and the salinity 34.5‰. The average temperature in the tank during storage was 15.9°C. On the Tuesday afternoon the animals were handled according to the 9 holding conditions described in Section 3.1.

4.2 Diver Caught – Trial 2

Razor clams were harvested on a Sunday 07/03/99 by divers from an unclassified bed in Torbay. The animals were held from Saturday night until Monday morning in a tank of seawater by the harvester. On the Monday morning the razor clams were delivered to a local despatch centre where they were bundled and packed into a cool box with frozen chill blocks, prior to being sent by overnight courier to Hull. They were received on Tuesday morning in the Seafish laboratory in Hull for analysis and for extended shelf-life trials. On receipt, the animals were checked. They had been banded into bundles of ten animals and had been clearly sorted by size, none were damaged. It was subsequently determined that the seawater tank used for initial holding had not been aerated.

Due to the limited number of animals supplied they were divided into five of the trial's conditions: chilled wrapped, chilled unwrapped, iced wrapped, iced unwrapped and wet storage. The wet storage sample was placed in a Seafish small-scale standard design depuration tank.

4.3 Dredge Caught – Trial 3

This trial was based at Circebost on the Island of Great Bernera off the west coast of Lewis in the Western Isles. The animals were harvested by the thirty-six foot fluidised bed dredger ‘GILL’ in 1.5 to 4 fathoms of water in West Loch Roag on Thursday 01/07/99.

The trials were carried out in a remote area on the west coast of Uist with very sparsely populated surrounding land. This loch is subject to strong currents and a free exchange of water with the Atlantic Ocean.

Initial hauls resulted in animals being landed on deck from a soft substrate.

Few animals were caught compared with the subsequent hauls taken from hard ground nearby. There also appeared to be more damaged animals from the soft ground than the hard ground. It was not possible, given the constraints on the day, to record the amount of animals damaged nor to record the total catch quantity either for the day or for any individual haul. The animals taken from the soft ground were also found to have their siphons and pedal openings packed with silt. Both *Ensis siliqua* and *Ensis arcuatus* were caught at the same time and were similarly affected.

Figure 9 – Catch taken from soft ground

Figure 10- Catch taken from hard ground

Each tow lasted approximately 10 to 15 minutes. In commercial practice the catch was then placed on a sorting table and any animals badly broken were rejected. Animals with breaks that did not pass through both shells were retained. All animals retained were then placed loose in baskets on the deck until such time as successive hauls had produced enough to fill three baskets. These were then transferred to a 120 litre tank held on the deck of the vessel. The tank was then filled with water at the end of fishing, prior to steaming back to port.

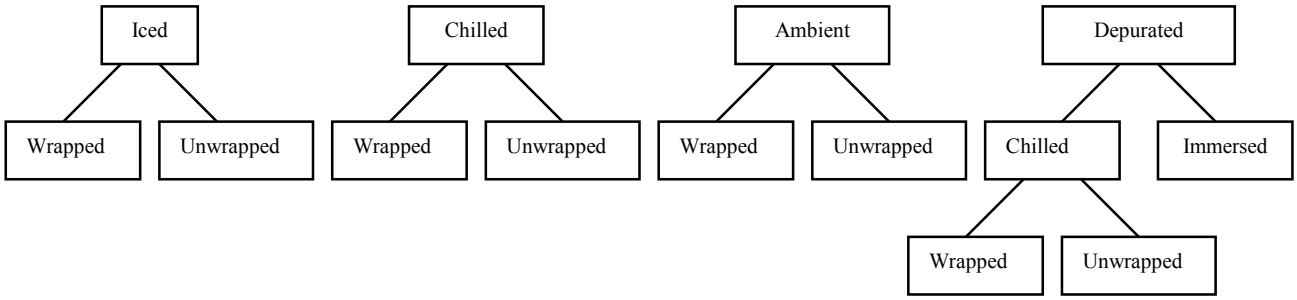
For the trials, as each haul was placed on deck a selection of animals that had no obvious traumatic injury were selected. These animals were sorted and banded. The animals were then held dry and horizontally in perforated plastic boxes on deck. These boxes were covered to provide protection from the wind and sun. Fishing started at 09.40, the first haul was on deck at 09.45 and fishing finished at 13.45.

At the end of the fishing operations, the two boxes of selected animals were placed in the holding tank with the loose commercial catch. When the vessel arrived back at the pier, the loose commercial catch was sorted according to species and banded by the crew. This was done by placing the animals in a “drainpipe” tube that gave a “nominal” 1 kg weight per bundle. No attempt was made to grade or further sort the

catch for damaged animals. At this stage a further selection of the commercial catch was taken for the trials to compare with that taken earlier and were sorted and banded. This gave four conditions:

1. *Ensis siliqua* taken from soft ground and banded on capture;
2. *Ensis arcuatus* taken from soft ground and banded on capture;
3. *Ensis siliqua* taken from hard ground, handled by crew and then banded on landing;
4. *Ensis arcuatus* taken from hard ground, handled by crew and then banded on landing;

Samples of these batches were transferred the few yards to a shore facility where they were placed in separate laboratory-scale trial depuration tanks. Once the tanks were loaded the depuration cycle was started. Samples were also taken at this time for microbiological assessment. Samples of the commercial catch were also placed, wrapped and unwrapped, in ambient, iced, and chilled conditions without being depurated. The diagram below illustrates the conditions under investigation.



The table below shows the weight, quantity of animals per tank and number found to have minor chips to the shell or damage when assessed at the end of the depuration cycle:

Table 2 - Weights/Damage by Depuration Tank

Tank/Condition	Weight Kg	Number of animals	Average Weight g	% Damaged
1	7.094	100	7	14
2	3.195	100	3	19
3	5.915	56	10	78
4	6.178	184	4	13

Although every effort was made to select only undamaged animals, the restricted number of animals that were of a good condition meant that many had small nicks, chips and minor fractures that were only apparent when all the sand and silt on the outside of the animals had been dislodged during depuration. The constraints on available numbers of clams also hindered obtaining equal and representative numbers for the depuration trial.

At the end of depuration, observations were also made of mortality and whole animal condition. The purified batches were then further divided to provide storage samples that were banded and un-banded. These were then held chilled in insulated containers and transported to Hull, together with the unpurified samples in their respective conditions.

The animals were held in those conditions at Hull until all the animals in each group had died or there were insufficient numbers left to make a representative sample for assessment or microbiological testing.

5 RESULTS

5.1 Diver Caught Trials Results

5.1.1 Whole Animal Assessment

Whole animal assessment takes into account the condition of the animal with regard to its acceptability to a purchaser. The scoring system used is described in more detail in section 3.3.2.2.

Trial 1

The average temperature of the samples held in an ambient condition was 8.7ºC. The chilled samples had an average temperature of 2.8°C and the iced ones averaged 0ºC.

It can be seen from Table 3 that the animals held in the various conditions have effectively split into three groups. The animals held immersed and in ambient condition produced the worst scores and all were found to be dead after 10 days. The lowest score throughout the trial and hence the best physical condition was attained by those held chilled and wrapped. The other conditions had scores that fell between these.

Table 3 - Diver Caught *Ensis*
Whole Animal Assessment - Trial 1 Results

Condition	Observations	Days After Harvest		
		6	10	12
Iced Wrapped	% Dead	0.00	55.00	100.00
	Whole Animal Assessment	0.19	0.33	0.49
Iced Unwrapped	% Dead	10.00	33.00	92.00
	Whole Animal Assessment	0.16	0.35	0.52
Chilled Wrapped	% Dead	0.00	0.00	16.00
	Whole Animal Assessment	0.08	0.14	0.25
Chilled Unwrapped	% Dead	0.00	0.00	92.00
	Whole Animal Assessment	0.10	0.21	0.49
Ambient Wrapped	% Dead	0.00	100.00	--
	Whole Animal Assessment	0.13	0.76	--
Ambient Unwrapped	% Dead	0.00	100.00	--
	Whole Animal Assessment	0.29	0.69	--
Depurated Chilled Wrapped	% Dead	0.00	10.00	16.00
	Whole Animal Assessment	0.15	0.34	0.36
Depurated Chilled Unwrapped	% Dead	0.00	0.00	60.00
	Whole Animal Assessment	0.18	0.34	0.37
Depurated Immersed Storage	% Dead	15.00	100.00	--
	Whole Animal Assessment	0.18	0.57	--

The best quality score after twelve days was the sample that was chilled and wrapped with a final score of 0.25.

Trial 2

Table 4 shows the results for the second trial. The condition of the animals was markedly inferior to those in trial 1. As with trial 1, the chilled and wrapped sample gave the best overall results. The animals held immersed produced the best score at day five, but then died. Having been held in an un-aerated tank for an extended period it is possible that they were non-viable upon transfer to a depuration tank.

Table 4 - Diver Caught Ensis
Whole Animal Assessment - Trial 2 Results -

Condition	Observations	Days After Harvest	
		5	9
Iced Wrapped	% Dead	0.00	0.00
	Whole Animal Assessment	0.43	0.53
Iced Unwrapped	% Dead	0.00	28.00
	Whole Animal Assessment	0.55	0.61
Chilled Wrapped	% Dead	3.00	7.00
	Whole Animal Assessment	0.40	0.06
Chilled Unwrapped	% Dead	0.00	0.00
	Whole Animal Assessment	0.56	0.53
Depurated Immersed Storage	% Dead	0.00	57.00
	Whole Animal Assessment	0.30	No assessment

5.1.2 Mortality

Trial 1

Those animals held chilled and wrapped, or depurated then chilled and wrapped, showed the lowest level of mortality. This may be due to a microclimate having developed within the tightly wrapped bundle, trapping brine and body fluids around the animals. The animals held in ambient conditions and in wet storage fared the worst, which was not unexpected. They had all died by day 12.

The iced samples did not survive as long as the chilled samples. However, it was found that a significant number of the iced bundles were sitting in non-saline ice melt water, which may have contributed to their premature mortality. At day 12, the depurated, wrapped and chilled animals did not exceed the levels of mortality of those animals that were not depurated, but held in a similar way. The animals that were depurated and held unwrapped suffered sixty percent mortality between day 10 and day 12. This indicates that depuration did not of itself inhibit shelf life if the animals were carefully handled and held wrapped and chilled post depuration.

Trial 2

The second trial appears to support the above points in emphasising the advantage of chilling over icing. Most of the chilled animals were alive on day nine. The iced, unwrapped and immersed animals fared worse with 28 - 57% dead at this time.

In this trial the iced animals suffered low mortality compared to that seen in trial 1, indicating that the presence of ice meltwater may have indeed contributed to the high level of mortality.

5.1.3 Eating Quality

Trial 1

Assessment was carried out in the Seafish laboratory in Hull. A low score indicates poor quality. The results are shown in Table 5 below.

Table 5 - Diver Caught *Ensis* - Eating Quality Assessment - Trial 1

Condition	Days After Harvest	
	9	11
Iced Wrapped	3.1	2.7
Iced Unwrapped	3.4	2.7
Chilled Wrapped	3.8	2.7
Chilled Unwrapped	3.6	2.6
Depurated Chilled Wrapped	3.6	2.9
Depurated Chilled Unwrapped	3.3	2.8

The cooked sensory assessment of the animals in this trial on day nine gave a range of scores between 3.1 and 3.8, with iced wrapped giving the worst score of 3.1 and chilled and wrapped giving the best score of 3.8.

By day 11 the animals had deteriorated slightly to give scores of between 2.6 and 2.9, with chilled and wrapped again giving the best score.

The condition that gave the best sensory scores at day nine was the chilled and wrapped sample. However, by day eleven all the six conditions are giving similar scores, with the depurated chilled and wrapped sample proving slightly better than the others. Depuration appeared to have no significant effect on eating quality.

Trial 2

The results are shown in Table 6. On day 5 the animals held “immersed” gave the lowest (worst) score (2.4) of those assessed. This puts the animals in the “sour” range of odours and flavours. It is unlikely that these animals would have been acceptable to consumers.

The animals held chilled and wrapped had a score of 3.7, exhibiting the best odours and flavours. These animals were exhibiting flavours well above the neutral level toward sweet attributes.

Table 6 - Diver Caught *Ensis* - Eating Quality Assessment - Trial 2

Condition	Days After Harvest	
	5	9
Iced Wrapped	3.5	2.8
Iced Unwrapped	3.1	1.8
Chilled Wrapped	3.7	3.0
Chilled Unwrapped	3.5	2.6
Depurated Immersed Storage	2.4	None assessed all dead

By day 9 all of the samples had further deteriorated, particularly the iced and wrapped samples which were sour, ammoniacal and off. This level of deterioration was not observed in the samples held in the same condition in the first trial and it may be that the difference is related to the longer period of time between harvest and being stored in this trial. No samples were available from the depurated and immersed storage condition as they were all dead.

5.1.4 Bacteriological Results

No significant levels of *Total Coliforms* or *Escherichia coli* were found throughout these trials.

The TVC and *Pseudomonas* results from trials 1 and 2 are shown in tables 7 and 8 overleaf. Generally, there was little significant difference between the different batches.

Table 7 – Microbiological Analysis - Trial 1

	Iced wrapped	Iced unwrapped	Chilled wrapped	Chilled unwrapped	Ambient wrapped	Ambient unwrapped	Depurated chilled wrapped	Depurated chilled unwrapped	Depurated chilled unwrapped	Depurated Immersed Storage
Aerobic Bacteria Day 9	1.0×10^4	1.2×10^4	1.9×10^3	2.4×10^4	5.2×10^4	3.7×10^4	2.2×10^3	4.5×10^3	4.5×10^3	1.0×10^4
Aerobic Bacteria Day 12	1.3×10^4	3.9×10^4	2.0×10^4	7.2×10^4	None All Dead	None All Dead	4.0×10^4	9.1×10^3	9.1×10^3	None All Dead
Pseudomonas sp Day 9	1.0×10^4	1.0×10^4	1.9×10^3	1.5×10^4	5.2×10^4	7.1×10^3	1.6×10^3	1.0×10^3	1.0×10^3	5.6×10^2
Pseudomonas sp Day 12	3.0×10^3	2.0×10^4	2.0×10^4	2.0×10^4	None All Dead	None All Dead	2.2×10^3	5.0×10^3	5.0×10^3	None All Dead

Table 8 – Microbiological Analysis - Trial 2

	Iced wrapped	Iced unwrapped	Chilled wrapped	Depurated chilled wrapped	Depurated chilled unwrapped
Aerobic Bacteria Day 2	Not sampled	1.0×10^3	5.8×10^3	1.7×10^3	Not sampled
Aerobic Bacteria Day 5	2.7×10^3	1.0×10^3	5.4×10^3	1.8×10^3	1.0×10^3
Aerobic Bacteria Day 9	1.2×10^4	3.6×10^4	5.7×10^3	6.8×10^3	Not sampled
Pseudomonas sp Day 2	Not sampled	4.0×10^2	5.0×10^2	6.0×10^2	Not sampled
Pseudomonas sp Day 5	8.0×10^2	4.0×10^2	6.0×10^2	1.1×10^3	1.6×10^3
Pseudomonas sp Day 9	6.0×10^2	6.8×10^3	1.5×10^3	3.1×10^3	Not sampled

5.2 Dredge Caught Results

5.2.1 Depuration

5.2.1.1 Temperature

The average temperature in all four depuration tanks was 10.9°C. The temperature ranged from 10.3 to 11.7°C.

5.2.1.2 Ammonia:

During the depuration cycles, the ammonia levels rose from zero to between 0.09 – 0.19 parts per million (ppm) by the end of the trial, indicating activity in all four tanks. Due to the different masses and numbers of animals in each tank, any detailed comparison of ammonia production rates is not meaningful.

5.2.1.3 *Dissolved Oxygen:*

The Oxyguard continuous monitoring equipment was not in commission throughout this trial. Due to the remote location we were unable to effect a replacement and therefore took individual measurements with a hand held unit as time permitted. DO levels remained between 7.5 – 9.7 ppm throughout the trial which is satisfactory.

5.2.1.4 Visual Observations:

The table below shows the notes taken during the depuration cycle.

Table 9 - Observations by Tank of Dredged Ensis - Trial 1

	Siliqua from soft ground, banded on capture	Arcuatus from soft ground banded on capture	Siliqua from hard ground handled by crew as normal	Arcuatus from hard ground handled by crew as normal
Time after start of depuration	**TANK 1**	**TANK 2**	**TANK 3**	**TANK 4**
16 hrs	Animals have **both** siphons and pedal openings **PACKED** with sand. Siphons out. About 1/3 had feet out. Slight foam e.g. present on top of depuration tank	Animals have **both** siphons and pedal openings **PACKED** with sand. Most feet out, siphons out. Slight foam.	Totally foamed up. Most feet out. Siphons out.	Clear, ¾ feet out. Siphons out.
23 hrs	Slight foam. Lots of sand being ejected from animals. Most feet and siphons out. Small amount of faeces.	Some sand purged. Most feet and some siphons out. Foamed up. slight faeces.	Mostly foam. Most feet and all siphons out. Slight sand purged.	Very slight foam. All feet and siphons out. Lots of faeces.
40 hrs	½ tank foamed up. Most siphons and feet out. Some movement. Large amount of sand/ detritus on tank bottom.	All foamed up. All feet and siphons out. Large amount of sand/detritus on tank bottom.	Very thick foam over whole tank. All feet and siphons out except for one bundle that looks like it is heavily jammed with sand. (None ejected). Some sand on tank bottom.	Foamed up. ½ feet and siphons out. Some occasional good movement on those with feet out. Some sand on tank bottom.

The results concur with observation of these animals in previous trials where the animals appear to remain dormant on initial insertion into the tanks and then gradually recover. However, all four groups on this occasion seemed to take longer to show signs of activity than with diver caught animals.

With the exception of one bundle that did not respond to re-immersion, the *E.siliqua* held in tank 3 (taken from hard ground and handled by the crew in their normal fashion) were held immersed for a longer period on the vessel and produced the best overall visual indications that the animals were respiring/functioning well.

5.2.1.5 Microbiology

It was not surprising to find very low initial levels of bacterial fauna and flora in the samples from such a remote harvesting area.

Tables 10 and 11 show the various levels of organisms tested for, before and after depuration.

As can be seen, no salmonella species were detected at all. The highest *E. coli* count was only 50 CFU and the highest count for *Pseudomonas* was 40 CFU. Although one sample of *Arcuatus* gave a relatively high TVC (Total Viable Count) of aerobic bacteria, it was not repeated in any of the others samples and may just indicate one rogue dead animal in that batch sent to the laboratory.

Subsequent samples taken post depuration failed to give indications of any trend that was significant. Given that the fishing grounds that the animals were taken from are so remote from potential contamination and that no holding condition produced a marked increase in colony forming units, it would be wise to repeat the trial with animals taken from a contaminated 'B' class area.

Table 10 – Microbiological Analysis: Dredged *Ensis siliqua.*

	Start condition Siliqua Sample 1	Start condition Siliqua Sample 2	Note:
E Coli	20.0	20.0	NH - Normal Handling = Held on deck ,loose, unbanded with no protection from elements
Salmonella	0.0	0.0	GH - Good Handling = Banded on harvest, protected from elements
Aerobic/TVC	1.9×10^2	1.8×10^2	Upon steaming for port both sets held in seawater taken from harvesting area
Pseudomonas	0.0	0.0	

Bacteria	Days since Harvest	Non Depurated				Depurated			
		Chilled unwrapped **NH**	Chilled wrapped **NH**	Slight Damage Chilled wrapped **NH**	Slight Damage Chilled unwrapped **NH**	Chilled wrapped **NH**	Chilled wrapped **GH**	Chilled wrapped **NH**	Chilled unwrapped **NH**
TVC	2						4.7×10^4	7.7×10^4	4.7×10^4
	4	7.5×10^4	6.2×10^4						
	7					5.6×10^4	2.0×10^4		2.0×10^2
	9								
	12			2.4×10^4	1.5×10^4		4.9×10^4		
Pseudo	2	9.0×10^3	1.1×10^4				1.1×10^4	7.9×10^3	8.3×10^3
	4								
	7					0.0	0.0		0.0
	9								
	12			1.4×10^4	9.8×10^3		1.0×10^4		

Table 11 – Microbiological Analysis: of Dredged *Ensis arcuatus.*

	Start condition Arcuatus Sample 1	Start condition Arcuatus Sample 2	Start condition Arcuatus Sample 3	Note:
E Coli	50.0	40.0	20.0	**NH - Normal Handling = Held on deck ,loose, unbanded with no protection from elements**
Salmonella	0.0	0.0	0.0	**GH - Good Handling = Banded on harvest, protected from elements**
Aerobic/TVC	1.3×10^3	1.1×10^2	1.4×10^2	**Upon steaming for port both sets held in seawater taken from harvesting area**
Pseudomonas	0.0	40.0	20.0	

Bacteria	Days since Harvest	Non Depurated								Depurated		
		Ambient wrapped **NH**	Ambient unwrapped **NH**	Iced, wrapped **NH**	Iced, unwrapped **NH**	Chilled wrapped **NH**	Chilled unwrapped **NH**	Slight Damage Chilled unwrapped **NH**	Slight Damage Chilled wrapped **NH**	Chilled wrapped **GH**	Chilled wrapped **NH**	Chilled unwrapped **NH**
TVC	2									9.4×10^4	2.9×10^4	4.7×10^4
	4	1.7×10^5	2.0×10^5	2.8×10^5	8.2×10^4	4.6×10^4	8.2×10^4					
	7									2.0×10^2	2.6×10^5	7.9×10^4
	9				9.0×10^4							
	10							1.9×10^4	1.6×10^5	4.9×10^4		1.5×10^5
	12			1.6×10^5	5.6×10^5		1.3×10^5					
Pseudo	2									1.2×10^4	6.9×10^3	1.3×10^4
	4	8.8×10^3	1.2×10^4	1.4×10^4	1.4×10^4	9.1×10^3	1.3×10^4					
	7									0.0	2.0×10^5	1.0×10^3
	9				0.0							
	10							8.0×10^3	2.0×10^4	1.0×10^4		7.6×10^4
	12			1.2×10^5	4.0×10^5		3.0×10^4					

5.2.2 Storage

5.2.2.1 Whole Animal Assessment

The whole animal assessment scores are shown in Table 12. Overall the whole animal assessment scores for diver caught ensis are much lower than those obtained for dredge caught. For example, the quality score for the E. siliqua 4 days after capture ranged from 0.7 to 0.40 and the scores for the E. arcuatus ranged from 0.07 to 0.95 for the same period. In comparison the scores on day 6 of trial 1(shown in Table 3), for the razor clams that had been harvested by divers, gave better scores that ranged from 0.08 to 0.29.

The depurated animals were all subject to chilled storage after depuration and gave similar scores to those non depurated animals stored in the same way. This indicates that depuration had no detrimental effect on the post-storage whole animal assessment.

Table 12 - Whole Animal Assessment - Dredged *Ensis sp.*

Conditions		Species A= E. Arcuatus S= E. Siliqua	Days After Harvesting		
			4	8	11
Non Depurated	Ambient, wrapped, normal handling	A	0.95	--	--
	Ambient, unwrapped, normal handling	A	0.95	--	--
	Iced, wrapped, normal handling	A	0.61	0.61	0.54
	Iced, unwrapped, normal handling	A	0.26	0.60	0.42
	Chilled, wrapped, normal handling	A	0.30	0.49	--
	Chilled, unwrapped, normal handling	A	0.14	0.44	--
	Chilled, wrapped, normal handling	S	0.18	0.68	--
	Chilled, unwrapped, normal handling	S	0.07	0.75	--
Depurated	Chilled, wrapped, good handling	A	0.07	0.49	--
	Chilled, wrapped, slight damage	A	0.38	0.64	0.61
	Chilled, wrapped, normal handling	A	0.12	0.23	0.50
	Chilled, unwrapped, normal handling	A	0.09	0.51	--
	Chilled, wrapped, normal handling	S	0.08	0.43	0.62
	Chilled, unwrapped, normal handling	S	0.09	0.69	--
	Chilled, unwrapped, normal handling	S	0.13	0.41	--
	Chilled, unwrapped, slight damage	S	0.40	0.75	--
	Chilled, wrapped, slight damage	S	0.36	0.57	0.75
	Chilled, wrapped, good handling	S	0.08	0.49	--

5.2.2.2 Mortality

The results for mortality are shown in Tables 13 and 14. Ensis arcuatus held in an ambient condition died considerably faster than those kept chilled or iced.

The dredge caught animals suffered a much higher rate of mortality compared with those that had been harvested by diver. Mortalities were at 30 - 60% for dredged animals after 4 days compared to little mortality at all for diver caught after 6 days. There does not appear to be any difference in mortality between depurated and non depurated *Ensis siliqua*.

For the *Ensis arcuatis* held in similar chilled storage conditions the non depurated animals had a better survival rate on day 4 but were similar on days 8 and 11.

Table 13 - Percentage Mortality of *Ensis siliqua* - Dredged Trial

Days since harvest	Depurated			Non Depurated	
	Chilled wrapped GH	Chilled wrapped NH	Chilled unwrapped NH	Chilled wrapped NH	Chilled unwrapped NH
4	50	60	50	45	50
8	83	83	67	100	85
11	83	100	100	--	100

Table 14 - Percentage Mortality of *Ensis arcuatus* - Dredged Trial

Days since harvest	Depurated			Non Depurated					
	Chilled wrapped NH	Chilled unwrapped NH	Chilled wrapped GH	Ambient wrapped	Ambient unwrapped	Iced wrapped	Iced unwrapped	Chilled unwrapped	Chilled wrapped
4	60	52	52	72	45	35	38	32	31
8	77	62	70	100	100	58	48	N/Assessed	62
11	100	83	83	--	--	86	87	95	100

Note: NH - Normal Handling = Held on deck ,loose, unbanded with no protection from elements
GH - Good Handling = Banded on harvest, protected from elements

5.2.2.3 Eating Quality Assessment

Assessment was carried out in the Seafish Laboratory in Hull. A low score indicates poor quality. There were a limited number of animals available.

The lowest score was derived from the chilled, wrapped E. siliqua on day 8, which was not depurated and was handled by the crew, as per their usual practice. This group had actually scored very well at day 4. Iced unwrapped E.arcuatus handled in a similar way did not appear to deteriorate at all. The storage on ice, although it may kill the animal, may also preserve the positive aromas and flavours. Those E.siliqua that were treated to 'good handling', depurated and subsequently wrapped and chilled also maintained these positive attributes.

Table 15 - Eating Quality Assessment - Dredged *Ensis sp*

Condition and Harvesting	Days Since Harvesting	
	4	8
Non-Depurated		
Chilled, unwrapped, *E. siliqua*, NH, non depurated	4.0	--
Chilled, wrapped, *E. siliqua,* NH, non depurated	4.0	2.0
Chilled, unwrapped, *E. arcuatus*, NH, non depurated	4.5	--
Iced, wrapped, *E. arcuatus* , NH non depurated	4.5	--
Iced, unwrapped, *E. arcuatus*, NH, non depurated	3.0	3.0
Chilled, wrapped, *E. arcuatus,* NH, non depurated	3.5	--
Chilled, wrapped, *E. arcuatus*, NH, non depurated	3.5	--
Depurated		
Chilled, wrapped, *E. siliqua,* **NH**, depurated	3.5	2.7
Chilled, unwrapped, *E. arcuatus,* **GH**, depurated	3.0	3.0

Note: NH - Normal Handling = Held on deck ,loose, unbanded with no protection from elements
GH - Good Handling = Banded on harvest, protected from elements

6 DISCUSSION AND CONCLUSIONS

Throughout these trials all methods of assessing the animals have indicated that ambient storage temperature results in an inferior product. This may be even more pronounced in the summer months if efforts are not made to limit the effects of high temperatures. It appears also, from earlier work, that leaving the animals unbanded for long periods results in accelerated deterioration.

Direct application of ice to the animals also seems to result in increased mortality particularly with immersion of the animals in ice melt water. Non-contact chilling of the live animals maintains quality for the longest period of time and so fulfils the current demands of the UK industry in supplying a live product to the most distant markets.

It is not clear at this stage if there is an advantage in holding the animals in water on board the vessel as opposed to dry. Factors that may influence the success of wet storage would be water temperature, application of an effective aeration system and the previous handling history of the animals.

Currently, animals harvested by divers on the west coast of Scotland on day 0 are being transported to Glasgow were they are sorted and packed before being transported by air to Manchester Airport on day 2. They are then transhipped on day 3 to Hong Kong arriving there on day 4. The dealers in Hong Kong need to be able to hold the animals alive for two days to distribute them to their customers on Mainland China. Those customers then need two days remaining shelf life to sell them to the end user. (*pers. com*. Mr. S. Lee). This means that animals need to be able to show signs of life 8 or 9 days after capture. The dived animals that were stored banded, chilled and wrapped appear to be able to meet this criteria.

There are clear indications from these trials that the production of a premium product is more likely to come from non-dredged sources of supply. Diver and foreshore harvesting of animals rarely results in traumatic damage to the animals or substantial ingestion of sand and silt into the siphons or pedal opening.

However, it should be noted that for the dredge trial, the vessel used had an ‘old’ style fluidised dredge and that progress has been claimed for subsequent generations of the dredge design reducing the number of animals damaged (*pers. com.* C. Henderson). There have also been developments in other designs that use propellers which are lowered to the seabed to blow sand away from the target animals (*pers com.* Prof. E Fahy) and it is claimed that a non-fluidised extraction method and air lifts may also improve the quality of animal landed on deck. (*pers com.* M. Blood-Smythe).

Sorting, grading and banding helps maintain animals in a good condition. Common sense suggests that this should be carried out as soon as is practicably possible. The time delay implications of these handling operations should be investigated in future trials.

Holding the animals in still seawater without aeration was observed on one occasion during this work to be harmful to the animals. An essential requirement for food safety is that any water the animals are immersed in must not be a source of contamination.

Application of the correct depuration technology does not seem to adversely affect any of the quality indicators measured but the time delay associated with depuration must be accounted for in the total storage life.

Due to operational constraints on the dredger "GILL" it was not possible to harvest animals from a 'B' class area and verify if dredged animals would depurate or to assess if animals taken from soft grounds would depurate/de-grit when their siphons have been packed with sand/debris.

Future work should address some of the questions that remain, namely:-

1. Can dredged animals depurate?
2. Is the type of substrate in which dredging takes place a factor in the above?
3. What level of damage can be sustained by the clams and still result in an ability to depurate and/or survive transportation to market?
4. How long can these animals be left unbanded before irreversible quality losses start to take place?
5. Is there any advantage in holding these animals dry or wet between capture and landing to a packing/depuration centre?
6. What is the most effective form of transportation - either chilled or vivier

It is hoped that some of these questions will be investigated and answered in the near future.

ADDENDUM

Further work carried out since these trials has shed doubt on the crucial issue of the ability of dredged razor clams to reliably depurate, when using current dredging technology.

7 RECOMMENDATIONS FOR GOOD HANDLING PRACTICE

Based on current knowledge, the following simple actions on the part of the harvester, which are common to all methods of capture, will be beneficial to product storage life and quality:

- Sort the catch as soon as it lands on deck or on the beach, reject any dead/traumatically damaged animals or those with the foot jammed out between both shells.
- Do not re-immerse harvested animals in any water or in any circumstances that may cause contamination, especially not over the side of the boat in harbour.
- Handle the animals with care. When moving them, place containers down gently. Do not drop or otherwise mishandle them. Percussive shock reduces storage life.
- Separate the different species of razor clams.
- Orientate all animals such that the siphons or feet are all the same way round and bundle together using elastic bands both top and bottom. Hold the animals in a horizontal orientation.
- Place in a suitable container, either a basket or box and protect from excessive exposure to wind, rain and sun.
- If possible chill the catch. Alternatively, use sacking or old carpets soaked in seawater, placed over the containers, to produce a micro climate that will help to prevent desiccation.
- If the catch is due to be depurated, reduce the length of time out of water to a minimum. For hand gathered animals the maximum time between leaving the water and delivering to a dispatch centre should be no more than 24 hours. (The ability of dredge caught animals to depurate still has not been proven).
- Prior to final shipping to a customer or for storing for extended periods of time, wrap each bundle of animals in a sheet of greaseproof paper, secure with tape or elastic bands and keep chilled but out of any melt water.
- Do not allow the animals to come into direct contact with ice if a live product is required.
- Chilling of the animals should be carried out/continued in establishments ashore and in onward transportation.

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