Bord Iascaigh Mhara
Irish Sea Fisheries Board

The assessment of fish quality before and after a device used to separate pelagic fish (mackerel) from offloading delivery water

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1. Introduction

At the request of the Sea Fisheries Protection Authority (SFPA), the quality of mackerel before and after a device used to separate pelagic fish from offloading delivery water (Fig. 1a), was conducted by BIM on 30th November 2012 at the new pier, Killybegs.

It should be noted that the quayside separator, which forms the subject of this assessment is similar in operation principles to that which is normally used by vessels to separate or recirculate the majority of tank water from fish at discharge (Fig. 1b).

(a) (b)

Figure 1. Devices used to separate pelagic fish from offloading delivery water: (a) Proposed device subject to this assessment, (b) Device used by pelagic vessels to recover or discharge delivery water.

2. Methodology

2.1. Overview

Random samples of fish from *Genesis II*, a refrigerated seawater (RSW) vessel, were assessed in the following 3 locations from vessel to processor:

1. Prior to discharge from *Genesis II*;
2. During discharge on exit from the separating device to the tanker and
3. Upon discharge of the tanker at the processor (Arctic Fish Sales, Killybegs).

Fish quality was assessed at each of the stages throughout the delivery chain from vessel to processor using the attributes described in the BIM Mackerel Quality Guide.

To monitor the temperature of fish throughout the delivery chain (i.e. the cold chain management), 6 fish were fitted with internal temperature loggers and tagged.

2.2. Sampling Logistics

BIM staff arrived at *Genesis II* alongside the new pier in Killybegs, at the time agreed with the SFPA of 07:30. The ambient air temperature was recorded as 2°C (Fig. 2).

Figure 2. 30 November 2012; 07:30. *Genesis II* alongside the new pier in Killybegs. Separator in position and BIM staff launching temperature loggers in preparation for the quality assessment procedure.

Due to an incompatibility between the diameter of the vessel's recirculation hose with that of the outlet manifold on the separating device (Fig. 3), the planned discharge through the separator was postponed while the separator was modified to accept the vessel's hose. This was accomplished at 11:00 when the vessel and separating device were successfully connected.

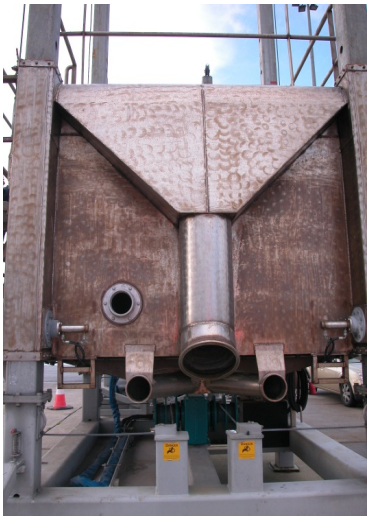


Figure 3. The large inlet and smaller outlet manifolds of a separating device.

Discharge of fish from the selected RSW tank began at 11:14 and was competed at 11:22. The discharge rate of the pump (c. 70t/hr) was provided by the ship's engineer. The ambient air temperature at this stage in the procedure was 4°C.

The post-separator sample was taken at 11:18 using a fish basket placed under the flow of fish exiting the separating device on top of the transport tanker (Fig. 4).

Figure 4. Preparing to take a sample of fish from the top of the tanker at the point of exit of the fish from the separator.

The final sample was taken at 11:33 from the tank to which fish was discharged from the transport tanker. Discharge began at 11:30 and finished at 11:55 (Fig. 5).

Figure 5. Fish being received by the processor following discharge from the tanker.

The total time taken from offload of the selected RSW tank to reception at the processor was 8 minutes. The approximate volume of the fish offloaded was 10 tonnes.

2.3. Sampling details

A random sample of 10 fish were removed on each sampling occasion (i.e. Vessel, post-separator, processor).

The core temperature of each fish in the sample was immediately recorded by inserting a calibrated, hand-held temperature probe (*Jenway 220* digital thermometer) through the vent of the fish and into the centre of the body cavity.

Following this process, a quality assessment of each fish in the sample was conducted in accordance with industry best practice as detailed in the BIM Quality and Handling Guide for Mackerel.

Seven freshness attributes (i.e. Eye condition, Body colours and reticulations, Iridescence, Flesh texture, Rigor, Gill odour and Gill colour) and three physical attributes (i.e. External condition and the internal condition of the flesh and the gut wall) were assessed in each case and an average score determined for each attribute.

2.4. Cold chain tracking

The inspection hatch to an RSW tank was opened and a non-random sample of 6 fish were removed from the tank by crew of *Genesis II* using a fish basket and passed immediately to the sampling team.

A *Dwyer BDL-1* (www.dwyer-inst.com) button temperature logger (0.5°C resolution) set to record temperature at 1 minute intervals (Fig. 6), was inserted into the mouth of each fish and pushed down into the stomach. A paper label, numbered in pencil, was inserted into the mouth of each fish and an identification tag of pink polyethylene ribbon, numbered using a black marker, was tied around the caudal peduncle (i.e. the end of the body before the tail) (Fig. 7).

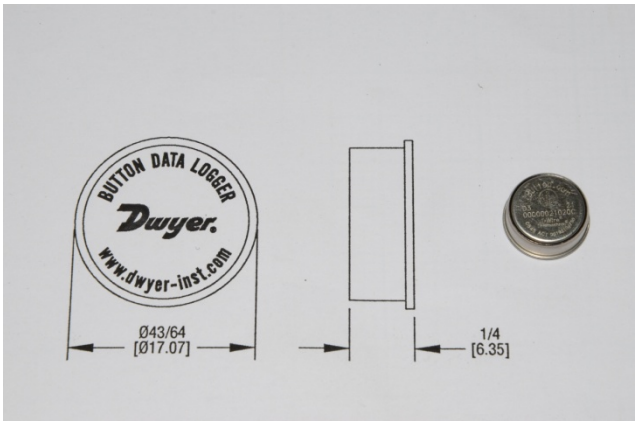


Figure 6. The *Dwyer BDL-1* button temperature logger used to measure and record the core temperature of fish throughout the cold chain from vessel to processor.

Figure 7. A mackerel tagged and with logger inserted and ready for return to the RSW tank of *Genesis II.*

Each fish was assessed for each of the seven freshness attributes contained in the BIM Quality Guide for Mackerel and photographed before being immediately returned to the RSW tank aboard the vessel.

2.5. Recovery of tagged fish

Following delivery to the processor, tagged fish were identified and removed from the processing line by Arctic Fish Sales' staff.

Fish were returned to the wet area/laboratory next to the discharge area and were assessed for three physical attributes (i.e. External condition and the internal condition of the flesh and the gut wall) as detailed in the BIM Quality Guide for Mackerel.

3. Analytical approach

The average (mean) score for each of the attributes at each sample location was visualised in a series of graphs. For this purpose, sample locations were numbered as follows:

1. Vessel;
2. Transport vehicle;
3. Processor.

4. Results

Discharge rate The rate of discharge through the separating device was equivalent to that of the pump speed provided by the ships' engineer and the capacity of the tank being offloaded.

4.1. Tagged fish

4.1.1. Physical attributes

Tagged fish passed through the offloading and delivery system with no evidence of any external damage (Appendix II) or degradation of the internal flesh quality or the condition of the gut wall (Appendix III).

All attributes scored exactly the same as the sample of fish examined from the vessel, prior to discharge.

4.1.2. Temperature logger data

The core temperature of tagged fish rose at a steady rate of 0.1°C degrees per minute on removal from the RSW tank for the insertion of tags and labelling. Once returned to the RSW tank, fish reached the temperature of the RSW seawater at a slower rate of 0.04°C per minute. A similar rise in temperature of 0.06°C per minute was recorded from discharge to reception at the processor.

The rise in core temperature recorded by the internal loggers was also reflected in the core temperatures of fish, taken using a temperature probe at each stage in the delivery chain.

4.2. Untagged fish

4.2.1. Freshness attributes

The majority of the changes seen in the attributes of fish passing though the delivery chain are directly related to known affects of temperature increase on fish quality.

Differences were recorded in the following attributes:

- Core Temperature
- Rigour
- Flesh texture
- Gill odour

No differences were recorded in the following attributes at any stage in the delivery chain:

- Eye quality;
- Body colour;
- Internal flesh quality and
- Condition of the gut wall.

Constant lighting conditions were not available to consistently assess iridescence and gill colour. As fish were assessed under variable lighting conditions (i.e. early daylight and vessel lights to fully lit (fluorescent) laboratory conditions) the data collected on these attributes were not considered further.

Although the air temperature was relatively low (4°C) over the course of the sampling period (26 minutes; 11:14 to 11:30), a rise in the core temperature of fish, of approximately 1°C, was recorded as the fish moved through the delivery chain.

An increase in temperature (0.45°C) was recorded between samples taken from the vessel and the transport vehicle, with a further increase, albeit to a lesser extent, between samples from the transport vehicle temperature and at the point of discharge in the processor (0.26°C).

A change in rigor was also noted that followed the trend in core temperature, with fish becoming less stiff and softer as time progressed.

A change in gill odour, which became slightly stronger (i.e. decreasing score) with the slight increase in core temperature, was also detected.

4.2.2. Assessment of Mackerel (BIM Quality Guide)

The 10 fish sampled at each location were graded in accordance with the quality assessment scheme detailed in the BIM Quality Guide for Mackerel (Table 1).

No difference in the physical attributes, described under "Market Specifications" in the guide, were recorded, with all fish determined as being of "Very High" grade.

The slight differences noted between freshness attributes at different sampling locations were also evident when combined scores were used to determine grades based on freshness.

Fish at the vessel were of "Very High" grade with those sampled post-separator and at the processor being a grade lower (i.e. High), but allocated, as such, by a very small difference in scores (i.e. 1% and 2%).

Table 1. Average scores and grades for freshness attributes and market specifications of 10 fish measured in accordance with the Assessment of mackerel contained in the BIM Quality Guide for Mackerel.

Location	Freshness Attributes		Market Specifications	
	Score (%)*	Grade	Score (%)*	Grade
Vessel	87	Very High	87	Very High
Post-Separator	78	High	88	Very High
Processor	79	High	88	Very High

* Very High = > 80%; High = 61% to 80%

5. Conclusions

Given that the discharge rate of fish was consistent with the normal rate of discharge, transit of fish through the separating device was not noticeably delayed or hindered.

The changes noted in fish quality over the course of the delivery process reflect expected and known changes in these attributes following discharge.

Changes in these attributes form the basis of the industry's necessity to move fish from vessel to processor as quickly as possible.

On the basis of the data collected, there is no evidence that the separating device affected the offloading speed or the external or internal quality of the fish examined from the point of discharge from the RSW tank, through the separating device to the point of reception at the processing facility.

APPENDIX I

Data Sheets

Sample Number	1			Date						30/11/2012	
Location	Alongside Vessel, New Pier, Killybegs, Co. Donegal										
Vessel	Genesis II			Pump speed						c.70t/hour	
Sample origin	RSW Tank; Pre-separator										
Samplers	Frances O'Dwyer (BIM) and Dr Conor Nolan (BIM)										
Time sample taken	08:15			Sample Processing time						00:30	
Fish Number	1	2	3	4	5	6	7	8	9	10	Average
Core Temperature (°C)	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
Fish Tagged	Y	Y	Y	Y	Y	Y	N	N	N	N	
Attribute	Individual Score										Average Score
Eye	4	4	4	4	4	4	4	4	4	4	4.0
Body Colour and reticulations	4	4	5	4	5	4	5	5	4	4	4.4
Iridescence	5	4	5	4	5	4	5	5	4	4	4.5
Flesh texture	5	4	4	4	4	4	4	5	4	5	4.3
Rigor	5	4	4	4	4	4	4	5	4	5	4.3
Gill odour	5	4	4	4	5	4	4	4	4	4	4.2
Gill colour	5	4	4	4	5	3	3	4	4	3	3.9
Total Score	33	28	30	28	32	27	29	32	28	29	29.6
External Damage	N	N	N	N	N	N	N	N	N	N	Average
Internal Flesh	3	3	3	3	3	3	3	3	4	3	3.0
Internal gut wall	5	5	5	5	5	5	5	5	5	5	5.0

Sample Number	2			Date						30/11/2012	
Location	Alongside Vessel, New Pier, Killybegs, Co. Donegal										
Vessel	Genesis II			Pump speed						c.70t/hour	
Sample origin	RSW Tank; Post-separator										
Samplers	Frances O'Dwyer (BIM) and Dr Conor Nolan (BIM)										
Time sample taken	11:18			Sample Processing time						00:30	
Fish Number	11	12	13	14	15	16	17	18	19	20	Average
Core Temperature (°C)	-0.3	-0.4	-0.3	-0.3	-0.4	-0.5	-0.5	-0.3	-0.3	-0.2	-0.35
Fish Tagged	N	N	N	N	N	N	N	N	N	N	
Attribute	Individual Score										Average Score
Eye	4	4	4	4	4	4	4	4	4	4	4.0
Body Colour and reticulations	4	5	4	5	5	5	5	5	5	5	4.8
Iridescence	4	4	4	4	4	5	4	4	5	5	4.3
Flesh texture	5	4	4	4	4	4	4	4	4	4	4.1
Rigor	4	3	3	3	3	4	3	3	4	4	3.4
Gill odour	4	3	4	4	4	3	4	3	4	4	3.7
Gill colour	3	2	4	3	3	2	3	3	4	4	3.1
Total Score	28	25	27	27	27	27	27	26	30	30	27.4
External Damage	N	N	N	N	N	N	N	N	N	N	Average
Internal Flesh	3	3	4	3	3	4	3	3	4	3	3.3
Internal gut wall	5	5	5	5	5	5	5	5	5	5	5.0

Sample Number	3			Date						30/11/2012	
Location	Arctic Fish Sales, Killybegs – Lab area next to hoppers										
Vessel	Genesis II			Pump speed						c.70t/hour	
Sample origin	Factory hopper immediately after discharge from tanker										
Samplers	Frances O'Dwyer (BIM) and Dr Conor Nolan (BIM)										
Time sample taken	11:33			Sample Processing time						00:30	
Fish Number	21	22	23	24	25	26	27	28	29	30	Average
Core Temperature (°C)	-0.1	-0.1	0.1	-0.3	-0.3	-0.2	-0.1	-0.1	0.3	-0.1	-0.09
Fish Tagged	N	N	N	N	N	N	N	N	N	N	
Attribute	Individual Score										Average Score
Eye	4	4	4	4	4	4	4	4	4	4	4.0
Body Colour and reticulations	5	5	4	5	5	5	5	5	4	5	4.8
Iridescence	5	5	4	5	5	5	5	5	4	5	4.8
Flesh texture	4	4	4	4	4	4	4	3	4	4	3.9
Rigor	3	3	3	4	3	3	3	2	4	3	3.1
Gill odour	5	4	4	3	4	3	4	3	3	3	3.7
Gill colour	5	4	4	3	3	3	4	3	3	3	3.5
Total Score	31	29	27	28	28	27	29	25	27	27	27.8
External Damage	N	N	N	N	N	N	N	N	N	N	Average
Internal Flesh	3	3	3	4	3	3	3	3	4	3	3.2
Internal gut wall	5	5	5	5	5	5	5	5	5	5	5.0

APPENDIX II

Cold Chain Tracking

Digital photographs of fish containing temperature loggers direct from *Genesis II* prior to discharge (Vessel) and upon discharge from the delivery tanker at Arctic Fish Sales (Processor).

Note: Fish 4 was not recovered, although the logger was returned. This is considered to have been a communication failure between sampling personnel and processing line staff (i.e. the recovery of the logger rather than the whole fish was considered to be the objective).

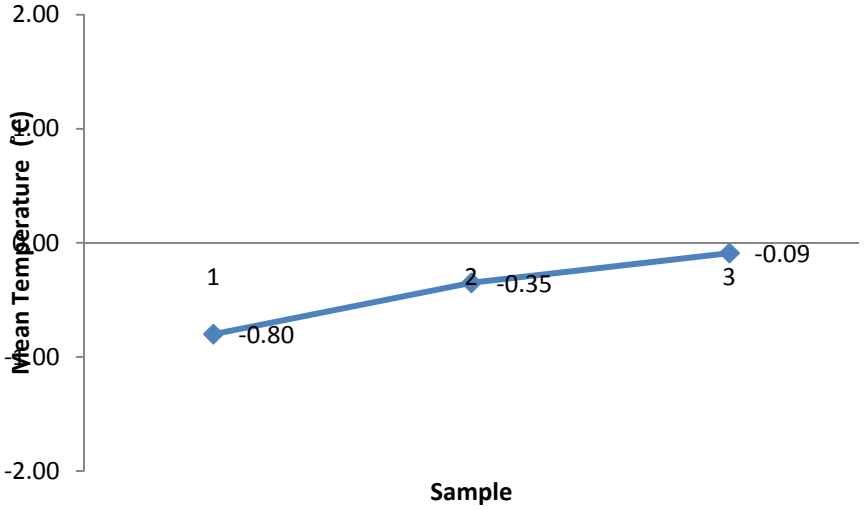
Fish N$^{o.}$	Vessel	Processor
1		
2		
3		
4		
5		
6		

APPENDIX III

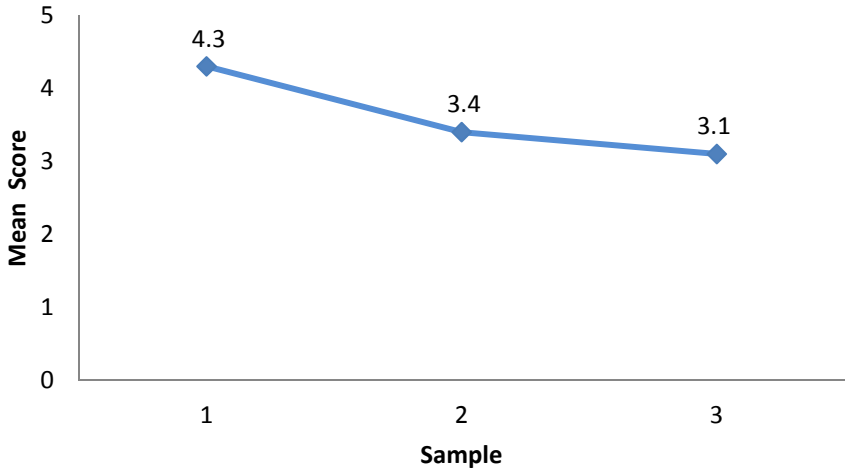
Freshness and Physical assessment

- The average score (mean) of freshness and physical attributes of samples of 10 fish from sampling points (Sample) prior to discharge from *Genesis II* (1), after the separating device (2) and at the point of arrival at Artic Fish Sales (3).

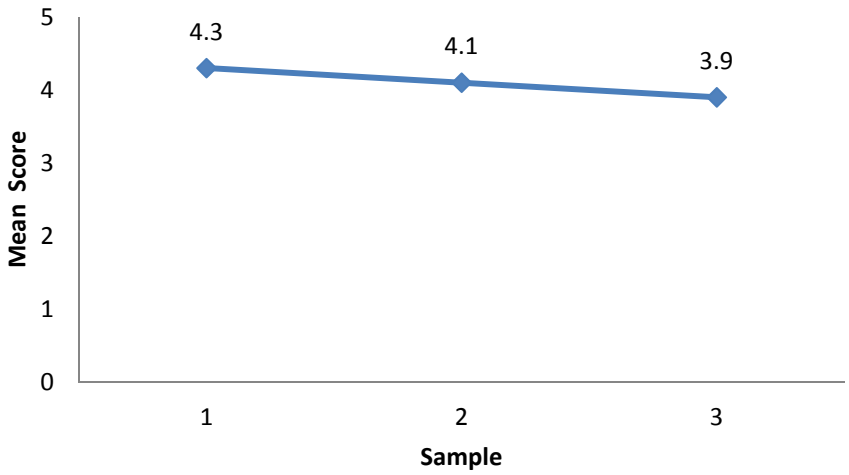
FISH CORE TEMPERATURE (Probe)



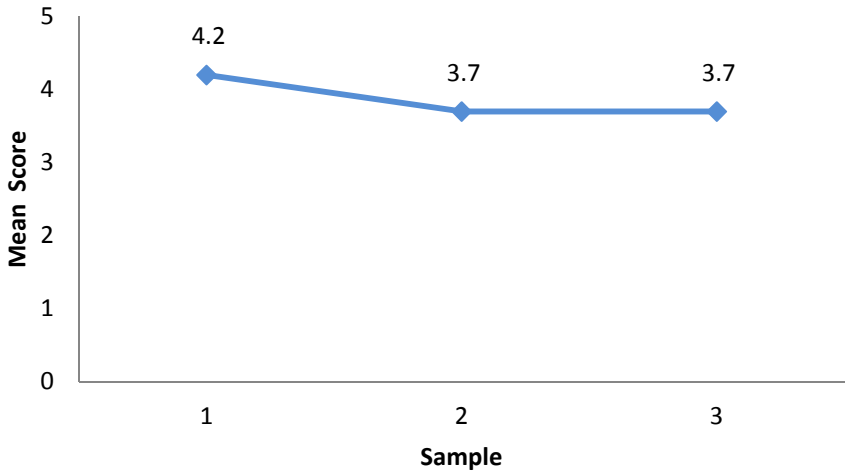
RIGOR



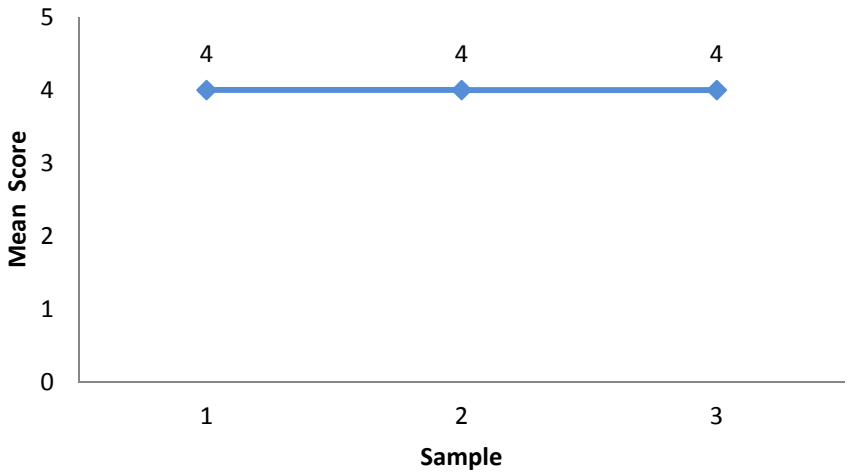
FLESH TEXTURE



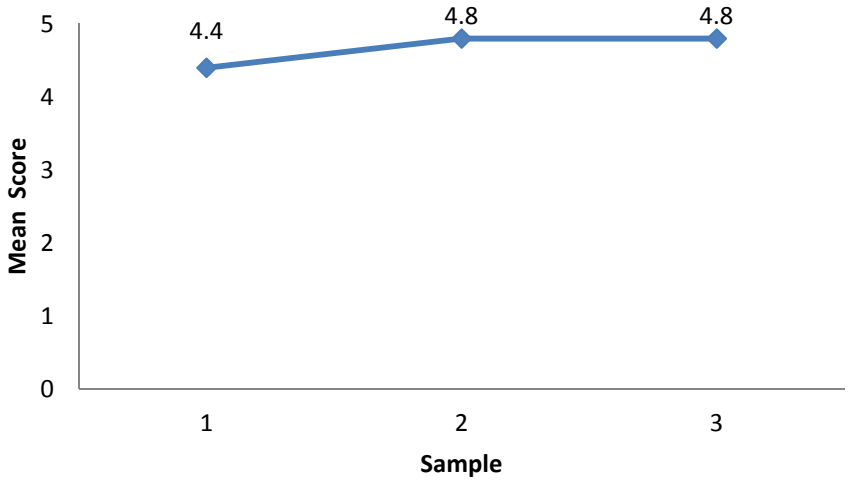
GILL ODOUR



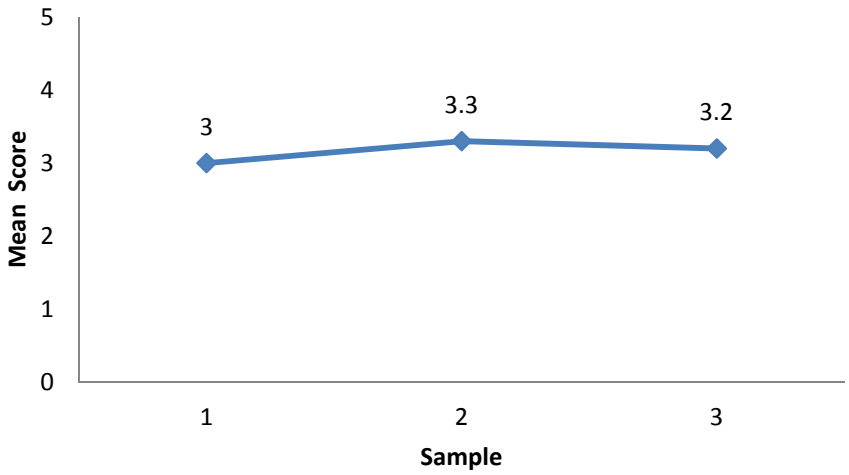
EYE


5
4
3
2
1
0
Mean Score
4
4
4
1
2
3
Sample

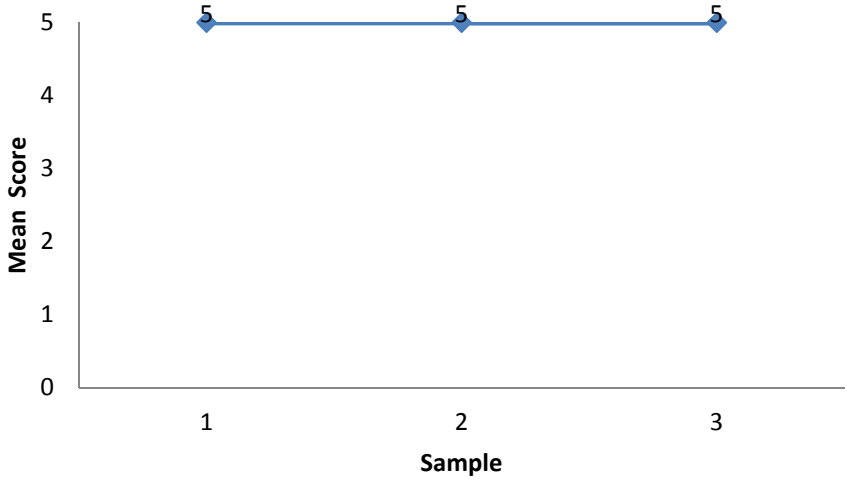
BODY


5
4
3
2
1
0
Mean Score
4.4
4.8
4.8
1
2
3
Sample

INTERNAL FLESH



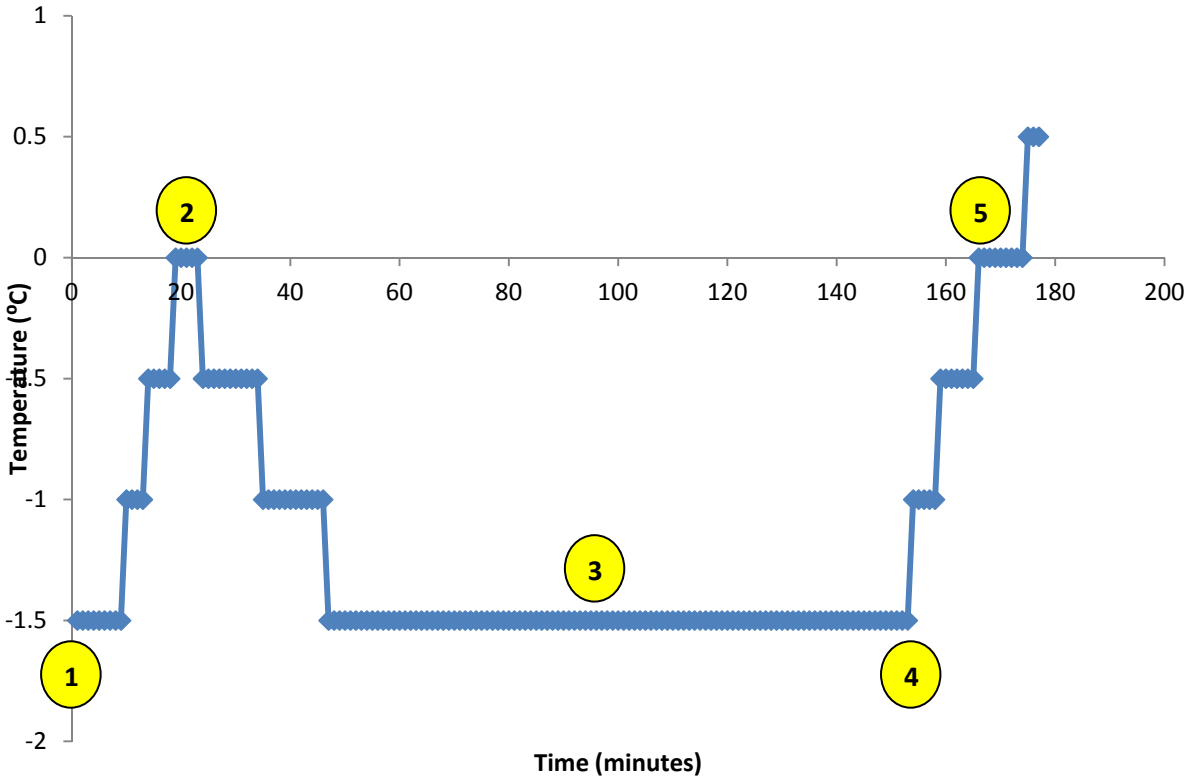
INTERNAL GUT WALL



APPENDIX III

Fish core temperature measured using a *Dwyer BDL-1* temperature logger (0.5°C resolution) set to record temperature at 1 minute intervals, inserted into the mouth of each fish and pushed down into the stomach.

FISH CORE TEMPERATURE (Logger)



1. Logger inserted into the stomach of the fish through the mouth. The initial core temperature reflects the temperature of the RSW in the holding tank of *Genesis II* and gradually rises in response to being removed from the tank and being exposed to the ambient air temperature;

2. The sample of fish (containing loggers) are returned to the tank on *Genesis II* following logger insertion;

3. During the time taken to modify the separator coupling, the fish core temperature equilibrates with the temperature of the RSW within the tank on *Genesis II*;

4. The offloading procedure begins and fish are discharged. The core temperature begins to rise once the discharge process begins;

5. The logger is recovered from the processing line and returned to the onsite wet area at Arctic Fish Sales.