CAWTHRON INSTITUTE

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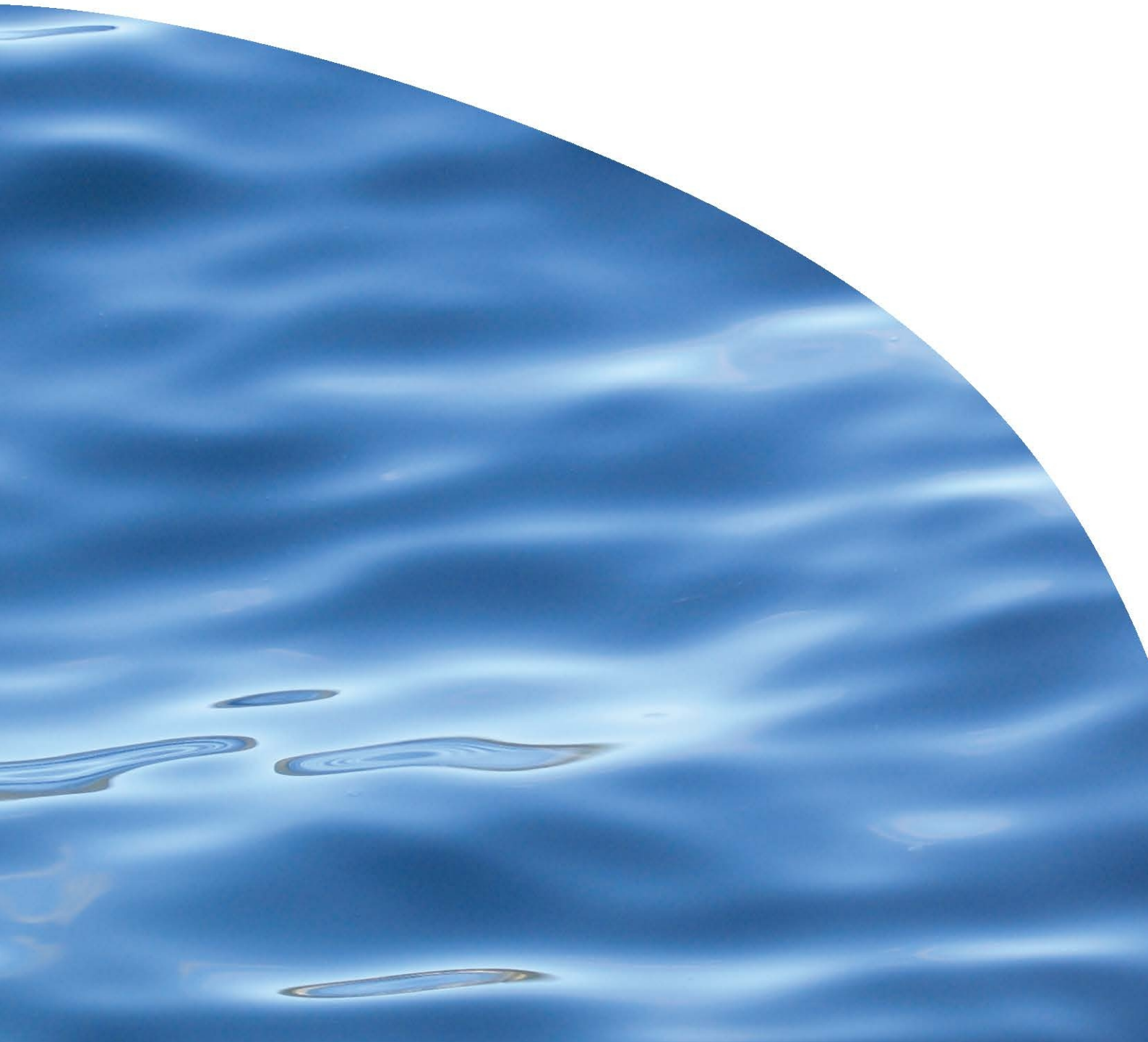
TEMPERATURE AND HUMIDITY OF KAITAIA WEED DURING HARVESTING, STORAGE AND TRANSPORT AND SUGGESTED INFLUENCES ON SPAT VIABILITY



TEMPERATURE AND HUMIDITY OF KAITAIA WEED DURING HARVESTING, STORAGE AND TRANSPORT AND SUGGESTED INFLUENCES ON SPAT VIABILITY

KEVIN HEASMAN

Marine Farmers Association
Blenheim

CAWTHRON INSTITUTE
98 Halifax Street East, Nelson 7010 | Private Bag 2, Nelson 7042 | New Zealand
Ph. +64 3 548 2319 | Fax. +64 3 546 9464
www.cawthron.org.nz

REVIEWED BY:
Andrew Fidler

APPROVED FOR RELEASE BY:
Jacquie Reed

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1. BACKGROUND INFORMATION

Cawthron Institute was contracted by the Marine Framers Association (MFA) to assess the parameters and influences of the handling and transport of Kaitaia weed/spat (hereafter referred to as weed) on the viability of the mussel spat found in the weed. To assess this, the temperature and humidity of Kaitaia spat was measured and logged through various processes i.e. transport to the shed from the beach site, packing into 10kg bags, storage in the chiller, transport to Coromandel, unpacking and loading onto the vessel and the trip to the mussel farm for deployment.

We were fortunate to have Kaitaia weed come ashore on four consecutive tides (see Appendix 1 for event diary) thus providing spat which had been exposed for an increasing period of time.

Weed collected on the 2nd September on the midday tide is referred to as the "Tide 1" batch. There were 63 bags from this tide.

Weed collected on the 3nd September on the midnight to 2am tide is referred to as the "Tide 2" batch. There were 44 bags from this tide.

Weed collected on the 3nd September on the midday to 2pm tide is referred to as the "Tide 3" batch. There were 45 bags from this tide.

Weed collected on the 4th September on the midnight to 3am tide is referred to as the "Tide 4" batch. In excess of 60 bags were collected from this tide.

2. METHODS

2.1. Transport on the beach

The weed was collected from the water in baskets or hand nets and placed in trailers or on the back of trucks. The temperatures profiles of the weed on top of the load and within the load were unknown, to find this out, experiment 1 was undertaken.

2.1.1. Experiment 1

At approximately 1am, weed was loaded onto a trailer (capable of holding approximately 600kg of weed). During the loading process temperature data loggers were put into the weed mass. The loggers were placed into the weed when there was approximately 40cm of weed loaded in the trailer. The loggers were placed approximately 20cm horizontally from one edge of the trailer, one in the middle of the weed and one about 20cm horizontally from the opposite edge of the trailer. Loading of weed was then continued on top of the loggers. Once the trailer was loaded to the maximum, one temperature data logger was buried 20cm into the weed on the left

front of the trailer, another 20cm deep into the weed on the right front of the trailer and one on the surface of the weed on the front of the weed mass in the trailer.

2.2. Holding experiments

Generally collectors pack the weed into 10kg bags and place them in a chiller until transported to the farm site. The weed may either be held in an open bag or a sealed bag while in the chiller. The bags may also be stacked in bins or layered on the floor. The chiller temperatures of the various collectors vary and some have been estimated to be as low as 4^0C.

In this instance, all the batches of weed arriving at the shed were packed immediately after arriving if it was collected during the day, or packed at 8am the morning following a night collection. The weed was packed in 10kg bags and immediately stored in a precooled chiller which automatically turned on at 8.4^0C and turned off at 6.4^0C.

2.2.1. Experiment 2

Experiment 2 was designed to determine the temperatures of the weed held in bins in the chiller.

Four bags were selected at random and three temperature data loggers were placed in each bag (total of 12 loggers): one logger placed 5cm from the edge of the bag; one in the middle of the bag and one 5cm from the opposite edge of the bag. These bags were then marked and placed in the chiller.

2.2.2. Experiment 3

Experiment 3 was designed to establish the relative humidity (RH) variation between an open bag of weed and a closed bag of weed.

Two 10kg bags of weed had humidity loggers placed on the top surface of the weed in the bag. One bag was left open to the air in the chiller (as this method has been used by one weed collector to increase the speed of chilling of the weed). The other 10kg bag of weed with the humidity logger was sealed. When the bags were loaded onto the vehicle for transport to the Coromandel, the bag of weed which had been open to the air was sealed. Both these bags were then placed in a bin for transport.

2.3. Transport experiments:

Generally, collectors will load weed into the chiller on a transport vehicle in the evening and travel overnight for the weed to be deployed first thing in the morning. There are three methods of transporting the weed.

The first involves placing the bags of weed in a layer on the vehicle chiller floor; frozen 1.5L plastic bottles are placed in between and on top of the bags. Another layer of weed is then loaded and the bottles are placed in between and on top of the bags. This continues for up to 7 or 8 layers depending on the size of the load. The refrigeration unit in the chiller is not activated if bottles are used.

The second method involved placing a layer of bags on the chiller floor, a layer of ice is then placed over the bags (the thickness of this layer can vary between collectors) and another layer of bags loaded on top of the first. This will continue until the load is full. The chiller refrigeration unit is not activated if ice is used.

The third method involves using fish bins. Two bags of the weed are put into each bin and the bins stacked on top of each other. There are gaps between the edges of the bins which allow air to flow around the bins. The bins avoid crushing of the lower stacked bags by the bags above. Only one collector uses bins.

The transport experiments tested the influence of loading in bins and also the influence of ice on the weed.

The weed was loaded in to the vehicle in the following manner:-

Weed from Tide 1 – 10 bags were put into bins, 53 bags into ice.
Weed from Tide 2 – 10 bags were put into bins, 34 bags into ice.
Weed from Tide 3 – 10 bags were put into bins, 35 bags into ice.
Weed from Tide 4 – 10 bags were put into ice, 53 bags into bins.

The bin method is simply having two bags of weed weighing 10kg placed in a fish bin and then they are stacked on top of the other.

The ice method is placing the 10kg bags of weed in layers with a small amount of ice between the bags and between each layer. It must be noted that due to the high demand for weed, heavy application of ice was avoided. This may have produced less decisive results but it is believed that there was sufficient ice to provide some indication of the influence of ice.

2.3.1. Experiment 4

Experiment 4 was designed to get an indication on how the temperature varied between bags of weed held in bins in the chiller and during transport. The bags in bins system had two bags of weed placed in each fish bin and the bins stacked. There is air flow within the bins and no crushing of the weed by the weed above. This data should be compared with the data derived from experiment 5 below where the temperatures were determined in a bag of weed covered with ice and surrounded by other bags of weed. This ice method is the alternative to bins. In the ice method, bags

of weed are stacked 5 high and 4 deep (this may vary with loads) with the limited amount of shaved ice or frozen plastic bottles covering each layer of weed.

2.3.2. Experiment 5

Experiment 5 was to test the influence of ice on the temperature profile in the 10kg bag of weed. To test the influence of ice on the surface mussels in the bag, 4 data loggers were placed from the edge of a bag: a logger was placed at the edge; 10cm from the edge of the bag towards the centre of the bag; 20cm from the edge of the bag and in the middle of the bag of weed. This bag was placed low down in the pile of iced bags and iced placed around it.

2.3.3. Experiment 6

Experiment 6 was to test the difference in temperature between bags held in ice in the vehicle during transport - the 10kg bags of weed placed in layers on the bed of the vehicle and covered with a thin layer of ice. The bags were stacked 5 layers high. 5 data loggers were put into the centre of each of the 5 bags of weed. 4 of the 5 bags containing a logger were put at the left, right, top centre, bottom centre of the bag mass. The remaining bag with a data logger was positioned in the middle of the all the iced bags in the transport vehicle. The data from this experiment can be compared with the data from the latter part of experiments 3 & 4.

2.4. Grow-out experiments

2.4.1. Experiment 7

Experiment 7 was designed to test the influence of the methods described above. Retention of the spat from weed subjected to different processes, and deploying it onto spat ropes (but the same backbone or associated backbone) will be assessed.

The influences of the following parameters will be tested:

1. Weed age out of water - To test this, weed from each tide was seeded on their own.
2. Weed held in ice during transport – All weed that was transported in iced bags were seeded on their own.
3. Weed held in bins during transport – All weed that was held in bins during transport were seeded on their own.
4. Weed position within the iced bag – The weed that was on the outside of the iced bag was seeded separately to weed from the middle of the iced bag.

2.5. Viability and count

Viability of spat was tested in the Coromandel and the respective numbers of spat per kg were counted. The viability of the spat from each batch was estimated using the

stain test. The number of spat per kg of weed, the viability, and the size of the spat were also determined from the outer edge and the middle of the iced bags.

All the weed was then seeded on ropes in the Coromandel. Samples should have been collected at 2 weeks, 4 weeks and 6 weeks post settlement and counted to determine their degree of survival and retention. However due to unforeseen difficulties only one sample was collected after 3 weeks.

3. RESULTS

3.1. Transport on the beach

Figure 1 The temperature of the weed at the surface and within the mass of weed on a trailer during loading and during a 40 minute travel along the beach to the shed starting at midnight.

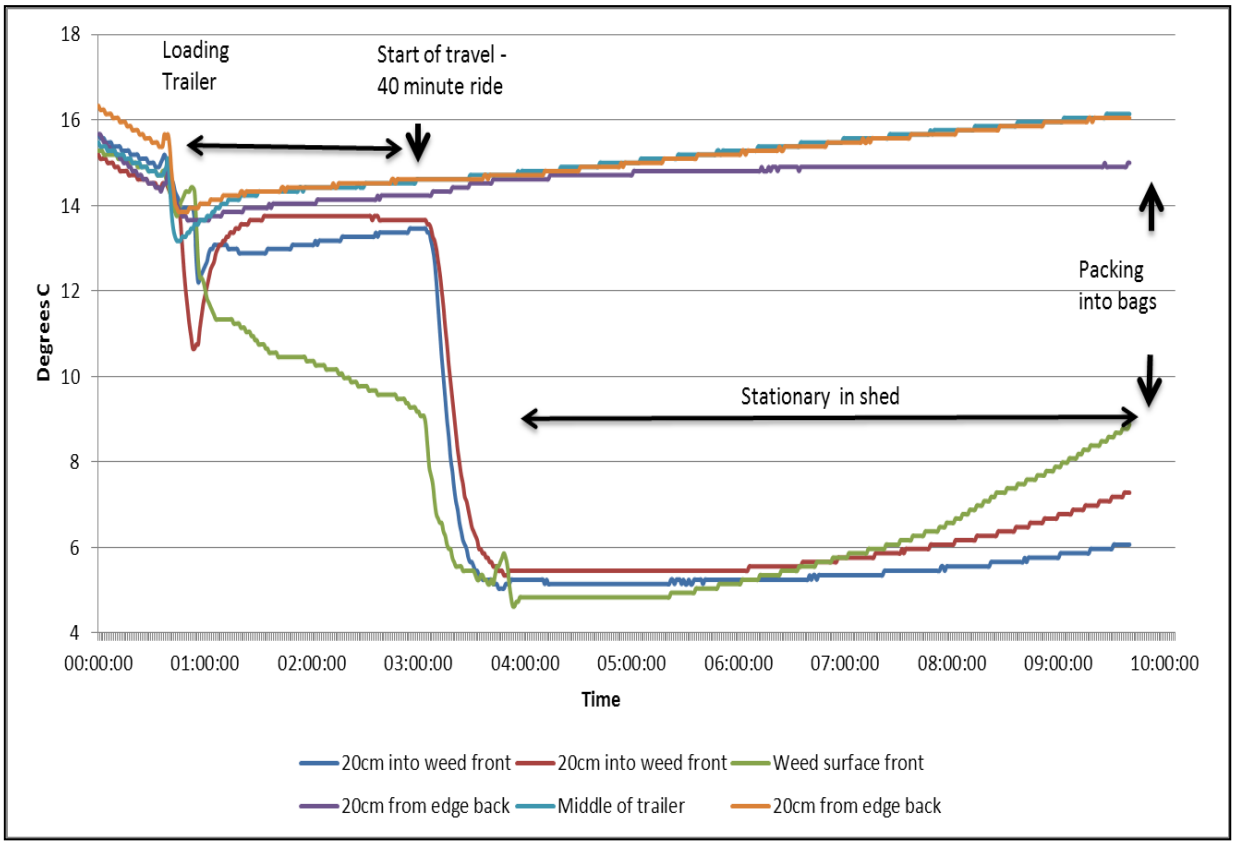


Figure 1 above shows temperatures of the weed during loading and transport to the shed, a period of approximately 9.5 hours. The data loggers deep in the weed showed an increase between 1^0 and 2^0C over the duration of transport and storage. The influence of wind and wind chill is far more severe on the outer 20cm (at least) of the weed. This weed dropped in temperature from 13.8^0 to 5^0C and then maintained a temperature below 6^0C for another 5 hours.

3.2. Holding experiments

3.2.1. Experiment 2

Figure 2. The temperature profile across a bag held in a bin in the chiller over 41 hours

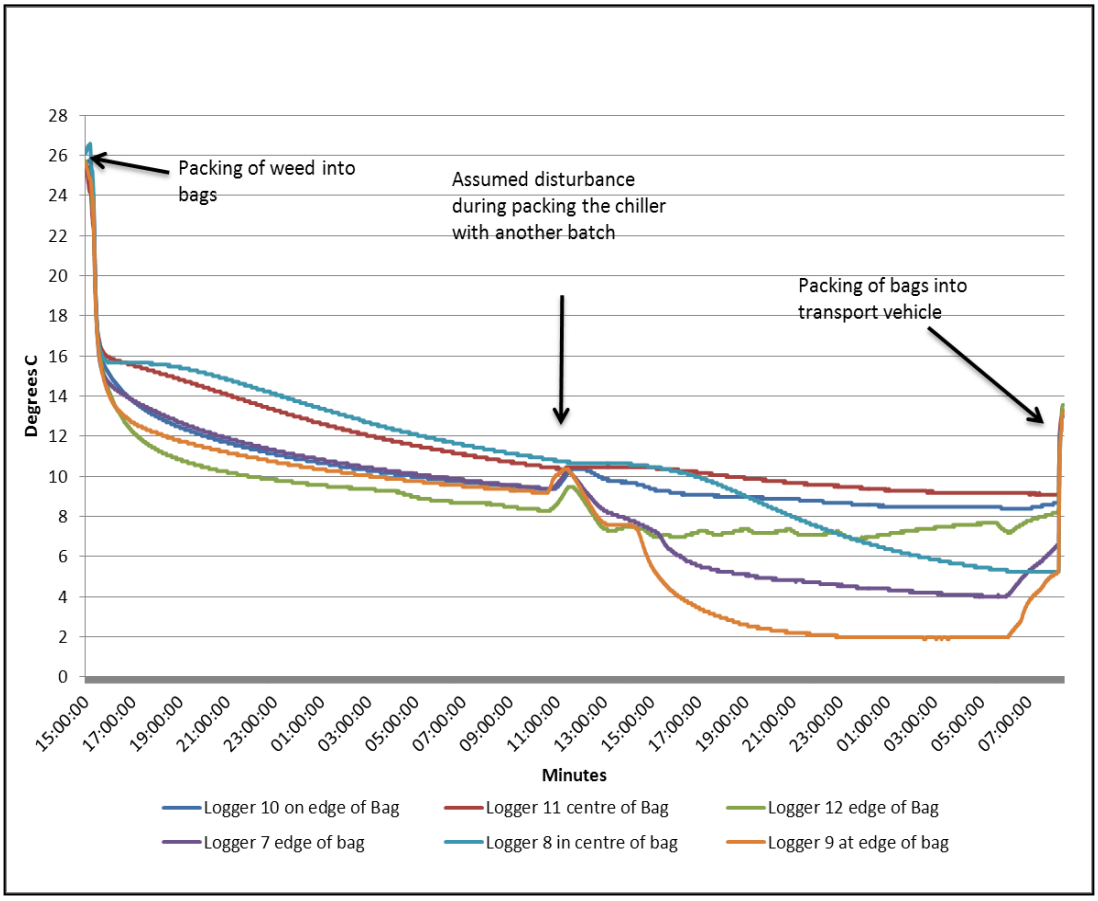


Figure 2 shows the temperature at the edge, centre and opposite edge of two bags of weed held in the chiller and then transported to Coromandel in a refrigerated truck. The results show the gradual drop in temperature, well within acceptable range of the weed, when held in the chiller. However, on being placed in the vehicle it became obvious that one bag that was positioned in a particularly cold spot, all the loggers within it showed temperatures dropping below 5.5^0C and even as low as 2^0C.

3.2.2. Experiment 3

Figure 3. The Relative humidity (%) in an open and closed bag held in the chiller and transported to Coromandel

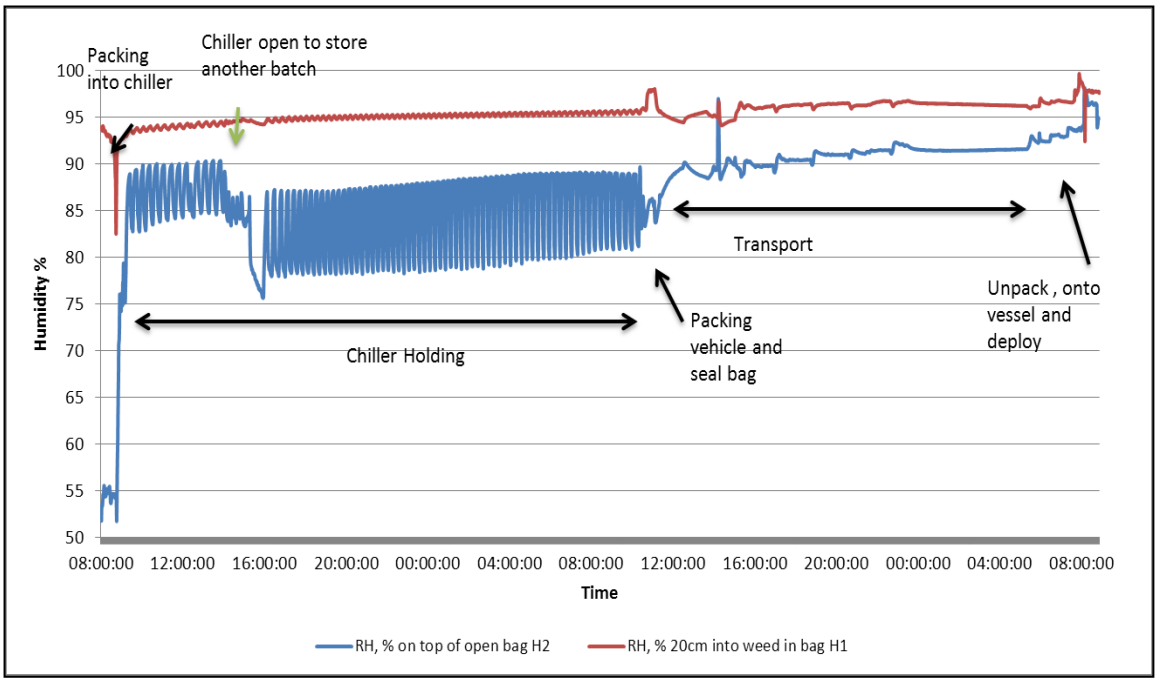
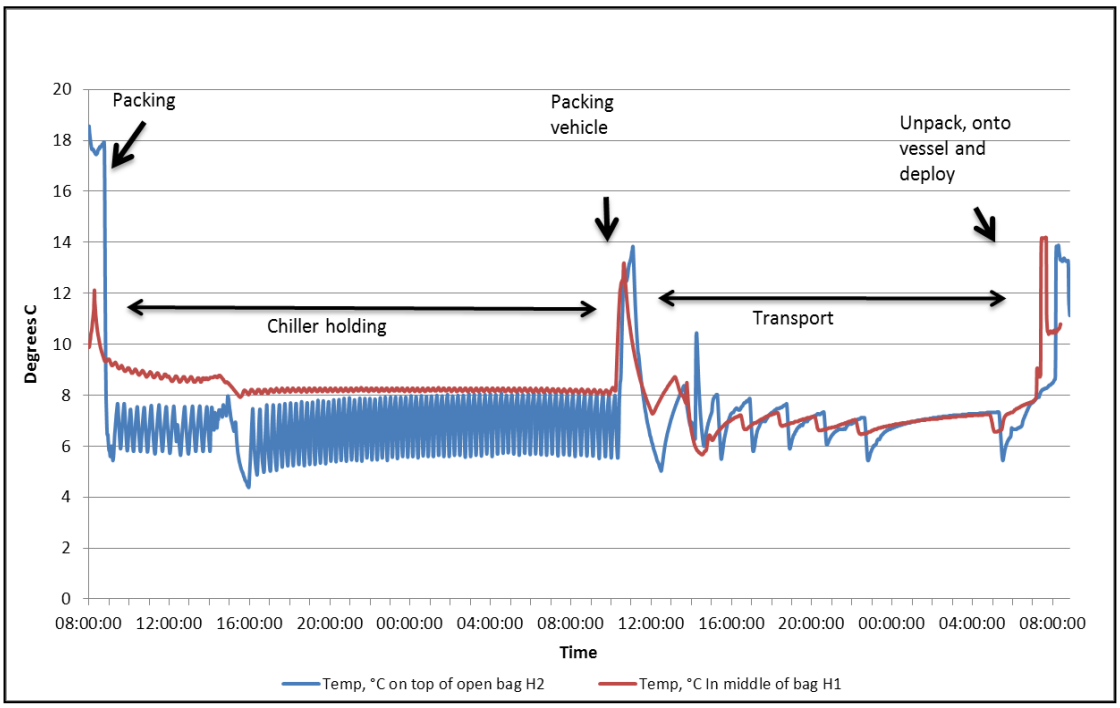


Figure 4 The temperature profile of the same bags seen in figure 2 above. The temperature logger in the sealed bag was buried 20cm deep (red) while the open bag temperature logger was on the exposed surface.



Figures 3 and 4 show the relative humidity (RH) and temperature in an open (blue line) and sealed bag (red line) respectively. The graph represents a period where the bags of weed were put into the chiller, packed into the vehicle and transported to Coromandel. The open bag (blue line) was sealed when it was put into the vehicle. The blue line shows the distinct vertical movement associated with the on/off phase of the refrigeration unit in the holding chiller. The influence is less pronounced during transport. The RH varies between 77% and 89% during the period in the chiller and after it was sealed (when put in the vehicle) shows a gradual increase during transport. The sealed bag (red line) started at a RH of 93% and did not drop below this for the entire period of holding or transport.

The temperature (figure 4) in the open bag also oscillated with the on/off phase of the refrigeration unit in the holding chiller with the lower levels of the oscillation consistently going below 6^0C. The temperatures during transport were more consistent but the open bags still showed a tendency to drop below 6^0C with the chiller unit on/off cycle.

3.3. Transport experiments

3.3.1. Experiment 4

Figure 5 Temperature across four bags of weed. Packed in bags, stored in the chiller, packed in the vehicle and transported to the Coromandel. All of these bags were in bins.

Note: Red lines are the middle of the bags; blue lines the edge of bags.

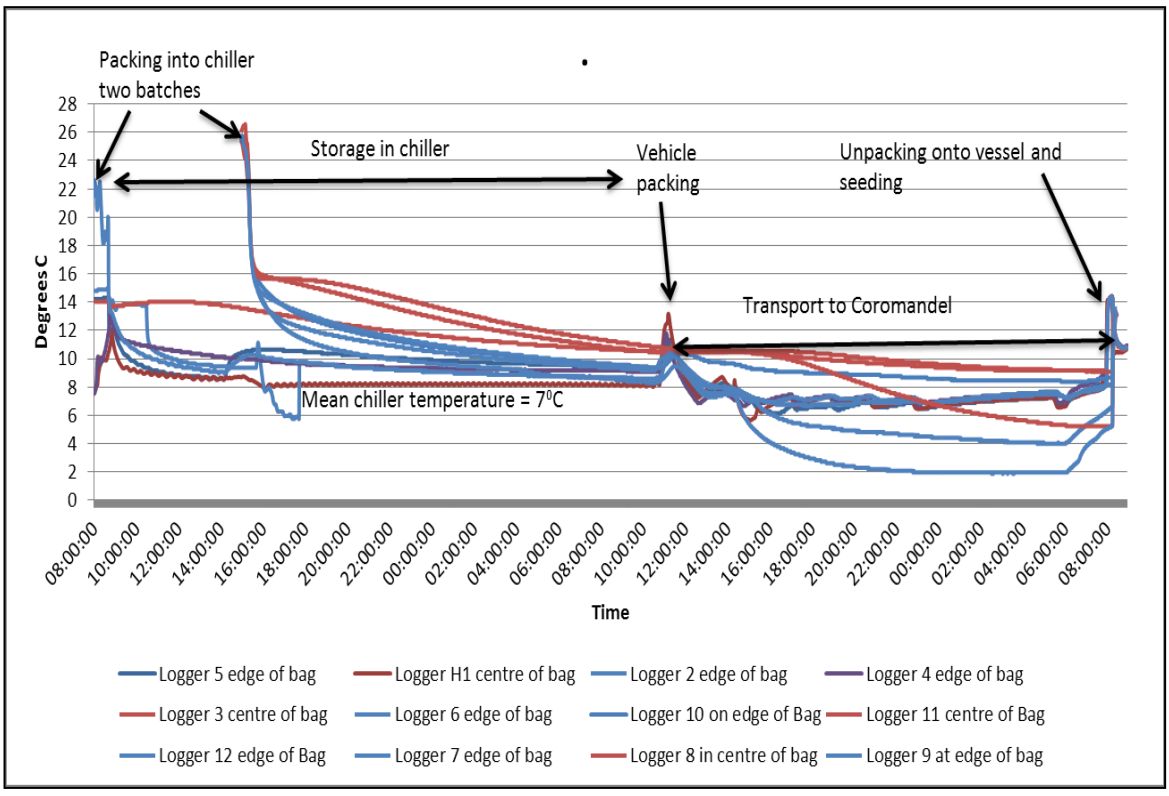


Figure 5 shows the temperature at the edge and middle of four bags of weed. This graph includes the data from figure 2. Three of the four bags maintained temperatures from one edge of the bag to the other above 6.2^0C and generally at or above 7^0C. The entire contents of one bag dropped to between 2^0C and 5.2^0C. This data shows that the temperature of the weed in bags can vary by up to 7^0C in the same storage.

3.3.2. Experiment 5

Figure 6 The temperature across a bag which is surrounded by a thin layer of shaved ice.

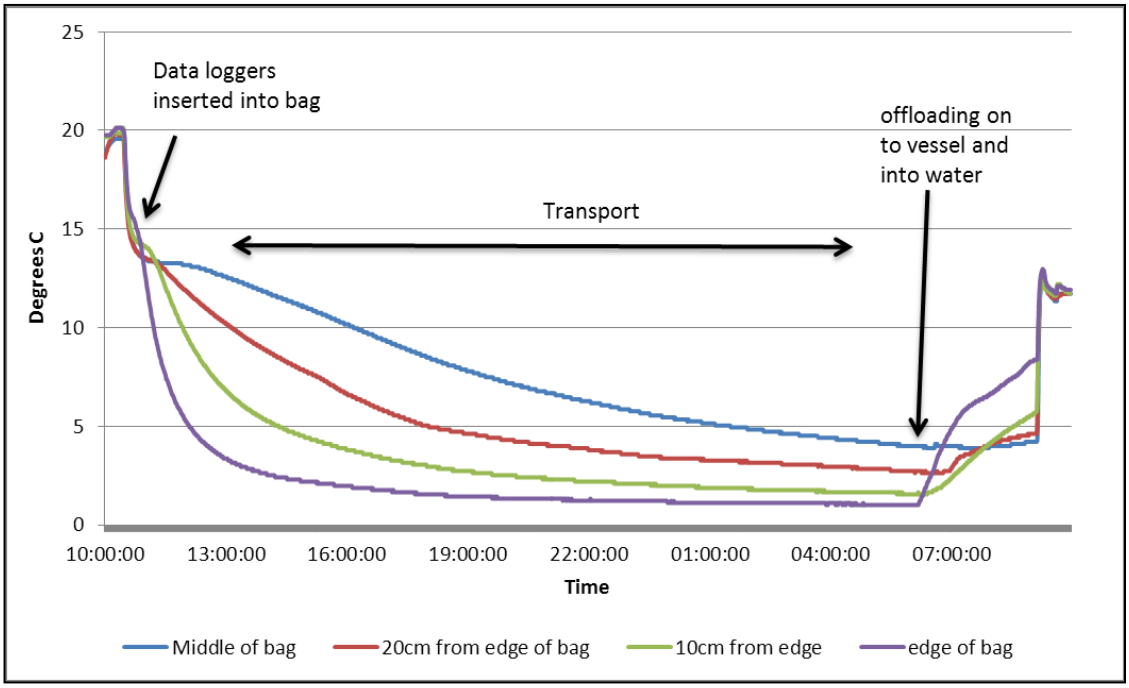


Figure 6 shows the gradient of temperature from the edge to the centre of the bag of weed covered in a thin layer of shaved ice. The edge of the bag rapidly drops below 3^0C (after approximately 3 hours) and reaches a low of 1.6^0C. 10cm from the edge of the bag the weed reaches a low of 2^0C. 20cm from the edge of the weed the temperature reaches a low of 3.5^0C. The centre of the bag reaches a low of 4.5^0C. On being offloaded at the vessel the edge of the bag warmed up rapidly however the weed at the centre of the bag went from 4.5^0C to 12.5^0C very rapidly when being deployed in the water which is an instantaneous increase in temperature of 8^0C.

3.3.3. Experiment 6

Figure 7 The internal temperature of bags of weed held in ice. The bags were positioned on the left, right, bottom, middle and top of the stack of iced bags.

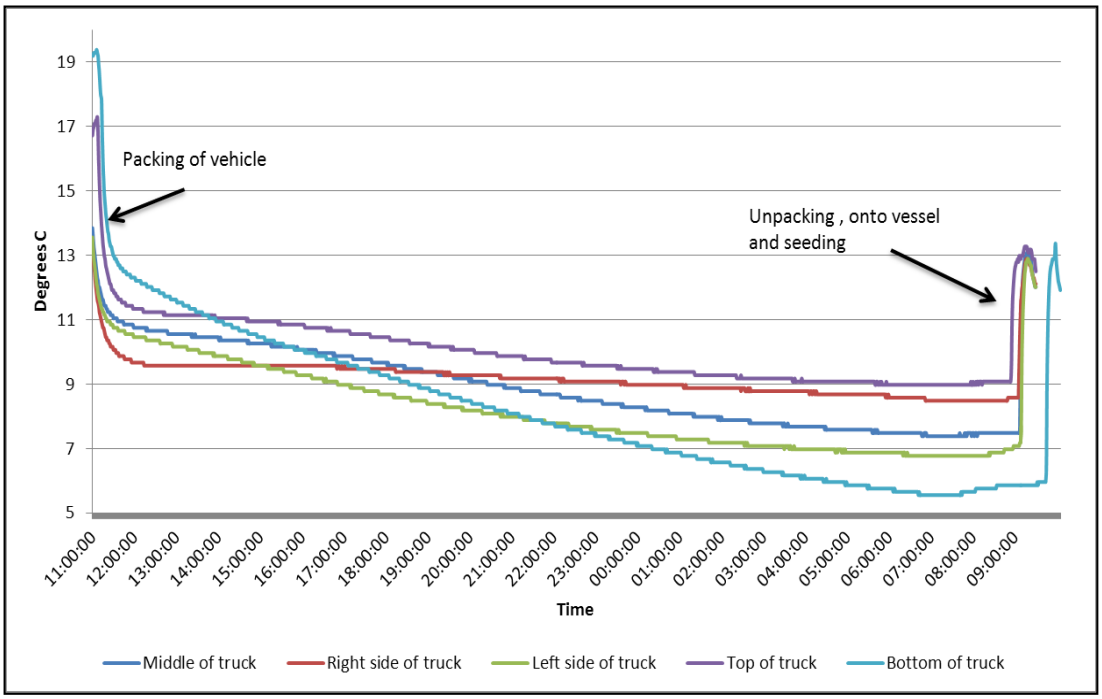


Figure 7 shows the internal temperature of five bags of weed. The bags were packed in the vehicle in shaved ice and transported to the Coromandel. The left side of the weed stack in the vehicle and the bottom of the weed stack in the vehicle both went below 7^0C. The bags on the right side, middle and the top of the weed stack ranged in temperature from 7.4^0C to 9^0C.

3.4. Grow-out experiments

3.4.1. Experiment 7

Samples were taken from the ropes at the end of September. Unfortunately only a single rope sample of each treatment was taken and so the results are subject to seeding rate variation. As a result of this, the data was not included in the report as it is potentially misleading.

3.5. Viability (stress) and count per Kg

The results of the estimated number (counted using multiple samples from each batch) of spat found on each kilogram of weed, the viability of the spat (as determined using the stain test), and the size of the spat from each tide and the outer edge and middle of the iced bags (tide 4) are shown in Table 1.

Table 1. The results of the estimated number of spat found on each Kilogram of weed, the viability (stress) of the spat, and the size of the spat from each tide and the outer edge and middle of the iced bags.

	Tide 1	Tide 2	Tide 3	Tide 4	Outside of the iced bag from tide 4	Inside of the iced bag from tide 4
Count	1051000	856000	742000	644000	631000	726000
Viability (% not staining)	74	77	82	93	93	98
0.15mm to 0.3mm	48%	43%	50%	53%	51%	48%
0.3mm to 0.5mm	51%	56%	49%	46%	48%	51%
0.5mm to 1mm	1%	1%	1%	1%	1%	1%

4. DISCUSSION

These experiments shows that spat on the weed are subjected to high variations of temperature.

Transporting the weed on the beach (Experiment 1, Figure 1) showed a surprising influence of wind chill. The temperature of at least the top 20cm of weed on the trailer dropped ~8^{0}C in a very short space of time and then remained below 6^{0}C for several hours. There are two points of concern here: the first being the rapid temperature drop (which is undesirable for small spat) and the second being the fact that the spat were at a temperature which is consider to be detrimental to the spat (i.e. below 7^{0}C) for an extended period. Further work needs to be undertaken on the lowest tolerable temperatures. Anecdotal evidence and discussions with other spat workers (e.g.

SPATnz) suggest that spat should not go below 7^0C. Therefore, until further work can come up with a definitive tolerance level, 7^0C will be considered to be the benchmark used in this document. In addition, the same discussions indicate that humidity below 90% is not desirable for spat. This will have to be researched further to determine definitive tolerance levels.

There were six experiments which relate to holding and/or transporting of spat. Figure 2 shows the temperature of weed at the edge and middle of the 10kg bags held in bins in the chiller for approximately 4^0 hours. The bag holding loggers 7, 8 and 9 went below the cut off 7^0C threshold, to the point where one edge went down to 2^0C. It is suggested that this bag may have been in the direct flow of chiller air. This highlights the necessity to have a uniform flow of chilled air around the bags of weed without the air blasting directly onto the bags of weed.

Figure 3 shows the relative humidity in a closed bag and an open bag of weed. The humidity at the surface of an open bag of spat fluctuates between 77% and 89%. The on/off phases of the chiller refrigeration unit can be seen in the graph. As mentioned above, it is suggested that a humidity level below 90% is not desirable. The actual parameters have not been scientifically defined and is probably influenced by a number of natural factors (e.g. exposure period, temperature). The weed in the middle of the open bag in the chiller (Figure 4) also dropped below 6^0C for an extended period whereas the sealed bag only dropped below 6^0C for a brief period and generally was found to be between 7^0C and 8.3^0C. A combination of reduced humidity and low temperatures would impact on spat survival and retention.

Figure 5 shows the temperature logged from two beach collections with a total of 12 loggers. The data shows that the middle of the bags (red lines in Figure 5) have a time lag in dropping to the chiller and transport temperature of 7.5^0C. The middle of the bags do appear to remain within acceptable limits except for the bag discussed in Figure 2. Even the outer edges of the bags held in bins remain above 7^0C. This is not the case with iced bags.

Figure 6 shows the temperature of four data loggers paced at the edge, 10cm from the edge; 20cm form the edge and the middle of a bag. Even though the bag was lightly iced the temperature of the weed throughout the bag dropped below 5^0C with the edge of the bag remaining below 3^0C for over 13 hours. This would probably prove lethal to most spat. When this spat is reintroduced to the water, which was at an estimated 14^0C, the rapid increase in temperature may stress or kill any surviving spat.

Figure 7 shows the temperature of the middle of bags of weed transported stacked in the vehicle and with a thin covering of ice. The bags at the bottom of the stack (in this case the stack was 5 high) went to 5.5^0C. The bags at the top of the stack did not go below 9^0C. There is a wide variation in the temperature of bags depending on how

they are stacked. The bag on the left side of the truck was 2^0C cooler than that on the right side of the truck. Another point of concern is that the bags at the top of the truck were 3^0C warmer than the bottom of the stack. Since it is advised that the spat does not go below 7^0C, it is of some concern that the bags on the left side of the vehicle and at the bottom of the stack went below 7^0C.

Due to issues with the collection of samples from the seeded ropes there were no results from Experiment 7.

5. CONCLUSION

The following points are made regarding the beach transport, packing, holding and transporting of Kaitaia weed:

- The number of spat on the weed declined with each spat fall.
- Weed is often going below 7^0C which is suggested to be detrimental to spat survival and retention.
- Wind chill is a significant factor in the surface (at least the top 20cm) of weed on the trailer when traveling at night or possibly cold conditions. Some form of wind break would be advisable to reduce this chill effect. Transport in full summer sun has yet to be tested.
- Holding spat in bins appears to be more desirable than covering them with ice, providing the bags do not get direct air blasted on them from the chiller.
- The spat on the edges of ice chilled bags are likely to be less viable due to the cold temperature they experience.
- The difference in temperature between the cold spat (i.e. colder than 7^0C) and the water temperature into which the spat are being seeded is sufficiently large as to generate concern for the wellbeing of the spat when being seeded. This requires testing and well planned physiology experiment will help determine acceptable ranges.
- Bags of weed should be sealed when placed in storage or during transport to reduce the impact of desiccation and rapid temperature fluctuation.
- Rapid temperature increase and decreases that the spat experience are potentially detrimental to the survival of the spat.

- The number of viable spat decreased with the period the spat had been out the water. (I.e. the number of stained spat increased).

6. RECOMMENDATIONS

- In future experiments we recommend that data loggers should be included in a day-time collection, at the peak heat of a hot summer's day, to determine the extreme temperatures that the spat may be experience.

- There must be three replicates from each experiment seeded on the grow-out ropes.

- Summer extremes should be tested.

- Spat should be seeded out at different sites simultaneously to assess differences in retention.

- Investigate the physiological response ranges of spat during transport.

- Control the temperature variability found throughout the process to within the range determined in the above bullet point.

- The temperature and humidity tolerance levels of the spat should be determined.

7. APPENDIX 1 – EVENT DIARY

Arrived at Kaitaia at 5:30pm on the evening of Monday 2nd September.
A load of weed (63 bags) was collected at midday on Monday the 2nd, this load was not monitored. This collection was referred to as “Tide 1”.

Weed (44 bags) was collected on the next tide (referred to as “Tide 2”) at midnight of Monday 2nd and Tuesday 3rd. Conditions in the trailer with the weed was monitored. The collection was completed at approximately 3am on Tuesday 3rd. This batch of weed was bagged at 8am on the morning of Tuesday 3rd and put in the chiller. Data was gathered in the trailers for the duration of the weeds time in the trailer. Some loggers were then also put into the bags to monitor temperatures in the weed while being transferred and held in the chiller.

Some weed (45 bags) was collected on the midday tide at (referred to as “Tide 3”). No data loggers were put into the trailer of this batch as the weed collection was rapid and by the time I arrived at the collection site the trailer was on its way back to the packing shed. However some data loggers were put into the bags of this load when they went into the chiller during the afternoon.

Weed was collected on the 1:30am tide on the morning of Wednesday 4th (in excess of 60 bags, referred to as Tide 4). Loggers were used in the trailer to determine transport and holding temperatures.

All the weed was loaded onto the transport vehicle starting at 9:30am on the morning of Wednesday 4th. Weed was loaded in bins and in ice to provide transport variation. Loggers were put into the bags with ice to determine the local impacts of ice on the temperature of the weed.

A program was worked out with Jonathan to test the weed from each “tide” and different holding or transporting conditions. Weed left Kaitaia on the evening of Wednesday 4th and was seeded on Thursday 5th in Coromandel. Weed counts and stress levels were assessed in Coromandel. Data loggers were sent to Cawthron for downloading and analysis.