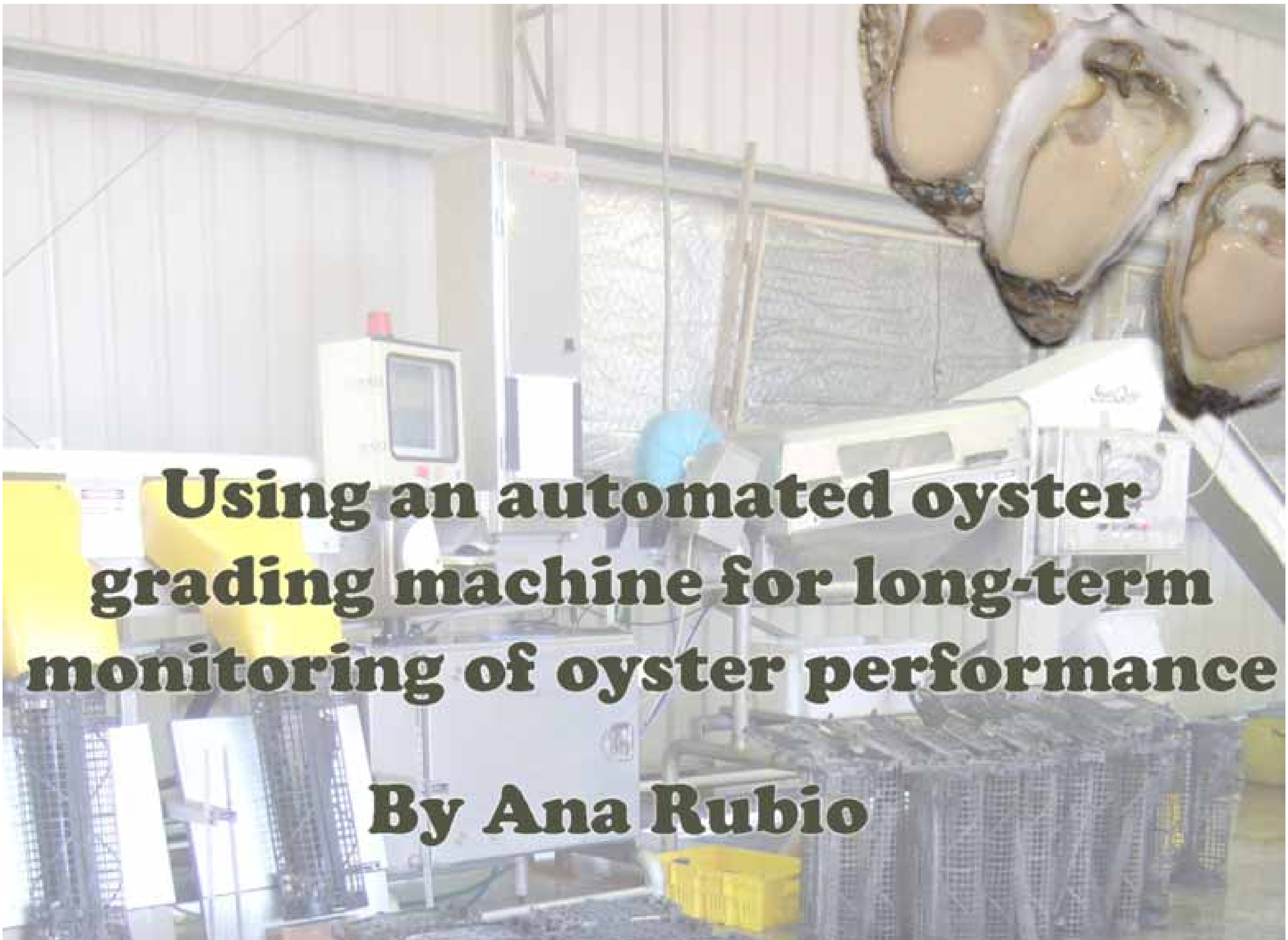

Using an automated oyster grading machine for long-term monitoring of oyster performance

By Ana Rubio

2009 Science and Innovation Awards
for Young People in Agriculture, Fisheries and Forestry

Australian Government
Department of Agriculture, Fisheries and Forestry

Australian Government
Fisheries Research and Development Corporation

McASH Clyde River Oysters

Wheelers Oysters

Using an automated oyster grading machine for long-term monitoring of oyster performance

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Overview

While large, good condition, well-shaped oysters have high market value, they require optimal growing conditions and labour intensive techniques to culture. To handle this NSW oyster growers are progressively moving towards innovative technologies, one of which allows automated bulk processing of oysters. Growers now purchase sophisticated graders that clean, count and sort large number of oysters quickly and efficiently. While graders are routinely used to count and sort oysters into batches of similar size, these machines are actually measuring the characteristics of individual oysters. This presents an unprecedented opportunity to collect high-quality oyster growth and growing area performance data. This project focuses on the assessment of oyster lease and cultivation method performance. This can be translated into a management tool for improving the industries' productivity and environmental sustainability. The project also demonstrates the possibility of implementing a long term oyster performance monitoring program, with minimum additional effort from the growers.

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Background

Based on industry data, NSW Sydney Rock Oyster (SRO) production was in a state of decline from the mid 1970's to early 2000. Over the last decade, however, SRO production levels have stabilised as a result of progressive action towards new oyster technologies and management systems, in addition to improved catchment activities. This has led to significant improvements in oyster handling, environmental and disease management, and the coordination of stakeholders within catchments to improve environment protection and improve water quality and catchment health. Consequently oyster production decline appears to have initiated a turning point in the industry. The industry has become more proactive with growers showing a real long-term commitment to the health of their waterways. Oyster growers are also making ongoing efforts to implement new technologies and best practices to ensure the long-term sustainability of the industry. An example of their commitment is reflected in an increasing number of oyster producing estuaries that are implementing Environmental Management Systems. These systems build frameworks for implementing best practices and the ongoing monitoring of water quality and other measures to ensure the health of the waterways.

In recent years many NSW growers have invested in highly sophisticated oyster grading machines. These graders are split into those that sort by weight and those that sort by shell shape. For the purposes of this project we concentrate on the latter. These use 3-dimensional measurements of the oyster during the grading process. This is the most common grader in NSW with a fifth of the oyster producing estuaries having access to at least one. These graders are also frequently used among the oyster growers in South Australia and Tasmania. The grader not only cleans and sorts the oysters but also allows growers to be much more accurate and consistent regarding oyster size, mortality rates and quantity sent to market. The machine can handle large volumes of oysters in a short amount of time (e.g. 5,000 oysters can be graded in 30min at medium speed, i.e. 150 oysters/min. Grading time can be further decreased by increasing grading speed but this come at the expense of measurement accuracy).

The number of times per year that oysters are graded is an important factor in the optimisation of the cultivation process. Grading allows for the removal of dead oysters, culling of over-catch and the checking of oyster health. In addition, by keeping similar size oysters together, inter-oyster competition can be minimised; larger oysters in a batch can 'hog' the shared resources, starving nearby animals. Most oyster growers only start using the grader towards the end of the oyster growth cycle, with marketable-size oysters. However, these machines can accurately grade oysters of 30-40mm shell length and above. By using the grader from earlier life stages growers could exploit these machines for other purposes.

Maintaining similar oyster sizes is not the only factor for optimum production. There is a combination of environmental factors, estuary circulation, flushing times, temperature, salinity, nutrient levels and levels of pollutants as well as husbandry issues that will affect oyster performance. In particular, oyster growth and oyster condition is known to vary significantly not only across different oyster growing estuaries but also across cultivation areas within an estuary. Quantifying the capacity and performance of oyster growing areas (i.e. oyster leases) will assist growers in managing their cultivation space in a more sustainable and productive way.

Potential changes in the environment of an oyster growing estuary or lake, through increased urban development, changes in agricultural practices, extreme events, or long-term climate change will have a significant influence on oyster productivity. However, at present, oyster growers are generally not in a position to adequately measure changes taking place in their growing areas as they lack accurate quantitative oyster production and environmental data. Every year the aquaculture branch of NSW Industry & Investment collects oyster production data from the oyster growers in each estuary. However, these data only allow a bulk comparison of productivity between estuaries from an economic point of view. An increase in oyster production from one year to another based on this production data does not necessarily mean that the estuary is more productive but that more oysters were sold independently of oyster quality or size. It is very difficult to assess such inter-annual changes estuarine productivity. At present we have little appropriate baseline data against which any changes can be related. Consequently, data collected using the oyster graders could be very useful. This data could, for example, contribute to the selection of priority lease areas according to production levels. Moreover, where environmental, climatological or hydrological data also exists for the growing areas it could also help us understand the relationship between the physical and chemical environment and oyster performance.

This project was set-up as a pilot study to test if the capability and output of the oyster graders could be used to answer some of the common production questions that growers face these days. The aim was to carry out experiments in the field that would cause as little interference as possible with the day-to-day husbandry and production protocols that growers are currently undertaking. The less the experiments differ from normal growers' practices, the more likely growers will integrate these methods into their daily routines.

Scope of project

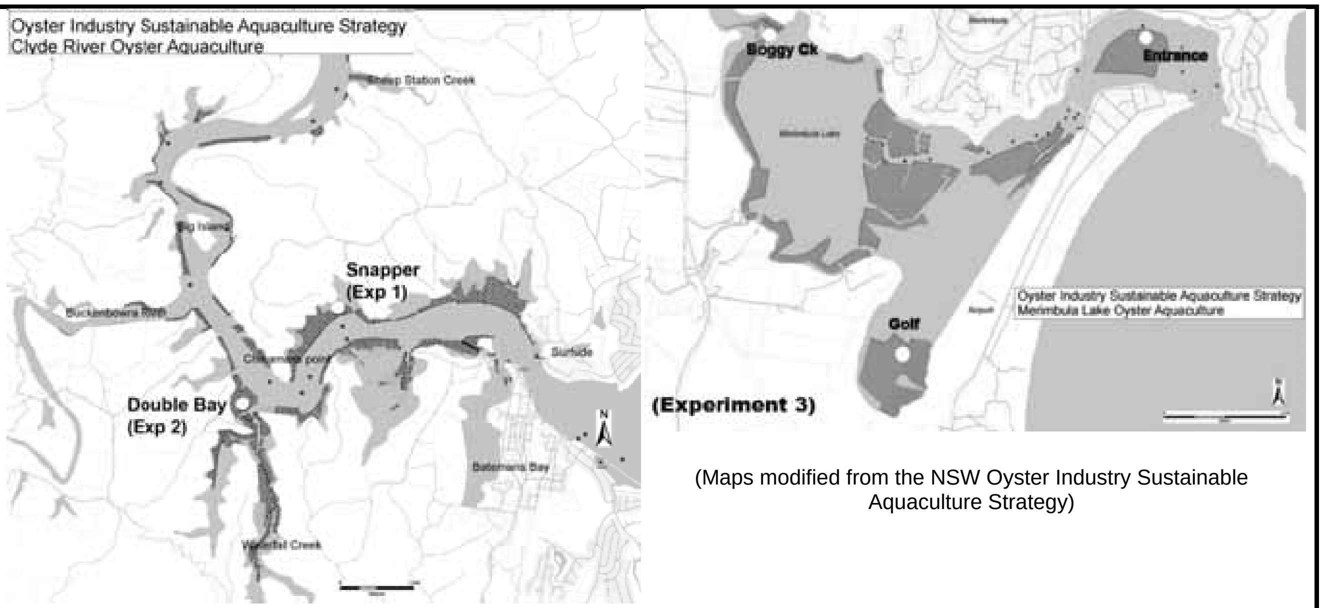
This project aimed to develop a system that will allow oyster growers to quantify the oyster productivity, mortality and performance of their oyster lease and cultivation systems. We use the output files of automated oyster graders that are routinely generated as batches of oysters are graded. By following the progress of batches of oysters (i) cultivated using a variety of culture systems, (ii) at different locations or (iii) by handling them in slightly different ways, oyster performance was monitored with time or compared across cultivation conditions. In most cases oyster growers have a good understanding of their systems, however by quantifying oyster performance, growers will be able to test hypothesis or to explore new management approaches.

Objective

1. To test if automated oyster graders can assist in the quantification of oyster performance (growth and mortality rates) under different scenarios:
    a. To quantify oyster performance across cultivation methods
    b. To quantify oyster performance across oyster leases
    c. To quantify oyster performance subject to different husbandry management practices

Methods- *How can we use the oyster grader to gather oyster performance data?*

The project was undertaken in two growing areas in the NSW south coast: Clyde River and Merimbula Lake (Figure 1). At both locations there is access to an automated oyster grader. Each oyster grader is managed in slightly different ways by the main operator. These graders and corresponding oyster operators were chosen as a result of their expressed interest in the project's aims and outcomes, which were discussed prior to submitting the application. Oyster growers from the Hawkesbury River were also interested in being part of the project, in particular to examine issues related to Triploid Pacific Oysters. Unfortunately, this was not possible as oyster spat from the hatchery in Tasmania was delivered later than scheduled and in lower numbers than expected. This complicated the experimental design and compromised the timeframe of the project which needed to be completed in less than 12 months. Consequently two experiments were set-up in the Clyde River to make up for the loss of the Hawkesbury experiment. As a result, two different experiments were run in the Clyde River and one in Merimbula Lake.



(Maps modified from the NSW Oyster Industry Sustainable Aquaculture Strategy)

Figure 1: Geographical location of leases/ growing areas where experiments took place on (left) the Clyde River and (right) Merimbula Lake

The two oyster graders used in this project were purchased from the same company- SED Shellfish Equipment Pty Ltd, who have also been very supportive of the project and happy to assist with technical difficulties when operating the grader. The two oyster graders were the same version and had the same operating program (Shellquip Grader MK 6). Figure 2 illustrates a collection of photographs that show the different parts of the grader. Oysters are loaded on to the singulator which is comprised of a loader, inspection belt, washer, elevator, a separator and a spacer. Oysters going through this part of the grader separate from each other providing a continuous line of individual oysters. After the oysters pass through the sorter. This part is comprised of the grading control unit that has a camera, a computer and, the sorter conveyor belt. Oysters pass under the camera, which records the size characteristics of each oyster. As a result the oysters are assigned to a specific grade that has been previously predefined in the grader software. Oysters travel along the sorter conveyor belt to a location that depends on the grade. Here an air-jet blows them off the belt and into a chute that holds the basket for collecting that specific grade. The number of oysters going into the different baskets can be set to a specified level. Once reached, a light comes on to indicate that the basket needs to be replaced. Consequently number of oysters per grade/cultivation method/husbandry condition can be controlled to ensure consistency through the experiment.

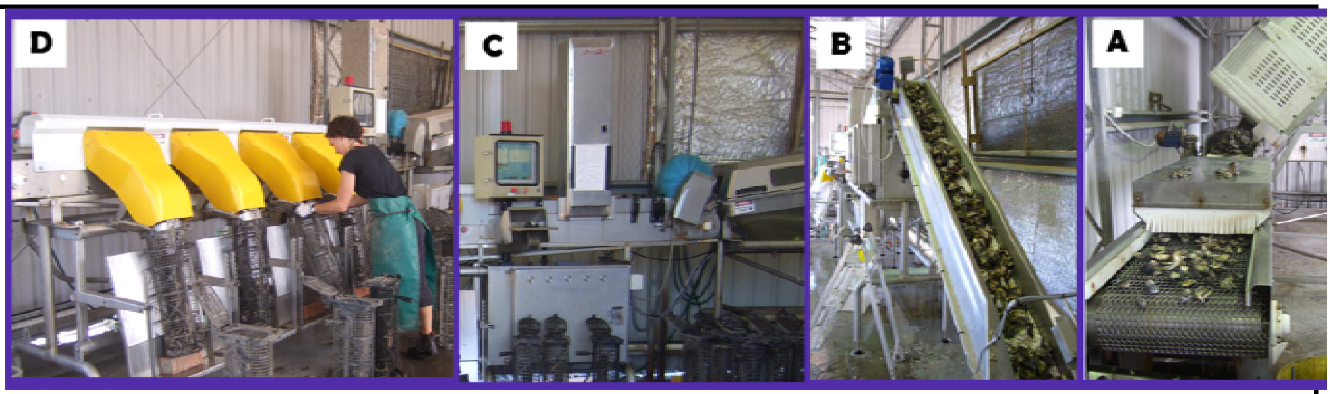


Figure 2: The Singulator is comprised of a Loader, Inspection Belt & Washer (A), Elevator (B); a Separator and a Spacer (right had side of C). The Sorter is comprised of the Grading Control Unit including the Camera and Computer (left hand side of C); and the Sorter conveyor belt with the chutes (D)

A series of *Recipe*s were set up at the start of the experiments as per the oyster grader operational manual. These *Recipe*s were saved and used throughout the project to ensure consistency with regard to the size of the grade groups and densities used in each experiment (Figure 3). At the end of each grading operation a batchfile is created which summarises the number of oysters going into each grade, the *Recipe* name, the total number of oysters graded and rejected, and the time taken in the run (Figure 3, raw measurements for each oyster are not currently available from the software). The batchfiles can be viewed on Excel so that information can be extracted and compared across batchfiles created throughout the experiment/trial. Basic Excel use will allow oyster growers to extract information on oyster performance as long as a protocol is in place to identify different batches and for naming the batchfiles. This information can easily be linked to stock control spreadsheets/softwares to assist growers in managing their stock movements and to get instant information on oyster performance. Unfortunately at present few growers are using the batchfile information as they only use the grader to physically grade the oysters. In most NSW oyster farms the grader is only used shortly before the oysters are sent to market but they are not integrated through the farming process as across the oyster life cycle.

Experiments were set up as where possible to minimise disruption to the day-to-day husbandry practices by the oyster growers involved. By doing this we anticipate a better acceptance and take up of the techniques described here. A large number of oysters was used in each experiment (approximately 5,000 oysters per batch in each experiment) in order to maintain a large sample size throughout the project to provide representative statistics for the oyster batches. The speed at which oysters were graded in all experiments was maintained at approximately 150 oysters/min. As mentioned previously, the oyster grader could grade oysters at a faster speed, however measurement accuracy will be reduced accordingly. *Recipe*s to be used for each experiment where set up at the outset of each experiment based on the oyster batch that the oyster growers made available for this project. Each of the oyster batches had a common origin (spat source) and /or age (spawning time). A representative number of oysters if not the whole batch was put through the grader with a temporary *Recipe* in order to see the size distribution of the batch. From the preliminary grades we quantified the population size distribution and we selected oysters from specific grades to work with. Ideally oysters selected for each experiment were representative of one grade to facilitate the measurement of oyster growth through time. However, in most cases, the oyster batches had a wide size distribution as insufficient oysters were available if only one grade was chosen. The narrower the polygons (which define oyster size range) in the *Recipe* for each grade the more uniform size/shape the oysters have in each grade. Therefore the experiments ran at the Clyde River were set up using two of the smaller grades while the experiment in Merimbula started with oysters from one single grade. Further information on the set up of each experiment has been included in the corresponding experiment headings below.

Figure 3: Screen capture of ShellQuip software in the middle of a run.

```
Grade          Bag Totals          Total Bags Bag A Count Bag B Count % of Batch
35-45          100                   7.0      0           44          14.48
45-55          100                  20.0      44          0           39.78
BOTTLE         90                   20.0      3           0           35.09
BISTRO         80                    3.0      0           7           4.81


Batch Summary
Recipe File    35--Bistro RETURN
Total Rejects  300                                                    5.84
Graded Oysters 4838
Start Time     9:00:37 AM
Start Date     29/03/2010
Process Time   0:31:49
Avg Oysters/Min 156
Startups       2
```

Figure 4: Batchfile example at the end of a run

[Left top window shows an oyster being captured by the camera and measured (Length x Width); Right top window shows a visual representation of the *Recipe* used in which each polygon corresponds to a grade and each dot corresponds to a previous oyster graded and allocated to that colour polygon/grade; Left bottom window shows the number of oysters set to go into each grade, how many oysters are at any time in each filling basket and the total number of baskets filled based on total oysters/bag; Right bottom window shows an overall summary of the oysters graded. In addition there are options to look at the statistics of the oysters being graded and the option of adjust the grading in the middle of the run]

Experiments

Three experiments were set up to address if automated oyster graders could assist oyster growers in the quantification of oyster performance under different scenarios without major deviations from their routine farm practices. The experiments were designed to answer questions raised by the oyster growers involved, which in most cases are shared by the rest of the industry. This project only addressed a few questions that are specific to the oyster grounds where they were undertaken. However, the approach and the development of the experiment is transferable to any oyster ground independently of location or scale of enterprise. Description and results of each experiment are presented below. Plots were generated by simply comparing or extracting values from one batchfile to another.

Experiment 1- Cultivation method performance – 'In which cultivation method (trays, adjustable height or floating long-line systems) oysters grow better?'

Oyster growers use several cultivation methods depending on the stage of the life cycle (size) of the oyster, on the physical and environmental conditions of the oyster growing areas and/or lease infrastructure available at a location. Optimising production for an area could be achieved by using the cultivation method that performs best in the local oyster ground. Over recent years new cultivation methods continue to be adopted by the NSW oyster industry as they move away from tarred products. Environmentally friendly recyclable and lighter materials are used on the cultivation units and lease cultivation frames. During this transition process growers have the opportunity of shifting to new cultivation methods that will enhance oyster production in a given area. Here describe a pilot study in which oyster performance using three cultivation methods is compared. In order to minimise the potential effect that different oyster growing grounds within an estuary/lake will have on oyster growth we selected an oyster lease at Snapper Point in the Clyde River (Figure 1) that had infrastructure to grow oysters in (i) trays (intertidal, exposed at low tide);(ii) SEAPA baskets in adjustable long-line systems with baskets at a fixed height (intertidal, exposed at low tide) and (iii) floating SEAPA long-line systems (surface, continuously immersed in the top layer of the water column).

The oyster batch used in this experiment was bought from an oyster spat supplier from the northern rivers a few months prior to the experiment set up. There were approximately 17,000 oysters in the batch providing us with ~5,000 oysters per cultivation method (3). Oysters from the whole batch were graded using a pre defined *Recipe* (Table 1). Most oysters were assigned into the smaller grades (Grade size 1 & 2). After grading a third of the whole batch and looking at the size distribution of the oyster batch it was found that the oysters had a wider size range than expected. As a result oysters from the first three grades Grade1-3 were used in the experiment in order to obtain the sample size of 5,000 oysters/cultivation method. It is worth bearing in mind that the grading process can stress oysters, potentially leading to premature mortality. As such we aimed to minimise the number of grading processes within the experiments. Grader manufacturers and oyster growers recommend grading oysters once, or at most twice a day or significant mortalities can occur.

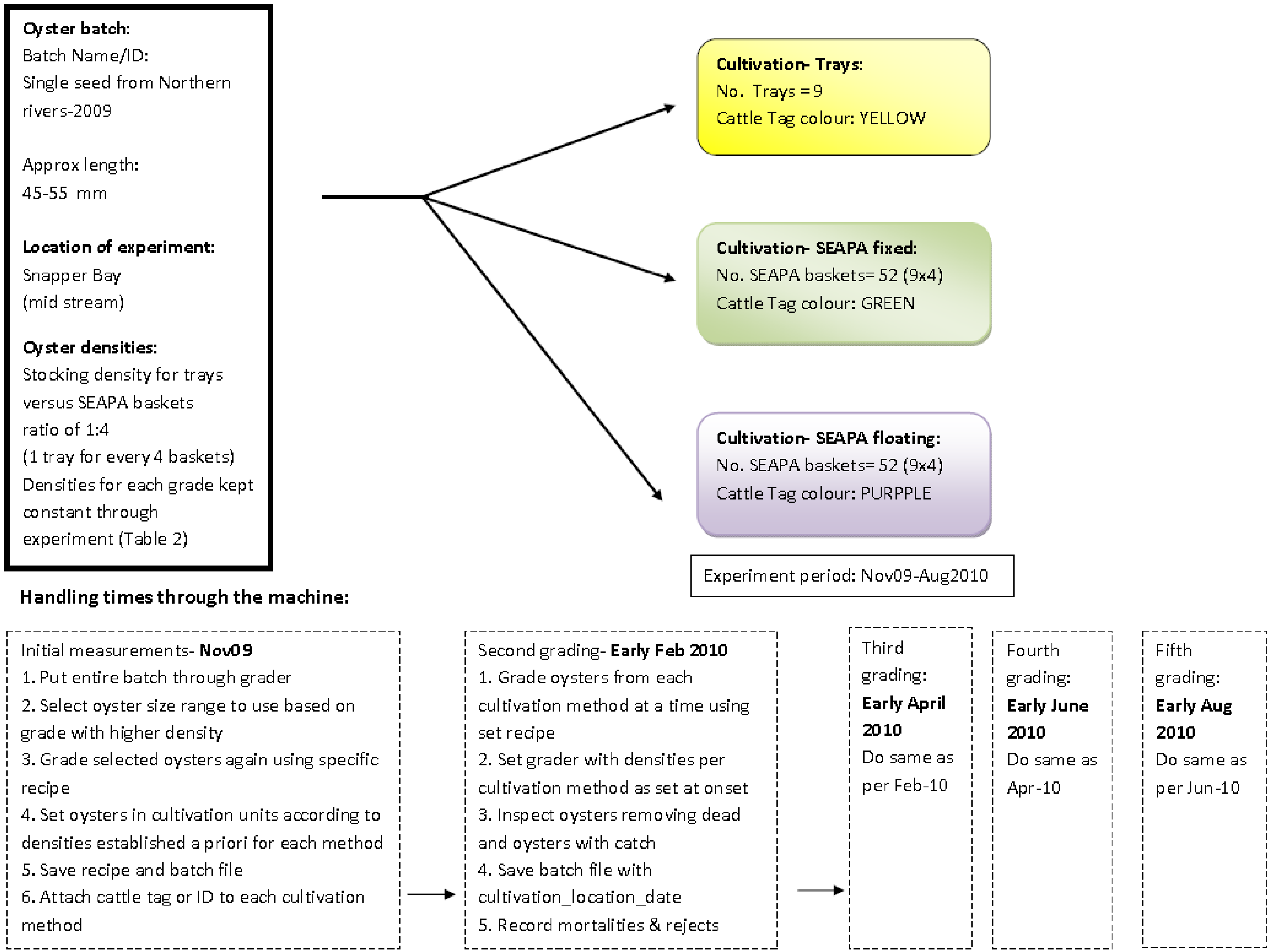
Oyster density levels were set a priori based on oyster grower's farming protocols and knowledge for each cultivation type and taking into consideration oyster size (Table 2). In order to keep similar densities between trays and SEAPA baskets we decided that an approximate similar stocking density would be achieved based on a ratio 1:4; Trays:SEAPAs as per figure below (Figure 5). Mortality rates in the oyster batch used in the set-up of this experiment were quantified (by removing dead oysters from belt prior to entering in the singulator) adding up to 1%.

Figure 5: Stocking density levels were maintained across cultivation methods throughout the experiment by setting similar levels at a ratio of 1:4; Tray: SEAPA baskets as visualised on the picture

<u>Experiment 1 set-up specifications:- Comparison of cultivation methods:</u>

Oyster enterprise collaborator: Mc Ash Oysters
Oyster batch description: Single seed wild spat from Port Macquarie (collected on slats)
Lease location: Snapper Point, Clyde River, NSW (Figure 1)
Date set-up of experiment: 24th Nov 2009
Date end of experiment: 3rd August 2010 (Total days of experiment: 252 days)
Variable to test: oyster performance cultivated using different methods
Frequency of grading: every 2 months (on average 63 days)
Recipe used: Combination of '35-BISTRO-Return' & '45-PLATE SEAPA' (Table 1)
Stocking density/grade/cultivation method: Table 2
Number of cultivation units at set-up/start: Table 3
Experimental design diagram: Figure 6

Figure 6: Diagram representing experimental design for Experiment 1 – comparing performance of cultivation methods



Different colour cattle tags were used to distinguish cultivation units from each cultivation method as they were all deployed on the same lease at Snapper Point. Oysters were brought into the shed and graded approximately every 2 months. Oysters from the same cultivation method were taken out of the trays or SEAPA baskets and graded as one group, independently of the oyster size. *Recipe* and density in each cultivation method were used as per set-up. As oysters were loaded on to the inspection belt of the oyster grader, dead and over-catch oysters were removed. Dead oysters were counted to confirm mortality numbers. This was calculated by subtracting Total graded oysters + rejects + doubles between subsequent grading processes. Over-catch oysters were culled and put back on the system for grading. Approximately, 2% of the oysters graded came out as rejects. These oysters were put through the grader a second time, thus reducing reject numbers to 0.5%. The 0.5% of reject oysters were added to a cultivation unit that was partially full at the end of the grade. Cultivation units that were half full at the end of the grading process were combined with other units of similar grades (Grade 1 with Grade 2 and so on) so as to maintain density levels as close to the initial set-up as possible. Average shell length for each grade was recorded from the grader software so that increases in size could be calculated by using a weighted average shell length. At this point the batchfile was saved and named using the date, cultivation method and lease location. The same procedure was repeated for the oysters of the other two cultivation methods (as per experiment design in Figure 6).

Table 1: *Recipe* and adjustments used in Experiment 1. Grades and adjustments were kept constant throughout the experiment

Points of reference for the different grades

Polygon points	**Point 1**	**Point 1**	**Point 2**	**Point 2**	**Point 3**	**Point 3**	**Point 4**	**Point 4**		
Grade	**Length**	**Width**	**Length**	**Width**	**Length**	**Width**	**Length**	**Width**	**Name**	**Size**
1	37	31	49	41	59	1	71	11	**35-45**	**very small**
2	44	36	55	46	66	7	77	16	**45-55**	**small**
3	50	41	62	52	72	12	85	21	**Bottle**	**medium**
4	58	49	73	62	83	19	97	32	**Bistro**	**large**
5	63	54	78	66	90	25	103	35	**Plate**	**market size**

Adjustments used with the above *Recipe*:

	Length	**Width**
Grade 1	-6	0
Grade 2	-4	0
Grade 3	-4	0
Grade 4	0	0
Grade 5	0	0

Table 2: Oyster stocking densities for each grade and cultivation method based on oyster grower's knowledge and own farming practices.

Grade / cultivation type	**TRAYS**	**SEAPA**
Grade 1- 'Very small 35-45'	400	100
Grade 2- 'Small 45-55'	400	100
Grade 3- 'Bottle'	350	90
Grade 4- 'Bistro'	300	80
Grade 5- 'Plate'	250	60

Table 3: Summary of the number of cultivation units per method and grade at the start of Experiment 1 based on information from Table 1 and Table 2.

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Grade/Name	**TRAYS**	**Floating SEAPA**	**Intertidal SEAPA**
Grade 1- 'Very small 35-45'	4	4 x 4 (16)	4 x 4 (16)
Grade 2- 'Small 45-55'	5	4 x 5 (20)	4 x 5 (20)
Grade 3- 'Bottle'	4	4 x 4 (16)	4 x 4 (16)
Grade 4- 'Bistro'	-	-	-
Grade 5- 'Plate	-	-	-
Total oysters at start	9 Trays (5000 oysters)	52 SEAPA (5040 oysters)	52 SEAPA (5040 oysters)

This experiment ran for 252 days. During this period, by comparing the summary information saved in the batchfiles from each grading process, oyster growth for each cultivation method could be estimated along with how many oysters died or were lost from the system. From Figure 7 it can be seen that the most of the oysters grew to reach Grade-3 with a small percentage of them reaching larger grades after 8 months of experiment. However, about 5% of oysters showed little or no growth, remaining in the small grade (Grade-1). Data used to create plots for Figure 7 does not take into account mortality information. In order to assess best cultivation method performance we also need to take into account mortality. Figure 8 and Figure 9 show the mortality rates recorded at each grading independently of the grade. As previously mentioned, mortality data was calculated by comparing through time the total number of oysters alive (Total graded, rejects and oyster with over-catch) at the end of each grading activity. This method does not allow us to calculate mortality rates by oyster size unless dead oysters are measured manually. Overall we can see from the plots that oysters growing in Trays had the highest mortality rate. This numbers not only reflect natural mortality but also oysters that were lost when handling the trays at the lease. It seems that growers are having problems with this cultivation method as the trays will frequently split open when transferring them from the rack and rail at the lease to the oyster punt (oyster grower comment). As a consequence to take this into account, the number of dead oysters removed from the inspection belt at each grading activity was used as the mortality data related to Trays instead of calculating the mortality rate from the data summarized in the batchfile.

Environmental and weather aspects can affect significantly mortality rates. In addition we might expect different environmental conditions to influence oyster survival differently depending on the physical characteristics of the different cultivation methods. As can be seen from Figure 8, extreme heat events that occurred early in 2010 resulted in increased mortalities across the three cultivation methods, in particular significantly affecting oysters growing on trays. Growers believed that trays, especially at low tide, can absorb and retain significant amounts of heat if air temperatures are over 30°C. We can also see from Figure 8 that major rain events could also impact the survival of oysters, especially on trays and, to a lesser extent, on floating SEAPA baskets. Oysters in floating cultivation units get exposed to the superficial freshwater input during rain events. If the rain event is large and depending on the flushing of the estuary, the freshwater plume could stay on the surface of the water column for long periods of time inhibiting filtration of oysters. These results are worth noting as these days many growers are moving from intertidal cultivation methods to floating long line systems. Overall mortality rates recorded over the 8 months of experiment we slightly higher than expected by the oyster grower involved in the experiment. Annual % mortality was estimated to be 14.2%, 10.9% and 38.7% for floating long-line, adjustable height long-line and trays cultivation respectively.

Finally, data on the number of oysters per grade and mortality rates can be integrated into an oyster performance indicator by calculating the weighted shell length averaged through time. Figure 10 shows how oysters in the different cultivation methods perform with time. From this plot we can see that oysters in long-line systems performed better than in intertidal tray cultivation. Floating long-line systems appear to have slightly better performance than adjustable height long-line systems, however the difference does not seem significant and the risk of losing oysters in a surface floating system under heavy rain events could influence the performance of this cultivation method.

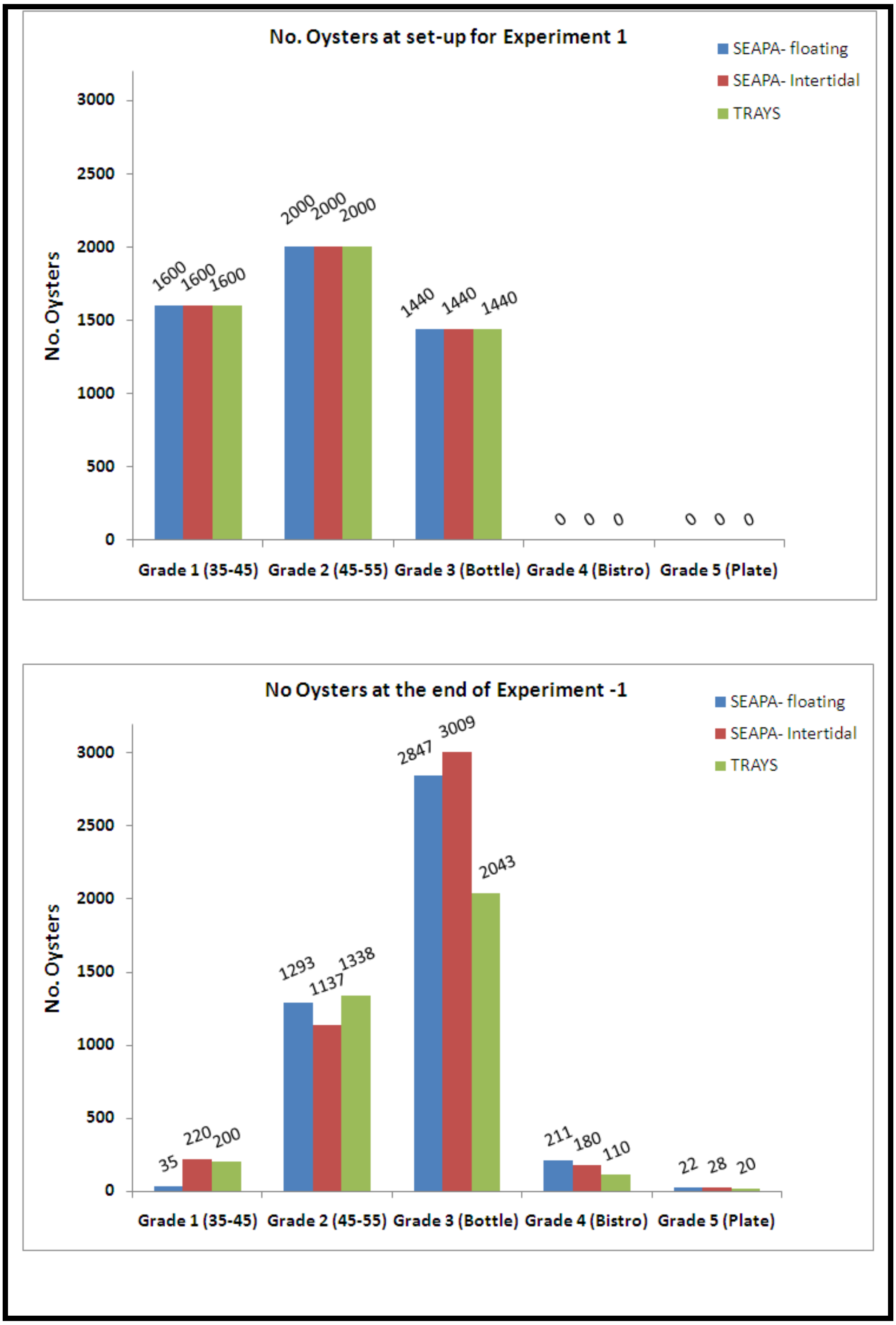


Figure 7: Total number of oysters graded in each grade for each cultivation method at the start and end of the experiment (252 days later)

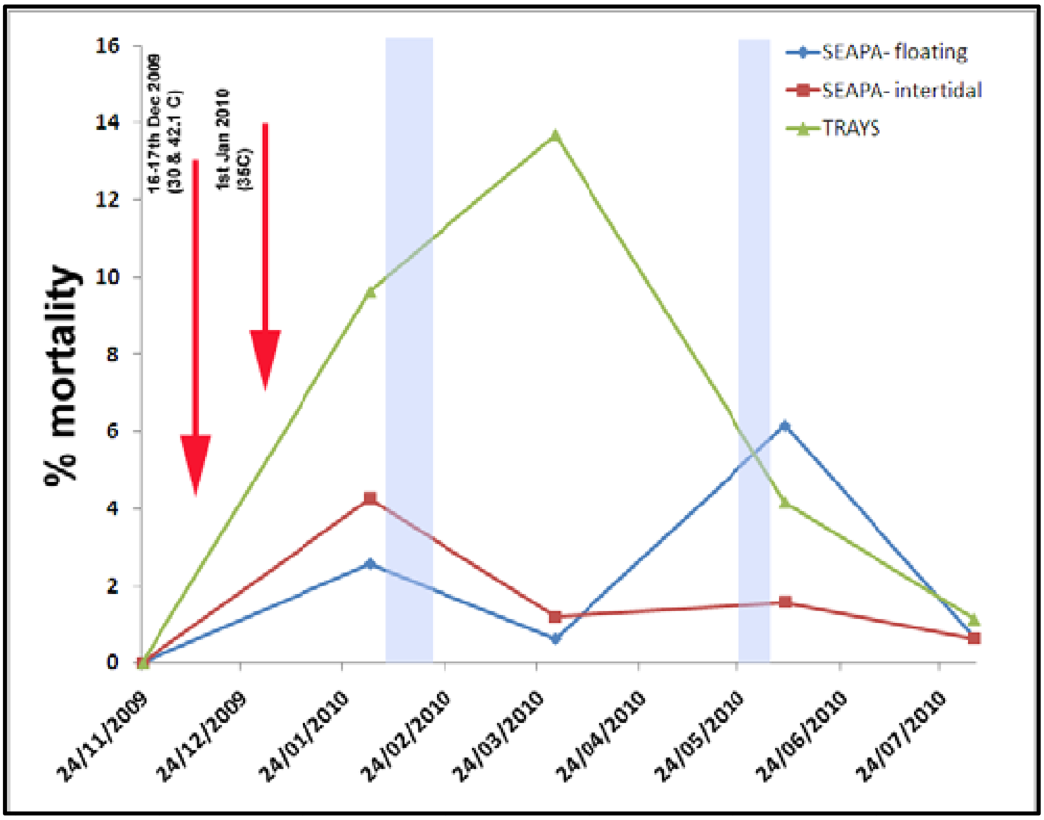


Figure 8: Percentage mortality throughout the experiment for the different oyster cultivation methods. Red arrows represent days of very high air temperatures during the day and blue bins represent periods of heavy rainfall.

[Rainfall recorded at the Catalina Club in Batemans Bay: first week of February 2010 over 3 days a total of 96mm and in mid February over 4 day a total of 187mm. For the period of 25th -31st May the total rainfall recorded was 167mm (BOM data for Rainfall station no 69134)]

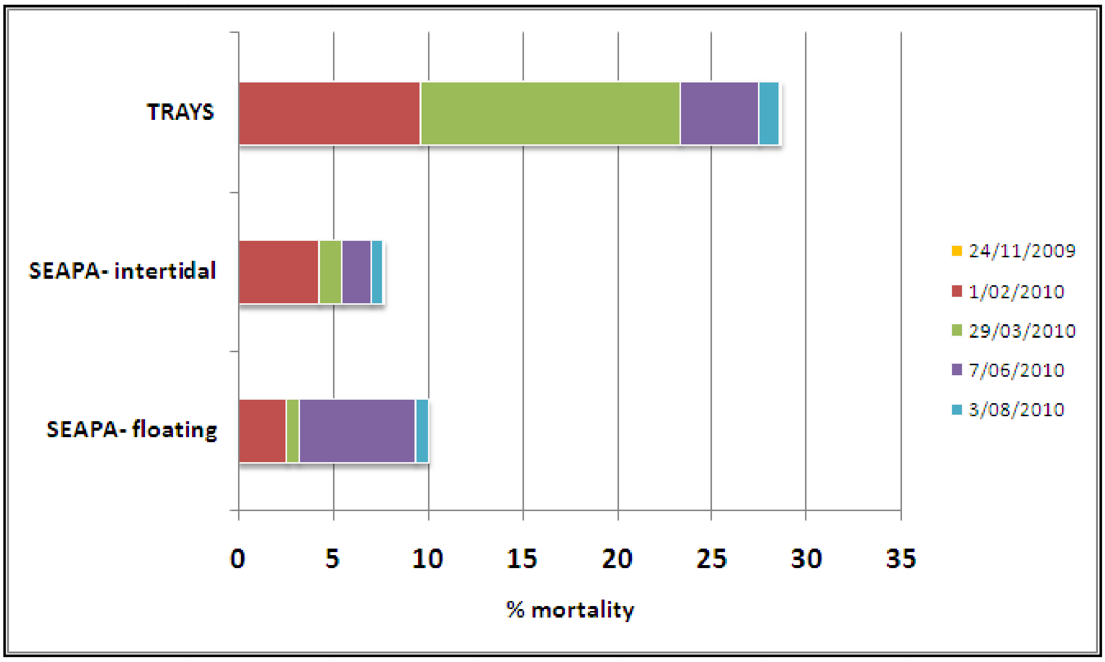


Figure 9: Cumulative percentage mortality for every grading process (approximately every 2 months) and for each cultivation method

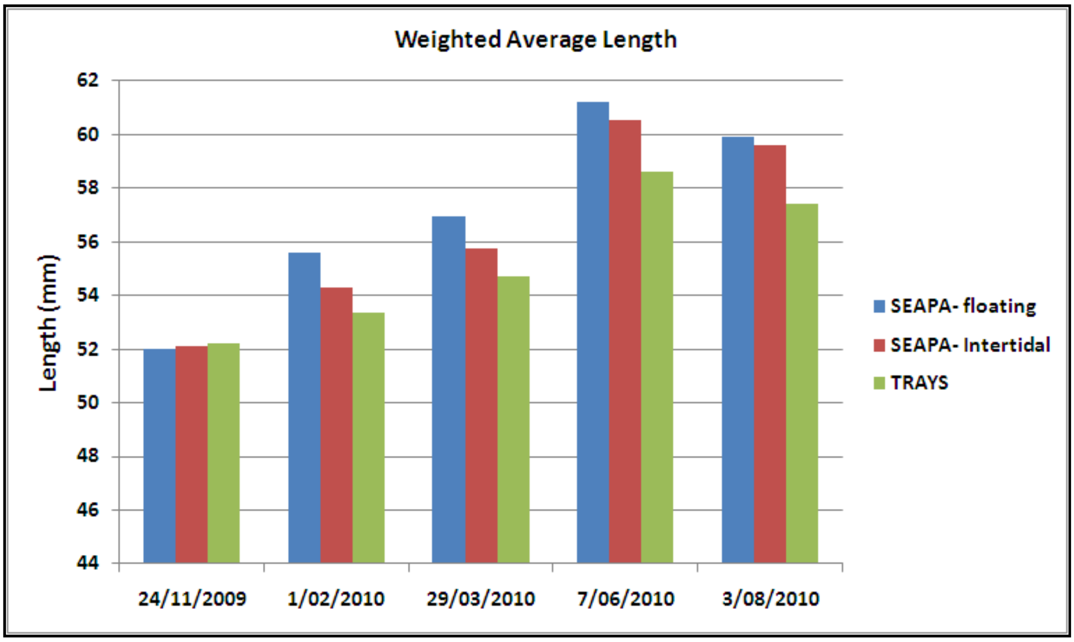


Figure 10: Weighted average shell length (mm) through the experiment for the different cultivation methods taking into consideration the average shell length calculated by the software of the grader of each grade and the number of oysters graded for each size

Experiment 2- Frequency of grading – 'How often should I grade my stock?'

Another management question that growers are interested is how often they should be handling their stock in other to (i) maintain similar size oysters within each batch, so that individual oysters performs equally from a filtration and metabolic point of view, (ii) maintain optimal density levels as oyster grow and (iii) inspect their stock to manage fouling, overcatch and general health. As grading with automated graders have become easier and quicker, more frequent handling handling is now possible. However this approach incurs in high operational costs (i.e. fuel and operational resources) and more handling may have adverse effects on oyster performace. In this experiment we aimed to find the optimal grading frequency to produce the best oysters performance. The grower at whose farm the experiment was undertaken handles his stock at least once every 3-4 months depending on the time of the year and environmental condition of the waterway. Consequently he suggested testing the following intervals: 6, 10 and 14 weeks (Figure 12) corresponding to our experimental groups of High, Medium and Low frequencies.

The experiment was run at a midstream lease of the Clyde River, in an area called Double Bay (Figure 1). Relatively small oysters (around 45-50mm shell length) were sourced from a spat producer in the northern rivers and were cultivated in SEAPA baskets on floating long-line systems. The original batch was graded and handled as per Experiment 1 in this case using a *Recipe* that sorted oysters from 25mm to Bottle size (Table 4). A total of 5,000 oysters were used for each frequency group. Oysters chosen for the experiment were selected from the proportion of the batch that fell in Grade 2 & 3 (Table 5 and Figure 14). SEAPA baskets were colour tagged according to each grading frequency group for easy identification.

Experiment 2 set-up specifications: frequency experiment

Oyster enterprise collaborator: Mc Ash Oysters
Oyster batch description: Single seed wild spat from NSW northern rivers (collected on slats)
Lease location: Double Bay, Clyde River, NSW (Figure 1)
Date set-up of experiment: 21st Jan 2010
Date end of experiment: 3rd August 2010 (Total days of experiment: 194 days)
Variable to test: oyster performance graded at different frequencies
Frequency of grading: every 6, 10 & 12 weeks (Figure 12)
Recipe used: 25-Bottle SEAPA (Table 4)
Stocking density/grade/cultivation method: 100 oysters/SEAPA basket
Number of cultivation units at set-up/start: Table 5
Experimental design diagram: Figure 11

The procedure followed in this experiment was similar to Experiment 1. Oysters to be graded as per the schedule in Figure 12 were brought into the shed; SEAPA baskets were emptied and loaded on the oyster grader. Oysters were inspected as they were travelling towards the elevator. Dead oysters and those with over-catch were removed and counted and culled as per previous experiment. Oysters were graded at a medium speed of approximately 150 oysters/min. Reject oysters at the end of the grading run were put through the machine a second time reducing the number of rejects significantly. A schematic of the process followed has been described in Figure 11. Batchfiles generated at the end of the grade were saved naming them with the date, location and frequency group.

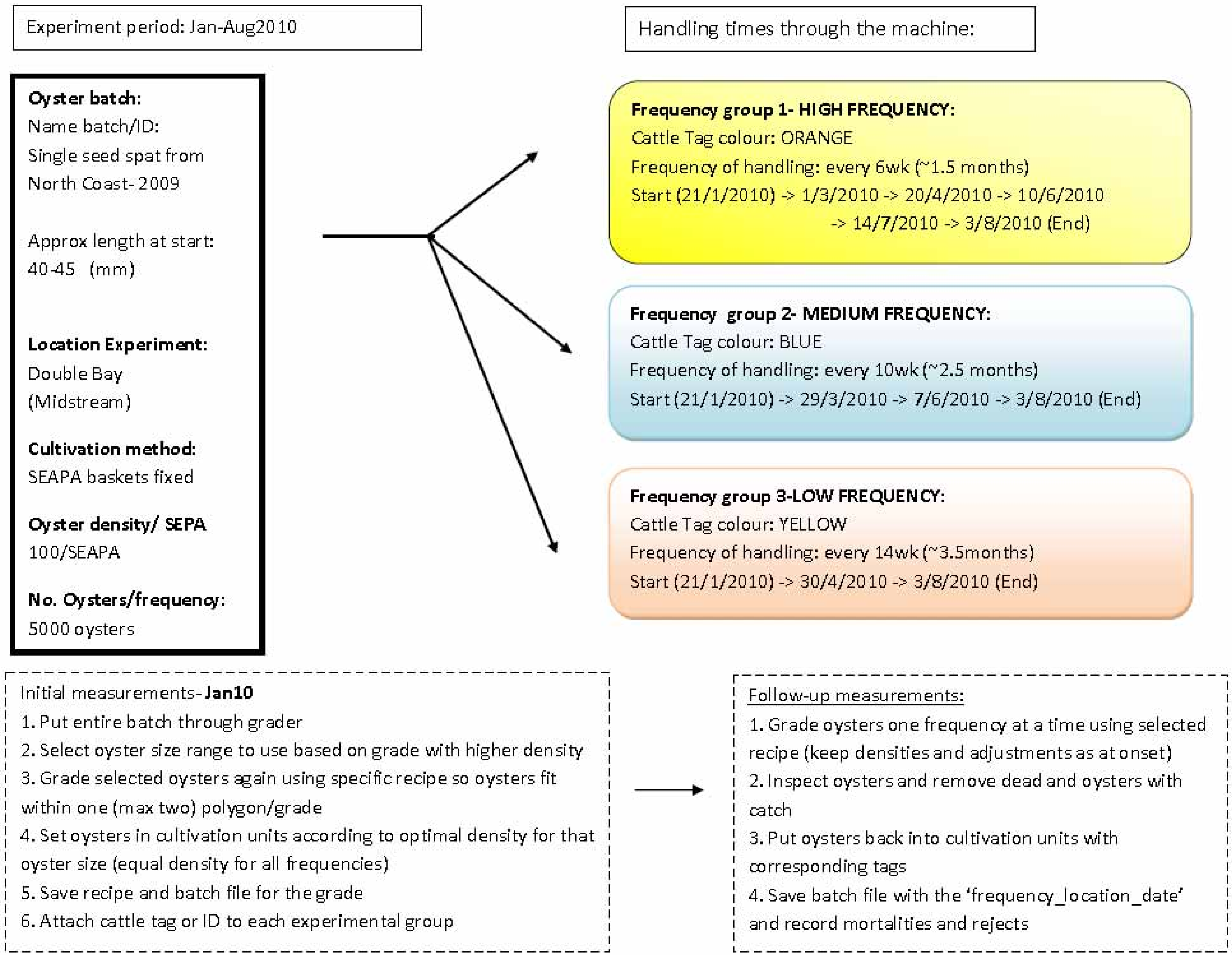
Table 4: *Recipe* used in Experiment-2 (25-Bottle SEAPA) and density of oysters per size-grade

Polygon points	**Point 1**	**Point 1**	**Point 2**	**Point 2**	**Point 3**	**Point 3**	**Point 4**	**Point 4**		
Grade	**Length**	**Width**	**Length**	**Width**	**Length**	**Width**	**Length**	**Width**	**Cut-off**	**Name**
1	30	25	40	34	49	0	60	7	100	**25-35**
2	37	31	47	39	58	1	69	9	100	**35-45**
3	45	35	57	48	65	9	77	16	100	**45-55**
4	50	41	70	59	72	12	95	29	100	**Bottle**

Table 5: Number of SEAPA baskets and densities at the start of Experiment 2

Grade	**# SEAPA for experiment**	**Densities**	**Average Shell Length (mm)**
Grade 1 (25-35)			41
Grade 2 (35-45)	30 x 3	100	49
Grade 3 (45-55)	20 x 3	100	56
Grade 4 (Bottle)			64
TOTAL	**50 SEAPA (5000 oysters)/ experiment**		

Figure 11: Diagram representing experimental design for Experiment 2 – Frequency of grading stock



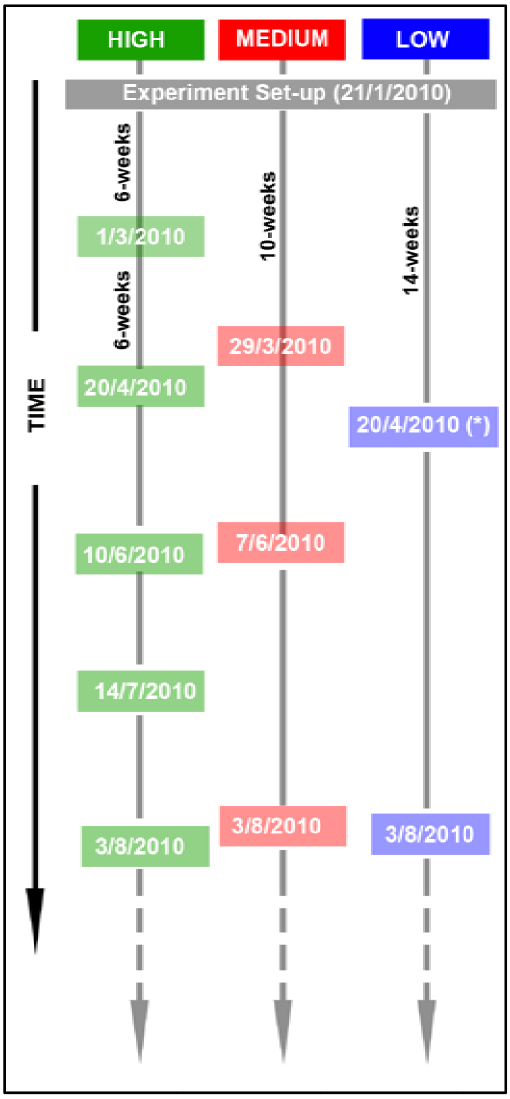


Figure 12: Sampling schedule for Experiment 2 based on grading frequencies to be tested

While oysters at the start of the experiment were selected to be Grade-2 and Grade-3, after the first grading process (6 weeks after the start of the experiment) it was found that a small number of oysters (8.5%) fell into Grade-1 (Figure 14). This raises issues regarding the accuracy of the oyster grader's performance as an experimental tool. However, it is worth noting that oyster size used in this experiment was at the smallest limit recommended by the manufacturer if grading accuracy is needed. It can also be seen from right column of Figure 14 that we obatined some anomalous results during the week of the 7th and 10th July 2010 with very high numbers of oysters in the largest grade. Further discussion on the accuracy of the grader and best way of minimising this error has been included in the discussion section (Page 27).

Overall a significant effect on oyster performance based on frequency of handling was. As can be seen from the left column on Figure 14, the Low grading frequency group (grading every 14 weeks) appeared to grow more than the Medium, and the Medium also grew more than the High frequency group. This could be a result of oysters from the lower frequency groups spending more time at the lease (i.e filtering and growing) than the oysters from the higher frequency groups. Some oyster growers commented that oysters from the High frequency group did not have as much soft shell growth (shell frill) compared with the Low frequency group. They suggested that the slow growth was a result of more shell frill being broken during grading and handling processes.

Mortality levels among the grading frequency groups were considerably smaller in the Low frequency group compared to the High or Medium groups (Figure 13). Again and as per Experiment 1, mortality levels in the experiment were higher than expected by the oyster growers. The annual percentage mortality estimated based on mortalities recorded in the 6-month experiment were 28%, 30% and 13% for the High, Medium and Low frequency groups, respectively.

In addition, a number of characteristics were noted across the grading frequency groups. For instance oysters from the high frequency group had a more regular shape than the low frequency group. Towards the end of the experiment, oysters from the high frequency group fitted mainly into Grade 2 & 3, while oysters from the low frequency were spread among the 4 grades. This pattern might be a result of large oysters taking advantage of close-by smaller oysters and therefore growing at a faster rate due to their higher filtration capacity. Consequently by grading oysters more frequently and maintaining even sizes, oysters get an equal chance to keep up with the rest of the batch and reduce the number of small (potentially stunted) oysters in the stock.

It was also noted that oysters from the low grading frequency group had more over-catch (approx. 140 oysters) compared with the medium group (approx 60 oysters) and the high (approx 30 oysters). As oysters are handled more frequently it is easier to keep up with over-catch as oysters spend more time out of the water drying and growers have the opportunity to cull them as they get graded or handled.

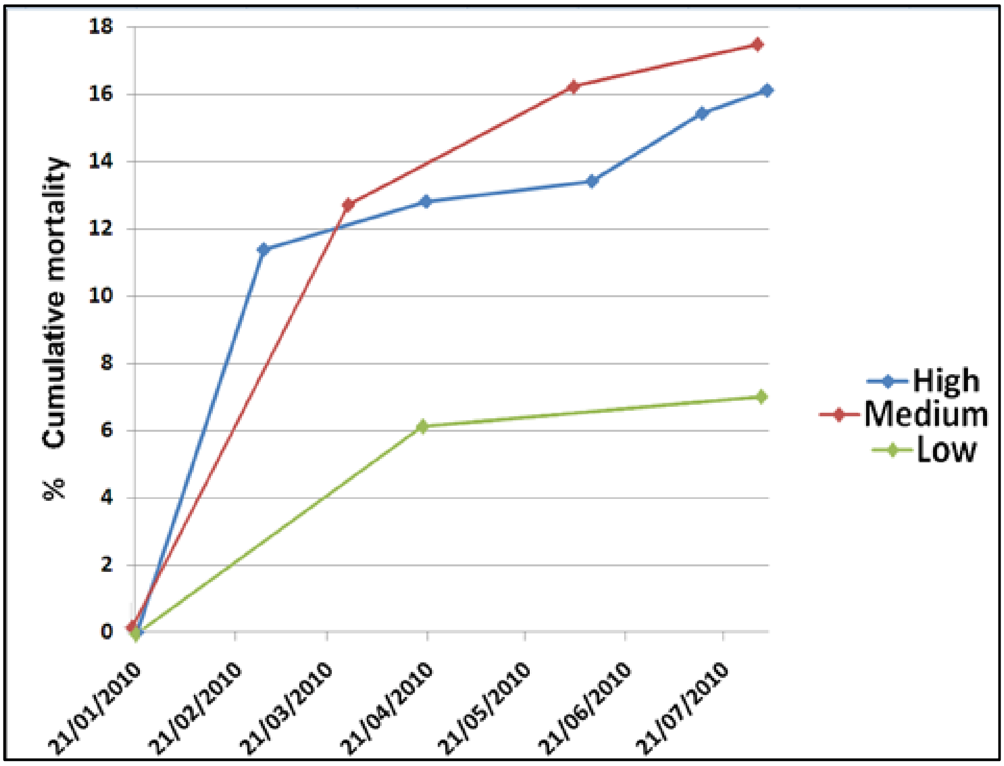
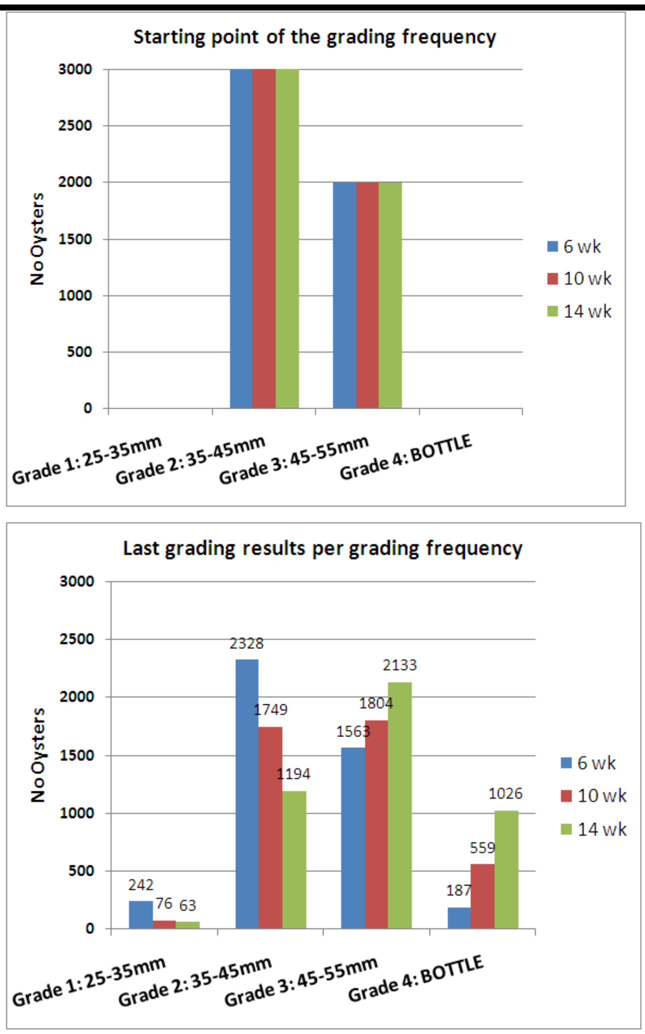


Figure 13: Cumulative mortality (%) for each of the frequency grading groups throughout Experiment 2

Overall experiment showed that oyster performance under different husbandry management practices can be quantified by using the batchfiles generated by the automated oyster grader.

Future experiments should concentrate on longer periods under which oysters are not graded to identify the optimal frequency under which oysters are not compromised but oyster growers take full advantage of their production levels.



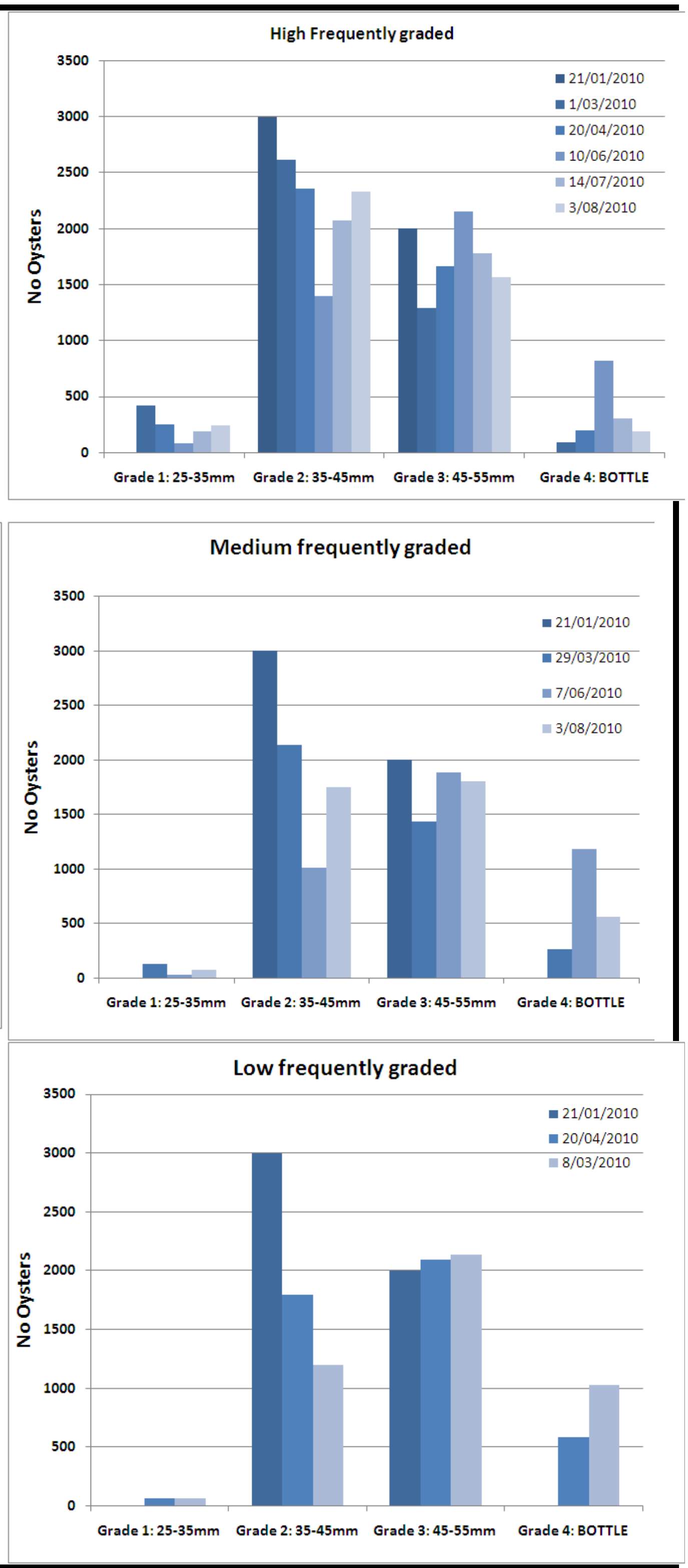


Figure 14: (left column) Number of oyster per grade at the start and end of the experiment by grading frequency groups. (right column) Number of oysters per grade through time split by grading frequency groups.

Experiment 3- Stocking densities – 'What stocking density results in best oyster performance?'

A challenging topic among oyster growers and researchers is to determine the optimal oyster stocking density under which growers get best return in production. Quantifying this level is complicated as it depends on many different aspects including nutrients and food availability for oysters, variable growth rates under different cultivation methods and geographical and seasonal changes in environmental and physical characteristics of waterways. Some of the NSW oyster growers have tested the effect of varying density levels in their cultivation units but the large majority of growers seem to be guessing or using the densities that someone else is using. Since optimal stocking densities could vary from lease to lease within an estuary as these are characterized by different environmental conditions, it is important to take into consideration this spatial variability when comparing oyster performance from various sources.

In this experiment we tested if the oyster grader could give us usefull information on oyster performance based on oysters cultivated under different stocking densities but using a common cultivation method. The experiment was undertaken at three lease locations in Merimbula Lake (Figure 1); on a lease close to the mouth of the lake with more oceanic water influence, on a lease within a productive bay half way through the lake and, on a lease at the back of the lake with some creek influence. The oyster batch used for this experiment was hatchery sourced as part of one of the NSW disease-resistant breeding programs (QX-resistant batch May 2008). Average oyster size at the start of the experiment ranged between 65-75mm shell length and 25±5g whole wet weight. The experiment was run using oysters cultivated in floating bags on long-line systems. The oyster grower involved in the experiment was interested in quantifying the difference in oyster performance from cultivating 100, 80 or 60 oysters/bag at these three locations in Merimbula Lake. A total of 5 replicates were used per density and location (Figure 15). Oyster performance was assessed by comparing number of oysters being allocated to a grade through time. As per previous experiments dead, reject and over-catch oysters were recorded.

The original batch of oysters was graded through the machine by creating a *Recipe* based on the size range of oysters. In this case we aimed to set up the experiment with oysters from a single grade size (Grade-2, in Table 6) in comparison to both of the previous experiments in which we set-up the experiments with oysters from various grades. However, the oyster grader still generated some error as a 0.3% of the oysters were allocated to Grade1 instead of Grade2 as per set up.

<u>Experiment 3 set-up specifications: stocking density experiment</u>

Oyster enterprise collaborator: Wheeler Oysters
Oyster batch description: Hatchery spat (QX-resistant May 2008)
Lease location: Entrance (north of the bridge), Golf Bay (midstream) and Boggy Ck (back lake), Merimbula Lake, NSW (Figure 1)
Date set-up of experiment: 23rd Nov 2009
Date end of experiment: 2nd August 2010 (Total days of experiment: 252 days)
Stocking densities: Low: 60 oysters/bag; Medium: 80 oysters/bag; 100 oysters/bag
Frequency of grading: under 3 months
Recipe used: ana3 (Table 6)
Stocking density/grade/cultivation method: 100 oysters/SEAPA basket
Number of cultivation units per stocking density/location: 5 (Table 7)
Experimental design diagram: Figure 15

Figure 15: Diagram summarising the set-up of Experiment 3 – comparing oyster performance under different stocking densities

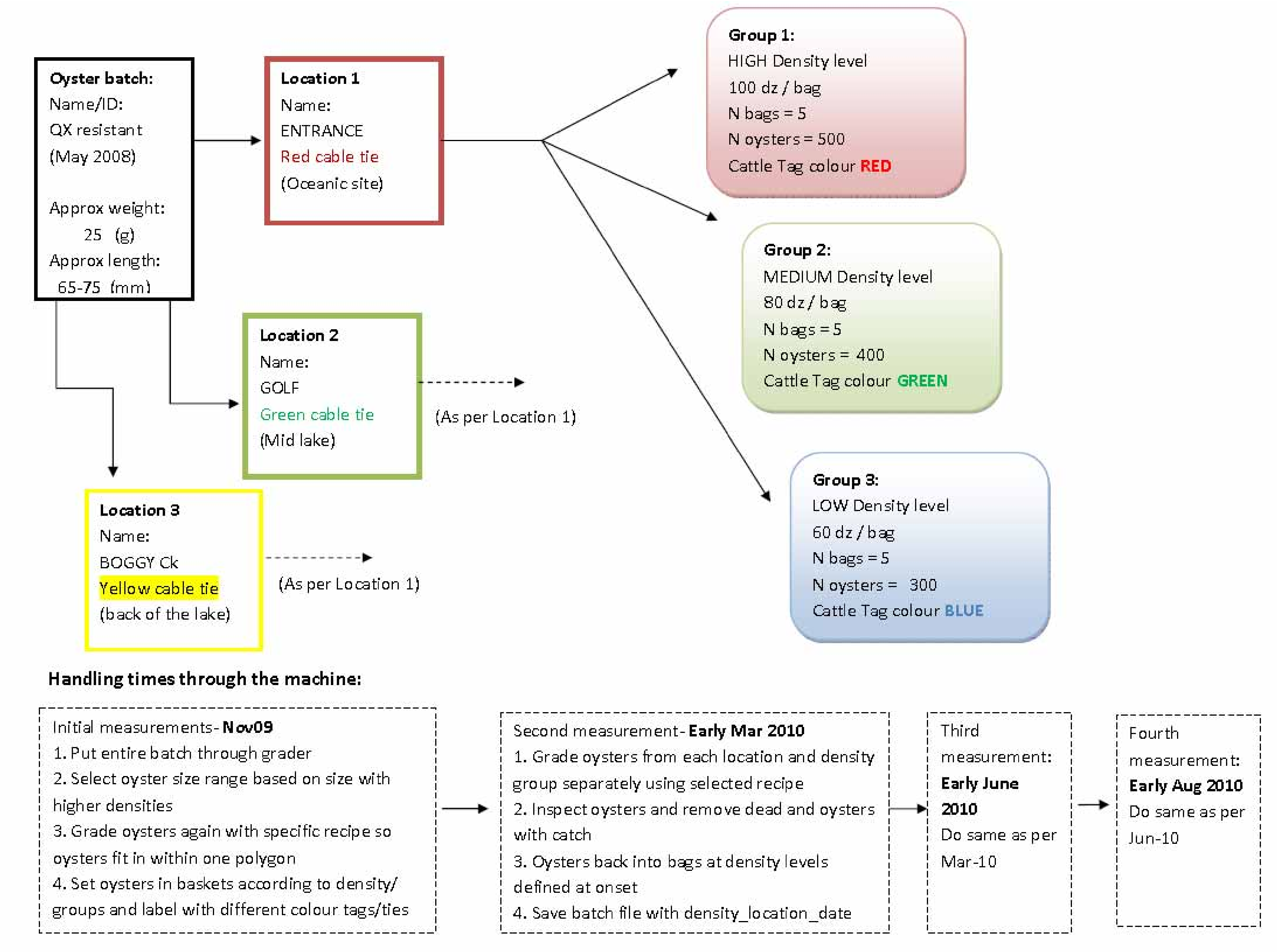


Table 6: *Recipe* used in Experiment-3 (ana3)

Polygon points	Point 1	Point 1	Point 2	Point 2	Point 3	Point 3	Point 4	Point 4	
Grade	**Length**	**Width**	**Length**	**Width**	**Length**	**Width**	**Length**	**Width**	**Name**
1	42	41	81	12	32	29	75	6	**45-55**
2	48	47	88	18	41	41	81	11	**Bottle small**
3	60	59	100	22	48	47	91	15	**Bottle large**
4	70	68	110	31	60	58	100	22	**Bistro small**
5	102	99	125	35	70	68	113	27	**Bistro large**

Table 7: Number of bags and oysters per density and location

Density/Location	Entrance	Golf Bay	Boggy Ck
Low (60 oysters/bag)	5	5	5
Medium (80 oysters/bag)	5	5	5
Large (100 oysters/bag)	5	5	5

A number of issues occurred throughout the development of this experiment. Oysters and bags from all sites, including Boggy Creek at the back of the lake, suffered from significant barnacle fouling during the first months of the experiment. Barnacles do not tend to be present at the back of the lake due to brackish waters. However the Merimbula region was severely affected by drought conditions at the start of the experiment increasing significantly the salinity levels of the whole lake and allowing oceanic fouling organisms to thrive and colonise the back waters of Merimbula Lake. In addition a few extreme air temperatures occurred in mid Dec-09 (42°C), first week of Jan 2010 (29°C) and 22nd Jan 2010 (31°C). During the length of the experiment two major rain events took place: on the 16th Feb 2010 with 242mm over 3 days and on the week of the 25th May 2010 with 149mm over 5 days (BOM data from Merimbula Airport weather station #069147). These environmental extreme events appear to have significantly affected the performance of all the experimental oysters, in particular at the lease in Boggy Creek at the back of the lake (Figure 16). During the first 3 months of experiment, higher number of oysters died in all locations for all stocking densities. These mortalities might have been a result of the extreme air temperatures occurring in the middle of the day at low tide during the Christmas period. Out of the three lease locations Boggy Creek appears to be the one with higher mortalities and therefore the one with lower potential for high oyster production. Mortality levels were more dependent on the location than the stocking density.

Overall oyster performance was found to be better at the highest stocking density (100 oysters per bag) used in this experiment (Figure 17) despite general findings from previous scientific studies. However, it is worth noting here that the stocking densities chosen in this experiment were overall lower than the average used by many growers. So it appears that oysters were not compromised at all as a result of competition for space and/or food resources. Oyster growers have observed previously that by filling the cultivation units at very low densities, oyster performance does not improve but instead results in poor growth. It is believed that when oysters, as gregarious animals, have lots of space in the cultivation unit, it will lead to poor growth rates as a consequence of continuous movement and rocking.

Another variable tested in this experiment was the condition index of oysters at the end of the experiment. Originally we planned to check condition index for every density level and location after each grading process every 3 months. However, as a result of the large number of dead oysters found at the first grading process it was decided to check condition only at the end as oysters need to be killed in order to check their condition. If a larger number of oysters had been used in the experiments, condition index would have been used as another variable in the assessment of oyster performance. Consequently, it is recommended that in any attempts to replicate this experiment, some oysters be set aside for testing condition level. From Figure 18 and Table 8 it can be seen that condition index across the oysters was quite variable and there was no clear relationship to density or location. In summary oysters from Boggy Creek had slightly lower condition while oysters form the Entrance maintained similar condition levels across the densities. The highest levels of condition index were found at Golf Bay for Low density oysters however, the medium density showed the poorest condition similar to oysters from Boggy Ck.

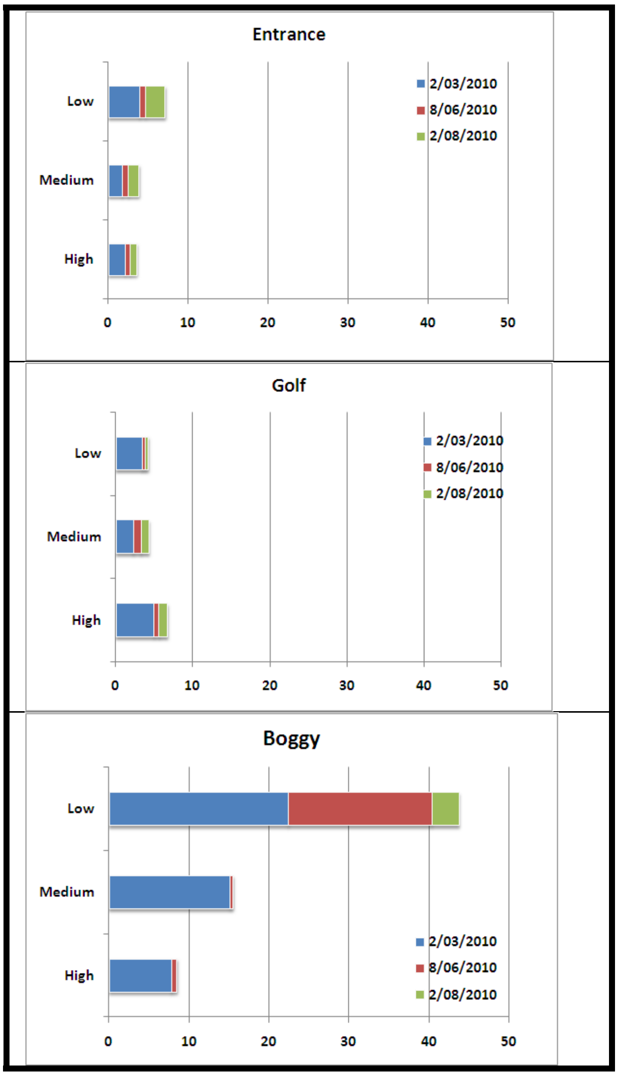


Figure 16: Percentage mortality of oysters per stocking density level and for three location in Merimbula Lake (Entrance: oceanic site; Golf: mid-lake site; Boggy: back lake site)

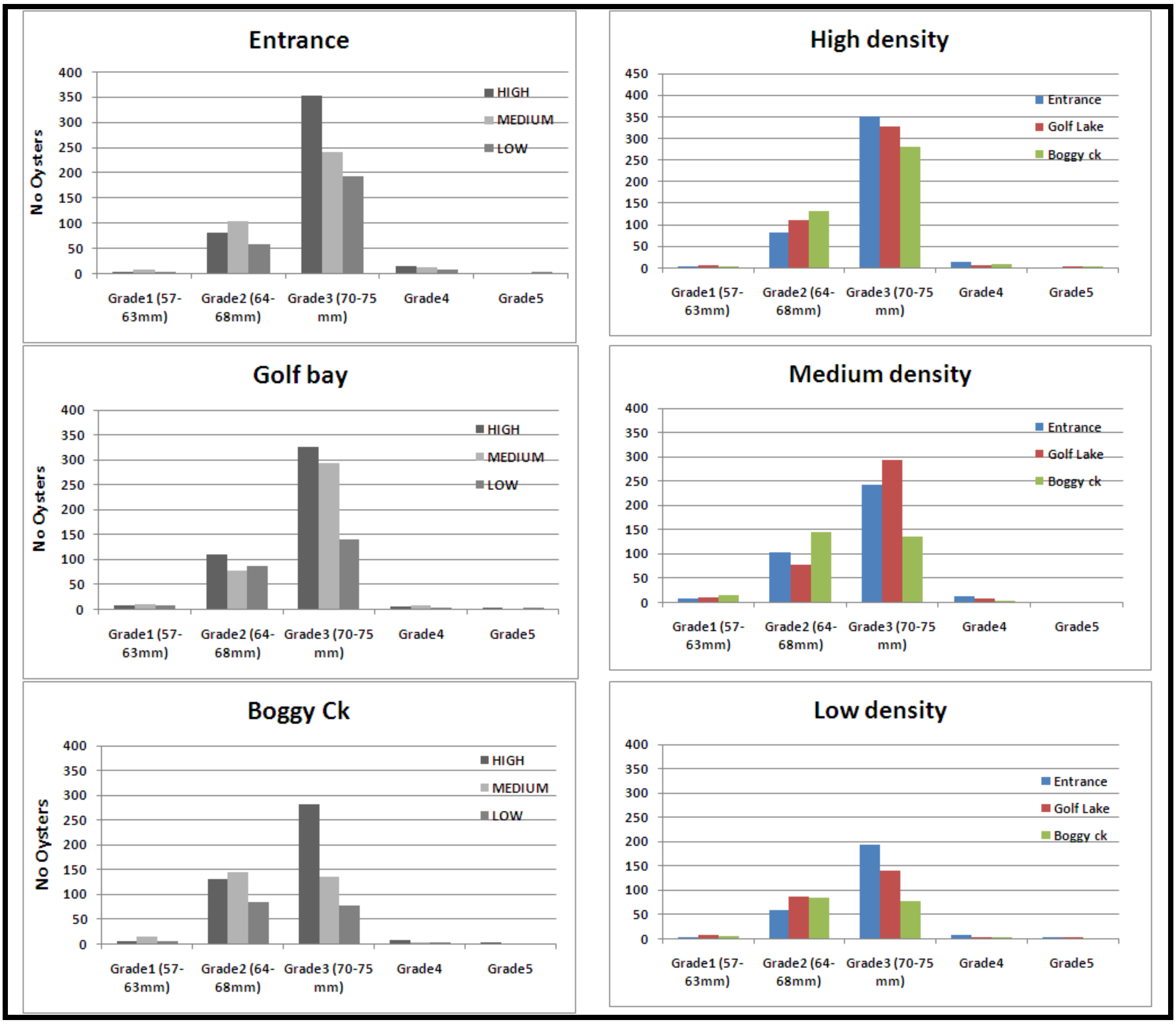


Figure 17: Number of oysters per size grade for the three stocking density levels at each location

Table 8: Condition Index scores for 15 oysters from each density level and location. Scores correspond to oysters in Figure 18

	High	(Label)		**Medium**	(Label)		**Low**	(Label)	
Entrance									
	0	3	1	2	3	2	3	2	3
	0	1	1	1	3	0	3	0	2
	0	1	2	1	3	0	0	1	2
	0	3	1	3	2	1	1	0	3
	3	2	2	1	3	2		0	1
									2
	High			**Medium**			**Low**		
Golf									
	2	1	2	1	3	1	1	3	1
	2	0	3	0	0	2	2	3	3
	2	1	2	0	0	1	1	3	3
	1	2	1	1	1	1	1	3	2
	2	2	0	0	1		3	1	
				1				3	
Boggy	**High**			**Medium**			**Low**		
	1	1	1	1	0	1	0	3	1
	1	2	1	2	1	1	1	1	2
	1	1	0	1	1	1	1	0	1
	1	1	0	0	1	1	0	1	1
	1	2		0	1	1	2	0	
	1						2		

Figure 18: Oysters opened for visual assessment of the condition index for the different density levels and at the three locations. Scores (Table 8) were given as per the Seafood CRC Sydney Rock Oyster Grading System (see appendix)

Discussion – *can automated oyster graders be used as experimental tools?*

Three of the most frequently asked questions by oyster growers were tested in this project through simple experimental design and the use of an automated oyster grader. The main aim was to test if output files from oyster graders could assist growers in quantifying oyster performance so that they can tailor their management approach based on this performance. This project was not set up to provide a definitive answer to these questions. Instead it represents a feasibility study and provides a suggested methodology that growers can follow in the future, using scaled up experiments, to help address these questions.

Until now, oyster growth experiments have been undertaken by research teams in which oysters were weighed or measured manually. This approach has limitations, specifically in regards to the sample size of oysters to be used in the experiments. In order to have a representative sample size, large numbers of oysters are required to capture the natural variability inherent in the oyster population. The larger the number of oysters the more time is required to weigh or measure them. By using automated oyster graders large number of oysters can be weighed/measured/graded relatively quickly. For example, it would take about 2 full days to weigh and measure (3-dimensions) 1500 oysters in addition putting the data into electronic form. An oyster grader will measure (2 dimensions) the same amount of oysters in less than 10min including the storage of the data on an electronic file. The approach used here also had some inherent errors. Based on the experiment results, oyster graders showed errors in 0.3-8.5% of the total oysters per batch allocating them accurately to a specific size grade. Nevertheless, this may still be more accurate than manual measurement. Some of the grader error could have been reduced by grading the oysters at slower speeds and/or by grading the oysters twice at the outset of the experiment (possibly with a recover period in between) so as to get a more precise initial grade of oysters.

In this project ShellQuip oyster graders were used, however any other automated grader, that measures weight or size, could be used as an experimental tool as long as data is recorded in an easy readable format that are easy to be subsequently analysed by the oyster farmers.

Overall this project has found that the oyster grader's batchfiles are collecting enough information to help the grower make management decisions. However, if the batchfiles could also store individual oyster statistics data not summary information, it could offer more specific insight information potentially exploring other data analysis that could have answered other questions. This extra information would have made the analysis much easier and more useful. Overall oyster graders offer an unprecedented opportunity to easily monitor oyster characteristics throughout most of the cultivation life cycle and from different intra- and inter-estuary locations. By setting up a practical monitoring protocol to be used with the grading machines, much more consistent, accurate and useful data can be collected, with little extra effort. This could assist growers and aquaculture managers to set production indices for oyster leases allowing for the monitoring and comparison of oyster performance and estuarine production through time. Gathering this data will provide much more accurate information than any experimental study on oyster performance in addition to allowing characterization of lease areas. This information will benefit the oyster industry so that they can direct effort, investment and get a higher return from productive oyster leases.

An increasing number of oyster graders are being purchased this year in NSW. This investment has been a major step forward in innovation in the industry and therefore, changes in the farming procedure need to be tailored to incorporate the use of this machine. At present, only a proportion of the industry is using these machines. However, if growers can see the utility of implementing these machines to their full potential, a greater uptake is likely. This can significantly improve their productivity and the productivity of the NSW industry as a whole contributing towards the sustainable production level of 120,000 bags of premium oysters by 2013 set by the NSW Oyster Industry Sustainable Aquaculture Strategy.

Further investigations

Oyster grader data could be linked to other data sources collected in oyster growing areas which can assist in the understanding of estuarine processes, in the identification of biological indicators in coastal water monitoring or assisting in the development of explanatory models of the oyster-farming ecosystem. It can also contribute to mapping oyster productivity across oyster leases within an estuary or lake. This could also be expanded to wider spatial scales covering oyster producing areas along the NSW coastline.

Oyster graders could also assist in the quantification of oyster performance across different species of oysters. For instance in those estuaries where both Sydney Rock Oysters and Triploid Pacific oysters are cultivated, growth performance could be easily recorded and compared assisting in the management of both species.

Industry outcomes and benefits

This project aimed to develop a system that will allow oyster growers to quantify oyster productivity and oyster lease performance and to be able to rank them according to production levels. This report shows how the information contained in the batchfiles generated by the oyster grader could assist growers to answer questions on production rates and performance of cultivation methods. It is worth noting that the information generated by the grader could in principal be linked to management software to assist in the data feed in relation to stock control. If oyster growers were to integrate the output from these machines into their day-to-day operational management, they would be able to record accurate data that could be link to environmental, weather or catchment information supporting some of the results recorded through the grader. One of the features that the oyster growers involved in the project found most beneficial was the option of recording accurate mortality data.

The grader output could also assist growers and researchers in setting base line performance levels for the different growing areas within an estuary against which to measure environmental change (including effects of catchment development or impacts of global warming). Of primary importance could be the development of a standardized set of performance indices as a reference for spatial and temporal (yearly) variations in oyster performance.

A long term goal is to set up a set of easily implemented protocols for continuous monitoring of oyster performance. While this would obviously entail a small amount of extra bookkeeping at the time of grading, the goal would be to integrate this into standard procedures so that a continuous long term monitoring program could be established across a wide group of sites. The approach used in this project will hopefully provide useful information in setting up such a monitoring framework.

Knowledge transfer and extension work

This project has had the ongoing support of the NSW oyster farmers, especially those involved directly in the project. While the project was being undertaken, I took the opportunity of informing many other oyster growers about the project aims and its progress. Many farmers expressed interest in receiving a copy of the final report. The growers involved in the project played an integral part in forming practical, non intrusive frameworks for the collection of data. Oyster farmers are generally a very proactive group who are keen to become involved in scientific projects that relate to their industry and to the environment in which they work. Consequently, by sharing this report amongst them, I hope that they will be encouraged to use the oyster grader towards collecting production data, accurately quantifying mortality rates and learning more about the variability of the natural environment around their lease areas. These factors can make a real difference in their efforts to improve their business and therefore, assist with the industry's long-term sustainability.

Preliminary results were presented at one of the most popular national aquaculture industry conferences held in Hobart in mid May 2010 (see appendix for copy of poster presentation). I also took the opportunity of gathering feedback on the project approach and results at the time from members of the Tasmanian oyster industry whom I visited after attending the conference. As per NSW, very few growers from Tasmania actually looked at the information generated in the batchfiles. A number of options were presented through the year to inform NSW oyster growers about this project. This included the 2010 NSW Coastal Conference that was held in Batemans Bay. A number of coastal councils and coastal catchment group also expressed their interest in the project.

On completion of this project, copies of the final report will be widely spread to at least one oyster grower from each growing estuary in NSW. Project outcomes will be announced at the upcoming newsletters of the NSW Farmers Association- Oyster branch, NSW Industry & Investment and ShellQuip. Other groups and associations that would receive a copy of this report include: Oyster Consortium; Oceanwatch Australia, Seafood CRC, SA/TAS/QLD Oyster Growers Associations; NSW coastal councils; Coastal Catchment Management Authorities

In addition, part of the results from this project will be incorporated in a peered reviewed publication.

Acknowledgements

I would like to thank DAFF and FRDC for selecting and sponsoring my project for the 2009 Science and Innovation Awards for Young People in Agriculture, Fisheries and Forestry. This project has given me the opportunity of pursuing my engagement with the NSW oyster industry and testing the project's idea that rose towards the end of my PhD research project when I saw oyster graders in use for the first time. The project would not have been possible without the full commitment and interest of Mc Ash Oysters (Clyde River), Wheeler Oysters (Merimbula Lake) and other members of the industry. Both oyster enterprises have been great project co-partners who are keen to continue exploring the oyster grader outputs towards improving their business management. I would also like to thank Wayne O'Connor and Michael Dove (NSW Industry & Investment- Aquaculture branch) for initial brain storming and their support on the project. Also thanks to SED Shellfish Equipment Pty Ltd for their technical support (training, software) and for their interest in the project.

Appendix

'TWO BIRDS WITH ONE STONE'— USING FARM EQUIPMENT FOR LONG-TERM MONITORING OF OYSTER PERFORMANCE

Australian Government Fisheries Research and Development Corporation

Australian Government Department of Agriculture, Fisheries and Forestry

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This project is a FRDC sponsored award under the 2009 Science and Innovation Awards for Young People in Agriculture, Fisheries and Forestry. The award aims to develop innovative scientific ideas that will provide long term benefits to Australia's rural industries. Preliminary results are presented here.

Introduction: Automated oyster graders = a farm tool, an experimental tool or both?

Over the last decade there has been an important turning point in the Sydney rock oyster production in NSW. After a three-decade decline, production has now stabilised. This is a result of the industry taking progressive action towards new management systems and implementing new technologies. As an example, some NSW oyster growers have recently invested in highly sophisticated oyster grading machines that clean, count and sort large number of oysters quickly and efficiently. Such graders record the characteristics of every oyster sorted, providing an unprecedented opportunity to collect high-quality growth and growing-area performance data. This project will use these graders to assess oyster performance between cultivating methods and across growing areas, providing new management data towards improving the industries' productivity and environmental sustainability.

Aim: Application

The project aims to develop a system that allows oyster growers to quantify oyster performance and mortalities under different scenarios. Results will assist growers to set baseline performance levels at the different growing areas against which future changes related to a changing environment can be assessed.

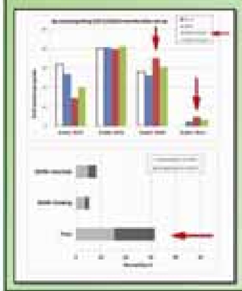
Methods: how?

Shellquip oyster graders were used at two NSW oyster growing areas: Clyde River (off Batemans Bay) and Merimbula Lake.
Batch files from the graders provided oyster data for analysis.
Different experimental scenarios were used to answer three questions set by the oyster growers:

Experiment 1 'cultivation methods'

'Which of the cultivation methods produce better/larger oysters?'

1 lease: Snapper Point, Clyde River, NSW
3 cultivation methods: intertidal trays, floating SEAPA baskets, fixed-intertidal SEAPA baskets
Density: 1 tray equivalent to 4x SEAPA baskets
5,000 oysters/ method
Oysters graded every 2 months
Start: Nov-09; End: Sept-10

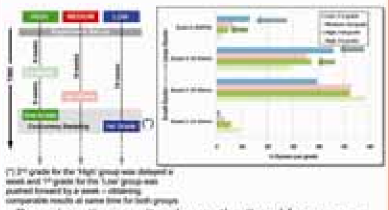


From 1st grading- SEAPA floating units gave better oyster growth, with worst results from trays. Mortalities were also largest in trays- although approximately half of the mortalities were due to trays splitting when handling at lease

Experiment 2 'Frequency study'

'How often should I grade my stock?'

1 lease: Double Bay, Clyde River, NSW
Cultivation methods: Floating SEAPA baskets
Density: 100 oysters/ SEAPA basket
Grading frequency of groups: 6, 10 & 14 weeks
5,000 oysters / frequency group
Start: Jan-10; End: Sept-10

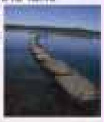


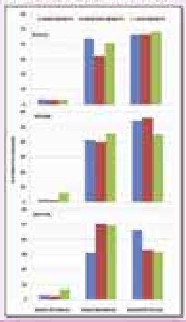
Based on the results above, the 'Low' frequency (14 wks) group showed the best oyster growth, especially when compared with the 'High' frequency group. All groups have suffered similar mortality (11.2%±1.6). Further grading activities will test the robustness of these results.

Experiment 3 'Stocking densities'

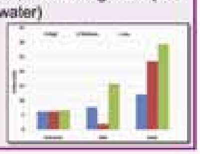
'What are the optimal stocking densities for best oyster performance?'

Where: Merimbula Lake
3 leases: at the entrance, mid and back of the lake
Cultivation methods: Floating pillows
Densities: 60; 80 & 100 oysters/ cultivation
5 replicates
Oysters graded every 3 months.
Start: Dec-09; End: Sept-10





Preliminary results indicate that even at the 'High' density, oyster performance is not being compromised. However, major oyster losses at the back of the lake during January 2010 heat wave, while being dried (out of water)



Conclusions & limitations

- Results presented here are part of an on-going project to be completed by October 2010. This project has a duration of one year limiting its scope.
- Experiments addressed growers needs and were set-up in such a way as to integrate with their day-to-day husbandry practices
- Currently oyster graders are mainly used for final grading prior to sending to market. By incorporating the use of the grader throughout the growing period, oysters can be kept in similar size-groups minimising inter-oyster competition to benefit growth performance
- Mortality data indicates that oyster growers appear to be losing more oysters than expected
- Proof of concept: by using the information generated by the oyster graders, growers can easily monitor growth rates/ performance, mortality rates and productivity to answer different management questions
- Future work should be expanded to cover additional sites and allow for longer time series.

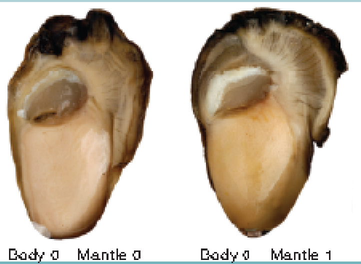
Acknowlegments

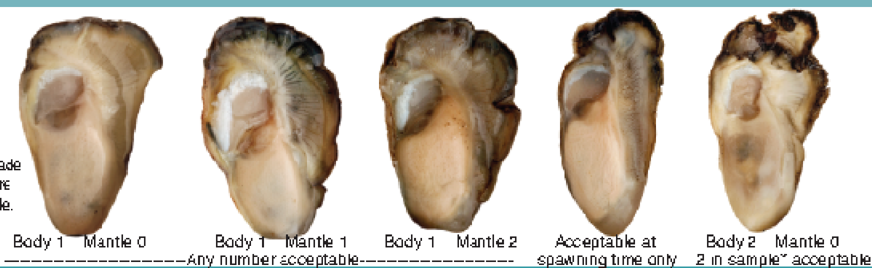
I would like to thank Mc Ash Oysters and Wheelers Oysters, in addition to Wayne O'Connor and Mike Dove, and the Shellquip staff for their time, assistance and advice

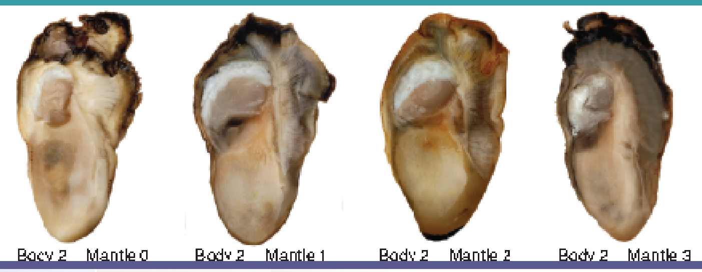
AUSTRALIAN SEAFOOD COOPERATIVE RESEARCH CENTRE

SYDNEY ROCK OYSTER GRADING SYSTEM

GRADE (minimum)	BODY & MANTLE CONDITION (this grading system applies to all size ranges)	SHELL FULLNESS (minimum)
A SUPREME Very good condition oyster with full fat cover across the body and mantle, oyster fills shell and may rise above shell perimeter, consistent across shipment	No B or C Grade oysters are acceptable.	**0**
B PREMIUM Noticeably plump, the condition cover extends across the oyster and preferably extending out into the mantle. Some stomach may be visible, limited variability across shipment	Any A Grade oysters are acceptable.	**1**
C THRIFTY Generally a poorer condition oyster with less coverage over the body and mantle resulting in greater visibility of the stomach, poor shell fullness and greater variability in shipment	Any A Grade oysters are acceptable. Any B Grade oysters are acceptable.	**2**







A Grade: 0 only; 1 not acceptable; 2 not acceptable

B Grade: 0 acceptable; 1 acceptable; 2 max 2 in sample* acceptable

C Grade: 0 acceptable; 1 acceptable; 2 max 4 in sample* acceptable

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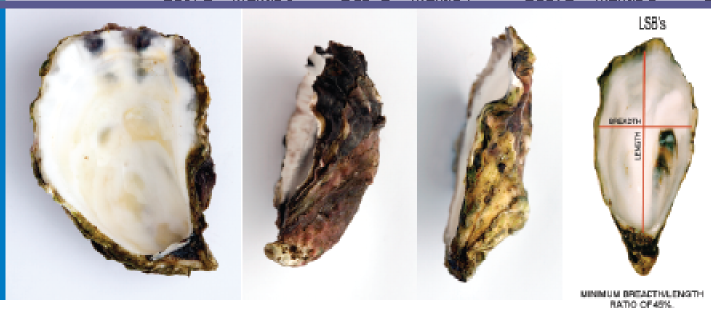
SIZE SPECIFICATIONS
(top shell length)

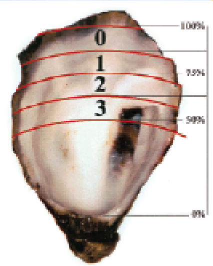
- LARGE 90 - 100mm
- STANDARD 75 - 90mm
- PLATE 65 - 75mm
- BISTRO 55 - 65mm
- COCKTAIL 45 - 55mm

SHELL SHAPE
(preferred)



Shell shape of stick-grown Sydney Rock Oysters will vary considerably depending on the amount of time they have been left to grow on the stick. This grading system acknowledges the shape variation that can exist in Sydney rock oysters grown on sticks for most of their life.

The size grading specification is to be applied where practicable during grading operations on the basis of best endeavours to obtain as uniform product as possible. The product must be represented accordingly. Body and mantle condition can be assessed using the above criteria.



* sample size 12 oysters