Oyster Over-catch: Cold Shock Treatment

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NON-TECHNICAL SUMMARY

2010/734 Oyster Over-catch: Hypersaline Cold Shock Treatment

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PROJECT OBJECTIVES:

1) Increased Australian oyster production and value

2) Enhanced oyster farming efficiencies and effectiveness

3) Make available relevant cold tolerance parameters for oyster, key fouling and pest species to the industry for uptake

PLANNED OUTPUTS:

1) Provide proof of concept of cold shock treatment for over-catch control in a commercial environment

2) Establish operating guidelines for the application of cold shock in treating Sydney Rock and Pacific Oyster over-catch on crops of Sydney Rock Oysters, and diploid and triploid Pacific Oysters

3) Confirm the effectiveness of cold shock in treating a range of additional pest species (barnacles, hairy mussels, flatworms etc)

4) Industry access to the treatment protocols, range of impacts and access to the prototype equipment in operation.

OUTCOMES ACHIEVED

The recruitment of fouling or pest organisms to cultured oysters and growing infrastructure imposes a major financial impost for oyster culture throughout Australia and serves as a particular deterrent to industry expansion in certain regions. Oyster farmers have a range of management options such as mechanical cleaning, drying or cooking to control fouling, but each option typically has its limitations. Cold-shock, through immersion in chilled (-12 to -16°C) hypersaline (180 - 200 g l^{-1} NaCl) baths, is a comparatively new technique that has demonstrated the potential to effectively control a range of pest species without adverse effect on the host oysters. Most notably, hypersaline cold-shock can be used to control subsequent natural oyster settlement known as “over-catch”.

Under the auspices of this program a commercial scale, hypersaline, cold-shock bath, dubbed the “Super Salty Slush Puppy” was constructed to provide proof of concept of cold shock treatment for over-catch control. The cold shock bath was deployed to Port Stephens NSW where it was successfully used for both experimental and commercial scale biofouling treatment (Objective 1).

In experimental scale laboratory trials, the cold tolerances of various size classes of both Sydney Rock Oysters (*Saccostrea glomerata*), Pacific Oysters (*Crassostrea gigas*) were assessed and tolerance estimates were determined (Objective 2). Overall cold shock tolerance in both species was size-dependent with smaller individuals succumbing faster. Comparatively, *S. glomerata* of up to commercial size were less tolerant of hypersaline cold-shock than *C. gigas*. In field trials, the capacity to exploit these differences to control both *S. glomerata* and *C. gigas* over-catch was demonstrated. Using the commercial hypersaline cold-shock bath, immersion for a period of 45 or 75 sec were both shown to be effective in controlling *S. glomerata* (mean size 14 mm) and *C. gigas* (mean size 22 mm) over-catch on commercial crops of *C. gigas* (mean size 65 mm). Following 45 sec immersion, >90% of fouling oysters were destroyed, while a total exposure time of 75 sec saw all fouling oysters killed. In both cases, no significant increase in commercial stock mortality was observed following treatment and no impact on oyster physical or reproductive condition was observed.

In laboratory trials, the effectiveness of cold shock in treating a range of additional pest species was confirmed (Objective 3). Cold-shock was found to be particularly destructive to “soft-bodied” pests such as flat worms (*Imogine mcgrathi*) and smaller organisms such as barnacles (*Balanus trigonus, Amphibalanus variegatus*) up to 1 cm in diameter. Each of these species died following immersion periods of as short as 15 sec. Cold-shock tolerance of hairy mussels (*Trichomya hirsutus*), like oysters, was found to be size dependent, although these mussels were found to be considerably more resistant than similar sized oysters. However, as observed with oyster over-catch, mussels control can be achieved with hypersaline cold-shock and simply requires care in ensuring a significant size differential between the size of fouling organism and the host oyster.

In the conduct of these trials several additional observations of relevance were made. Both CaCl or NaCl were as the basis for hypersaline baths and were found to be similarly effective. Ultimately, NaCl was used for the field trials because of significantly reduced cost. Comparisons of cold-tolerance of small triploid and diploid *C. gigas* found no significant differences between the two oyster types. Finally, some evidence of the capacity of hypersaline cold-shock to treat mudworm was also observed although further experimentation would be required.

Reflecting the variables inherent in treatment, the variables involved in the cost of operation are similarly complex. The primary beneficiary of the treatment is oysters approaching or having reached sale size, i.e. when the oyster has considerable time and costs invested in it. Based upon simple assumptions, the operating cost of treatment is $1,215 per 100,000 of 60 to 80 mm [top shell measurement] oysters, or, put another way, a cost of $4,200 for 345,600 sale size oysters with a $1m sale value. Even when capital costs are included, and assuming that other mitigation measures see the equipment used only once every four years, the cost per dozen for treatment works out at 3.4 cents per dozen.

As is reflected in the below list of outputs produced, there has been successful and wide dissemination of information about the Project and its achievements. In addition, the prototype in operation at Port Stephens has had two field days and has been, and will continue to be, made available for inspection by appointment for those unable to attend the field days.

LIST OF OUTPUTS PRODUCED

In addition to the tangible output of a prototype commercial scale unit to administer hypersaline cold shocks (the slush puppy), the following communication outputs were generated by the project.

Super Salty Slush Puppy Newsletter (see Appendices)

Cox, B., Johnston, K., Dove, M., O'Connor, W., (2011) Cold shock control of biofouling. International Oyster Symposium 4. September 15-18 2011, Hobart, Tasmania, Australia.

O'Sullivan, D., (2011) Treating oyster over-catch and other pests with 'slush puppy'. Austasia Aquaculture Volume 25 No 2 – Winter 2011 pp 28 – 33

Paparo, J., (2011) WA Fish eNews. 28 January 2011

O'Connor, W., Johnston, K., Dove, M., Cox, B., (2012) Cold shock to control biofouling on cultured Oysters. Australasian Aquaculture 2012. March 1-4 2012, Melbourne, Victoria, Australia.

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1. INTRODUCTION

1.1 Need

The Australian oyster industry has always encountered challenges from "over-catch" (fouling) and pest species from a myriad of sources: oysters, barnacles, sea squirts, flatworms, mudworm etc. While these pests are regionally specific, the issue is common across all growing areas and in all cases is a major financial burden. This financial burden in multifaceted and thus difficult to quantify, but includes losses from discarding over-caught product and that which is mudworm and even flatworm "infected", retarded performance (lesser performance due to disrupted access to food supply or damage caused by heat treatments currently used to treat over-catch), labour costs (re-handling of product and current treatment and amelioration methods), and market returns (not limited just to the directly impacted product). In South Australia it is estimated that 50% of Pacific Oysters introduced to leases as spat are lost through deaths and kills of oysters. This loss is estimated at 30% in Tasmania. These losses cannot be solely attributed to over-catch and other fouling, and pests, but they are without doubt a significant contributor. The impact in South Australia and Tasmania is thought to be substantially less than what happens in NSW (unfortunately there are no reliable measures of spat and juvenile oyster introductions for NSW to determine whether the anecdotal advice of only a 35% yield is accurate).

Farming practices, such as site selection, growing methods and pest removal treatments, are used to limit the impact of over-catch and are, to varying degrees, effective. However, these practices are costly, can cause stock losses or be detrimental to the growing performance of the oysters, can pose OH&S risks ("Cooking" = hot water dipping) and none are known to be holistic to the range of pests that need to be treated.

One of the larger oyster farming operations in Australia – Southern Cross Marine Culture – embarked upon a project to develop a more effective over-catch/pest treatment methodology based on hypersaline cold shock that has wider application for the oyster industry and perhaps for other shellfish.

Neither the research provider (Port Stephens Fisheries Institute) nor the principal investigator is aware of the use of this technology elsewhere to control fouling.

Through the Oyster Consortium/SfCRC, Marine Culture wished, and continues to wish, to contribute its existing IP and continued development of the hypersaline cold shock methodology.

Marine Culture's willingness to "share" the knowledge and IP it has already developed is due to the opportunity to draw on wider industry participation which brings with it the opportunity to obtain the scientific proof and support for the treatment method being developed; and ultimately, a wider acceptance, adoption and lower cost of production and maintenance. Without impugning Marine Culture's intentions there's always the situation that if their neighbours employ the same mitigation measures then the chances of Marine Culture avoiding the mudworm infestation etc. are reduced. In addition, with Australia being a net importer of oysters and experiencing aggressive pricing challenges in its export markets from emerging producers like Chile and established growers like New Zealand, Australia needs to do better in respect of its cost of production if it is to have an industry into the future.

As the proponents, Marine Culture would not proceed with the development of their leases in Port Stephens (48 ha) until it has a viable and safe method for the treatment of over-catch[i]. In acquiring those lease sites Marine Culture had submitted a detailed business plan which had been reviewed and accepted by NSW DPI and which showed how Marine Culture would ultimately be farming an output of 750,000 dozen Pacific Oysters off the area. This of itself is significant as it would increase the reported total oyster production from NSW by 12.5%, or a GVP of almost $5m. Additionally, Marine Culture believes that the application of the treatment method to its South Australian operations for the treatment of barnacle over-catch at Coffin Bay as well as the treatment of mudworm and flatworm throughout the SA operations will facilitate significant improvements in profitability of its operations there. As with over-caught oysters, mudworm and flatworm affected oysters are typically discarded as the market for meats verses the labour costs in recovering those meats is not commercially viable.

Undoubtedly the greatest initial benefit will be for NSW aquaculturists as over-caught oysters cause significant labour costs and in many instances, because of those costs, the over-caught oysters are simply thrown away; those that are “recovered” are typically chipped away to recover the host and sometimes some of the over-catch (resulting in very unattractive product) or opened (host and over-catch) and the meats recovered for the low value bottle market. Benefits to NSW farmers will also arise from the fact that cold treatment will effectively treat flatworm and other parasites (possibly mudworm) and other shell fouling organism other than other oysters. This broad spectrum control of fouling will additionally benefit oyster producers in Tasmania, South Australia, and Queensland where significant labour costs and product loss from these forms of fouling and pests.

Reliable and accurate costing of oyster growth, performance and output degradation arising from over-catch and parasites does not exist, nor is there empirical data on market impact. However, the experiences of the Consortium members and knowledge of just how detrimental the impacts are led the Consortium members to unanimous support for taking the cold shock treatment to the next stage.

Influential in achieving the unanimous support for this project from members of the Oyster Consortium was the universal concern over OH&S issues and the costs of current methods of treating over-catch. These involve techniques such as extended periods of emersion, the application of salt or dipping in near boiling water, with the latter being the most common and also the most prone to problems and a source of OH&S concerns, especially so when done at sea. If the oyster growing unit is plunged into boiling water for less than the time required then the oysters will require retreatment. If the oysters are removed from the heat too slowly and you've cooked the mantle (i.e. the oysters food ingestion point) or killed it altogether, not to mention the risks of having large quantities of near boiling water on a crewed oyster barge!.

An alternative, shown to have potential, was the cold shock treatment by immersion in saturated saline solution which, due to the amount of salt, can be as low as -30° C. Marine culture had commissioned initial investigative research by NSW I&I (Heasman, 2005) in which experimental, small scale cold shock trails "*resulted in the death of advanced rock oyster over-catch in as little as 5 seconds and complete mortality after exposure periods of 60 seconds and above. By contrast, no deaths nor discernible negative effects on the health and flesh condition of host Pacific Oysters were detected for cold shock durations of up to 2 minutes*". This work however needed to be expanded to include a more comprehensive range of oysters sizes and types, and fouling organisms. Further, and critically, the method needed to be assessed on a large scale under commercial operating environments to demonstrate practicality and cost effectiveness.

A commercial scale hypersaline cold-shock unit was constructed, factory tested in Tasmania and relocated to Port Stephens where preliminary commissioning and shed based trials were undertaken using oysters from Port Stephens that had been left out over spring and summer to be over-caught. The host oysters were from areas within existing leases and of a variety of sizes and included both Sydney Rock Oysters and Pacific Oysters over-caught with both species. These factory and shed trials confirmed the efficacy and application of the Heasman research and shown that the machine can operate at a commercially viable speed (SEAPA unit in/output each 2½ seconds ([being the efficient clip on and off speed for SEAPA growing modules onto inter-tidal long lines); but those trials had also identified the need for a much more exhaustive study into the range of host sizes and ages, and the type and sizes of the over-catch, against varied salt concentrates in the bath and the temperature of the bath. In addition, and of equal importance, was the need to volume trial the operations for unit throughput and latent temperature maintenance.

Moreover, the factory and shed trials had not addressed the treatment of forms of over-catch other than other oysters, oyster pests and the wider application to other shellfish.

The Seafood CRC Project sought to complete the factory and site trials.

1.2 Objectives

1. Increased Australian oyster production and value

2. Enhanced oyster farming efficiencies and cost effectiveness

3. Make available relevant cold tolerance parameters for oyster, key fouling and pest species to the industry for uptake

2. COLD-SHOCK AS A MEANS TO CONTROL BIOFOULING AND PEST SPECIES ON CULTIVATED OYSTERS

2.1 Introduction

The Australian oyster industry has always encountered challenges from a myriad of "over-catch" (fouling) and pest species including oysters, barnacles, mussels and sea squirts, flatworms, mudworm etc. While these pests are often regionally and temporally specific, the issue is common across all growing areas and is a major financial burden.

Oyster farming in Australia has evolved and the majority of production now comes from intertidal leases, in part because it permits emersion to be used as means to limit the impact of fouling and pest species. However, intertidal exposure, while useful, has not been sufficient to overcome fouling in all areas. Accordingly a range of additional treatment methods have been developed. These methods include extended periods of emersion on rafts or onshore ("drying"), mechanical removal ("culling") or immersion in hot water ("cooking", 80°C for approximately 3 sec). The latter, cooking, has been found to be very effective in destroying oyster over-catch (natural settlement of wild oysters), particularly where the over-catch are emersion tolerant Sydney Rock Oysters, *Saccostrea glomerata*, on less emersion tolerant Pacific Oysters, *Crassostrea gigas*. In this case, simple emersion or drying would often see a large host *C. gigas* die well before the smaller *S. glomerata* over-catch. The effectiveness of drying is also very dependent on prevailing climatic conditions and does not occur uniformly in a stack of oyster trays being treated. Cooking is useful in controlling this over-catch; however, the margin for error between destroying fouling and killing the host is only a few seconds and cooking related mortality is common. It is also an important consideration for oyster growers that the method selected treats the host and the equipment that the oyster is farmed in.

An alternative to existing fouling control methods shown to have potential is cold-shock treatment through immersion in chilled, hypersaline (brine) solutions. In initial laboratory trials Heasman (2005, unpublished report) confirmed the potential of cold-shock (-16°C) to treat small *S. glomerata* over-catch on large *C. gigas*. These trials also showed that where there was a large size differential between host and over-caught oysters the margin for error between fouling destruction and loss of the host oyster was of the order of a minute, which considerably reduced the risks in using this method of treatment compared to others .

To further assess the potential for industry adoption of hypersaline cold-shock as a treatment for biofouling, trials were undertaken to more comprehensively assess hypersaline cold-shock tolerance across a broader size range of oysters and to assess its impact on other common fouling organisms.

2.2 Materials and Methods

All oysters and associated fouling organisms used during this study were collected from the vicinity of commercial oyster leases in Port Stephens, NSW, Australia. When not used immediately for evaluations, organisms were held in seawater at ambient temperature (20-23°C) and salinity (33-35 ppt) in the Mollusc Hatchery at the Port Stephens Fisheries Institute until required.

In the laboratory, hypersaline cold-shock baths were created by chilling 4 L volumes of hypersaline solution (200 g L^{-1}) in a minus 80°C chest freezer until the desired temperature (-16°C) had been reached. Hypersaline solutions were prepared by adding commercial pool salt (NaCl, Cheetham Salt, Price, SA) to seawater. Test organisms were then contained in 1 cm mesh plastic onion bags and immersed in independent replicate baths for the desired period. The temperatures of the baths were monitored to ensure they remained at -16 ± 1°C for the duration of each trial. Following immersion, each group of organisms was immediately placed in a seawater bath at 22-24°C for approximately 1 h. With the exception of flatworms, each replicate group was then deployed into the estuary in Port Stephens and post treatment survival was assessed after 24 h and again after 7 days.

Field based trails were conducted in a commercial scale hypersaline cold-shock bath comprising an insulated tank with a variable speed conveyor belt passing from one end to the other (Fig. 1). The bath was designed to operate using Seapa baskets (Seapa Pty Ltd Edwardston, SA) or similar sized oyster containers and modulation of the conveyor belt speed was used to control immersion times.

Figure 1. Cold-shock bath

Laboratory Trials

The hypersaline cold-shock immersion tolerance of six common fouling species was evaluated: oysters *S. glomerata* and *C. gigas,* hairy mussels (*Trichomya hirsutus*), barnacles (*Balanus trigonus* and *Amphibalanus variegatus*) and flatworms (*Imogine mcgrathi*). The respective size classes of each species tested and the immersion times are given in Table 1. In each case, 3 replicate groups of organisms were tested at each size class/immersion time combination. The number of organisms in each replicate group is given in Table 1. For each species, control groups of untreated individuals were maintained under identical conditions (without hypersaline cold-shock) to ensure general experimental conditions were not a cause of mortality.

Trials involving oysters and mussels used single unattached specimens. The barnacles however remained attached to oyster shells on which they had originally settled. A mixture *B. trigonus* and *A. variegatus* were present with the former being slightly more abundant (approx. 60%). Flatworms were collected from commercial oyster trays. Only a limited range of immersion times were tested for flatworms as previous research had indicated that *I. mcgrathi* was intolerant of hypersaline solutions alone (O'Connor and Newman, 2001).

Table 1. Size classes and immersion times tested for five fouling species affecting commercial oyster production in NSW, Australia

Species	**N***	**Size classes (mm)**	**Immersion times (secs)**
Sydney Rock Oysters (*Saccostrea glomerata*)	10	16-25, 26-35, 36-45, 46-55, 56-65	5, 15, 30, 60, 120, 300, 600
Pacific Oysters (*Crassostrea gigas*)	10	7-15, 14-29, 20-48,	5, 15, 30, 60, 120, 300, 600
Hairy mussels (*Trichomya hirsutus*)	4	6-29, 32-50	5, 15, 30, 60, 120, 300, 600
Barnacles (*Balanus trigonus, Amphibalanus variegatus*)	>10	2-12	5, 15, 30, 60, 120,
Flatworms (*Imogine mcgrathi*)	3	25-35	5, 15

**N = the number of individuals in each of three replicates used to evaluate each treatment size and immersion time combination.*

Field trials

Two trials were conducted in the field using a commercial scale hypersaline cold-shock bath. In both instances, the bath was chilled to -12°C and the salinity of the bath was adjusted to 180 ppt using commercially available pool salt.

Comparison trials

To compare the tolerance data from the laboratory and field based trials, two comparisons, similar to those done in the laboratory trials were repeated in the field. Specifically, groups of 10 triploid *C. gigas* (9.6 ± 0.8 mm) were immersed for 5, 15, 30 or 60 secs and groups of 10 *T. hirsutus* (17.3 ± 1.8 mm) were immersed for 15, 30, 60 or 120 secs. Following treatment, each replicate was immersed in seawater for 30 mins before being transferred to Port Stephens. Mortality was assessed after 24 h and 7 days.

Over-catch trials

30 baskets of over-caught *C. gigas* were collected from stock being commercially cultivated on an intertidal lease in Port Stephens. The mean size of the stock was (64.8 ± 6.1mm DVM and 48.8 ± 12.7 g) and it had both *C. gigas* (21.9 ± 4.3mm) and *S. glomerata* (13.8± 4.3mm) over-catch attached (barnacles, flatworms or mussels were not present). The numbers of adherent over-caught oysters on each cultivated *C. gigas* varied from 0-11, with an average of 1.47 over-catch per oyster.

a) 

b) 

Figure 2. Oysters over-caught with a) oyster over-catch (C. gigas, S. glomerata) and b) barnacles (Balanus trigonus, Amphibalanus variegatus)

Thirty cages of approximately 100 oysters were divided at random across three treatments. One group of 10 cages was immersed in the bath for 45 secs, a second group was immersed for 45 seconds followed by a second emersion of 30 secs, 5 mins later. A group of 10 control baskets remained untreated. Between treatments the hypersaline cold-shocked oysters remained out of water. Following treatment all baskets were returned to the same lease from which they were collected for monitoring after 24 h and 7 days.

A random sample of 20 oysters was collected (and sacrificed) from the baskets before the treatments commenced and from each treatment group 7 days after the treatment occurred. The condition of these oysters was assessed by determining their wet condition index (CI) according to the formula:

CI = soft tissue weight (g) x 1000/internal shell cavity capacity (g)
Where: Internal shell cavity capacity = whole weight (g) –shell weight (g) (Lawrence and Scott, 1982)

Each oyster was also assigned a macroscopic score reflecting the degree of gonad development on a scale of 1 to 5, where 1 indicates no evidence of reproductive development (spent or quiescent) and five was indicative of peak reproductive condition (fully veined gonad without evidence of spawning).

Statistical analyses

For comparisons of condition index and macroscopic data, homogeneity of variance was confirmed using the Cochran test (Winer et al., 1971) and single factor analysis of variance (ANOVA) was used to assess treatment differences.

2.3 Results

Cultured Oysters

The responses of both *S. glomerata* and *C. gigas* to cold immersion showed a clear trend for increasing tolerance with increasing size (Fig. 3). For *S. glomerata*, mortality in small spat (<35mm) could be observed after as little as 5 secs. All *S. glomerata* less than 45 mm were killed within 30 secs, while all tested oysters up to 65 mm (small commercial size) succumbed within 60 secs. Differences were apparent between levels of mortality observed after 24 h and that recorded after 7 days in treatments where less than 100% mortality occurred. These apparent differences were greatest in small oysters and were in part attributed to difficulties in determining viability of spat at 24 h without damaging individuals and compromising results.

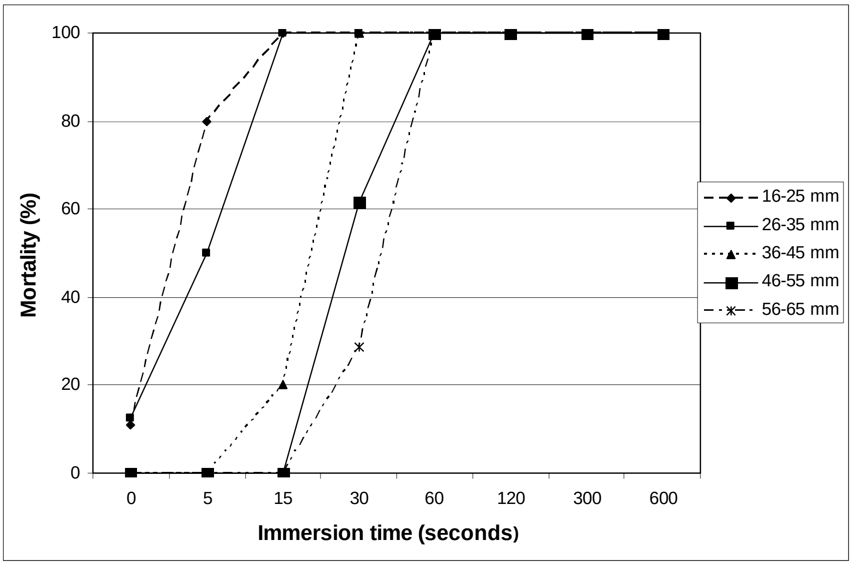

Figure 3. Mortality among hypersaline cold-shocked *Saccostrea glomerata* of various size classes 7 days after treatment

Cold-shock tolerance of small *C. gigas* was similar to that of *S. glomerata*, however as *C. gigas* increased in size they became progressively more tolerant, eventually being capable of surviving emersion for more than 60 secs, an outcome not observed with *S. glomerata* at any of the sizes tested up to 65 mm (Fig. 4). For *S. glomerata*, mortality in small spat (<35mm) could be observed after as little as 5 secs. All *S. glomerata* less than 45 mm were killed within 30 secs, while all tested oysters up to 65 mm (small commercial size) succumbed within 60 secs. Differences were apparent between levels of mortality observed after 24 h and that recorded after 7 days in treatments where less than 100% mortality occurred.

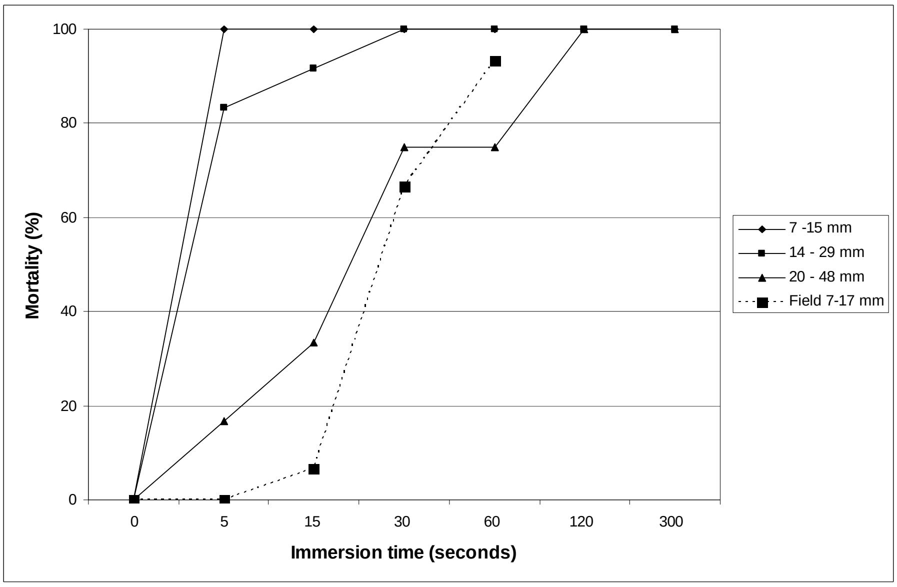

Figure 4. Mortality among hypersaline cold-shocked *Crassostrea gigas* of various size classes in the laboratory (-16°C) and in the field (-12°C) 7 days after treatment

Mussels

As observed with oysters, large *T. hirsutus* were more tolerant of hypersaline cold-shock than smaller individuals. For the given size class evaluated, *T. hirsutus* also showed greater tolerance of hypersaline cold-shock than either of the oyster species evaluated, although the vast majority were killed within 60 secs immersion (Fig. 5).

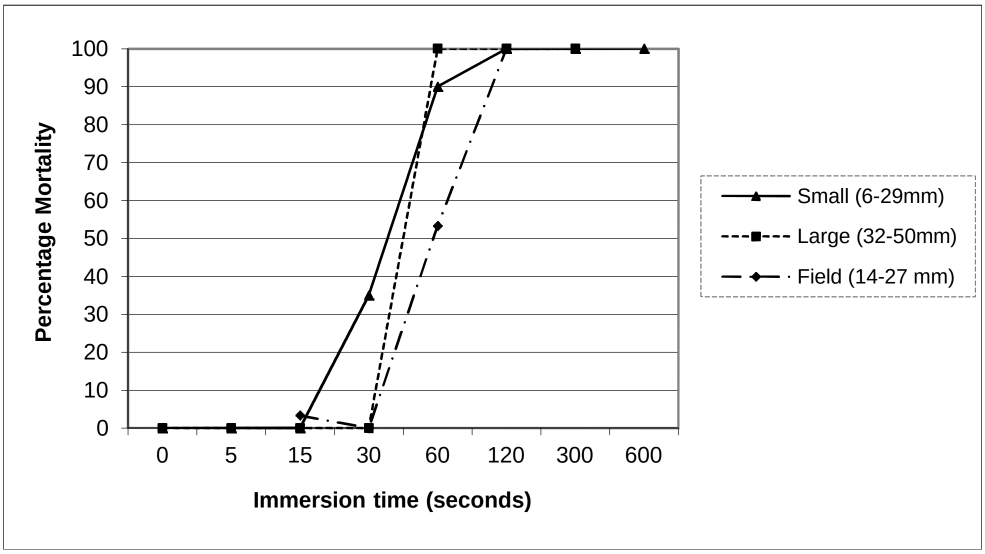

Figure 5. Mortality among hypersaline cold-shocked *Trichomya hirsutus* of two size classes in the laboratory (-16°C) and in the field (-12°C) 7 days after treatment

Barnacles

Barnacles were rapidly destroyed by hypersaline cold-shock treatments. Mortality levels of 36 ± 14% (μ ± SD) were recorded among stock exposed for as little as 5 secs, while all barnacles treated for 15 secs or more died within 7 days. No differences in tolerance between *B. trigonus* and *A. variegatus* were apparent.

Flatworms

Flatworms, *I. mcgrathi*, were completely intolerant of hypersaline cold-shock treatment. Excessive mucous-like secretion was evident within 5 secs and physical damage of the body margin was observed in worms exposed for 15 seconds. *I. mcgrathi* did not survive 5 secs or more exposure within the cold bath.

Field trials

Even though the field based trials clearly indicated the potential utility of hypersaline cold-shock to control oyster over-catch, they also indicated the importance of several variables. The repetition of the laboratory based trials using *C. gigas* and *T. hirsutus* confirmed the importance of temperature, with the increase from -16°C to -12°C leading to markedly higher survival of both species (Fig. 4 & 5, respectively).

No adverse impacts of hypersaline cold-shock treatment were observed on survival, CI or gonadal development of the commercial stock of *C. gigas*. No mortality was observed following treatment and both CI and gonad score (Fig. 6) increased significantly between the start of the experiment and the final sampling a week later (F= 30.48 & F= 9.18, respectively, df 3,76, P<0.001).

Comparisons among treatments after 7 days showed no difference in gonad score between controls and treated oysters, while the CI of oysters treated for a total of 75 secs was higher than that of either controls or oysters treated for only 45 secs.

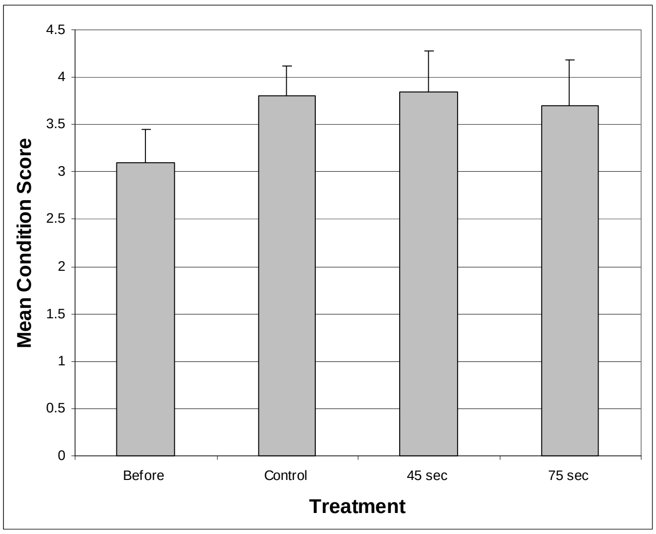

Figure 6. Macroscopic condition score of Pacific Oysters before hypersaline cold-shock treatment and one week after treatment for durations of either 45 or 75 sec

Cold-shock treatments were effective in destroying the majority of over-caught oysters. While no mortality of over-catch was observed among control treatments, immersion for 45 seconds destroyed 90% of over-catch. Among the survivors in the 45 sec treatment were both *S. glomerata* and *C. gigas* of various sizes, although size of the over-catch did not appear to explain survival. Rather, this looked to be related to position on the oyster and the degree of additional protection afforded by surrounding over-catch. All over-catch on the 75 sec treatment was dead within 7 days of hypersaline cold-shock treatment.

2.4 Discussion

In laboratory based studies, hypersaline cold-shock has been found to be particularly effective in treating a range of fouling and pest species that affect farming of the oysters *S. glomerata* and *C. gigas* across NSW. In general these outcomes were also clearly evident within field trials and augur well for the development of safe fouling control methods. The studies did however show that the tolerance of pest species varied significantly, probably due to a range of factors, and that the application of hypersaline cold-shock treatments will need to be varied in accordance with the species cultivated and the fouling organisms present.

The hypersaline cold-shock treatment applied comprised two fundamental stressors: temperature reduction and exposure to hypersaline solutions. Collectively these were found to be particularly effective in controlling “soft-bodied” pests such as flatworms (*Imogine mcgrathi*), which have been responsible for major stock losses in oyster and mussel faming in NSW (O'Connor and Newman, 2001, 2003). The ability to control these pests comes as little surprise as hypersaline solutions alone had previously been confirmed to kill this species (O'Connor and Newman, 2001). Similarly it is expected that the hypersaline solutions are likely to be useful in controlling a broad range of soft bodied fouling organisms that are susceptible to osmotic stress. Brine baths are effective in destroying fouling organisms such as starfish, sponges, hydroids, ascidians and algae (Minchin, 1996; Sharp et al., 2006; Boyd, 2008), which all variously affect oyster farming within Australia.

For organisms possessing an outer protective layer such as a shell or calcareous plates that afford some protection against osmotic stress, the size of the organism and the thickness of the plates may play a crucial role. Smaller organisms tend to have a large surface to volume ratio, which accelerates the rate at which vital organs are cooled. Smaller organisms also often have thinner shells that may afford less insulative protection. The barnacles used here are a common and costly pest to oyster farmers in south eastern Australia, but were readily destroyed by the hypersaline cold-shock treatment. This Balanid spp. are however comparatively small and further assessment is needed to test the efficacy of hypersaline cold-shock on other larger, potentially more robust species that affect farming elsewhere in Australia.

Cold tolerance of the molluscs tested was clearly size dependent (Figs. 3&4) with small individuals of each species succumbing faster. This again was thought to be a function of surface area and shell thickness, which is also observed when "cooking" is used to destroy over-catch. This differential is critical when dealing with conspecific (same species) fouling to allow a margin for error between over-catch destruction and the loss of the commercial crop. Although the stock used in this study was not as large (10-15 cm) as that used by Heasman (2005), the size differential in survival times observed in the earlier study were confirmed. Importantly, this study indicated the potential for hypersaline cold-shock to be used where smaller size differences between host and oyster over-catch occur. Fouling cycles are commonly annual and in many areas of Australia, the growth of Pacific Oysters is such that they may not exceed 4 – 6 cm before treatment is required. Field studies during this trial have clearly shown this feasible.

Clear species differences in survival were also evident between *S. glomerata* and *C. gigas* of up to commercial size. *S. glomerata* are less tolerant of hypersaline cold-shock than cool temperate *C. gigas* of a similar size. This would come as little surprise to industry, which has clearly seen similar differences between thermal tolerance of the two species during cold storage prior to sale. The extent of the difference is likely to be quite marked given that *S. glomerata* will die with refrigeration, whereas recent studies with *C. gigas* have shown that 50% of large oysters (10-15 cm) can survive 24 h storage at -22^{o}C (Strand et al., 2011).

The hairy mussel *T. hirsutus* was quite tolerant of hypersaline cold-shock in comparison to similar sized oysters. This was thought to have arisen from protection derived from the covering fine hairs on the external surface of the shell that could hold a layer of water and slow cold water penetration. This protective capacity may be enhanced within the field as these hairs commonly also trap a layer of silt which could improve the shells insulation capacity. Nonetheless, *T. hirsutus* is comparatively slow growing and through a combination of either vigilance and/or the need to treat oyster over-catch at least annually, hypersaline cold-shock should be an effective means of controlling mussel infestations while the mussels remain small. The comparative tolerance of this mussel species also serves to highlight the possibility of broader applications for hypersaline cold-shock. Commercial mussel species and other bivalves can be affected by over catch and may also benefit from similar treatment.

The effectiveness of hypersaline cold-shock as treatment for over-catch was confirmed in the field although it was evident that the tolerance of over-caught oyster fouling was greater than might be predicted on the basis of single oysters treated in the laboratory. This could be largely due to the reduction in surface area exposed to the cold hypersaline solution, but served to highlight a series of variables that need further investigation to better refine hypersaline cold-shock application so that this method can achieve its full potential. Other variables that are also likely to be important include, emersion times associated with treatment and temperature differentials between ambient and the hypersaline cold-shock baths. A study with *C. gigas* has indicated acclimation to cold temperatures can increase tolerance (Strand et al., 2011) and thus treatment effectiveness could be increased by treating in summer when immediate thermal prehistory is more conducive to thermal stress.

While the benefits of handling and cleaning oysters clearly outweigh the negatives, techniques used to handle and remove pests and fouling from oysters can be deleterious. Reduced growth and mortality can ensue. Studies with a number of mollusc species have shown handling can induce stress responses and reduce immunological function (Lacoste et al., 2001, 2002). In this study, survival of commercial stocks was unaffected by hypersaline cold-shock and the improvement in condition of oysters suggest the process is not overly stressful, however more sensitive methods of stress detection could be applied and longer term (>7 days) monitoring could be undertaken.

Note: ***Mudworms***

Polydorid mudworms were Australia's first recorded marine pest (Walker, 2011) and remain an impediment to mollusc culture to this day. Oysters can be highly adversely affected by mudworm and calls for a simple effective treatment constantly arise from the oysters industry. While practical issues precluded us from directly assessing the value of hypersaline cold-shock in mudworm control, some observations were made.

It is not unreasonable to expect that hypersaline cold-shock may be effective in controlling mudworm infestations. Hypersaline dips have been used to control Polydorid infestations in *Crassostrea virginica*, where even dips of a minute in saturated salt solution were effective in killing 89% of *Polydora websteri* if combined with drying for 2 h (MacKenzie and Shearer 1959). In the field trials undertaken in this study with commercial stock, cumulative dips of up to 75 secs were applied followed by 1-2 h of emersion before the oysters were returned to the lease, and therefore could have been an effective control. Observations of this stock confirmed that some mudworm was present and that some mortality was noted following treatment. Critically, there are four mudworm species known in NSW (Skeel, 1975) and we did not identify mudworm species. Nor did we attempt to adequately control experiments to allow any assessment of hypersaline cold-shock efficacy in controlling this type of fouling. Nonetheless, observations were encouraging and further experimentation appears warranted.

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3. BENEFITS AND ADOPTION

3.1 Cold Shock Not Stand-alone

The encouragement for the development of the hypersaline cold shock treatment was not necessarily as a front-line measure in the management and control of over-catch and biofouling. The treatment is seen as the measure when alternate fouling management control measures have failed, for example when:

- fallowing areas of product greater than 40mm where over-catch is known to be prevalent at settlement times;
- using variable height growing methods to move the oysters out of the settlement zone; and
- farm alignment and growing modules to take advantage of water energy to rumble product at settlement times.

Based on historical results it is anticipated that farms able to relocate product to areas not prone to over-catch and use variable height modules will be able to avoid the need for treatment three years out of four.

Figure 7. Example in Port Stephens of oysters left in a settlement zone and untreated

3.2 Wider application

Initially the focus was on a treatment method for Pacific Oysters (POs) hosting over-catch, particular Sydney Rock Oyster (SRO) over-catch due to the comparative “fragility” of POs compared with SROs. However, the wider application and the cost effectiveness compared with other viable methods such as drying for SRO’s over-caught by POs and/or SROs, indicates a much wider application.

While focussed on oyster over-catch, the treatment was always recognised as having application for other forms of soft and hard shell fouling and pests and the earlier section of this report deals with the efficacy of the treatment for such fouling. These applications were also recognised as having application for oyster farming areas across Australia for not just over-catch and mud-worm but also for things like Coffin Bay’s famous barnacle settlement (Fig.8).

Figure 8. Barnacle fouled oyster culture infrastructure in from Coffin Bay, SA

3.3 How to treat oysters

Earlier sections of the report identify the conceptual simplicity of the treatment. Oysters are immersed in the chilled hyper-saline solution and immediately or subsequently returned to the lease.

The duration of the immersion is dependent on the size, age, condition, type and shell thickness of both the host oyster and the over-catching oyster, or if not over-catch then the type of fouling or infestation. Timing is also dependent on salinity (while salinity is necessary to achieve the below zero temperatures, it is also part of the treatment) and the temperature to create the immersion and withdrawal shocks. Timing is also influenced by the means of immersion with a more vigorous or agitated method preferable. In addition, ambient temperature has an impact.

The prototype unit has been built with significant automation for the loading of units and return of units back to the line. Appendix 7.2 provides the technical drawings which demonstrate the mechanisation. This mechanisation is highly variable – at its fastest speed oysters travel through the immersion in 25 seconds, and slowest in 3 minutes and 30 seconds.

It has been found that oysters <40mm are not as prone to over-catch and it would be rare that there'd be need for them to be treated although test results show that they are treatable but the immersion times need to be carefully controlled. The primary beneficiary of the treatment is oysters approaching or having reached sale size, i.e. when the oyster has had considerable time and costs invested in it.

3.4 Cost to treat?

This very simple question does not have a simple answer. The trial unit is a very substantial piece of equipment capable of handling very large volumes "on water". However, the application of the technology is not restricted to such a grand scale operation and could be applied to shore based plunge systems such as is used for "cooking" treatment of over-catch and possibly at minimal cost by simply retrofitting existing equipment.

The cost to treat has two components:

Capital cost

The prototype unit with condenser has cost Marine Culture $76,000 (plus freight, GST exclusive and not including development time and costs) but this is designed to handle a farm holding up to 12m oysters at any one time on 48 hectares of leases.

In addition, the capital cost of the equipment (treatment tank, condenser and portable power source) may require an operator acquiring a forklift or other lifting equipment to move the equipment and, if to be operated on the leases, a vessel capable of safely handling the weight and the oyster load/return operations. The Marine Culture vessel to carry the equipment was specially designed to achieve very high stability for non-centre aligned weight while still being a working oyster farm vessel, which is the dominant use. The $58,000 spent on the vessel is of course significant but the use purpose means that very little of that cost attaches to the treatment cost.

However, for a shore based plunge operation using a retro-fitted hot water plunging tank and connected to shore power the capital costs would be much much less, likely less than $10,000 even if contracted out.

The denominator to come up with a per oyster treated capital cost is equally unclear as the use of the equipment will depend on the success or otherwise of mitigation measures for over-catch and other forms of fouling as outlined earlier, and whether the three years out of four of non-use is achieved.

For Marine Culture, the capital component of the sale product per unit cost is calculated on the volume treated on an annualised basis over the estimated equipment life.

The volume treated in a year when treatment is necessary is only of those oysters of treatment size with an allowance for those oysters that will be lost or deliberately discarded prior to or at sale harvest. An allowance of an additional 25% being treated but not making sale is applied. This is thought to be excessive but implicitly covers those slow growing oysters that drop out of the cycle but are not discarded.

However, treatment each and every year is not expected given control mechanisms in place (move stock out of known catching areas, move to high energy water and hold on high clips to maximise rumbling). The expectation of a one in four treatment is used. If it transpires that more frequent treatment is needed then the capital cost per sale oyster reduces – halved if treatment every two years and a quarter if done annually.

Based on developed holding capacity and a 20 year equipment life the cost per thousand sale oysters treated on an annual basis is $2.70. As indicated, if the equipment was used more than once every four years then the capital cost per thousand treated would reduce. For example, if there was an annual requirement for mudworm treatment and again for over-catch then the capital cost would be 33.75 cents per thousand oysters treated.

This is thought to be a worst case costing and for a shore based smaller scale unit the unit cost would be as low as one-tenth of the $2.70 every 4 years and 33.75 cents for a twice a year treatment based on sale volumes.

Operating Costs

In respect of the operating costs, the timing of the treatment in respect of the size of the over-catching oysters is not as significant as one would expect – given the large margin for error, within reason, it’s better to over-treat by increasing immersion time than risk having to come back and do it again. Nonetheless, the smaller the over-catching oysters the less immersion time is needed and therefore the greater the throughput.

Power consumption is also not straight forward as, apart from the initial chill down of the tank which is done via shore power, the unit is designed to operate off a generator. The prototype unit consumes 12kw per hour and requires a 3 phase connection when shore powered. A smaller or retro-fitted plunge boiling tank would require less power for chill down and consume at a much lesser rate but would be at a slower throughput due to the need for cold recovery.

If it was assumed that:

- the cost of generator fuel was the same as current electricity charges ($0.34 pKWH)
- time on lease was 4 hours and rack location and relocation time consumed 50% of the available time
- size of product being treated was 50-60mm (species found not to materially add to time required)
- over-catch was <10mm
- salt consumption based on pool salt bag rate of $5 for 25kg bag and maintaining the tank for 3 days with daily top up of 40% due to dilution
- fuel costs for the punt, labour costs, etc not included

then the consumable costs based on the trial unit would be:

	cents per 1,000 oysters treated
power (including 6 hours chill down)	11.81
salt	0.35
	12.15

In other words, the operating cost would be $4,200 for the treatment of 345,600 oysters with a value of approximately $1,000,000. As the size treated increases the volume treated obviously declines but the value of the oysters "saved" increases substantially.

3.5 Cost Benefit

Clearly the costings presented in the above section of the report are very uncertain due to both the variable need (due to circumstances and over-catch mitigation measures employed) and how the technology is applied (i.e. whether that be through a re-fit of existing equipment or development of a major piece of equipment to be able to handle 12m oysters, or something in between).

If the maximum cost approach is taken (i.e. a very under-utilised significant capital outlay), the operating cost works out at approximately $2.85 per thousand sale oysters treated, or 3.4 cents per dozen. This is a tiny fraction of the diminution in value of over-caught sales product and an insignificant cost to actually be able to have saleable product that would otherwise be, for example, mudworm infested.

4. FURTHER DEVELOPMENT

Despite the success of hypersaline cold-shock treatment to date, so great is the variety of fouling organisms and so extensive is the range of operating variables that can be manipulated, that this study has only been able to provide an insight into the potential of the process. Variables such as bath temperature, temperature differential between ambient seawater and the bath, the duration of emersion before and after treatment and the temperatures during emersion are simply a few examples thought to potentially be of significance.

While the tolerance of a diverse selection of pest species was assessed, these species are a small subsample of those that might be encountered in oyster farming regions in Australia. In particular, mudworms are a significant pest in oyster culture and warrant further attention. Observations made during this study were suggestive of the capacity of hypersaline cold-shock to be used to control mudworm infestations; however, these observations need to be treated with caution. No experimental controls were applied and the type/s of mudworm observed was not determined. As highlighted by Walker (2009) there is a paucity of information on the range of polydorid (mudworm) pest species occupying mudblisters in oysters and the extent to which they occur. Accordingly, further studies specifically designed to assess hypersaline cold-shock efficacy in polydroid control would be of value.

Oysters are not the only bivalve species cultivated in Australia and are not the only industry to encounter biofouling as a major challenge. The effort expended by the pearl industry in Australia to control fouling on commercial crops exceeds that of the edible oyster industry, while mussel and scallop culture has been similarly fouling afflicted. The opportunity exists for other industries to consider hypersaline cold-shock baths, if not regularly at least as a treatment for particular fouling types or at specific times.

Opportunities for further development also exist in respect of commercialising equipment access through “bay sharing” of the acquisition or an equipment manufacturer having units for lease or hire. Exploration of these type of opportunities are clearly beyond the scope of this report although on publication of the report agreement has been reached with Stainless Engineering and Design (SED), who built the prototype, to run an advertising program where that program will address retro-fitting existing equipment as well as design and build of new equipment, using the lessons learned from the prototype, tailored to the throughput needs of enquirers.

Additionally, the promotion of the “Slush Puppy” will continue, for example, an invitation has already been accepted to present the technology at the upcoming Shellfish Futures conference in Tasmania in August 2012. And Marine Culture has undertaken to hold further field days as well as allow access by appointment.

5. PLANNED OUTPUTS

Proof of concept of cold shock treatment for over-catch control in a commercial environment provided

This outcome has been achieved. As outlined in the earlier sections of the report both the scientific basis for hypersaline cold-shock treatment of over-catch and other biofouling, and its commercial application has been verified.

Operating guidelines for the application of cold shock in treating Rock and Pacific Oyster over-catch on crops of rock oysters, and diploid and triploid Pacific Oysters established

This outcome has only been partially achieved. For the trial equipment guidelines have been developed however the application of those guidelines to adaptations of that equipment cannot be developed until that equipment exists. Immersion periods against temperature and salinity of course are not necessarily common as the means of immersion, agitation of product while immersed and tank chilling method (and therefore maintaining the temperature) will require revision to the guidelines for the test equipment.

Effectiveness of cold shock in treating a range of additional pest species (barnacles, hairy mussels, flatworms etc) confirmed.

This outcome has been achieved. As outlined in the earlier sections of the report the scientific basis for hypersaline cold-shock treatment of additional pest species has been verified. Given the success identified on tested pest species opportunity exists to confirm the treatment for non-tested species and other biofouling.

Industry access to the treatment protocols, range of impacts and access to the prototype equipment in operation

This outcome has been achieved. There has already been wide dissemination of the hypersaline cold-shock treatment initiative to industry. The initial newsletter (see Appendix) was not followed through on as other, more effective, promulgation vehicles arose including stories in Austasia Aquaculture and WA Fish eNews and the presentation at the 2011 International Oyster Symposium and Australasian Aquaculture Conference 2012. This was in addition to field days and by appointment inspections of the equipment in situ at Port Stephens as well as promotion of the equipment by Stainless Engineering and Design.

Marine Culture has undertaken to leave its doors open for further inspection of the equipment and observing it in operation.

6. CONCLUSION

The project has been a success.

The recruitment of fouling or pest organisms to cultured oysters and growing infrastructure imposes a major financial impost for oyster culture throughout Australia and serves as a particular deterrent to industry expansion in certain regions. Oyster farmers have a range of management options such as mechanical cleaning, drying or cooking to control fouling, but each option typically has its limitations. Cold-shock, through immersion in chilled (-12 to -16°C) hypersaline (180 - 200 g l^{-1} NaCl) baths, is a comparatively new technique that has demonstrated the potential to effectively control a range of pest species without adverse effect on the host oysters. Most notably, hypersaline cold-shock can be used to control subsequent natural oyster settlement known as “over-catch”.

Under the auspices of this program a commercial scale, hypersaline, cold-shock bath, dubbed the “Super Salty Slush Puppy” was constructed to provide proof of concept of cold shock treatment for over-catch control. The cold shock bath was deployed to Port Stephens NSW where it was successfully used for both experimental and commercial scale biofouling treatment.

In experimental scale laboratory trials, the cold tolerances of various size classes of both Sydney Rock Oysters (*Saccostrea glomerata*), Pacific Oysters (*Crassostrea gigas*) were assessed and tolerance estimates were determined (Objective 2). Overall cold shock tolerance in both species was size-dependent with smaller individuals succumbing faster. Comparatively, *S. glomerata* of up to commercial size were less tolerant of hypersaline cold-shock than *C. gigas*. In field trials, the capacity to exploit these differences to control both *S. glomerata* and *C. gigas* over-catch was demonstrated. Using the commercial hypersaline cold-shock bath, immersion for a period of 45 or 75 sec were both shown to be effective in controlling *S. glomerata* (mean size 14 mm) and *C. gigas* (mean size 22 mm) over-catch on commercial crops of *C. gigas* (mean size 65 mm). Following 45 sec immersion, >90% of fouling oysters were destroyed, while a total exposure time of 75 sec saw all fouling oysters killed. In both cases, no significant increase in commercial stock mortality was observed following treatment and no impact on oyster physical or reproductive condition was observed.

In laboratory trials, the effectiveness of cold shock in treating a range of additional pest species was confirmed (Objective 3). Cold-shock was found to be particularly destructive to “soft-bodied” pests such as flat worms (*Imogine mcgrathi*) and smaller organisms such as barnacles (*Balanus trigonus, Amphibalanus variegatus*) up to 1 cm in diameter. Each of these species died following immersion periods of as short as 15 sec. Cold-shock tolerance of hairy mussels (*Trichomya hirsutus*), like oysters, was found to be size dependent, although these mussels were found to be considerably more resistant than similar sized oysters. However, as observed with oyster over-catch, mussels control can be achieved with hypersaline cold-shock and simply requires care in ensuring a significant size differential between the size of fouling organism and the host oyster.

In the conduct of these trials several additional observations of relevance were made. Both CaCl or NaCl were as the basis for hypersaline baths and were found to be similarly effective. Ultimately, NaCl was used for the field trials because of significantly reduced cost. Comparisons of cold-tolerance of small triploid and diploid *C. gigas* found no significant differences between the two oyster types. Finally, some evidence of the capacity of hypersaline cold-shock to treat mudworm was also observed although further experimentation would be required.

There has already been wide dissemination of the hypersaline cold-shock treatment initiative to industry. A widely disseminate newsletter was followed up with stories in Austasia Aquaculture and WA Fish eNews and the presentation at the 2011 International Oyster Symposium and Australasian Aquaculture Conference 2012. This was in addition to field days and by appointment inspections of the equipment in situ at Port Stephens as well as promotion of the equipment by Stainless Engineering and Design.

7. APPENDICES

7.1 Super Salty Slush Puppy Newsletter

AUSTRALIAN SEAFOOD COOPERATIVE RESEARCH CENTRE | Marine Culture | TORC TASMANIAN OYSTER RESEARCH COUNCIL LIMITED

the Super Salty Slush Puppy – Newsletter #1

high saline sub zero treatment for oyster over-catch and fouling

Welcome to the first of a series of newsletters on the development and trials of the application of technology for the management of oyster over-catch and fouling.

With the support of the oyster Consortium, Marine Culture, through the Tasmanian Oyster Research Council, has made successful application to the Australian Seafood CRC to take forward its development of a cold shock over-catch treatment system.

The intent of this newsletter is to introduce the initiative and explain the science behind it. Later newsletters will present the results of the sea trials of the equipment and the results of the work with the Port Stephens Fisheries Institute to verify the efficacy of the treatment and the range of applications.

Why?

Do any of these pictures apply to your farms?

Or might they sometime? Have you ever had a mudworm or flatworm infestation?

Over-catch is certainly not a new issue, indeed, without it we wouldn't have an oyster industry. However, once you've got the oysters in their growing modules, having the oysters or module or both over-caught reduces growing performance, contributes to losses and oft reduces the marketability.

The preliminary investigations have shown the potential for cold shock to control oyster over-catch of both Pacific oysters and Sydney rock oysters, but this is also likely to be effective in control of a variety of other fouling organisms such pigmy mussels (*Xenostrobus securis*) and hairy mussels (*Trichomya hirsuta*) which compete with oysters for food and bind them together in clumps. Effective control of barnacles, including common honeycomb barnacles (*Balanus trigonus*) is likely, while destruction of predatory Stylochid flatworms (such as *Imogene mcgrathi*) is almost assured.

Hyper and hyposaline baths have been used to control mudworm infestations (*Polydora* spp. and *Boccardia* spp.) in other bivalves and therefore the combination of hypersaline solutions and cold shock may well prove beneficial in the control of these worms that have such significant impacts on oyster health and marketability.

Finally this technology is likely to be effective in deterring a broad range of soft bodied fouling organisms ranging from algal growth to ascidians which variously impact bivalve culture across all Australian states.

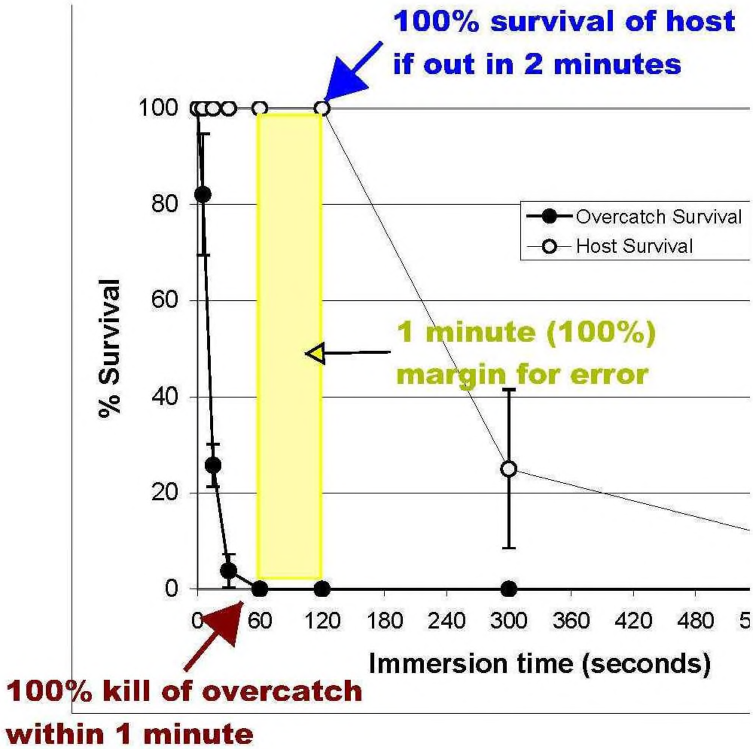
Other industries that face the significant the impost of fouling control and that may adopt this technology are the Pearl industry, most notably the northern silverlip pearl oyster (*Pinctada maxima*), but also those producing black pearl oysters (*Pinctada margaritifera*) and akoya (*Pinctada imbricata*). These pearl industries all handle stock far more frequently than the edible oyster industry, largely to remove fouling. The mussel industry may also benefit as it has significant over-catch problems and has suffered significant losses as a result of Stylochid flatworm predation.

What is the science?

The original idea arose from the thought that the effectiveness of the widely used "cooking" of oysters was more to do with the rapid temperature change when the oysters were plunged after the cooking.

Why not try cold instead of heat – roughly the same temperature differential can be achieved, much safer for personnel and likely less damaging to the host oyster if "over cooked".

An initial study of cold shock treatment was undertaken by Dr Mike Heasman, then with the Port Stephens Fisheries Institute.



The trial utilised an immersion quick freeze unit which are found on fishing boats and heavily over-caught oysters were immersed for varying times.

A saturated salt solution doesn't freeze solid till close to -30°C but for the trial the temperature was set at -19°C.

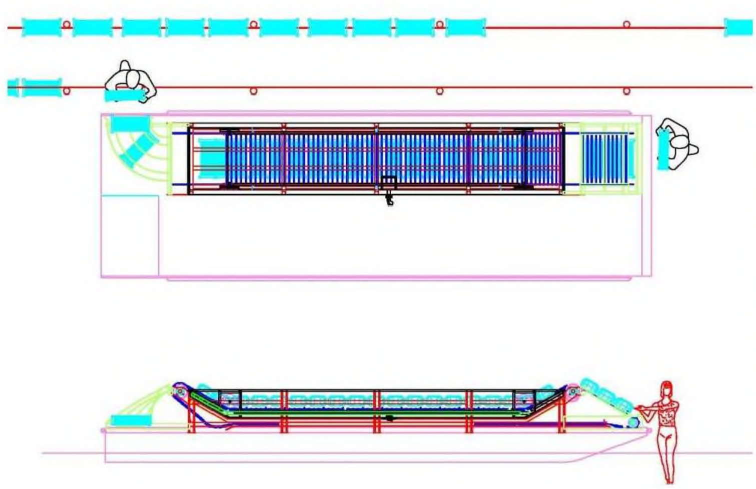
The trials delivered very exciting results – the graph says it all.

How to do it in the field?

It is important to stress that the application of the science can be in any number of forms – all that's needed is a vessel to hold a tank of high salt concentrate water, a means of chilling that water down to – 20° C or so and a mechanism to bring your oysters into the tank and after treatment immediately plunge the oysters back into normal temperature water. That, and a very loud egg timer.

Due to the perceived need to be able to process product "on lease" and looking for labour saving opportunities Marine Culture commissioned SED (Shellfish Equipment of Wynyard in Tasmania) to build an automated unit. Marine Culture predominantly uses SEAPA growing modules and the unit is designed for a staff member to unclip a module, put it on the feed and after coming out of the unit another staff member reclips the module back on the line. While what Marine Culture has had built is of some size, it's designed to be forked onto a vessel.

Marine Culture is happy for people to have a look, take pictures, ask questions and even pinch and adapt the design. But again it's stressed that the project is about the methodology and not what Marine Culture has built to implement the science. Arising from successful factory testing and the first field day when the unit was delivered to Marine Culture's shed at Port Stephens and the successful land based running of the unit for over-caught Sydney rock and Pacific oysters, it is understood that some farmers are looking at retro-fitting their existing cooking tanks and this seems to make perfect sense, and a very cost effective approach.



Marine Culture's willingness to share the knowledge and IP it has already developed is due to the opportunity to draw on wider industry participation which brings with it the opportunity to obtain the scientific proof and support for the treatment method being developed; and ultimately, a wider acceptance, adoption and lower cost of production and maintenance. There's also the hope that neighbours employ the same mitigation measures and we all avoid the mudworm infestation and re-infestation.

In addition, with Australia being a net importer of oysters and experiencing aggressive pricing challenges in its export markets from emerging producers like Chile and established growers like New Zealand, Australia needs to do better in respect of its cost of production if it is to have an industry into the future.

What's next?

What the project is about is the sea trialling of the unit and exploration of how effective a high saline sub zero treatment system will be in controlling various types of fouling, including oyster overcatch, on Pacific and Sydney rock oysters and their growing modules.

Those next steps will look also at the variables for immersion times and temperature for differing sizes and ages of Sydney rock and Pacific oysters in order to establish optimal and most cost-effective operating parameters for the various applications (oyster over-catch, other hard shell fouling, soft fouling, mudworm, flatworm, etc.).

Oversight of the testing and application is to be undertaken by Dr Wayne O'Connor of the Port Stephens Fisheries Institute.

Marine Culture has proceeded with the acquisition of a vessel suitable to putting the machine to sea along with the power generator. Due to the weight and size of the equipment a semi-special purpose vessel was needed – i.e. one with capacity, high stability and clear deck for when the equipment is on board as well as a vessel being usable for lease development and normal farm operations. After extensive consultation with the usual vessel builders, Marine Culture bought a punt from Maxcraft in New Zealand which was shipped disassembled in a 40' container and put together on site at Port Stephens.

Marine Culture believes it has achieved an excellent outcome with the vessel – the four pontoons deliver exception stability, despite its size the vessels gets easily on the plane with a single 75 HP motor and it steers straight and true.

Thank you

Many people have tirelessly given of their time and expertise to get us to where we at now and thanks are due to.

Dr Mike Heasman – Mike got the whole thing started with his work back in 2005 in proposing immersion quick freeze and proving up the idea

Dr Wayne O'Connor – Wayne leads the application studies to come and has been a strong supporter of the project

Garry Thompson at SEAPA – we now know we can freeze you baskets as well as cook 'em

Matthew Brown of SED Shellfish Equipment – brilliant job for the machine, and the input into the design is very much appreciated

Rachel King and the Oyster Consortium – your support and encouragement has been invaluable

Board of the Tasmanian Oyster Research Council for not just the financial administration but also having the vision to see the national benefit

Dr Graham Mair of the Seafood CRC – hate your paperwork, love your approach

Max Monkley at Maxcraft NZ – you've delivered on the boat in all respects – price, performance and fitness for the job

And it'd be wrong not to make special mention of Harvey Calvert, Matt Kosmeyer, Glen (Jacko) Jackson and Peter (Ripple) Kosmeyer for their hard work and perseverance.

More Information and for a Look See

For further particulars of the Super Salty Slush Puppy, or even just suggestions for a better name, please contact:

Bob Cox
Principal Investigator
Ph: 0418 338 797
Email: OYSTERS@pecserv.com.au

Inspection of the equipment at Marine Culture Port Stephens can be arranged through:

Peter Kosmeyer
General Manager
Marine Culture
Ph: 0418 88 44 77
Email: Ripple@marineculture.com.au

More Next Issue on how you can get on board

7.2 Technical Drawings

The treatment system developed is designed to be boat based, but, given the hope for very infrequent use, not permanently on board. Therefore, its construction is designed to allow the equipment to be lifted off and on. Being intended for boat use, part of that equipment includes a generator.

What has been constructed as the trial machine is for use on a 48 ha farming operation capable of handling a growing module every 2½ seconds (equivalent to 7,500 50 to 60 mm oysters per minute) without loss of latent cold. It takes approximately 6 hours to bring the temperature down to -17^{0}C as it holds 2,000 litres of seawater to which is added 500 kg of salt. Lower temperatures can be achieved but were found unnecessary for effective treatment.

Its design provides for on water unit loading of growing modules with immediate return to the water. The technical drawings in the following pages show the design.

It is therefore very substantial piece of equipment as is the condensor unit (Fig 9)) and the generator that goes with it. The weight of the equipment (tank, condensor and generator) plus the 2.5t of brine solution means that a substantial vessel is required.

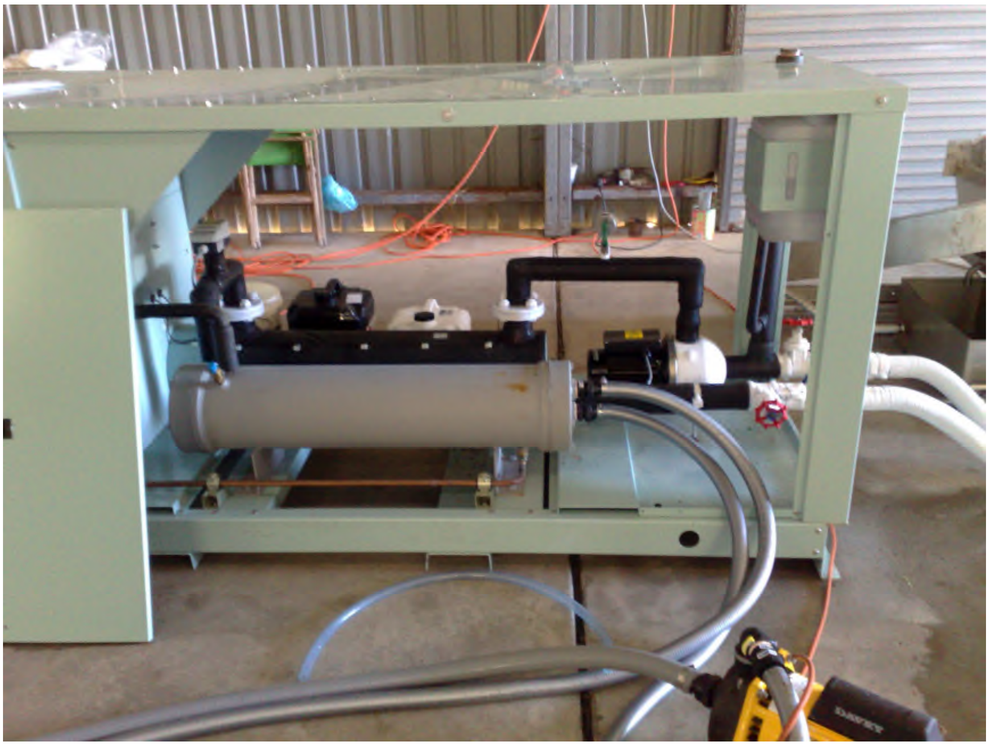


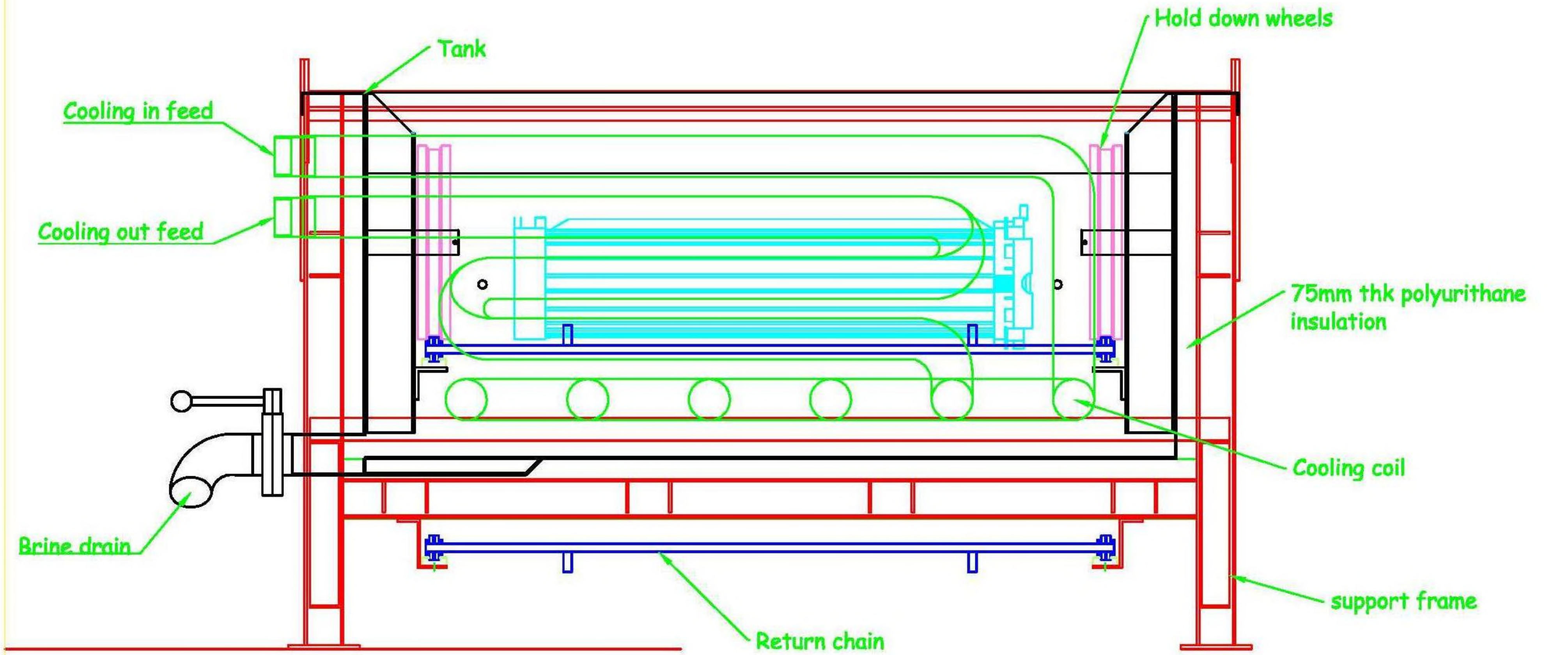
Figure 9. Condensor unit for prototype machine

And on following pages:

Figure 10. SED Technical drawing of prototype – end elevation

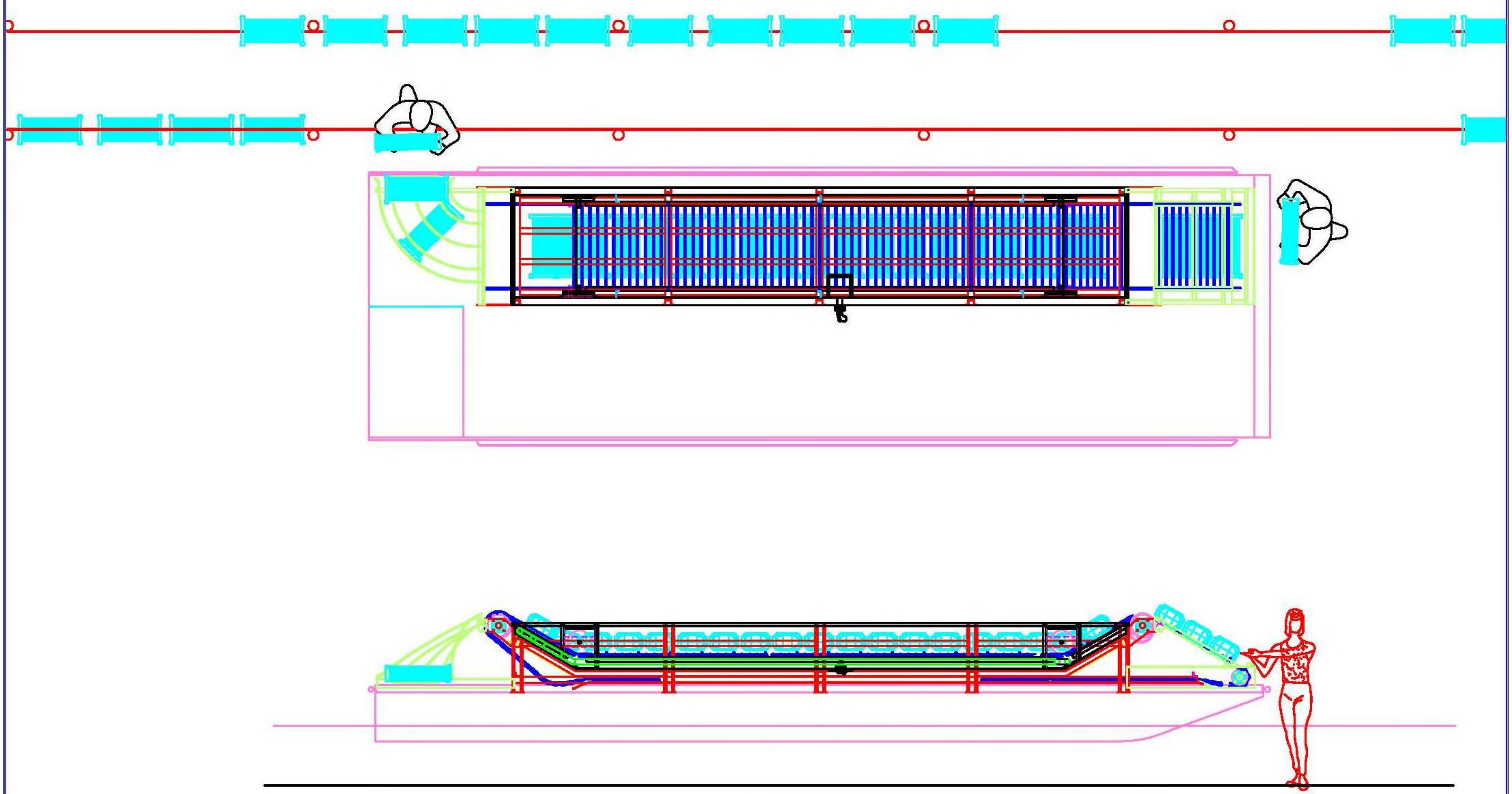
Figure 11. SED Technical drawing of prototype – plan and side elevation

Figure 12. SED Technical drawing of prototype – cross-section plan and elevation



Overcatch treatment tank

Material #		All Measurements in Millimetres				DESIGNED_BY	CHECKED_BY	APPROVED_BY_DATE	FILENAME	DATE	SCALE
Finish	RevNo	Revision note	Date	Signature	Checked	M Brown				21/12/09	NTS
Internal:						S.E.D. SHELLFISH EQUIPMENT PTY. LTD.		©Copyright: No part of this drawing or design shall be reproduced without authority from SED Shellfish Equipment P/l			
External:								JOB NO.	EDITION 01	SHEET GA	



Overcatch treatment tank

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Finish	RevNo	Revision note	Date	Signature	Checked	M Brown				21/12/09	NTS
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S.E.D.
SHELLFISH EQUIPMENT PTY. LTD.

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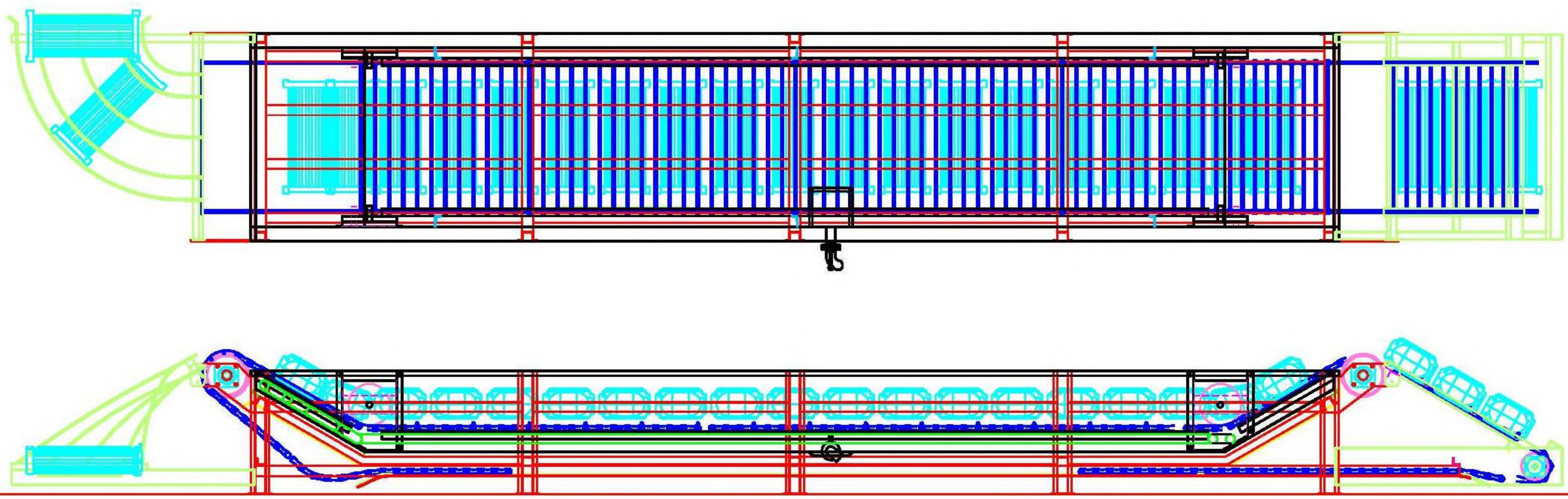

Overcatch treatment tank

Material #		All Measurements in Millimetres				DESIGNED_BY	CHECKED_BY	APPROVED_BY_DATE	FILENAME	DATE	SCALE
Finish	RevNo	Revision note	Date	Signature	Checked	M Brown				21/12/09	NTS
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	01	GA