Identification of natural mudworm species in South Australia Pacific oyster (*Crassostrea gigas)* Stocks

Jointly funded by the South Australian Oyster Research Council (SAORC) and Seafood Services Australia (SSA)

SEAFOOD SERVICES
AUSTRALIA

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September 2003

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NON TECHNICAL SUMMARY

Under a joint arrangement between Seafood Services Australia (SSA) and the South Australian Oyster Research Council (SAORC), a project was developed to investigate mudworm in South Australia to achieve the following objectives;

1. Implement a minor survey to gauge the variety of species across seven of the main oyster growing areas and give future direction on research requirements.
2. Train South Australian Scientists to provide them with the basic skills and knowledge in sampling, preservation and identification of mudworm species.
3. Identify the best management techniques to reduce mudworm infestation rates in SA.
4. Implement a workshop to build awareness of mudworm ecology and general management techniques with grass root oyster growers.

A minor mudworm survey was carried out in which between one and three dozen oysters from seven different growing areas were sampled for mudworm species, the survey involved industry members, scientists and industry experts and was implemented over a 2-day period in Adelaide. The survey only touched on the edge on the mudworm issue in South Australia, but provided a forum to train South Australian industry and scientist representatives in the sampling, preservation and the identification of mudworm.

The mudworm species identified were different from previously recorded species; which raised concerns and questions regarding the problematic species in SA. The confusion over the identification of some of the South Australian mudworm species highlighted the need for more investigative work in this area.

Height in the water column is considered the best management method for controlling mudworm infestations on the farm; this is very much supported through the extensive research conducted by Dr Handley. Dr Handley presented on mudworm ecology and management techniques at an industry workshop held in Port Lincoln to build awareness and to reiterate to industry the potential impact mudworm can have on oyster stocks, given the right environmental conditions for growth.

The results from the survey demonstrated that future work on mudworm is required. It is SAORC aim to expand on the work done to date to identify the species causing the blisters in various SA oyster growing areas and understand enough of their life cycles to recommend effective control strategies. Then management techniques suitable to the grower can be developed, ultimately giving growers the methods to farm oysters without the financial burden of mudworm infestations.

INTRODUCTION

Since the South Australian Oyster industry was established in the late 1980's, oyster growers have experienced infestations of spionid polychaetes 'mudworm', most frequently those belonging to the genus *Polydora*. The impacts of these worms on Pacific oysters and other molluscs are variable but most damaging forms of spionid infestations result from boring action of *Polydora* species and the subsequent formation of blisters. Oyster shells containing mudblisters are unsuitable for sale as mudblisters have an undersirable appearance and if punctured can release sediments, faecal deposits, and anaerobic metababolites including hydrogen sulphide.

Mudworm lays dormant until the right conditions take place, giving it the full ability to infest oyster stocks in minimal timeframes. Once it does affect your stocks it is difficult to eradicate, due to the continued re-infestations. Severe mudworm infestations may affect oyster health and condition in extreme cases, reducing farm production and providing on-going re-infestation of standing stock. Oysters are unsaleable when the blister is thin, but the meat can be sold by itself. The meat value is considerably lower than the ½ shell oyster value. Implementing correct oyster culturing height, which provides an environment that is not optimal for mudworm growth and settlement, can control Mudworm infestations.

South Australian (SA) oyster farmers have experienced infestations of spionid polychaetes ('mudworm') and high stock loss has been recorded in a number of oyster growing areas. South Australian oyster farmers are not necessarily aware of the treatment and prevention methods or the particular mudworm species causing the infestations of their stock. Communication with oyster growers in SA revealed that mudworm wasn't a major problem, yet on the other hand the processors advised that mudworm accounts for approximately five percent of losses in processed stock, which processors generally accepted due to the short supply of pacific oysters at the time of this study. But this could quite easily change with a shift in demand and supply of oysters, hence, processors would claim losses caused by mudworm.

Mudworm identification in South Australia and even Australia has been very difficult due to the lack of appropriate skilled people capable of identifying worms sampled from infested oysters. The shortage of SA specialised mudworm scientists prompted SAORC to train scientists on mudworm identification to increase their knowledge and skills, with the expectation that in-kind assistant could be provided in the future.

The effects of different spionid species on molluscs vary. There are a range of different species which have different characteristics and life cycles. The difficulty in identification and life cycles among species makes it hard to develop specific management techniques to prevent certain species infestation.

Sally Tonkin and Dr Patrick Hone had previously undertaken mudworm investigations in South Australia in the early nineties; a majority of research was conducted in Cowell. The work suggested a number of problematic polychaetes species (*Polydora websteri, P. hoplura & P. woodwicki*) and detailed prevention and treatment strategies.

The South Australian Oyster Research Council (SAORC) wanted to revisit mudworm in South Australia to achieve the following objectives;

5. Implement a minor survey to gauge the variety of species across seven of the main oyster growing areas and give future direction on research requirements.
6. Train South Australian Scientists to provide them with the basic skills and knowledge in sampling, preservation and identification of mudworm species.
7. Identify the best management techniques to reduce mudworm infestation rates in SA.
8. Implement a workshop to build awareness of mudworm ecology and general management techniques with grass root oyster growers.

The objective was to revise the current natural mudworm species on a whole of state basis. To ensure this was achieved SAORC contracted Dr Sean Handley (Mudworm expert) & Sebastian Rainer (*Polydora* expert) to assist with the survey and training of scientists and oyster growers. The project was aimed at gathering an indication on natural mudworm species and give initial guidance on the steps that are required to tackle the mudworm infestation issue in South Australian.

BACKGROUND

Mudworm Ecology

Mudworms are Spionid polychaete worms from the family Spiondidae, which comprises the most common polychaetes inhabiting marine intertidal and subtidal habitats. There are six genera of spionids from the "*Polydora* complex" identified in Southeastern Australia. Mudworm is recognised as an economically important pest, especially for shellfish culture, as they cause the formation of shell blisters or "mudblisters" - hence name "mudworm"- inside their host. Mudblisters reduce the market value of shellfish like oysters, and can have a parasitic effect in severe infestations.

<u>Mudblister formation</u>

Mudblisters are formed by shellfish such as oysters, mussels, scallops or abalone in response to an irritation in their shell and can be induced by mudworms boring through the shell matrix from outside (figure 1), or by their settlement on the internal shell margin as larvae. Mudworm secrete mucous which attracts sediment/faecal material around the oysters (figure 2. shows characteristics of a mudblister). The presence of mud is not necessarily a pre-cursor to blister formation, as blisters have been seen in subtidal oysters with no mud present (Handley 1995).

The contents of the blisters, if not aerated by the mudworm develop anaerobic metabolites including hydrogen sulphide, causing the release of offensive smells if punctured. Blisters can contain sequestered heavy metals, which are thought to buffer against acidic secretions produced by mudworms to dissolve the shell. The mudblister develops in stages and there is a distinct difference between larvae, adult and old blisters (figure 3)

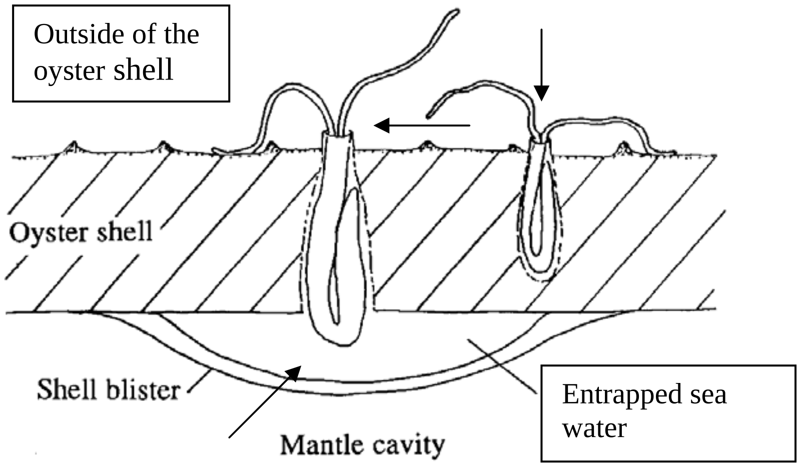


Figure 1. Shows how the mudworm settles on the outside of the oyster shell and bores its way through to the inside of the oyster by excreting acid. If they enter the shell too deeply they may penetrate the oyster's mantle cavity causing a blister to form.

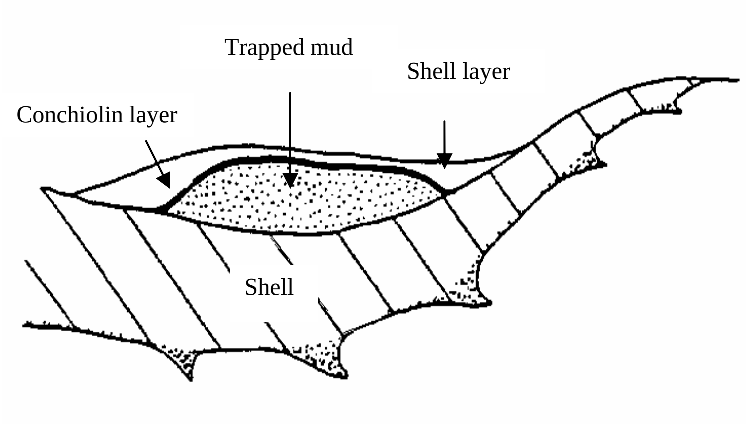


Figure 2. Shows the characteristics of a mudblister developed by an oyster.

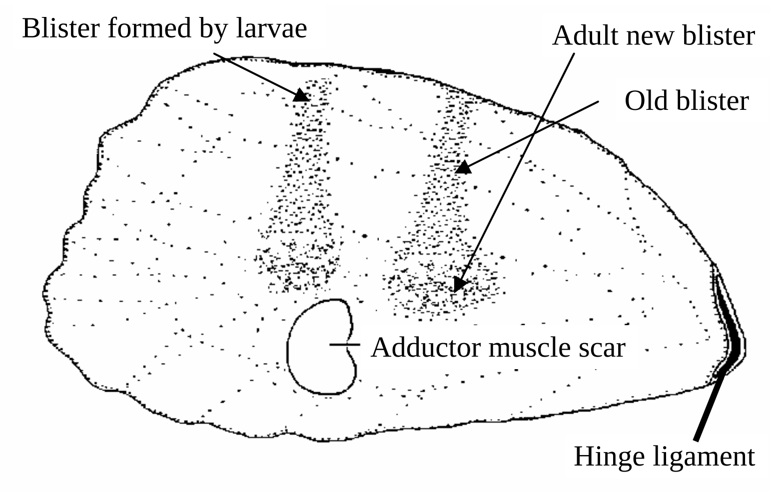


Figure 3. Shows the different types of blisters formed.

Oysters must expend energy to form the shellblister, and the oyster loses internal shell capacity inside their shell. The irregular shape of the blisters affects feeding currents of the oysters, resulting in a reduced capacity to feed, as the oyster expends more energy growing shell and filling in depressions around the blister. In extreme cases, a parasitic effect has been recorded as a result of the presence of large shellblisters (Handley 1998).

Mudworm Reproduction/life cycle

Spionids polychaetes show considerable variation in reproductive strategies. A majority of spionids are larval brooders; therefore they have egg capsules within their burrows. Commonly mudworm produce planktonic larvae. Sexual reproduction dominates the method of reproduction, but asexual reproduction has also been documented (budding or fragmenting).
There are two forms of larval production from brooding larvae (figure 4):

1. Lecithotrophy- larval feed via nurse eggs
2. Planktotrophy- larval feeding in the plankton

Further, poecilogonous larval production has been reported for some spionid species. Poecilogony means the mudworm can switch between lecithotrophy and planktotrophy larval producing methods.

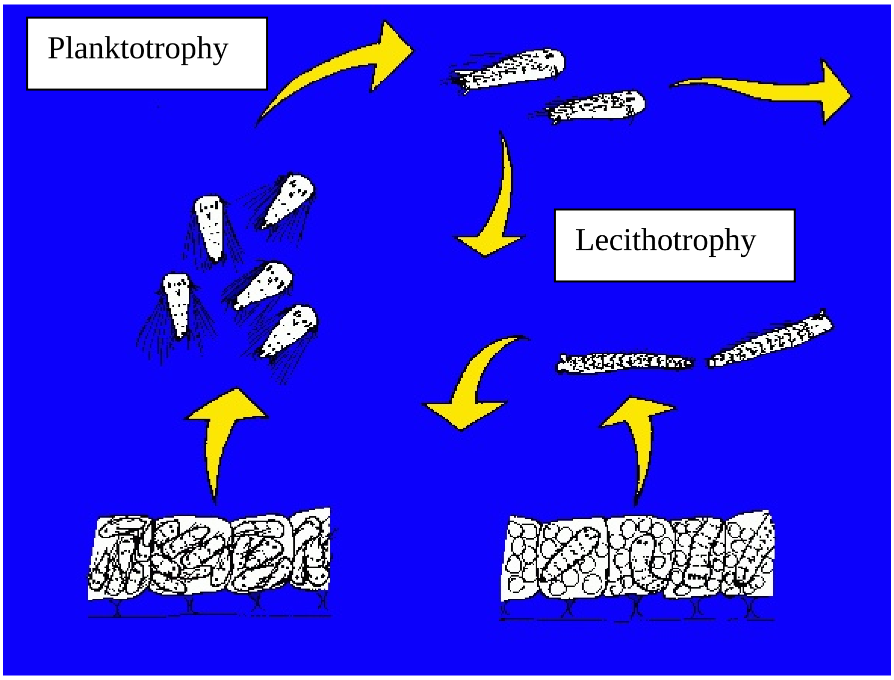


Figure 4. Shows two forms of mudworm larval production (1) Lecithotrophy (2) Planktotrophy

<u>Reproductive strategies</u>

Knowledge of mudworm reproductive strategies can be important in understanding the dynamics of infestations in shellfish culture systems. Planktotrophic individuals exhibit high population growth due to their fecundity advantage (ie. greater numbers of larvae), and wider powers of dispersal in the plankton, whereas, Lecithotrophic individuals have greater survivorship advantage, and have greater localised population explosions in areas once colonised.

Spionid boring mechanisms

It was once thought that Spionid boring mechanisms were resultant from abrasion from their specialised 5th setiger spines (as detailed in figure 6). However, recent experiments where spines have been removed, and microstructure of the burrows examined indicate shell dissolution results from metabolic acids produced by spionids, therefore providing significant evidence of entry into the shell by boring.

Blisters that are produced by the oyster can be constructed by either conchiolin (figure 1) or periostracum- like material which can be overlain by calcareous shell material. The conchiolin material is impervious to the acids produced by the spionid species and can also contain higher than ambient levels of iron, zinc and manganese which are thought to act as a defensive buffer against the blister.

Feeding mechanisms

Spionids are mostly deposit feeders, meaning they use their two palps (tentacle like structures, figure 5) to pick up sediment from the substrate around their burrows. Smaller species can be planktonic feeders. The worm extends its palps out of it's burrow and waves them around in the water column, or orientating palps in relation to water currents to collect its food. Food passes down the ciliated groove on the palps and is passed to the peri- and prostomium, then ingested. These worms are not true parasites and don't actually eat the oyster meat, but just use the oyster shell as a place of residence.

METHODS FOR SAMPLING, PRESERVATION AND IDENTIFICATION OF MUDWORM SPECIES

Five scientists from the South Australian Aquatic Science Centre, Primary Industries and Resources, South Australian Oyster Research Council & Flinders University assisted in the sampling, preservation and identification of natural South Australia mudworm species. The concept of inviting SA scientist to assist with identifying mudworm was to develop the skills & knowledge of those who participated, so that SA would have the capacity to extract and identify mudworm in the future.

To gain a representative sample of natural mudworm species in South Australia, thirty infested oysters from major growing areas were collected. Stansbury, Port Broughton, Cowell, Coffin Bay, Streaky Bay, Smoky Bay and Denial Bay provided infested oysters for identification purposes. Oysters were couriered to the SARDI aquatic science center in Adelaide, a day before the identification workshop for preparation prior to mounting on slides. To preserve the mudworms they were transported on ice, packaged in zip-lock bags to prevent fresh water from coming in contact with the shells.

Sampling spionid worms is restricted by the need to sample the host and then sample the worms in their host's shells. The use of vermifuges (an agent used to expel worms) has proven to be more efficient at removing worms from oysters than dissecting the shells. Vermifuges can be used to measure the frequency of spionid species within the oyster populations, whereas dissection of fresh shells is a more effective way to gain fine detail when identifying difficult species or new species. Crystalline phenol was the vermifuge used to exact mudworms from oyster shells in this experiment, but dissection was also performed. A dissecting procedure was implemented by carefully breaking the mudblister apart with needle nose pliers to find the mudworm, then removing it with forceps and mounting on a slide in glycerol. When using vermifuges, the worms that are identified are not necessarily blister forming species.

If specimens are not dead, they can be relaxed with Magnesium Chloride ($MgCl_2$) to provide better mounts when counting and identifying, alternatively 2-phenoxyethanol can be used as a relaxant. After the worms were removed they were fixed in 10% neutralized formalin (borax) in seawater and left in formalin for 24 hours to fix. They were then transferred to 70% isopropyl alcohol after washing to remove salt which makes the mudworms crystallize. It is important not attempt to use ethyl alcohol as a fixative! Post fixation with formalin of material fixed in alcohol does not work! Fauchild (1977) preservation techniques were used to preserve worms for identification purposes in this study.

Specimens can be viewed as whole mounts in water under a dissecting microscope, they can also be stained with vital stains to increase their resolution. Permanent mounts can be made with various proprietary products. An easy method is to temporarily mount specimens in glycerol which is miscible in water or alcohol, so specimens can be transferred after washing from formalin, or from storage in ethanol. To save time and costs several specimens can be mounted together beneath the same cover-slip. All specimens were whole mounted on standard slides and examined under dissecting and compound microscopes.

General Morphology- below is a diagram representing the hypothetical morphology of spionids.

The hypothetical Spionid:

Body elongate

Almost cylindrical x-section

Anterior regions usually widest

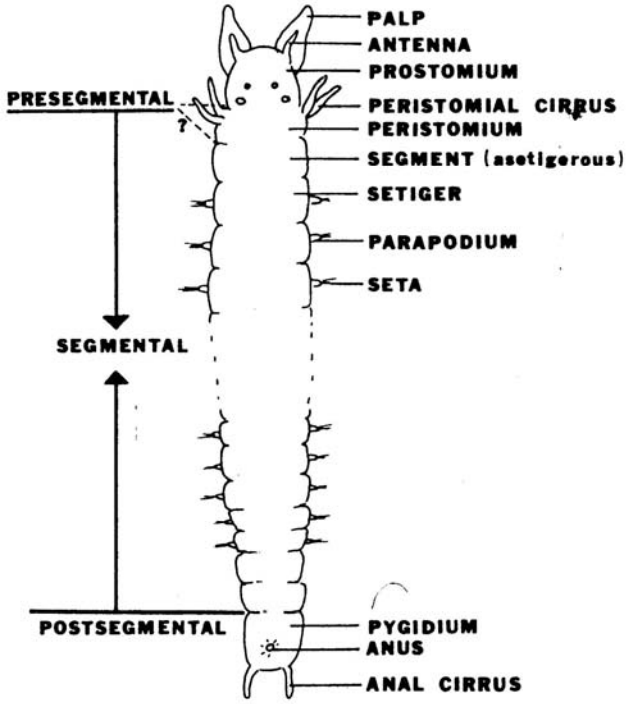
Body tapering

Numerous segments

The 5th segment is mostly modified

Parapodia have noto and neuropodia

Ventral nervous system



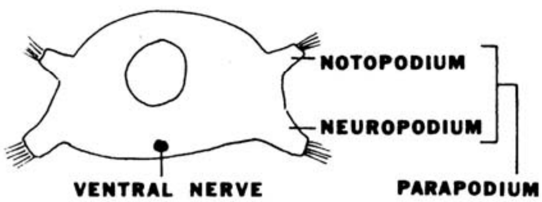


Figure 5. Spionid General Morphology

Diagnostic features- below is a list of the common diagnostic features used to identify spionids from South Australian infested oysters.

Diagnostic features
<u>Anterior</u>

Setiger 1

Setiger 5

Branchiae

Hooded hooks

Hooded hook structure

Pygidium

<u>Posterior</u>

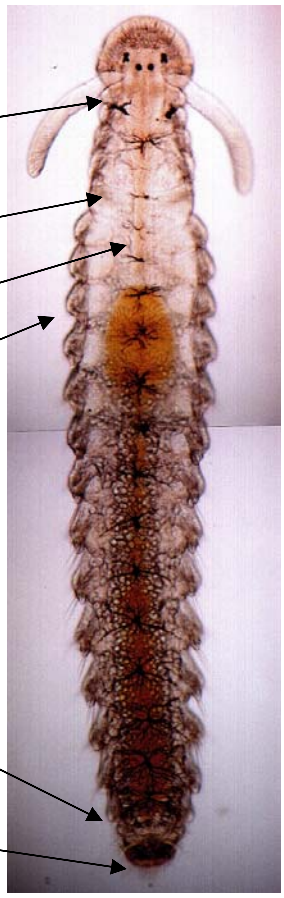


Figure 6. Diagnositic features

All diagnositic work undertaken was referenced to "The spionidae (polychaete) from Southeastern Australia and adjacent areas with a revision of the genera (Blake & Kudenov 1978)." This paper provided a guide that was referred to when working through the diagnositic features to identify the species of worms extracted from South Australian oysters. Light's (1978) manual was also used as a reference to diagnostic features for the identification of natural mudworms in South Australian pacific oysters.

SURVEY RESULTS

Through the survey process approximately 120 worms were identified from 137 sampled oysters, but not all worms extracted from oyster shells were examined. Oyster samples were taken from seven different South Australian oyster growing areas. The results from the survey are outlined in table 1.

Species	**Streaky Bay**	**Cowell**	**Smokey Bay**	**Coffin Bay**	**Port Broughton**	**Stansbury**	**Denial Bay**
Number of oysters sampled	28	25	8	24	18	30	4
Boccardia polybranchia			1	12+	1		1
B. proboscidea cf.[1]	13+		1	1	1		
B. chilensis	2		6	16+		4	
Polydora websteri				1			
Polydora websteri cf.						1	
P. latispinosa cf.[2]	3	9	4		7	4	2
P. haswelli				1			

Notes:
1. Habitat description does not support this species, but notosetae present and prostomium is not incised so it is not *B. polybranchia*
2. Constriction of hooded hooks varies markedly between individuals, anterior notosetal spines not in packets – could be *P. vulgaris* not previously described in SA or other *P. websteri* look-alike

Table 1. Mudworm species identified through a survey of infested oysters from seven South Australian growing areas.

Dr Geoffrey Read from the National Institute of Water and Atomspheric Research (NIWA) in New Zealand verified some results of mudworm sampled from Coffin Bay, Streaky Bay, and Port Broughton. These results include;

1) *Coffin Bay SA, 28 May, 2003, vial label identified as P.websteri and P. haswelli.*

Vial had 3 specimens: Two of which were *P. websteri*, and 1 undescribed species which was named 'coffin-streaky'. This species might be *P. woodwicki* of Blake & Kudenov (spines, pigment, short caruncle), which was desc from a single damaged (prob. regen pyg) specimen from Haliotis ruber. It didn’t match the c5 penicillate (geniculate B&K) notochaetae of that species.

2) *Streaky Bay, SA, 25 May, 2003, vial label identified as Polydora cf. latispinosa.*

Worms displayed were a mix of *Polydora websteri* (incl. palps with groove pigment line) and Polydora 'coffin-streaky' undesc.

3) *Port Broughton Bay, SA, 25 May, 2003, vial label identified as Polydora cf. latispinosa*

Species were identified as *Polydora websteri* only.

4) Streaky Bay, SA, 25 May, 2003, vial label identified as Boccardia proboscidea.

The mudworm was confirmed as *Boccardia proboscidea*. This species is very robust making it difficult to mistake it for any other species. These have recently been found in New Zealand paua, they are not true boring species but definitely create grooves in the shell with a mud tube roof, and possibly occupying abandoned tubes of other species.

Polydora latispinosa and *Boccardia polybranchia* wasn't viewed, therefore these to species were not assessed. Dr Read didn't recognise Blake & Kudenov's invented concept of *B. polybranchia* Haswell, which was probably *Boccardia chilensis* or it could possibly be *B. wellingtonensis*? *B. wellingtonensis* does have a small notopodium on c1 (fide Sato-Okoshi and Takatsuka 2001, correction of Read 1975).

Future Direction

Mudworm are present in each and every oyster growing bay, once they are given the right opportunity to infest oysters stocks, they will and they can be very damaging. Below is a list of potential further investigation strategies for mudworm research in SA, these include;

- Identifying problematic mudworm species causing mudblisters
- Investigate their lifecycles with special emphasis on the breeding cycle by routinely inspecting stock for the presence of eggs and fresh infection.
- As a potential extension to farmers about their growing level – test the effects of lowering the level with regards oyster growth and mudworm infestation
- Determine the optimum intertidal level in SA:
    - For avoiding mudworm infestations
    - Maximizing growth and condition
    - Can growing at the optimum level solve your problems, even in hot weather?
- Determine if heat stress is an issue- and model critical conditions to avoid
    - Use real-time temperature probes and tide gauges possibly utilising telemetry methods to tell growers when they need to drop their level
    - Or predict critical periods based on seasonal weather/climate forecasts
- Test the "Tonkin method" for each growing area
    - Is there a critical time that freshwater dipping can have a mafor impact on infestations and stop mudworms getting a foothold over summer?
- Investigate ecology of problem mudworms
    - Look for weak points in their life-cycle
    - Dispersal distances, planktotrophic vs lecithotrophic etc.

INDUSTRY WORKSHOP

Key note speakers, Dr Sean Handley & Dr Sebastian Rainer, presented on mudworm at a growers workshop held on 29th May, 2003 at the Port Lincoln Spencer Institute of TAFE. Approximately twenty five oyster farmers attended the workshop, positive feedback from growers suggested that greater awareness of mudworm ecology and general management techniques had been transferred to industry. Results from the survey were presented, general interactive discussion was held among the participants regarding future investigative work required to understand the life cycles of problematic species and the development of specific management techniques that could be used to break their life cycles.

MANAGEMENT TECHNIQUES

<u>Prevention</u>

The clear message is that mudworm prevention is much better than a cure. Dr Handley stated, "Once the horse has bolted out of the paddock it is very had to get back in". It is much easy to prevent mudworm infestation through oyster farming methods than it is to cure, once all your stock is infested, also prevention is much less expensive.

Generally it would be acknowledged that the main management control for mudworm is growing height. Mudworm thrive in areas where there is protection and food, this is most commonly found when growers reduce their growing height to gain extra growth. Dr Handley conducted various studies on growing height and the effects on mudworm infection, growth & condition in northern New Zealand. He identified that Extreme Low Water Neap (ELWN) (figure 6), or the highest of neap tides was the best position to grow oysters to avoid mudworm infection (See figure 5). Further studies conducted showed that ELWN provided the best oyster growth, condition, shell density and least larval blister formation (figure 7).

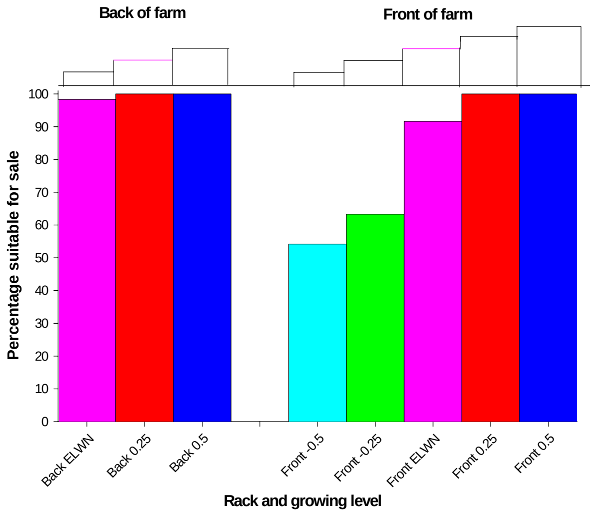


Figure 5. Shows the percentage of oysters suitable for sale in the half-shell at five different heights, oysters unsuitable for sale were caused by mudworm blisters (Handley 2002).

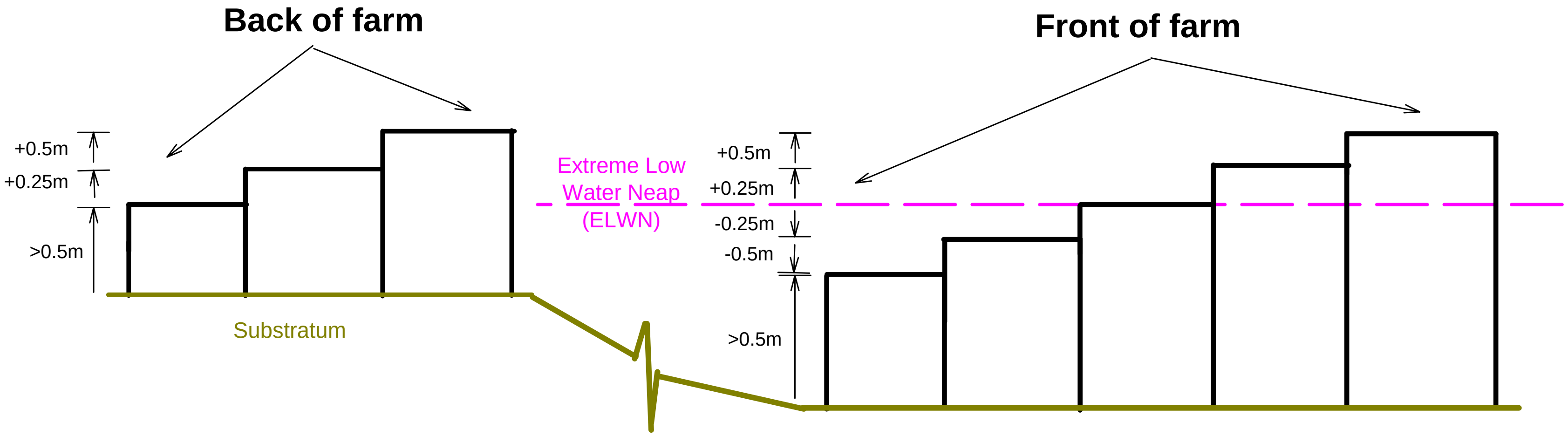
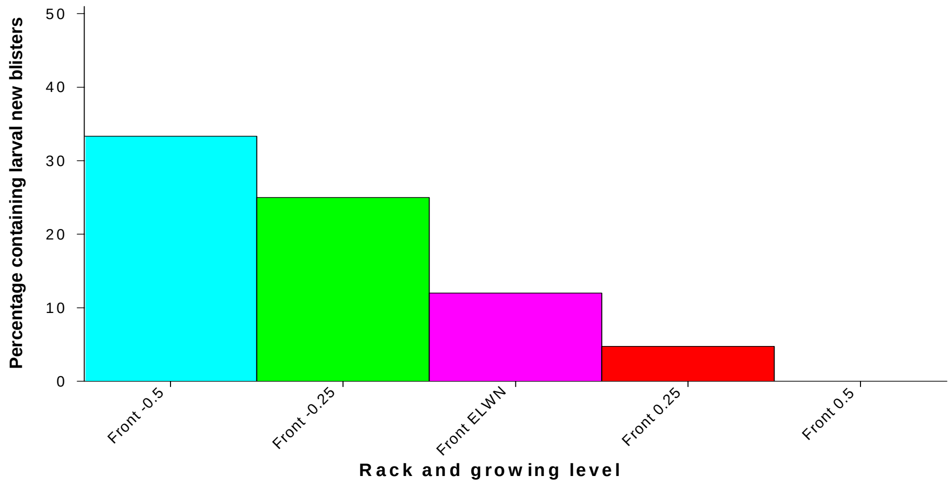
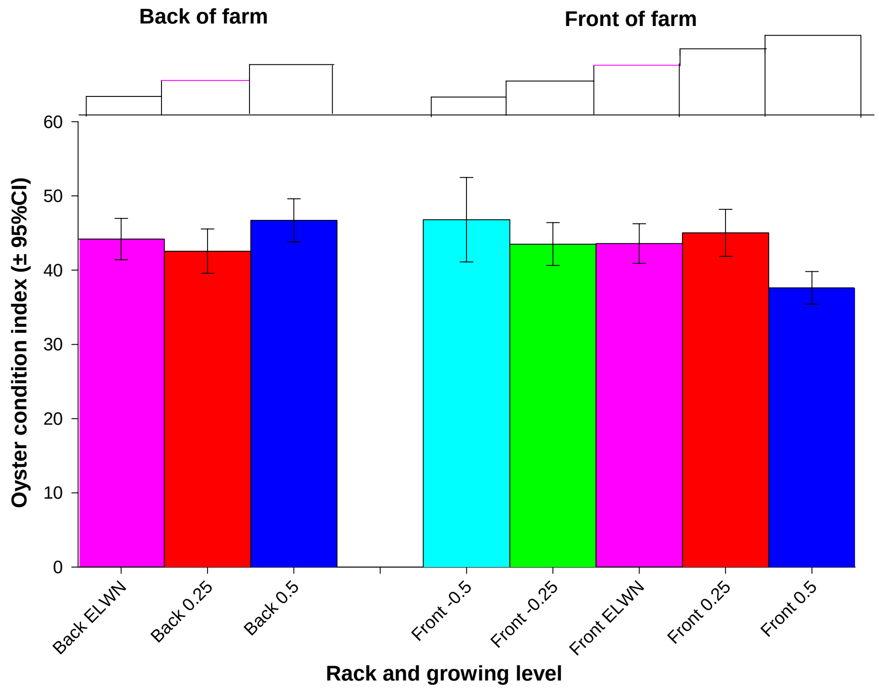


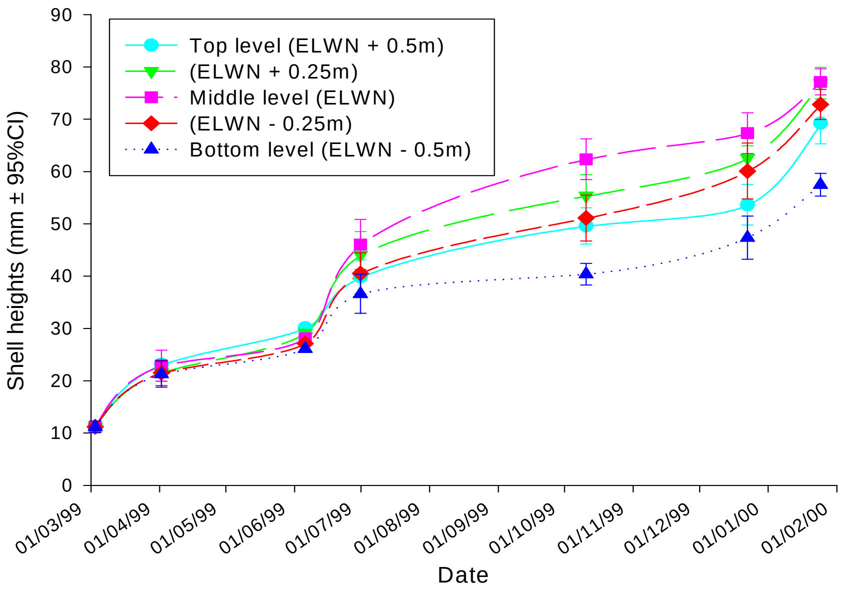
Figure 6. This diagram shows the experimental design used by Dr Handley to determine the best height for culturing pacific oysters in New Zealand (Handley 2002).


Percentage containing larval new blisters
50
40
30
20
10
0
Front -0.5
Front -0.25
Front ELWN
Front 0.25
Front 0.5
Rack and growing level

(a)


Back of farm
Front of farm
Oyster condition index (± 95%CI)
60
50
40
30
20
10
0
Back ELWN
Back 0.25
Back 0.5
Front -0.5
Front -0.25
Front ELWN
Front 0.25
Front 0.5
Rack and growing level

(b)



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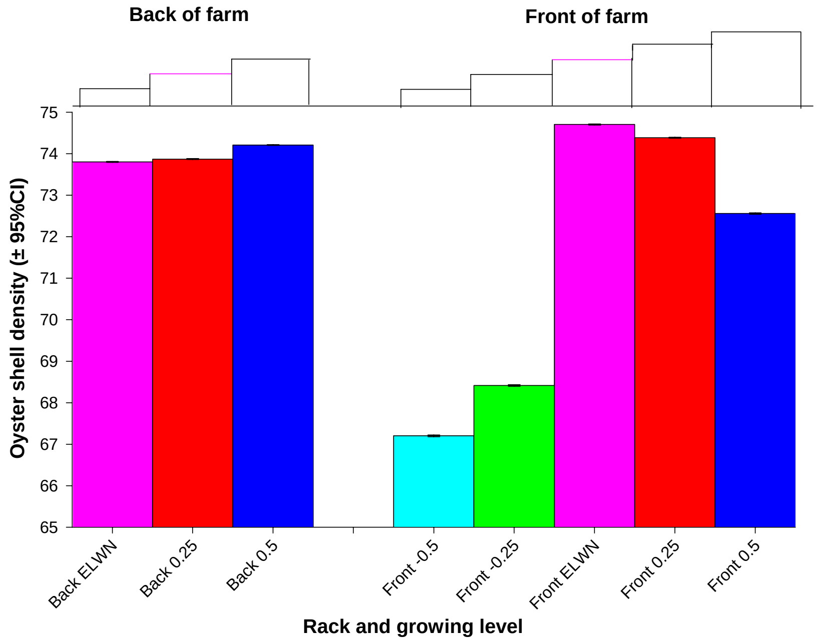

(d)

Figure 7 (a) Percentage of oysters containing new larval blisters from the front and back row. (b) Mean dry weight condition index of oysters from front and back row. (c) Growth rates of oysters at different heights (d) Estimates of oyster shell density from front and back racks, Houhora Harbour, January 2000 (Handley 2002)

		Back rack	
	ELWN	0.25	0.5
Oyster growth	5	3	1
Mudblisters	2	3	3
Oyster condition	3	3	3
Shell density	2	2	3
Total	**12**	**11**	**10**
	☺		

			Front rack		
	-0.5	-0.25	ELWN	0.25	0.5
Oyster growth	1	3	5	5	2
Mudblisters	1	2	3	5	5
Oyster condition	3	4	4	4	5
Shell density	1	1	5	4	3
Total	**6**	**10**	**17**	**18**	**15**
				☺	

Table 2. These tables summarise figure 5 &7 and clearly show that ELWN and just above is the best height for growing oysters to avoid mudworm infestation and it also provided the best oyster growth, condition and shell condition (Handley 2002).

Studies completed by Handley in 1992 & 2000 clearly show that the optimal methods to avoid mudworm infestations include; (1) keeping oysters at ELWN and above, (2) avoiding lowering oysters to boost growth as settlement of spionids increases below ELWN. The work also demonstrated that condition of oysters, didn't significantly differ between tidal levels, suggesting no advantage in dropping oysters below ELWN to increase growth or condition (table 2). Another finding of having oysters at ELWN was that oysters had an increased shell density, which in its self would reduce mudworm infections (table 2).

Given all the information above, ELWN may not be suitable height in South Australian conditions due to difference in our tidal system, "dodge tides" and extreme temperature range. But, it is evident that height is the critical management tool for preventing mudworm infection and further work may be required to experiment with height and mudworm infections in South Australia, similar to the work Dr Handley conducted in New Zealand.

<u>Cure</u>

Whilst it is always better to try to prevent mudworm from getting into the oysters than getting rid of them, some methods have been tried and success has been achieved to some extent. These include;

- Hot water dips (3 seconds at 80ºC)
- Freshwater plus detergent dips (the effectiveness and length of the dip depends on the mudworm stage of development)
- Supersaturated brine solutions and drying out periods

- "Tonkin method"
    - Kill juvenile mudworm before they are too difficult to control. When oysters are graded, they should be left in a bath of freshwater and detergent overnight
    - If the oysters are growing at the correct level a majority of infestations will be prevented. Dipping need only occur during periods of hot weather when oysters are more susceptible to infestation.

All the treatments work to some extent, but fresh water dipping is by far the easiest treatment and generally most effective. Freshwater dipping for a few hours works well at times, but if the water doesn't penetrate into the mudworms borrow the effectiveness is very limited. Dipping more mature worms may require freshwater baths between 24 & 48 hours.

Once the mudworm has been destroyed, the oysters are still left with the legacy of the blister, which need to be grown over before the oysters are suitable for the "half-shell" trade. This can be achieved, but if the infection is too severe the oysters probably should be discarded.

<u>South Australian oyster growing conditions</u>

The conditions in which oysters are grown in South Australia are much different to all other oyster growing areas in Australia and the world. Due to higher salinities and lower nutrient levels in SA, Pacific oysters' growth rates are often lower than those recorded in other countries. In South Australia the grow-out period is between 2-3 years compared to a 12-18 months in New Zealand, therefore the prolonged growout time gives oysters greater exposure to mudworm infestation from older oysters, therefore increasing likely-hood of infection. In SA there are generally fewer feral oysters and therefore the sources of re-infestation may be from other shellfish, for example, flat oysters (*Ostrea angasi*), razor fish (*Pinnia spp.*) and scallops (*M. asperrimuss, E. bifrons, P. fumatus)* etc. But, if infestations are rife in an area, then your oysters, or your neighbours oysters may be the source of re-infestation, which means the problem is an industry wide issue.

The water temperature is much higher on average compared to New Zealand and Tasmania, and could potentially inflict greater heat stress upon the oysters. Whilst the belief that lowering your oysters in summer can reduce heat stress, it has been noted that SA oysters become acclimatized to the warmer temperatures and holding them up is probably the best method as it is likely to kill the mudworms and reduce larval settlement.

Three main growing systems are used in South Australia, they include;
- BST/adjustable basket system
- Rack and rail pillow basket system
- Hybrid system using adjustable pillow baskets

SUMMARY / DISCUSSION

The survey only touched on the edge on the mudworm issue in South Australia. The confusion over the identification of some of the South Australian mudworm species highlighted the need for more investigative work in this area.

Through the natural mudworm survey, SAORC were expecting to uncover the same species that had been identified in the past. This was not the case, with a new species discovery, presently named *Polydora 'coffin-streaky' undescribe*. A number of other species where identified, these included; *Boccardia polybranchia, B. proboscidea cf., B chilensis, Polydora websteri, P websteri cf., P latispinosa & P. haswelli.* A number of these species were different from previously recorded species; this raises concerns and questions regarding the problem species in SA.

Mudworm infestations vary from year to year for reasons not fully known, but it could possibly be assumed that environmental factors play a large role. Comments from experienced oyster growers indicate that in a hot summer, if the oysters are exposed, the infestation levels are quite low in the following winter, whilst during a mild summer at the same height the mudworm infestations can be much more prevalent.

Height would be considered the best management method for controlling mudworm infestations on the farm; this is very much supported through the extensive research conducted by Dr Handley. Future research could be conducted in tandem with stress testing to determine if raising the level of oysters at certain times of the year to reduce mudworm infestations affects their health.

SAORC would like to expand on the current work to identify the species causing the blisters in various SA oyster growing areas and understand enough of their life cycles to recommend effective control strategies. Then management techniques suitable to the grower can be developed, ultimately giving growers the methods to farm oysters without the financial burden of mudworm infestations.

ACKNOWLEDGEMENTS:

This report is based on the notes and information provided by Dr Sean Handley. SAORC would like to thank Dr Sebastian Rainer for his assistance with mudworm identification and valuable input at the growers' workshop.

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