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Prawn industry black spot management: problem size and appropriate research

Steve Slattery and Dr. Richard Musgrove

PROJECT 2008/793

AUSTRALIAN SEAFOOD COOPERATIVE RESEARCH CENTRE

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Prawn industry black spot management: problem size and appropriate research

by

Steve Slattery* and Dr. Richard Musgrove#

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TABLE OF CONTENTS

Non-Technical Summary

2008/793 Prawn industry black spot management: problem size and appropriate research

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OBJECTIVES:

1 To determine the significance of melanisation (black spot) in prawns to producers and processors

2 To assess the need for further research on metabisulphite dipping and on the development of a dip meter

3 To assess the need for further research on 4-hexylresorcinol dipping.

NON TECHNICAL SUMMARY:

The black spot issues vary with each fishery. Sodium metabisulphite is the chemical of choice for the wild prawn fishing industry. There are many different ways this chemical is applied but industry does not always have the confidence that they are using it effectively. There is a need for further research and development in relation to sodium metabisulphite use by fishers and processors. Key areas include:

1. The most appropriate dipping regimes to use for specific operations.
2. Effective use of the dip to maintain consistent residues through increasing dip times for bulk dips and/or
3. A dip meter to monitor solution concentrations and inform decisions on appropriate dipping times, when to top-up and when to dump.

KEYWORDS: **Prawns, black spot, chemical treatment**

Acknowledgements

The researchers would like to thank the members of the Australian Prawn fisheries for the provision of their prawn handling practices and issues about black spot conditions experienced during their operations.

Background

Projects on improvements in black spot management and the development of a metabisulphite meter were supported by Industry representatives at the Australian Council of Prawn Fisheries R&D Planning and Consultation Workshop held in Brisbane from the 25th to the 26th of March 2009.

The board and associated members identified that the issues of irregular black spot rates and chemical residue levels needed to be resolved for there to be an improvement in product acceptability. The Program Manager of the Seafood CRC indicated that a scoping study of industry black spot treatment methods would be necessary to further clarify the Australian Prawn Industry position as a whole with regard to research on these topics.

This project comes under the Australian Seafood CRC Program 2: “Product Quality and Integrity” and contributes to the agreed outcome: Increased access to premium markets through fulfilment of consumer demands for safe, high-quality, nutritious Australian seafood.

Need

The ACPF workshop identified the R&D Priority 2 – Quality Assurance Action item "Black spot project to be developed by SARDI/QDPI, in conjunction with the CRC". There is a need to better define the issues surrounding the effective use of metabisulphite by the Australian Prawn Industry, and to refine the associated research requirements. This relates specifically to the reduction in dip effectiveness with successive dips and the development of on-boat dip concentration meter – a “metameter”.

Objectives

1. To determine the significance of melanisation (black spot) in prawns to producers and processors
2. To assess the need for further research on metabisulphite dipping and on the development of a dip meter
3. To assess the need for further research on 4-hexylresorcinol dipping.

Methods

A questionnaire was developed by Steve Slattery, Richard Musgrove, Bob Flemming and Paul Graham for industry to complete. Interviews were conducted mostly in person or by phone with wild capture prawn industry members in Bowen, Townsville, Cairns, Hervey Bay, Mooloolaba, Brisbane, Brunswick Heads, Ballina, Yamba, Maclean, Sydney, Adelaide, Port Lincoln, Darwin, Perth, Fremantle and Geraldton A copy of the questionnaire can be seen in Appendix 3. The data were collated and sorted for percentage of particular response and range of answers.

Results/Discussion

The wild prawn capture industry is under increasing competition from imported and domestic aquaculture product. While consumers perceive wild caught local prawns as a tasty food item they have a reputation of being of varying quality. One main defect is the frequent occurrence of black pigment on the head and tail surfaces.

Black spot is a preventable condition related to the physiology of the prawn. The enzyme polyphenol oxidase attacks the building block of the new cuticle (tyrosine) to make the pigment known as melanin (Nickelson and Cox 1977). This enzyme is affected by temperature and needs oxygen, UV light and copper ions to function. A number of different chemicals have been approved by FSANZ for use on prawns to prevent this chemical reaction from occurring: sulphur dioxide and sodium and potassium sulphites; ascorbic acid and sodium, calcium and potassium ascorbates; erythorbic acid and sodium erythorbate; citric acid and sodium, potassium, calcium and ammonium citrates; and 4-hexylresorcinol. Only the sulphites have residue standards to comply with.

Most of the prawn industry applies these chemicals using a quick dip. Sodium metabisulphite is the most common chemical used but there are products which also contain a mixture of the above. It is the amount of residue that is present in the prawn flesh that prevents the formation of melanin. The problem with using a short term dip in a chemical solution is the limited uptake of chemical to where it is need to provide this inhibition.

Individual fishery conditions

To help understand the differences in the responses to the questionnaire about their black spot issues, an understanding of the fishing operations in the various fisheries is required.

NSW Trawl

This is a sector of the East Coast Trawl fishery which targets school and ocean king prawns but will also catch other species occasionally. Most trawlers fishing in the northern NSW region are without freezer equipment and go to sea for only short periods of time, one to two nights at the most. The vessels use ice slurry or refrigerated seawater. Because of the markets supplied, the majority of catch is cooked at sea. If there are good catches of large prawns some of these are kept uncooked and unloaded without any treatment using a black spot retarding chemical. There are a few fishers who do dip in either sodium metabisulphite or Everfresh or soak in Everfresh but these latter operators market their own prawns as well as unload to the local Cooperative.

The untreated product may then be treated with a chemical at the receiving processing facility depending on the storage age intended for the prawns but they may also be shipped to Sydney untreated due to the short delivery time. Prawns are infrequently frozen for later sale but these may also be treated before freezing. When a chemical treatment is used it is usually a dip in either sodium metabisulphite or Everfresh using the recommended conditions.

Moreton Bay Trawl

This sector of the East Coast Trawl fishery is limited to Moreton Bay where a specific licence is required. It operates similarly to the NSW Trawl and a mix of species is usually caught. The trawlers tend to use refrigerated seawater or ice slurry to hold their catch and most prawns are dipped using sodium metabisulphite or with small amounts placed in the holding refrigerated seawater. Trips are usually of short duration as there are weekend closures for this fishery. Some fishers do not dip their prawns as they are cooked soon after capture.

SE Qld Trawl

The vessels operating out of SE Qld ports fish for a mix of species and have a range of holding conditions. The deeper water boats have freezing facilities and return most of the catch in this condition. The majority of product is dipped using sodium metabisulphite. Some NSW based vessels also have licences to fish in Qld waters. Comment by many fishers noted that king prawns are prone to black spot in certain areas and times of year. This condition could be due to the fact that these prawns are coming from deep water and therefore are of much lower temperature. When landed on a hot deck in summer the increased temperature rapidly mobilises the enzymes involved in development of the black spot pigment.

North Qld Trawl

Vessels operating out of Bowen, Townsville and Cairns fish the East Coast up into the Torres Strait and some fish Gulf waters. These vessels all have freezing equipment and dip their prawns in a solution of sodium metabisulphite prior to grading and freezing.

Only a limited number use Everfresh. When this chemical first became available here it was trialled by many within the industry but was considered ineffective. After obtaining descriptions of how it was prepared and used it became apparent that the contents of the Everfresh sachets were tipped into cold water. This compound has solubility difficulties below 15°C and should always be first dissolved in small volumes using seawater or room temperature tap water above this temperature before being diluted with chilled water or ice; or made up in warm water and then chilled directly. Once dissolved, the compound will stay in solution and provide black spot protection as supported by the residues described in the Everfresh soaking paper (Slattery et al, 2009).

Gulf Trawl

This fishery is dominated by factory trawlers which freeze all of the catch. The vessels can get very large catches when banana prawns are the target. Usually the freezing equipment is very efficient but it can be almost impossible to process adequately these large catches in a short time to ensure good quality when thawed. In these conditions the prawns are kept in the landing hopper, covered with ice if available and treated with sodium metabisulphite there. Usually with smaller catches there is no chemical present in the hopper water.

Western Australia

Vessels operate in defined fisheries from several Bioregions off the WA coast, such as the Mid-West Trawl (only small catches are made), Shark Bay, Exmouth Gulf, Onslow, Nickol Bay and Kimberley managed fisheries. All vessels licensed to operate in Western Australian prawn fisheries and some Northern Prawn Fishery vessels are licensed to operate in the Kimberley prawn fishery but very few do. A variety of prawn species are caught, including bananas, endeavours, tigers, brown tigers and western kings. The most abundant targeted species varies with fishery; bananas dominating in the north and western kings in the south. The great majority of vessels use a sodium metabisulphite dip; a few use melacide. Prawns are generally snap frozen uncooked (i.e. green) although there is one fresh (i.e. not frozen) prawn operation. Blackspot is generally more of a problem with high volume "boil"–forming species (i.e. bananas) than with grazers/burrowers (eg, tigers, western kings).

South Australia

Gulf St Vincent

Vessels operate out of Adelaide on short trips catching western king prawns exclusively. Prawns are usually not dipped, although there is one operator who does, using melacide. The catch is brought back in ice slurry, to be cooked on-shore the same day.

Spencer Gulf

Vessels operate out of Port Lincoln on longer trips, a few days either side of the new moon each month, again targeting western king prawns. The majority of the catch is dipped in sodium metabisulphite, then blast frozen green at –30°C (or below). Once frozen the catch is stored at -25°C. Prawns in excess of immediate handling capacity are stored in refrigerated seawater until processed (Thomas et al, 2003).

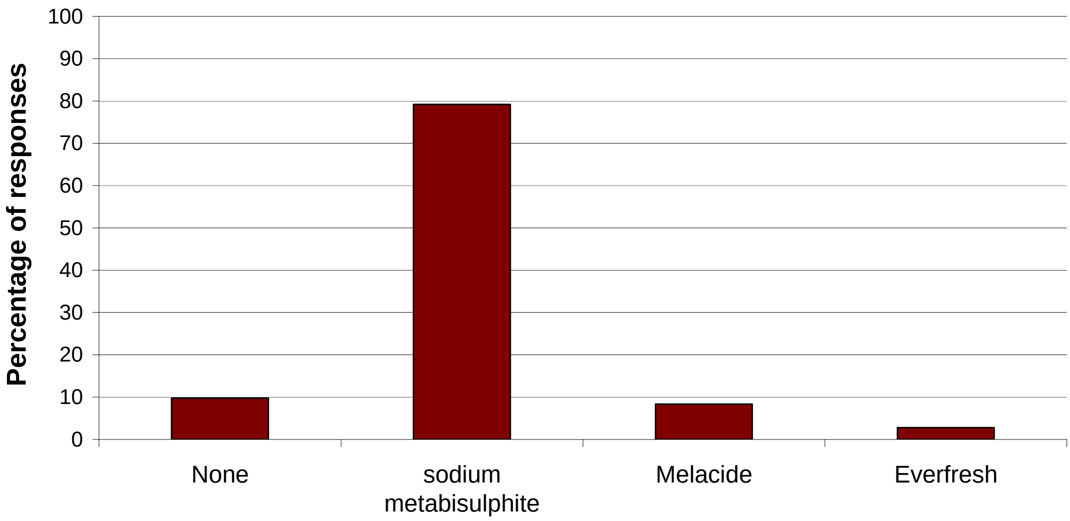
Answers to the questionnaire

A total of 69 interviews were conducted which represents nearly twice the original number designated. The graphs show the percentage of the total responses received for the answer or comment that each interviewee provided. Obviously if the fisher or processor did not use chemicals then the majority of the questions were left unanswered.

Section A Black spot and it's treatment

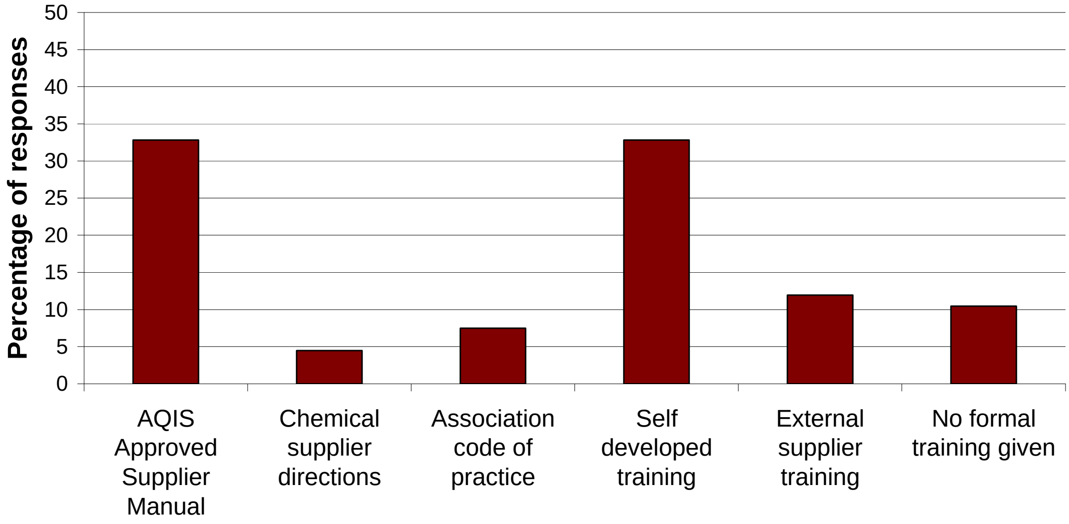
The following graphs present the percentage of the responses recorded.

Figure 1. Question A1: What chemical/product do you use to prevent black spot?



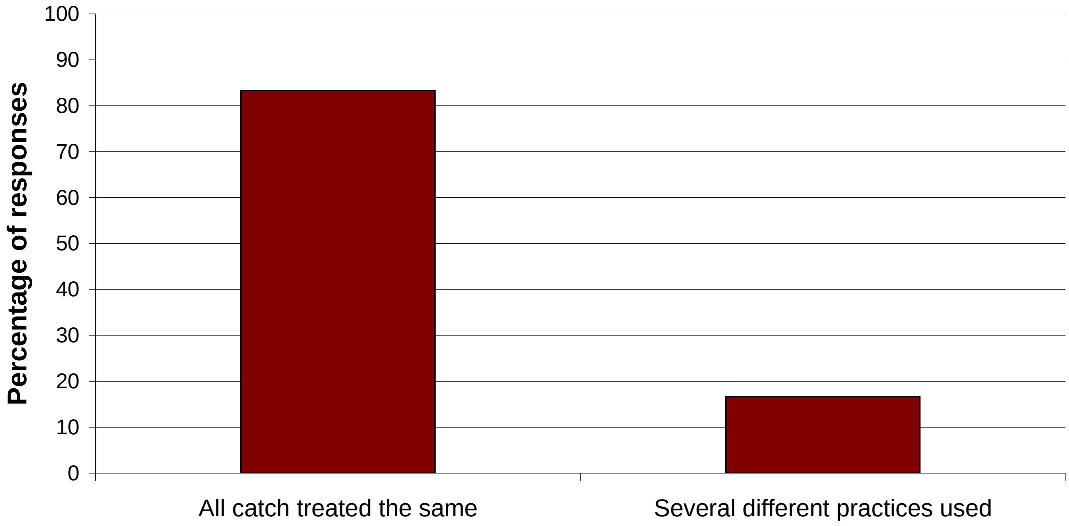
The most commonly used chemical for the prevention of black spot is sodium metabisulphite. This could be expected as sodium metabisulphite is the cheapest chemical to use as a dip. The other two chemicals which are applied by just a few fishers are Melacide, which is another form of sulphiting agent, and Everfresh. The former was not used on the east coast. Within some of the company fleets there was predominance of sodium metabisulphite use with usually only one boat using Melacide. It is unclear whether the use of Melacide would increase within these companies.

Figure 2. Question A2. What training methods/manuals do you use for crew on how to prevent black spot?



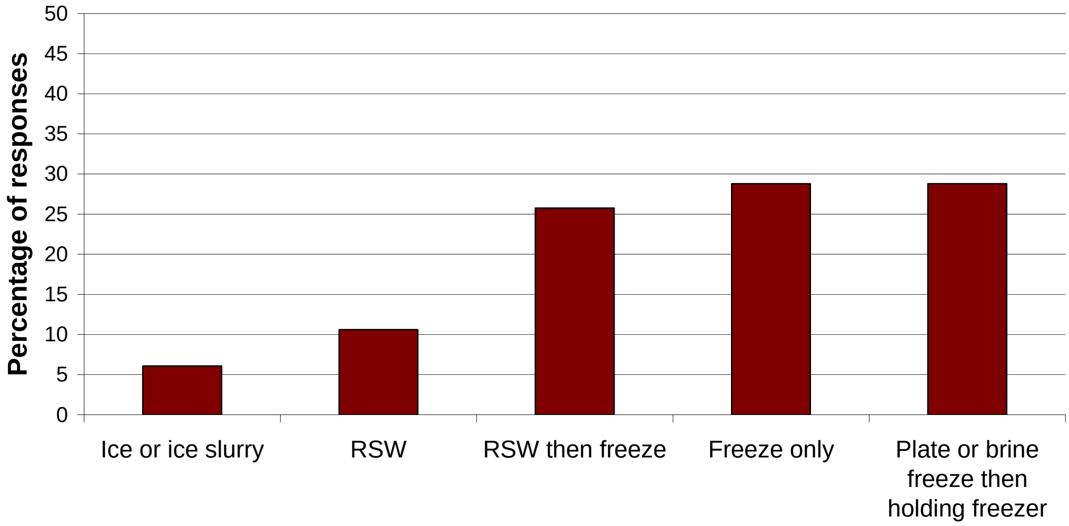
The majority of fishers have training manuals for their staff on how to process their catch. If they pack their prawns for export then this would be an AQIS Approved Supplier Manual. While domestic suppliers do not have this requirement most have developed in-house training manuals or used those supplied by their commercial association, chemical supplier or external training provider. Over 10% of operators did not report providing any training to staff but it could be presumed that some of these skippers do give some direction when inducting new crew but do not consider it a formal process that needs a manual. From reading a number of these manuals it is clear that they contain the minimum of procedures and do not cater for those occasions when the procedure may not be adequate to provide the best protection from black spot.

Figure 3. Question A3:Do you have different practices for different species or areas or seasons?



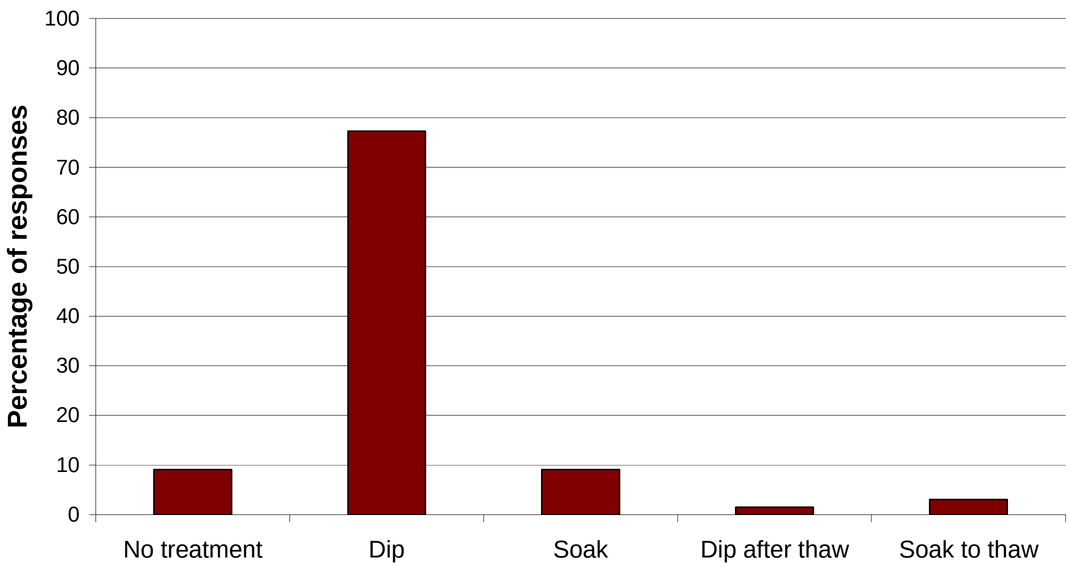
There are a small proportion of fishers who use alternate treatments for special conditions such as particular species and/or large catches. This aspect is important because a variation in treatment concentration and/or time may be needed when the catch becomes difficult to handle.

Figure 4. Question A4: What storage method do you use for dipped prawns on the capture vessel?



As you can see the majority of the catch is frozen at sea. Only the smaller vessels fishing close to port bring in their catch fresh. These quite different storage conditions need specifically designed chemical treatments to ensure the prawns contain an appropriate amount of residue to prevent black spot during later handling.

Figure 5. Question A5: How do you treat the prawns?

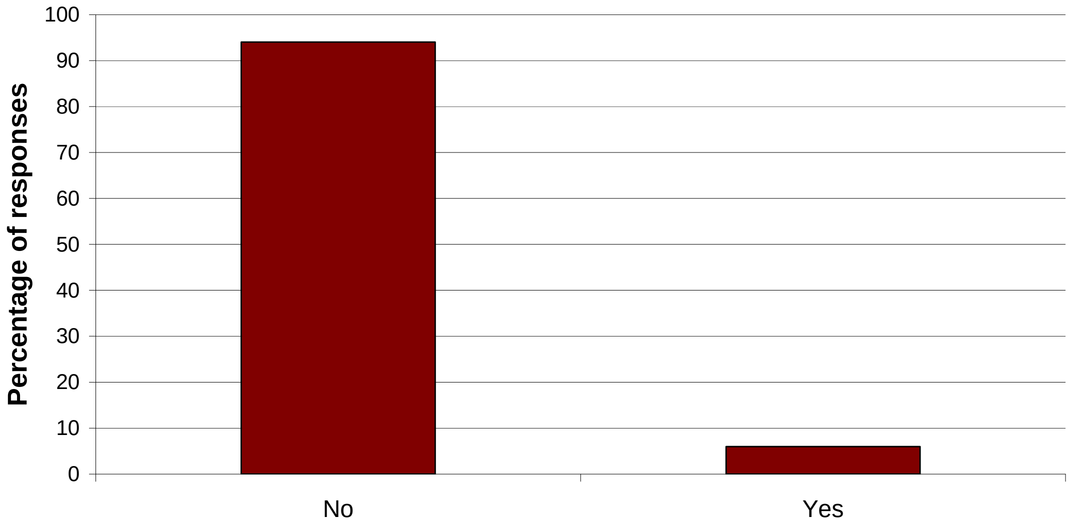


The fishers who cook their catch do not use any chemical. There are also some NSW fishers who unload their catch untreated because they only fish close to port and leave it to the factory staff to add any chemical. The overwhelming majority of industry dip their prawns rather than soak. The main reason given for using a dip is the short time available to sort and grade the catch before being stored as this longer treatment time was only convenient to prawn farmers. Another is that most boats have removed their brine tanks to allow more room for freezing equipment. However, soaking has long been used by prawn fishers as a means of treating their catch. A survey of Queensland prawn fishers conducted in 1988 found that 12.8% put sodium metabisulphite in their refrigerated seawater holding tanks (Slattery and Williams 1988).

When asked whether they would use a longer treatment time the reply usually centred on the issue of no recommended treatment parameters being available. This is mostly true for the use of sodium metabisulphite but when they were told of the finding of the Everfresh soaking experiments (Slattery et al. 2006), the interviewer was often asked for a copy of the extension leaflet (Appendix 5). One NSW fisher was identified who had developed his own soak method using Everfresh independent of this research.

Unless the company is large and can afford the latest in vacuum thawing equipment the majority of prawns frozen at sea are thawed under water. This thaw water can contain a black spot inhibiting chemical but some processors still dip after thawing. Unfortunately there is only limited information on what concentrations to use, but it has found that sulphite levels of 500mg/L were insufficient (Slattery et al. 1991) while Fatima & Qadri (1979) and Reullo & McBride (1976) found a thaw tank concentration of 800 mg/L SO_2 should be used.

Figure 6. Question A6: Do you use multiple chemical treatments before storage of a batch of prawns



Only rarely does industry apply multiple chemical treatments. Large capture vessels working in the Gulf do have multiple treatments. Also the species that come from very deep conditions and thus are very cold compared to the surface water temperature, such as royal reds and scarlets, need to be put into a hopper containing sodium metabisulphite immediately when landed onboard and then treated again before sorting to prevent black spot. This can result in very difficult working conditions for the crew as sulphite fumes build up in the sorting room. Comments from the Eastern King fishers suggest that this temperature difference may also apply to their operating conditions.

To provide industry with a viable multiple treatment method using Everfresh Sandy Woods-Meredith has permitted the release of details of a confidential consultancy he commissioned which will help the above fisheries. The report from this project is present in Appendix 4.

Question A7. How much chemical per volume of water do you use, and for how long do you use it?

Table 1. Chemical treatment methods used by industry surveyed.

Treatment	% of responses
Short dips	
None	10.7
300g/200 L for 90 seconds	1.8
0.5kg/100 L for 3 minutes	7.1
1kg/100 L for 30 seconds	7.1
1kg/100 L for 1 minutes	12.5
1kg/100 L for 1.5 minutes	5.4
1kg/100 L for 2 minutes	14.3
1kg/100 L for 3 minutes	3.6
1.5kg/80 L for 2 minutes	3.6
2kg/100 L for 2 minutes	16.1
2kg/100 L for 3 minutes	1.8
Soaks	
teaspoon/20 L overnight for 10kg	1.8
0.25-0.5cup (67-125g)/40 L for 30 minutes fresh only	1.8
1 Tablespoon/20 L for 20 minutes	1.8
1-2 Tablespoon/800 L for 8 hours	1.8
2kg/200 L RSW/200kg for 10 minutes	1.8
1kg/400 L for 20 minutes and redip at 0.5kg/400L for 30 minutes	1.8
2kg/100 L for 30 minutes	1.8
2kg/500 L for 8 hours	1.8
3kg/250 L for 3-5 minutes	1.8

Table 1 shows there are a great many different treatment methods used by the Australian prawn fishing industry. While many of these methods may result in adequate residues for many fishers unless the same processing procedures, and these do vary from boat to boat, are used it is difficult to recommend any particular one of the above methods. Most have been tested and modified from original recommendations to suit the particular vessel operating procedures.

Only a handful of articles were identified from the literature as pertaining to sulphite resides obtained from dipping prawns (Table 2). Of these only 7 are pertinent or very recent. The data are limited by the fact that, in the US, prawn heads are removed at sea before treatment which will lead to higher uptake. As there are no conversion formulas available, the headless experiments must be ignored for Australian conditions. In some experiments the prawns were prefrozen or washed after dipping and sometimes kept for several days chilled or longer in frozen storage before residue testing.

Table 2. List of authors describing experiments with sulphite residues.

Author	Publication date	Treatment form
Brown	1972	whole
Camber et al.	1957	headless
Edmonds	2006	scampi not prawns
Fatima & Qadri	1979	whole
Faulkner et al.	1953	whole
Finne et al.	1986	headless
Marshal & Otwell	1986	headless
Slattery & Williams	1991	whole
Slattery et al.	1991	whole
Smith	1980	whole
Tsukuda & Amano	1972	whole
Wagner & Finne	1986	headless
Weingartner et al.	1977	headless

While the leaflet by Seafish (2005) and the report by Edmonds (2006) do provide a useful list of alternatives to sodium metabisulphite, the actual details of dosage and dip capacity only apply to scampi (Nephropidae) which are called prawns in the UK. This species has a harder shell and slightly different body conformation (long claws resulting in a larger surface area than Penaeidae prawns) which would result in quite different residues,

There are many things that can affect the final residues obtained. The concentration of the dip solution and how long the prawns were immersed (Smith 1980) and the load that was treated (Slattery et al. 2009) all impact on residue. One important aspect for short term dipping methods is that there is a delay of several seconds at the start of dipping before any residue penetrates the prawn flesh (Smith 1980).

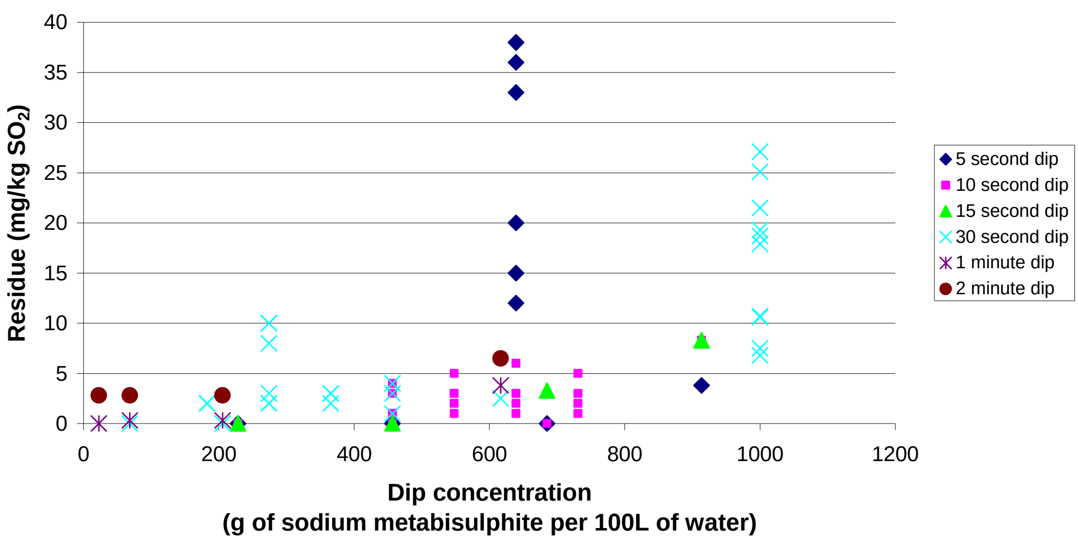
The fisheries that different researchers report on also has an impact: most prawns unloaded by trawlers in the US are deheaded (Camber et al., 1957) and then dipped whereas Australian prawns are all dipped intact. If the prawns were alive when dipped they can have significantly lower residues (Slattery et al., 1991). The size of the prawn treated also has an impact on residue with smaller prawns resulting in higher residues (Tsukuda and Amano 1972). Recently moulted prawns will have thinner shells which allow better uptake of chemicals. Progressive batches of dipped prawns put through a bulk dip will have diminishing levels of residue and thus eventually have little protection from black spot (Slattery et al., 2009) before the recommended capacity.

Washing (Marshall et al., 1986), ice storage or refrigerated seawater storage (Tsukuda and Amano 1972, Finne et al. 1986) after dipping will reduce residues remarkably. Drainage times, such as those usually encountered during grading, which are shorter than 5 minutes before freezing occurs, will result in residues in excessive of 100mg/kg while those longer than 10 minutes will result in insufficient residue to protect the prawns when thawed (Slattery et al., 1991). Residues diminished during frozen storage except when the prawns were glazed (Tsukuda and Amano 1972). After thawing the residue drops markedly. Finne et al. (1986) found on average that the residue dropped by 17% after freezing due to the washing effect of the thaw drip.

Ruello and McBride (1976) considered a residue of 30mg/kg in raw prawn flesh to be effective for black spot control. Many authors have found that black spot occurs when sulphite residues drop below 10 mg/kg (Smith 1980, Reullo 1974). Many respondents to this questionnaire stated that their residues, when taken to satisfy AQIS requirements, were below 10mg/kg. This is indeed a concern for anyone buying and thawing this product.

Figures 7 to 9 display the residues obtained by the authors in Table 2 from quick and extended dips and long term soaks in solutions which provide sulphite as the active chemical. All concentrations have been converted to the equivalent amount in grams of sodium metabisulphite per 100 litres of water, a form of measurement that is most convenient for industry application. Figure 7 presents sulphite residue data (as prescribed in the Food Standards) for whole prawns dipped for only short times in solutions of sodium metabisulphite.

Figure 7. Residues from dipping whole prawns in sodium metabisulphite solutions



To treat prawns quickly short dip times are needed. The immersion time ranged from several seconds to several minutes. Figure 7 shows that, due to the many different handling conditions applied by different researchers, similar dip conditions resulted in quite different residues for sulphite. Only solutions stronger than 600g of sodium metabisulphite resulted in residues greater than 10mg/kg SO_2. Within these data however, there are both prawns frozen after dipping (these contained the higher sulphite residues) and those that were kept under ice from several hours to days. As discussed in the page above, if the prawns are to be frozen they should be left to drain for a minimum of 5 minutes to avoid sulphite residues in excess of 100mg/kg. The one kilogram of sodium metabisulphite per 100L of water gives the best results and is the most convenient to use with most sodium metabisulphite purchased in one kilogram bags.

When the data from the experiments using headless prawns was added there are more treatments which resulted in residues above 10mg/kg. The removal of the head, while helpful in reducing the opportunity of black spot development, will lead to higher residues. Because all of the catch is landed whole by Australian fishers that data is not presented in this report so it is not used by industry to adopt incorrect dip times.

Figure 8. Residues from dipping whole prawns in sodium metabisulphite solutions

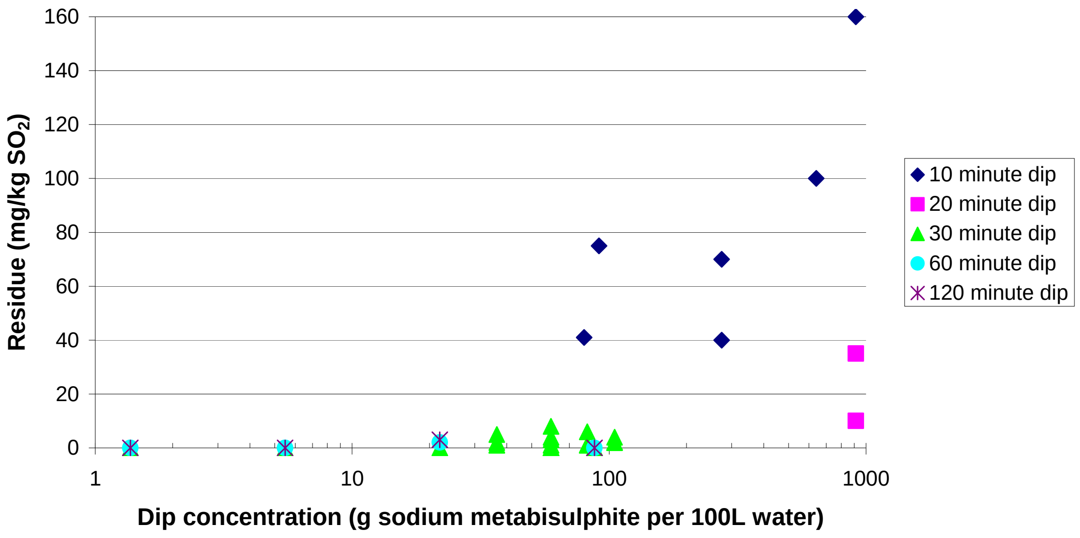


Figure 8 again shows that residue data from different experimenters can be somewhat inconsistent due to different handling conditions. However the basic premise is that longer exposure to lower concentrations of a chemical can result in better penetration of that chemical into the flesh of the prawn and with higher residue levels there should be better protection from black spot. When the immersion time is less restricted, lower dip concentrations can be utilised to obtain similar residues to those observed in Figure 7. This allows a more cost effective use of the chemical. The problem with extending dip times is that the amount of product that can be protected by just one solution is reduced as the dip time increases because there is a finite amount of chemical present in that dip. The data in Figure 9 (Slattery 1991) show consistent trends for long term exposure because the prawns were all handled in the same way on deck, when placed in the solution and when tested afterwards.

Figure 9. Residues from soaking whole prawns in sodium metabisulphite solutions

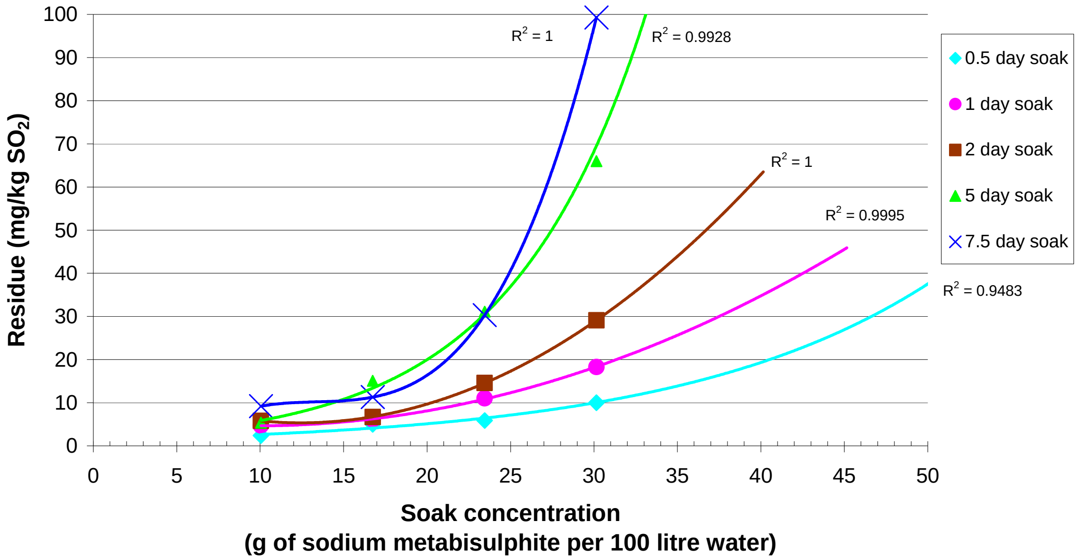


Figure 9 shows that overnight soaking (12-24 hours) can be used to provide adequate black spot protection and actually save industry money though the reduced consumption of chemical. A higher concentration than 30g per 100L may be necessary to achieve residues higher than 10mg/kg if only 12 hour soaks are to be applied. The trend lines have been extrapolated past the data to help anybody who is interested in using these times but the level of residues obtained using these higher concentrations cannot be guaranteed. This method is not appropriate for vessels still using galvanised tubing for their brine tanks as sodium metabisulphite will corrode this metal.

For those wishing information on how to apply an overnight soak using Everfresh the pamphlet developed for FRDC Project 2003/417 (Slattery et al. 2006) to present in Appendix 5.

Figure 10. Question A8: Do you test the treatment solutions?

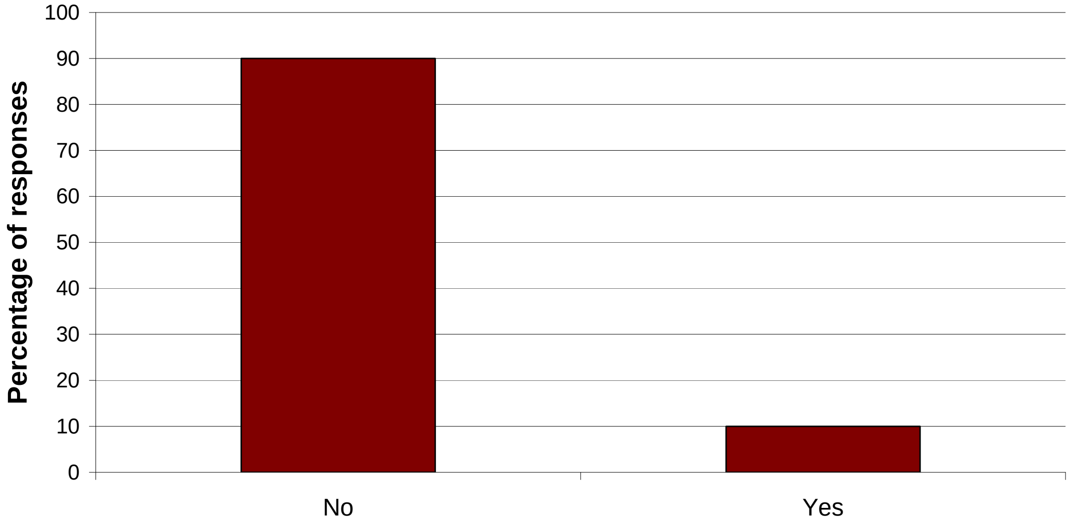
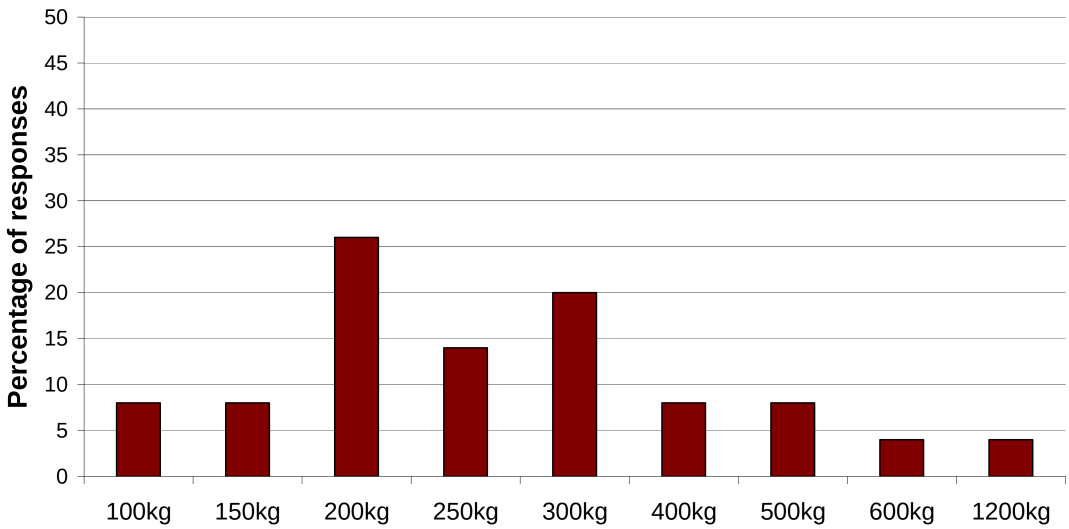


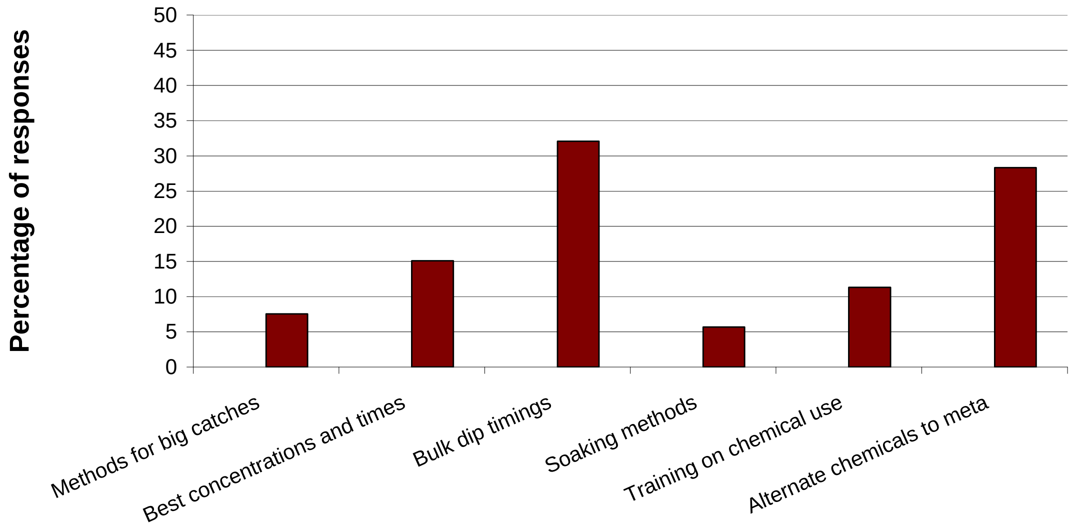
Figure 10 shows that few fishers tested their dip. While some replied "yes" this often meant that the residues in the meat were tested. Only a few fishers used Merckoquant Sulphite test strips to determine dip concentration. While this method had a lower correlation value with standard solutions than 5 other sulphite test kits (Poole and Slattery 2003) this is probably the easiest test method for industry to use. Even processing facilities rarely tested dip solutions and used the strips when they did. While comments were made that they would like to, when told of the many different kits and how they worked most said that they were too complex or difficult to use on a boat at sea. Until a digital test machine is developed it is unlikely that industry will monitor their dip solutions. Most fishers infer that their dip solutions are adequate from the random residue testing carried infrequently over the year of operation.

Figure 11. Question A9: After what weight of prawns do you change or top-up the treatment solution.



The wide range of responses about the maximum capacity of their dip solution indicates that there is little consensus on capacity of dips within industry. While chemical suppliers do recommend a capacity of 200kg using a 1kg/100L sodium metabisulphite dip for 30 seconds, this finding from the only published bulk dip efficiency study (Slattery et al. 2009) indicates that this is not sufficient if the same dip time is to be used for consecutive dips. Maximum capacities for scampi were presented in the Seafish (2003) leaflet but these were not supported by any experiments as confirmed by the report written by Edmonds (2006).

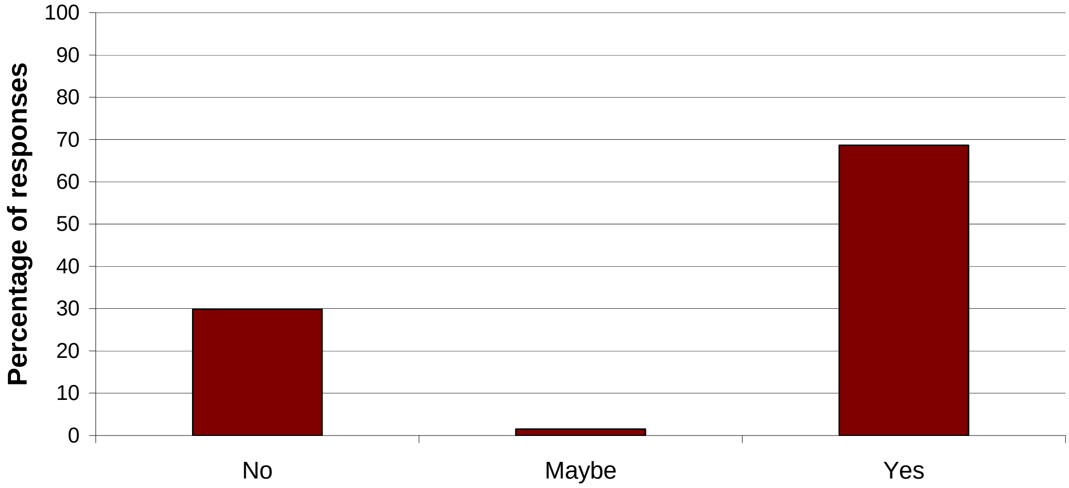
Figure 12. Question A10: What research do you think needs to be done to reduce black spot?



The most common requests for further research involved optimum procedures for bulk dips and alternative dip solutions. As the previous results show, some parts of industry are operating with a significant lack of knowledge about using chemical dips. There are a number of different prawn treatments on the market (although a majority still rely on some form of sulphiting agent) and many on the east coast had been given samples of XyRex to trial. Another reason for wanting alternatives is that sodium metabisulphite was in short supply and then the price went from $2.60 to $4/kg last year. The Seafish leaflet does list 9 alternatives to sodium metabisulphite with 5 being considered as competitive.

Section B A Dip Meter (Metameter)

Figure 13. Question B1: Would you be interested in purchasing a dip meter ("metameter") to monitor dip strength?



Almost 70% of respondents were interested in purchasing a dip meter. On further questioning this was largely driven by health issues surrounding metabisulphite use, and financial concerns relating to efficient use of dips. SO_2 gas released from sodium metabisulphite is known to cause skin and eye irritation, bleeding from the nose, and breathing difficulties, particularly in asthmatics (Marks et al. 1996, Chemwatch 2005). These symptoms had been observed by many of the fishers interviewed.

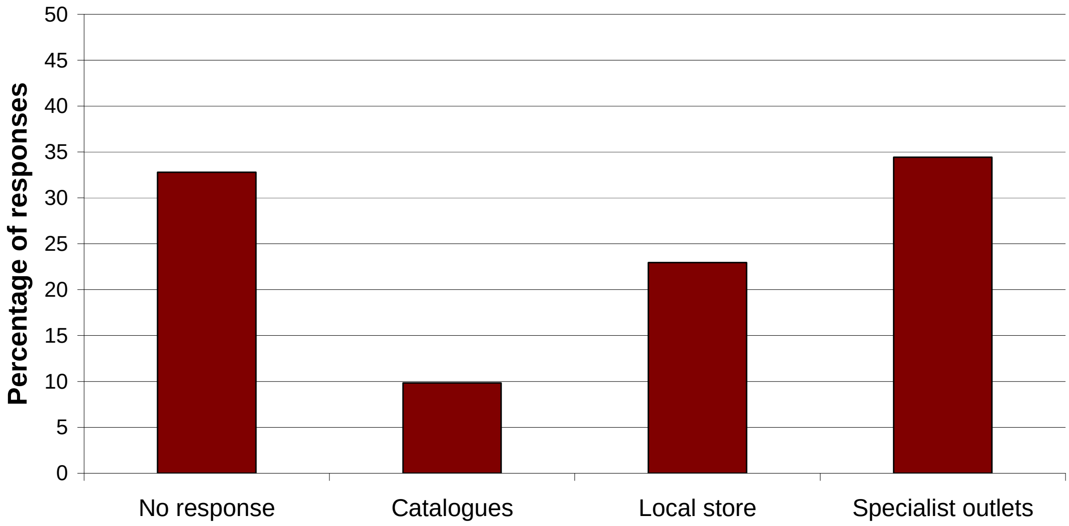
Question B2. Which sensor manufacturers (eg. temperature, salinity) currently service the prawn industry?

Most fishers were not able to give details on this but there were a wide variety of manufacturers listed (Table 3) from those that did respond. Morrell (Scales), ELL (Temperature gauges) were the most commonly listed, although most respondents did not display a preference.

Table 3. Responses to question B2.

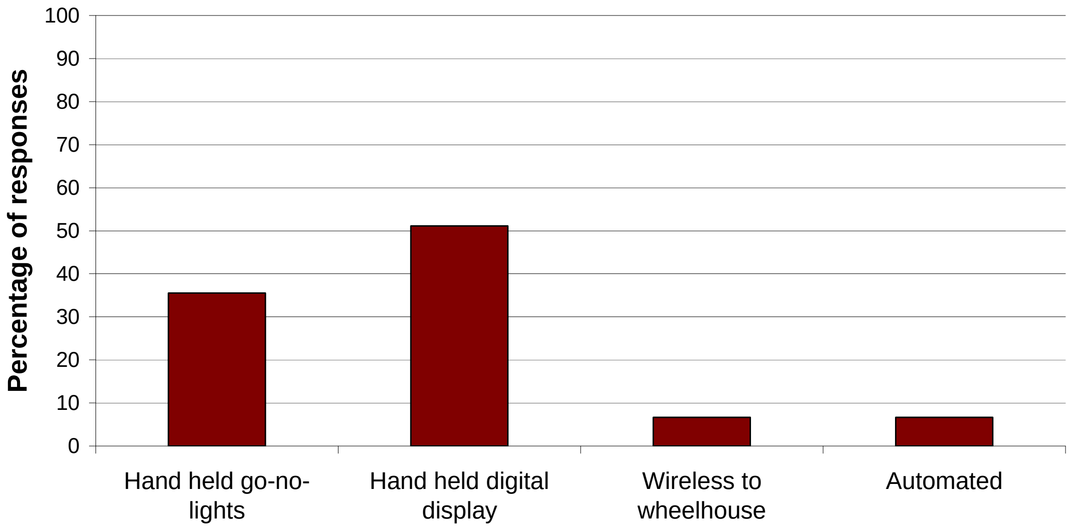
Response	Percentage of responses
No response	69.5
Any	10.2
Bell, EcoSolutions	1.7
Casio	1.7
Curley Refrign (CPS)	1.7
Danfoss	1.7
HLP Controls	1.7
Morrell (Scales), ELL (Temp gauges)	5.1
North Freeze, Biotech	1.7
Smitt, BTO	1.7
TFA	1.7
TPS, Long, Crown	1.7

Figure 14. Question B3: What are your purchasing methods: catalogues, local store, specialist outlets?



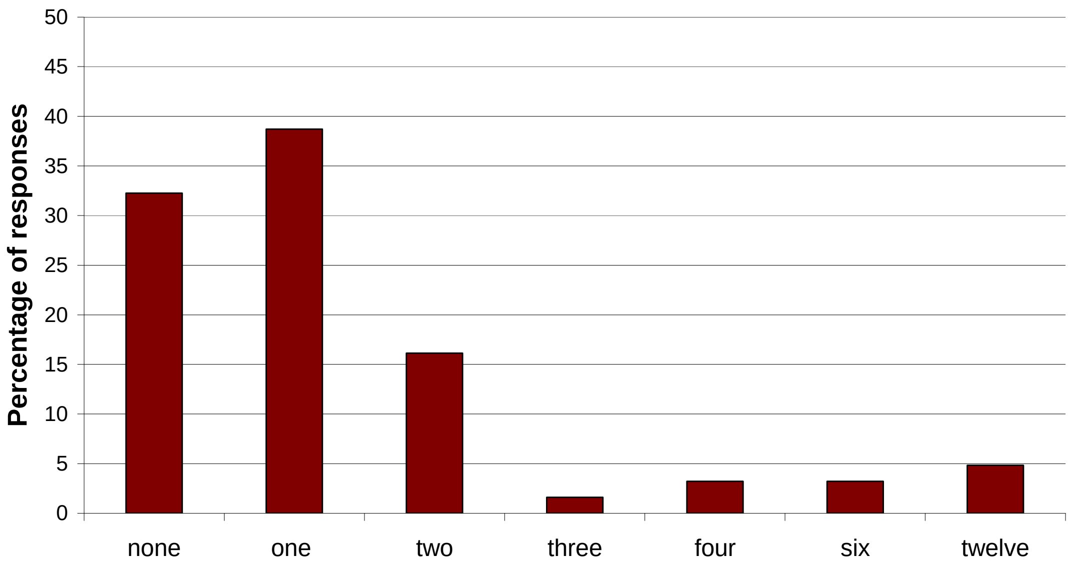
Question B3 responses were that electrical equipment was generally bought through specialist outlets, followed by the local store, with catalogues being the least popular (Fig 14).

Figure 15. Question B4: Which form of meter would be preferred?



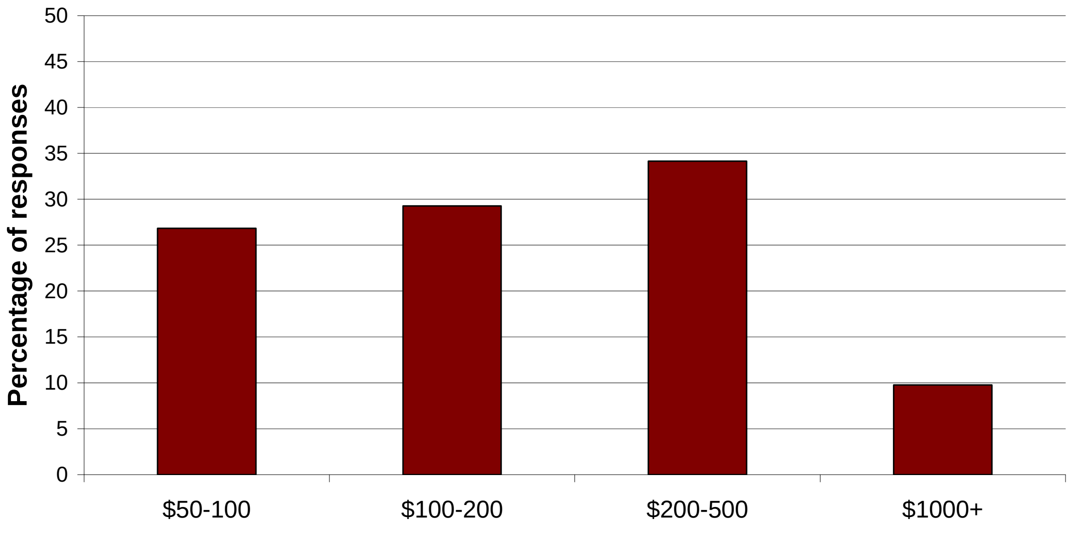
The preference was for a robust handheld digital meter (Fig 15). Having go-no go lights visible to the deck crew (e.g. red = too much metabisulphite; green = just right; yellow = too little) was also discussed with some mention of the usefulness of a digital display and data storage system (hard drive) in the wheel house.

Figure 16. Question B5: How many would you buy?



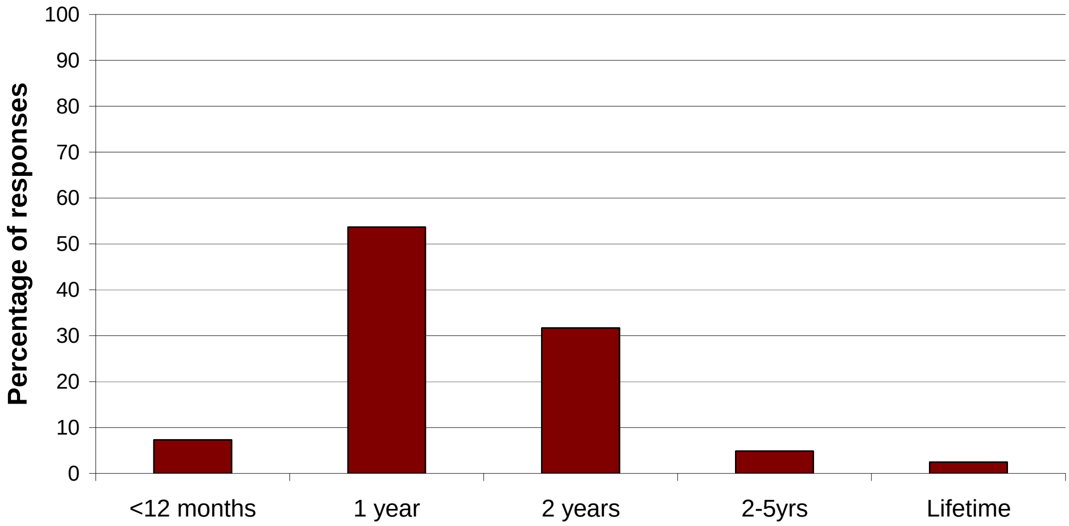
Of those who would buy a meter, one would generally be purchased per boat (Fig 16).

Figure 17. Question B6: What would be an acceptable purchase price?



The acceptable price varied greatly with the range between $200 and $500 in the majority (Fig 17).

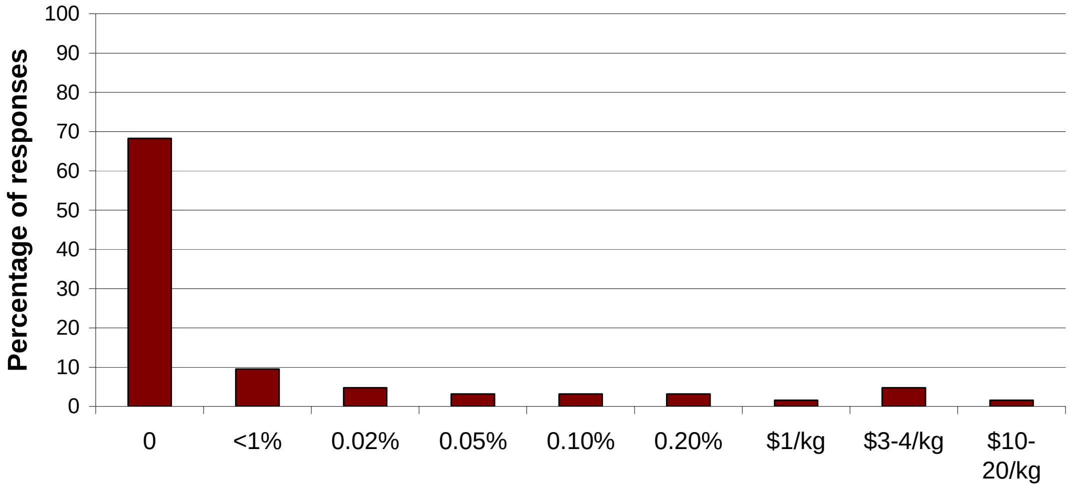
Figure 18. Question B7: How much warranty would you expect?



Twelve months to 2 years was considered a reasonable warranty period (Fig 18).

Section C Annual losses from prawns affected with blackspot.

Figure 19. Question C1: How much (% or $/kg) do you lose through downgrading of affected prawns - from harvest to initial sale?



There was apparently very little loss of income through downgrading of affected prawns. A number of reasons could be given for this response. Firstly, some individuals would not admit to black spot problems. This situation was classically defined when one of the authors interviewed a skipper who stated that his prawns were the best. The following day at the local processing plant staff were asked if there were any regular suppliers with black spot problems, only to be told that there was only one and that was the individual spoken to the previous day. Other fishers stated that when there were problems with black spot they took the prawns back and sold them through other markets or within their family associations as it was known that black spotted prawns are perfectly safe to eat when freshly caught. The retail sector, being investigated by others and so not part of this survey, should be able to provide better information about the level of black spot occurring on wild capture prawns. Also frozen prawns with insufficient reside will only go black when thawed so this might only be a major issue for the retail sector, again outside the scope of this study.

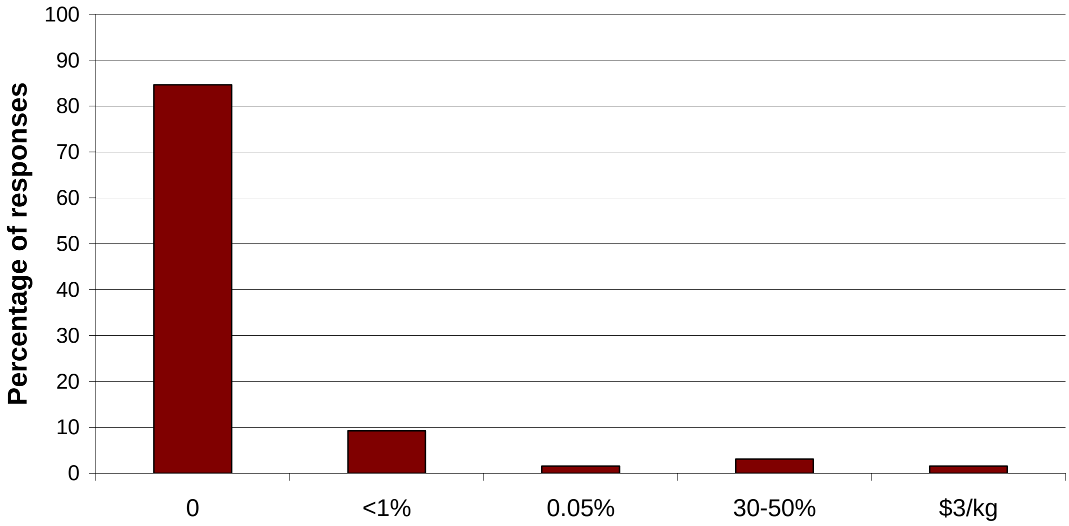
One justification given for choosing this response was that if black spot did occur there would be a lower price offered to the fisher for the prawns and no real record would be present in the accounts of why there was a price difference within the catch. No net loss would be recorded by the supplier as the downgraded prawns would be reprocessed and the cost passed on to consumers. This was certainly the most common response from fishing companies and processors in Western Australia and South Australia. When explaining their response to the next question some fishers said that only prawns that were totally rejected and then thrown away were perceived as having a net loss. This situation makes it difficult to quantify the real impact of black spot to all aspects of the seafood industry.

Another reason for recording no losses to blackspot was that there was indeed very little blackspot. Unfortunately unless stated directly to the interviewer there was no way of determining which of these explanations were the real reason for giving this response.

If losses were reported they were generally low, at less than 1% or $3-4 per kilogram. This value was also the amount that processors reported as the cost of processing the prawns to remove the heads and shell. While actual quantities may be small for some fisheries, even 1% is significant in fisheries catching large volumes of higher risk species (i.e. those with greater chance of developing black spot) such as bananas and eastern kings.

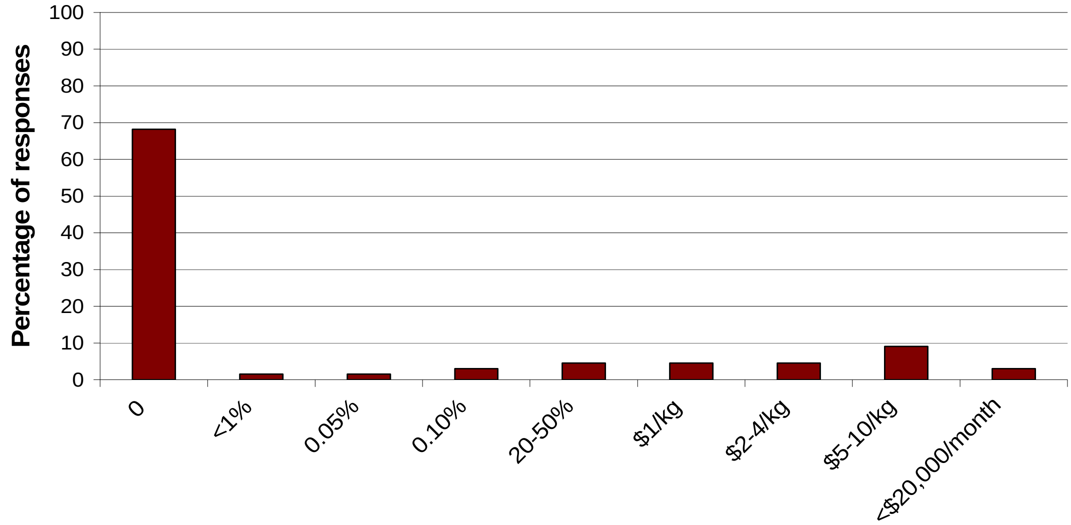
While responding to this question there was some interest expressed in further training, as suggested by respondents to Question A10 (>10%). There are ongoing industry-based initiatives aimed at improving current practices on prawn fishing vessels, however some skippers are unaware of improvements they could make.

Figure 20. Question C2: How much (% or $/kg) do you lose through destruction of affected prawns?



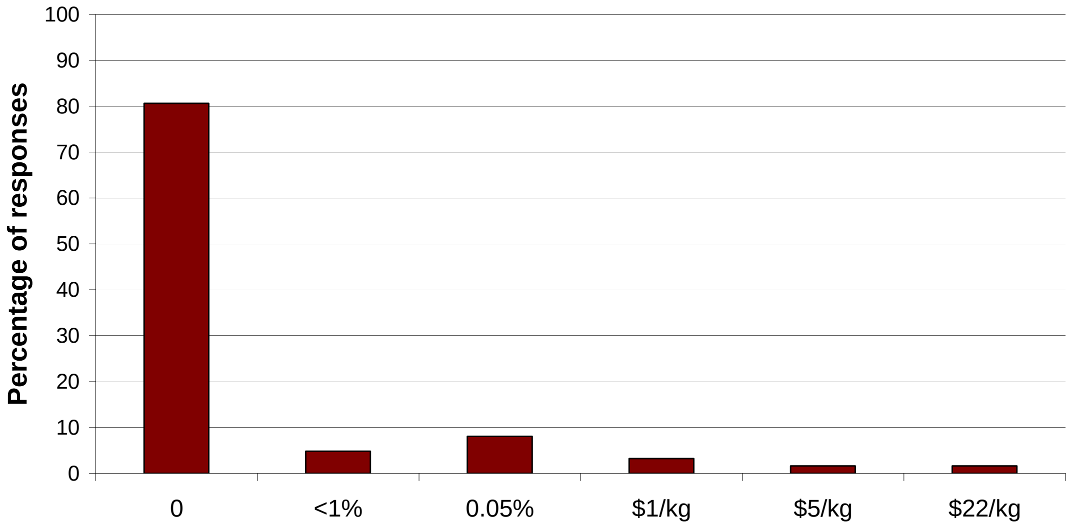
There is very little destruction of prawns due to the presence of black spot. As reported above the prawns were almost always value added or sold elsewhere. Because of the variation of prices for prawns at different times of the season fishers do not consider the discounting due to black spot as a real loss; only that they received lower price which is why this response was more frequent than the previous "no value". Again it is probably more of an issue for the retail sector.

Figure 21. Question C3: How much (% or $/kg) do you lose via any incremental on-costs arising from black spot?



The number of responses that valued incremental costs as zero was similar to the first question. The answers that did define on-costs were, however more detailed than for the previous answers. The costs for processing were higher because the costs for extra transport were included when product was returned. This explains the $5-10/kg being more prevalent than the $2-4/kg response.

Figure 22. Question C4: How much (% or $/kg) do you lose through consumer complaints?



A few fishers reported significant losses from processors, but because of the wholesale and retail chain separation for wild caught seafood, very few fishers are given feedback about their product.

Almost invariably WA and SA fishers reported no losses through any of these means. If black spot does occur in a significant proportion of prawns, the product is regraded and value-added (eg headless, cutlets) and the cost passed onto the consumer. Comments were also made that black spot was really only an issue with banana prawns (i.e. in the NPF) if at all. Consumer complaints of poor quality (including black spot) received by fishers were generally found to be the result of poor temperature control by the retailer/consumer after purchase from the fisher/processor but low residue levels would also lead to black spot when temperatures rise and no one would know which had the largest impact.

Recommendations

The absence of information about black spot at the retail level underestimates the true extent of this problem and therefore how important the need is for further research. The lack of consensus by industry on appropriate dip conditions to use shows there is a need to research postharvest dip procedures to improve product quality in the retail environment.

The research proposal should include investigations into alternative dips (eg. Everfresh) and the effects of variation in treatment time and dip concentration. In addition, given the popularity of the metameter concept, it is recommended that such a meter be developed. A basic metameter probe (not a working prototype in the sense of a complete unit) has already undergone limited testing in the laboratory to the extent that it is able to detect metabisulphite in seawater. A research proposal is now in development that will allow more comprehensive laboratory testing. If such work was successful, further funds will be sought for a series of field tests with a view to commercialisation. When these new methods have been evaluated they could be incorporated into training manuals and presented at workshops.

Benefits and adoption

Many sectors of the wild capture prawn industry have already benefited from this project. Industry practices and needs were invariably discussed during interviews, with the interviewer providing details of previous research and practices which were of direct benefit to the fisher, fleet manager or processing manager. There were numerous requests for the pamphlet on using the Everfresh soak method developed by FRDC Project 2003/417.

Many fishers expressed an appreciation of the extension activities provided by the interviewers, and started that the information gained would be used to improve their prawn handling and treatment practices showing that any new research finding would be readily adopted.

Further Development

A survey of retail outlets would be useful to give a clearer picture of the current cost of blackspot to the prawn industry.

Future areas of research and development should revolve around more effective black spot prevention and dip monitoring, including alternative dipping methods and solutions, the metameter and comprehensive training workshops/manuals.

Planned outcomes

The planned outcomes and benefits of this project were the identification of issues surrounding metabisulphite and 4-hexylresorcinol use and efficiency in the Australian Prawn fishery, including shelf-life and market perception.

The survey identified that

1. Fishers are not sure which were the most effective dip methods to use for the various prawn fisheries that operate around Australia.
2. They would like research and training to provide them with the latest details on what chemical to use and how to use them, as evidenced by amount extension activities that had to be undertaken by the authors while conducting this survey.
3. The industry would like easy to use sensor and test methods to ensure they are getting sufficient residue of chemicals into their product so that it will be protected while being handled by retailers and consumers.

Conclusion

As the provisions of this project restricted the study to surveying only fishers about black spot issues a true evaluation of the economic impact of this defect on the seafood industry was not possible. Even when directly impacted individual fishers did not provide much details on their black spot problems.

Sodium metabisulphite is the chemical of choice for the wild prawn fishing industry. There are many different ways this chemical is applied but industry does not always have the confidence that they are using it effectively. The fact that 80% use the one treatment for all catches, species and conditions shows their limited knowledge about how black spot inhibiting chemicals perform and how they impact on their residues. The varying storage methods used by industry will also impact on product residue and therefore protection in the retail sector.

A once only dip is industry's predominant method of treating prawns against black spot. How much to use and for how long and how much prawn is treated by each dip varies considerably around Australia. As industry tests their residues infrequently the effectiveness of these varying practices need to be authenticated through research. A literature review found there are still more details on effective black spot methods needed to be identified.

Industry identified several key areas for further research:

1. Effective use of the dip to maintain consistent residues through increasing dip times for bulk dips.
2. Are there better chemicals than sodium metabisulphte to use on prawns.
3. The most appropriate dipping regimes to use for specific operations.
4. A dip meter to monitor solution concentrations and inform decisions on appropriate dipping times, when to top-up and when to dump.

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Appendix 1: Intellectual Property

There was no intellectual property generated by this project. The individual answers provided by individual fishers will be kept confidential for privacy reasons.

Appendix 2: Staff

Steven Slattery
Richard Musgrove
Mohan Raj
Bob Flemming
Paul Graham

Appendix 3: Questionaire

Questionnaire

PRAWN BLACKSPOT PREVENTION, DIP MONITORING AND ANNUAL LOSSES

Company:
Address:
Fishery:
Species Caught:
Interviewee:
Date:

A) Blackspot and its prevention

1. What chemical/product do you use to prevent blackspot?

....
………………………………………………………………………

2. **What training methods/manuals do you use for crew on how to prevent blackspot?**……………………
……………………………………………………………………………
……………………………………………………………………………
……………………………………………………………………………
……………………………………………………………………………
……………………………………………………………………………
……………………………………………………………………..

3. Do you have different practices for different species or areas or seasons?

- No
- Yes if so what? …

………………………………………………………………………
………………………………………………………………………
………………………………………………………………………
………………………………………………………………………
………………………………………………………………………

(if necessary use a separate sheet to tell us about different practices)

4. What storage method do you use for dipped prawns on the capture vessel?

- Freezer
- Refrigerated seawater
- Ice
- Ice slurry
- Other if so what?

…………………………………………………………………
…………………………………………………………………

5. How do you treat the prawns?

- Dip
- Treated soak
- Other if so, what? ……………………………….

6. Do you use multiple chemical treatments before storage of a batch of prawns?

- No
- Yes if so what?

…………………………………………………………………
…………………………………………………………………
…………………………………………………………………
…………………………………………………………………

7. How much chemical per volume of water do you use, and for how long do you use it?

(If more than one method used please give detail on each)

……………………………………………………………………………
……………………………………………………………………………
……………………………………………………………………………
……………………………………………………………………………

8. Do you test the treatment solutions?

- Yes (if so what method do you use)

……………………………………………………………………
……………………………………………………………………
……………………………………………………………………
……………………………………………………………………

- No

9. After what weight of prawns do you change or top-up the treatment solution?

……………………………………………………………………………
……………………………………………………………………………

10. What research do you think needs to be done to reduce blackspot?……………………………………………………………………………
……………………………………………………………………………
……………………………………………………………………………
……………………………………………………………………………

B) A Dip Meter (Metameter)

1. Would you be interested in purchasing a dip meter ("metameter") to monitor dip strength?

Yes. No. ……………………………………………

2. Which sensor manufacturers (eg. temperature, salinity) currently service the prawn industry?

……………………………………………………………………
…………………………………………………………………….

3. What are your purchasing methods: catalogues, local store, specialist outlets?

……………………………………………………………………………
…………………………………………………………………………

4. Which form of meter would be preferred (eg. hand held, wireless communication, simple go-no-go lights, digital display or full automation)?

……………………………………………………………………………
……………………………………………………………………………

5. How many would you buy?

……………………………………………………………………………

6. What would be an acceptable purchase price?

…………………………………………………………………………….

7. How much of a warranty would you expect?

……………………………………………………………………………

C) Annual losses from prawns affected with blackspot.

1. **How much (% or dollar/kg) do you lose through downgrading of affected prawns - from harvest to initial sale?**

…………………………………………………………………….

2. **How much (% or dollar/kg) do you lose through destruction of affected prawns (i.e. dumping)?**

…………………………………………………………………….

3. **How much (% or dollar/kg) do you lose via any incremental on-costs (sorting / rework / double handling etc) arising from blackspot?**

…………………………………………………………..

4. **How much (% or dollar/kg) do you lose through consumer complaints?**

…………………………………………………………

Appendix 4: Developing Methods for Application of Everfresh to Deep Water Prawns

CENTRE FOR **FOOD TECHNOLOGY**

June 1998

Developing Methods for Application of Everfresh to Deep Water Prawns

Commissioned by: Sandy Woods-Meredith
11 Sutherland Street
North Buderim Qld 4556

QUEENSLAND GOVERNMENT

DPI QUEENSLAND

INTRODUCTION

The aim of the investigation is to identify conditions for the application of Everfresh which will prevent black spot developing on deep water prawns after capture in combination with sodium metabisulphite.

The chemical treatment by the client of deep water prawns after capture presently occurs at three stages during the sorting process. The first treatment occurs when the contents of the cod end are emptied into a dilute solution of sodium metabisulphite. The prawns are held for up to one hour then conveyed to a holding tank with a higher concentration. They remain in this tank for 20 minutes and after sorting are dipped into an even higher sodium metabisulphite solution for 30 seconds.

METHODS

The manufacturer of Everfresh recommends dipping prawns in a 0.2% solution for 2 minutes. This concentration has been compared with the standard of a 30 second dip in 1% sodium metabisulphite, which provides several more days protection from blackspot. The experiments will involve exposure of prawns to solutions of Everfresh at various concentrations for each stage. The concentrations to be used have been calculated from the modifications currently being used by the client for sodium metabisulphite.

The prawns required for the experiment will be dropped into the hopper containing 3kg/1000l sodium metabisulphite in seawater. The prawns will then be sorted into species and placed in batches of 20 in nylon mesh bags prior to dipping. The dipping experiments will be carried out in plastic tubs and prawns removed at the times specified by normal catch.

Stage 1

Fresh caught prawns, 80 of each species, will be stored for one hour in a solution containing 3kg of sodium metabisulphite per 1000L of seawater. After storage the prawns will be placed in solutions of Everfresh.

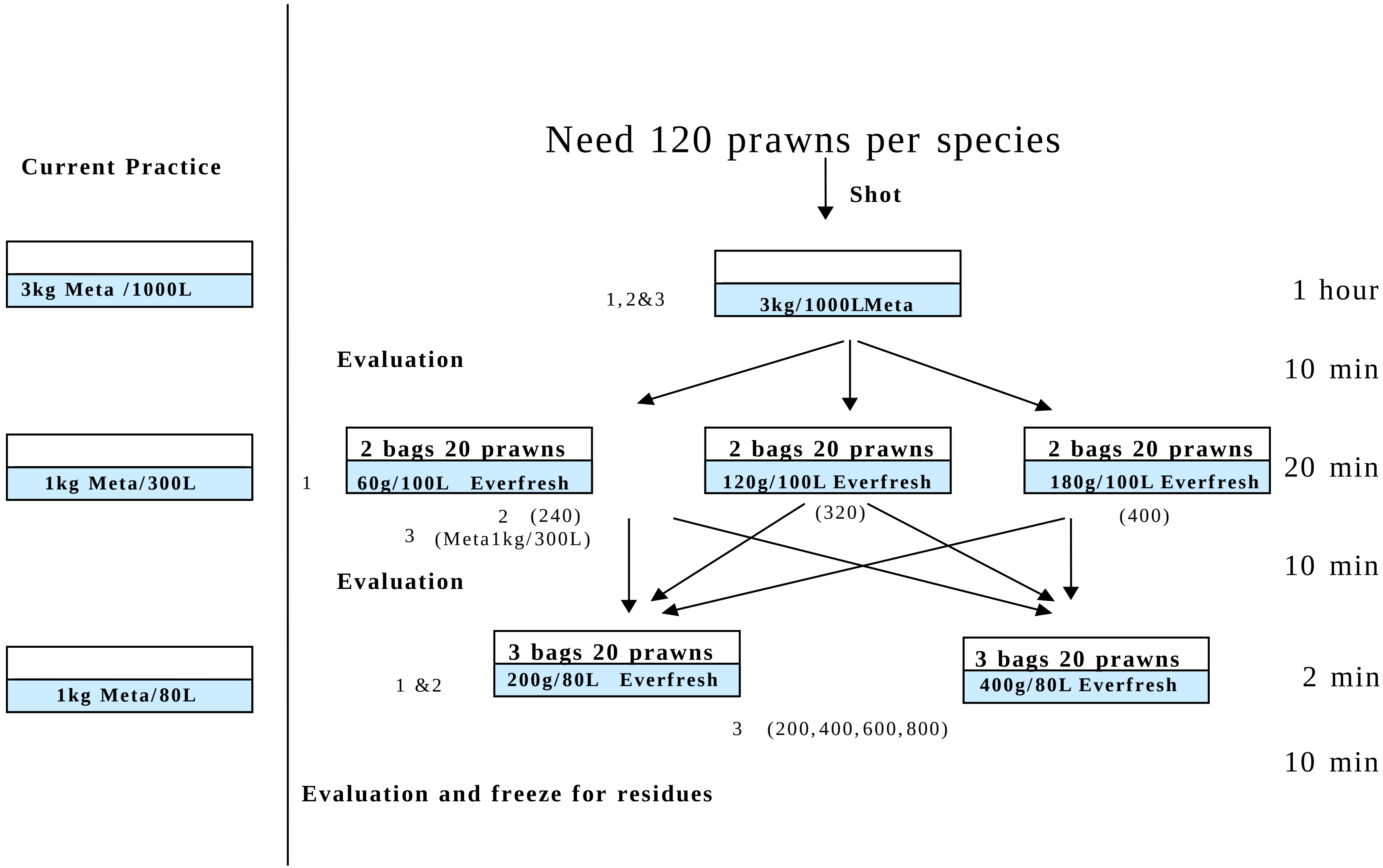
Stage 2

The prawns will be divided into two batches per treatment and stored in tubs containing the equivalent of 1-200g or 2-400g per 300L of seawater (60g or 120g/100L) where they will remain for 20 minutes. After storage the prawns will be stood for 10 minutes on deck and then appraised for the amount and location of black spot present.

Stage 3

The prawns will then be conveyed to a dip tank containing x-200g or y-400g of Everfresh per 80L of seawater where they will remain for 2 minutes. After storage the prawns will be stood for 10 minutes on deck and then appraised for the amount and location of black spot present. The batches without any black spot present will then be frozen and returned to the laboratory. After two weeks frozen storage the prawns will be thawed and then appraised for the amount and location of black spot present. Residue analysis will be carried out on batches, which do not exhibit black spot on thawing. This cost will be covered by Pointing Hodgesons Pty Ltd.

The diagram on the following page shows the treatments.


Current Practice
3kg Meta /1000L
1kg Meta/300L
1kg Meta/80L
Need 120 prawns per species
Shot
1,2&3
3kg/1000LMeta
1 hour
Evaluation
10 min
2 bags 20 prawns
60g/100L Everfresh
1
2 bags 20 prawns
120g/100L Everfresh
2 bags 20 prawns
180g/100L Everfresh
20 min
2 (240)
3 (Meta1kg/300L)
(320)
(400)
Evaluation
10 min
3 bags 20 prawns
200g/80L Everfresh
1 &2
3 bags 20 prawns
400g/80L Everfresh
2 min
3 (200,400,600,800)
10 min
Evaluation and freeze for residues

The experiment will be repeated for two to three shots depending on the amount of prawns of each species captured.

If there is no obvious protection against black spot present using 120g per 100l for stage 2 then increases in concentration of up to 240g per 100l for stage 2 will be trialled. If these are not adequate then the normal sodium metabisulphite treatment will be applied before the third stage Everfresh dip. If these concentrations are not effective then increases up to 800g per 100l will be applied for stage 3.

Black spot will be scored as a count of those prawns from the twenty in the batch with black spot on the head only and those with it present on both head and body. The extent of black spot will also be rated after the score using the following scale.

No black spot	a
Edges of shell, legs and tail turning black, gills darkening	b
Black spreading in from edges, head developing pigment	c
Black almost 25% of surfaces	d

After scoring the prawns from the third dip freeze the batch and return to the laboratory. After a weekend of frozen storage thaw the prawns slowly at room temperature. After 3 hours score the prawns for black spot. Score again after 6 hours. After this time freeze those prawns which did not exhibit black spot and give to David Williams for hexylresorcinol residue analysis.

Report to the client which combinations of Everfresh dip which were effective in prohibiting black spot.

RESULTS

The following tables show the scores for black spot on both species of prawn.

Plan A

Table 1. Incidence of black spot on Red prawns as a % after treatment with sodium metabisulphite and Everfresh

Dosage of Everfresh (ppm)	**Treatment times**							
	1 hour meta + 10 min air		20 min Everfresh + 10 min air		2 min Everfresh + 10 min air		6 hour thaw	
	Head	Head & body	Head	Head & body	Head	Head & body	Head	Head & body
60/200	0	0	0	0	0	0	0	0
60/400	0	0	0	0	0	0	0	0
120/200	0	0	0	0	0	0	0	0
120/400	0	0	0	0	0	0	0	0
180/200	0	0	0	0	0	0	0	0
180/400	0	0	0	0	0	0	0	0

Table 2. Incidence of black spot on Scarlet prawns as a % after treatment with sodium metabisulphite and Everfresh

Dosage of Everfresh (ppm)	**Treatment times**							
	1 hour meta + 10 min air		20 min Everfresh + 10 min air		2 min Everfresh + 10 min air		6 hour thaw	
	Head	Head & body	Head	Head & body	Head	Head & body	Head	Head & body
60/200	0	0	0	0	0	0	0	0
60/400	0	0	0	0	0	0	0	0
120/200	0	0	0	0	0	0	0	0
120/400	0	0	0	0	0	0	0	0
180/200	0	0	0	0	0	0	0	0
180/400	0	0	0	0	0	0	0	0
240/200	0	0	0	0	0	0	0	0
240/400	0	0	0	0	0	0	0	0
320/200	0	0	0	0	0	0	0	0
320/400	0	0	0	0	0	0	0	0
400/200	0	0	0	0	0	0	0	0
400/400	0	0	0	0	0	0	0	0

As shown above no black spot was detected for any of the treatments. There was some staining of the carapace that could initially be mistaken for black spot due to digestive enzymes escaping from the hepatopancreas. This occurs in all prawns soon after death and is dependent on temperature. All of the treatments were effective in preventing black spot. The higher concentrations were not trialled for the Red prawns because insufficient numbers were caught. This also led to fewer prawns being present for each treatment.

Residue analysis for 4-hexylresorcinol was carried out on a number of treatments and the data obtained is present in the following table.

Table 3. 4-Hexylresorcinol residues in Everfresh treated prawns

PRAWN SPECIES	**Treatment**	**4-hexylresorcinol (ppm)***
Scarlet	60/200	1.0
Scarlet	180/200	2.0
Scarlet	240/200	2.4
Scarlet	400/400	3.1
Scarlet	Control	<0.5
Red	60/200	4.1
Red	180/200	5.3

*Methodology from J. Assoc. Off. Anal. Chem. (1991) 74, 1003.

The following countries have approved Everfresh for use on crustacea

USA	approved for use as a processing aid (3/1992)
Australia	approved for use as a food additive (8/1996)
New Zealand	approved for use as a food additive (under harmonization with Australia)
Canada	approved for use as a food additive (5/1997)
Thailand	approved for use as a processing aid (1/1994)
South Africa	approved for use as a processing aid (10/1994)
Malaysia	approved for use for export only (10/1993)
India	Minister of Health advised it was OK in 1996
France	approved for 2 years (11/97) with a 1 ppm residue limit
PR China	approved for use as a processing aid (1/1994) with a 1 ppm residue limit
Mexico	no formal approval, registered for sale (6/1994)

Countries with applications pending
Spain (1/1992)
Taiwan ROC (9/1992)
Netherlands (4/1992)
Japan (5/1996) – **now prohibited**
Indonesia

The residues obtained from the treatments while high could not be regarded as excessive. They are however in excess for the two countries listed above which have residue limits and would cause difficulties if treated product was sent to these countries. The red prawns had higher residues because these prawns were much smaller in size to the scarlets. A lower concentration could be applied to reds without black spot developing.

RECOMMENDATION

The results of the experiments indicate that an initial dip in sodium metabisulphite followed by a secondary dip using 60 grams of Everfresh for 20 minutes and a third dip using 200 grams of Everfresh for 2 minutes will protect Red and Scarlet prawns from developing black spot after thawing.

Appendix 5: Soaking in Everfresh is cheaper and better Leaflet

Soaking in Everfresh is cheaper and better

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A recently FRDC/SSA funded project identified numerous alternate ways of using the prawn blackspot inhibiting compound sold as Everfresh. While the active compound, 4-hexylresorcinol, is much safer for consumers, the cost of using an Everfresh dip (A$0.128/kg) to treat prawns is much higher than the alternate sodium metabisulphite dip (A$0.04/kg). By using a longer term treatment of soaking combined with a lower concentration, better protection can be achieved at lower cost. This research investigated three different concentrations for five different soak times. All prepared solutions then had an equal weight of ice to that of the prawns being treated added to ensure rapid chilling and were then stored in a cold room at 2°C.

4-hexylresorcinol solution concentration and soak time	**Level of protection provided by soak versus dip for**	
	Banana prawns	**Black tiger prawns**
5mg/L for 3hrs	worse	similar
5mg/L for 6 hrs	worse	similar
5mg/L for 24 hrs	similar	similar
5mg/L for 48 hrs	similar	similar
5mg/L for 72 hrs	similar	similar
10mg/L for 3 hrs	similar	similar
10mg/Lfor 6 hrs	similar	similar
10mg/Lfor 24 hrs	better	better
10mg/Lfor 48 hrs	better	better
10mg/Lfor 72 hrs	better	better
20mg/Lfor 3 hrs	similar	similar
20mg/Lfor 6 hrs	similar	better
20mg/Lfor 24 hrs	better	better
20mg/Lfor 48 hrs	better	better
20mg/Lfor 72 hrs	better	better

Table 1. Blackspot protection after a soak in diluted Everfresh as compared with the standard 2 minute Everfresh dip

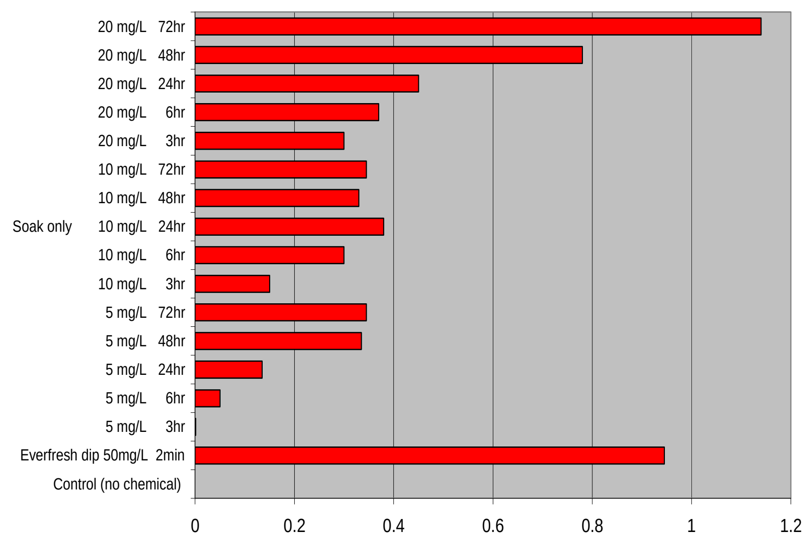

Figure 1. Residue measured as mg/kg 4-hexylresorcinol

Blackspot protection
The table above shows that when compared to a normal 2 minute dip in Everfresh, most of the soak treatments provide similar or better protection from blackspot.

Residue issues
Figure 1 shows all of the soak treatments will meet the US and EU residue standard of 2 mg/kg while only one treatment is unsuitable for Canada and China where there is a 1 mg/kg residue standard. The adoption of any new treatment must also be cost effective for industry. The next table shows the costs and dosages for each treatment.

Table 2. Treatment preparation, capacity and cost per kilogram of prawns.

Compound	Package size	Unit Cost	Concentration of active component & Dosage	Treatment	Treatment capacity	Cost per kg of prawns
sodium metabisulphite	1kg bag	A$4.00	6,700mg/L, 1kg/100L	1min dip	100kg	A$0.04
Everfresh	200g sachet	A$16.00	50mg/L, 1 sachet per 95L*****	2min dip	125kg	A$0.128
Everfresh	200g sachet	A$16.00	5mg/L, 1 sachet per 950L or 20g/95L	24hr or more soak	960kg	A$0.017
Everfresh	200g sachet	A$16.00	10mg/L, 1 sachet per 475L or 40g/95L	6hr or more soak	475kg	A$0.034
Everfresh	200g sachet	A$16.00	20mg/L, 1 sachet per 240L or 80g/95L	3hr or more soak	237kg	A$0.067

*** Everfresh has solubility problems at temperatures below 15°C.** It **must** be dissolved in water above 15°C before being chilled or diluted with chilled water or ice. Table 2 shows the amount each treatment is capable of effectively protecting and the cost per kilogram of prawns treated. A 5 mg/L 4-hexylresorcinol soak solution can be made by dissolving a 200g Everfresh sachet in 1000L of clean water and 500kg of ice. This will, with regular mixing, treat nearly 1000kg prawns effectively, after a long-term exposure (24 or more hours) and is cheaper to use than a sodium metabisulphite dip. A 10 mg/L 4-hexylresorcinol soak is similar to that described above, but is made using two sachets of Everfresh in 1000L while the 20 mg/L 4-hexylresorcinol soak solution requires four 200g sachets of Everfresh to be dissolved in 1000L. A paper has been published in the Journal of Aquatic Food Technology which describes the data in more detail.

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