FINAL REPORT

Aquatic Animal Health Subprogram: emergency response microalgal identification for the finfish aquaculture industry

Judith-Anne Marshall

May 2004

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2003/670 Aquatic Animal Health Subprogram: emergency response microalgal identification for the finfish aquaculture industry

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OBJECTIVES:

1. Instruct finfish aquaculture personnel in the identification of microalgae which are potentially detrimental to the industry.
2. Explore microalgal mitigation strategies with the finfish industry and workshop on viable industry solutions for microalgal blooms.

NON TECHNICAL SUMMARY:

OUTCOMES ACHIEVED TO DATE

The course and workshops provided awareness for industry of the potential threat of microalgae on productivity of the finfish aquaculture. The workshop discussion groups resulted in both the tuna and salmon industries working towards an industry based integrated monitoring program of potentially threatening microalgae species. Discussions on the impact of microalgae on fish health have led to some documentation of fish behavioral responses and pathology from exposure to microalgal blooms. Industry requests have led to the initiation of an ARC-linkage funding application from Assoc.Prof. Gustaaf Hallegraeff and Dr Marshall (for 2005-2007) to provide alert levels for microalgae and diagnostic pathology of fish exposed to harmful algal blooms.

Successful courses were run in Hobart for the salmon industry and in Port Lincoln for the tuna industry on identifying marine microalgae with the potential to cause mass mortalities of cultured fish. Results from the course questionnaire indicated that the courses were considered worthwhile by industry and that there was a need to continue the courses on a yearly basis to keep track of new and emerging species and name changes, train new personnel and participate in the discussion workshops as a forum for industry to exchange information and ideas with researchers on mitigation strategies and algae related fish health problems. The course brought awareness to industry of the need for sampling and identification consistency within the industry. The use of industry monitoring data for researchers to be able to investigate the algal related questions raised by industry such as algal succession trends, bloom prediction and risk alert levels was also addressed.

Workshops run for both salmonid and tuna industries brought to light the requirement for communication between companies on microalgal cell concentrations to allow management decisions to be made. At present there is no formal network on microalgal monitoring data between the companies in either the tuna or salmon industry. Development of an industry run network at lower management level was discussed in depth between representatives for both the salmon and tuna industry. Mitigation strategies were presented and their application discussed with industry.

The salmonid industry was supportive of algal monitoring being the most cost effective, practical and successful mitigation method. Sectors of the industry were in the initial stages of assessing venturation (aeration) as a practical mitigation strategy. The requirement for evaluation of venturation being successful in reducing fish mortality was identified as an area requiring more research. The tuna industry also indicated algal monitoring as the favored mitigation strategy. Discussion was held on whether other mitigation strategies could be adapted to suit the large-scale offshore operation of tuna aquaculture. Potential algal bloom mitigation methods used overseas were suggested, with monitoring and venturation concluded as being the most appropriate method in Australia at present until other strategies are researched for Australian conditions.

The impact of harmful algal blooms on fish health and potential microalgal mitigation strategies were discussed in depth. There is an ongoing recognition within both industries that many of the productivity losses due to reduced feed intake may be due to algal blooms. Also there was consideration of algal blooms being a predisposing factor in fish health problems, particularly in the salmonid industry.
The course was a valuable tool for all who attended, not only for the course information and substantial resource kit, but also for the discussion between industry companies, fish health professionals and research staff. It is hoped that a similar course will be funded on an annual basis.

KEYWORDS: **Harmful algae, aquaculture, fish mortality, mitigation, monitoring.**

ACKNOWLEDGEMENTS

The author wishes to thank Dr Peter Montague of the Cooperative Research Centre for Finfish Aquaculture for assisting with fund provision. Thanks to Assoc. Prof Gustaaf Hallegraeff of the University of Tasmania, School of Plant Science; Drs Kevin Ellard and Stephen Pyecroft of Department of Primary Industry, Water and Environment, Fish Health Unit, Tasmania; Dr Colin Johnston of Primary Industry and Resources South Australia; Mr Paul McNabb and Ms Melissa Gladstone of the Cawthron Institute, Nelson, New Zealand for their contribution in presenting the course and participation in the workshops. Also Miguel de Salas, Helen Bond (University of Tasmania) and Ken Lee with the South Australian Shellfish Quality Assurance Program crew for their assistance with the course.

BACKGROUND

Finfish aquaculture is worth around $750 million in production value per year in Australia, with southern bluefin tuna (SBT) and Atlantic salmon contributing around half of this value. The industry is constantly looking for new ways in which to increase productivity and decrease production costs. One area, which has been overlooked, is the impact of harmful algal blooms on fish health and their influence on productivity. In recent years, the Australian aquaculture industry has had to deal with major impacts of algal blooms, commonly experienced by overseas counterparts, which has heightened the awareness of the economic damage of harmful algal blooms (HABs).

The Tasmanian salmonid industry experienced problems with the heterotrophic dinoflagellate *Noctiluca scintillans* in 2001-2002 which was associated with decreased productivity and a high incidence of amoebic gill disease. In April - May 2003, the Tasmanian salmon industry experienced devastating losses due to raphidophyte and dinoflagellate algal blooms. Similarly, the SBT industry has been concerned with decreased feeding rates in the presence of blooms of the dinoflagellate *Karenia* sp. Overall, the industry is aware that the threat of a mass mortality event induced by algal blooms is real.

NEED

The availability of mitigation strategies was a key area identified by the Tasmanian salmonid industry. The most universal mitigation strategy used worldwide involves the monitoring of harmful algal species on a regular basis. Both salmon and SBT aquaculture industries employ personnel who are responsible for monitoring, but require regular training to maintain, improve and update their skills. The ability to indentify the potential algal threat will allow farm managers to make the appropriate decision on the risk involved and how to manage the threat.

OBJECTIVES

The main objective of this course was to instruct finfish aquaculture personnel in the identification of microalgae that are potentially detrimental to the industry. However, the opportunity to explore microalgal mitigation strategies with the finfish industry and workshop on viable industry solutions for microalgal blooms provided a valuable forum for the exchange of ideas within and between industries.

DELIVERY

Two 1-day courses were delivered at the University of Tasmania, School of Plant Science, Hobart, Tasmania for the salmon industry and one 2-day course at the Lincoln Marine Science Centre, Port Lincoln, South Australia for the tuna industry. Programmes for the courses and attendee lists are presented in Appendix 1. Staff involved in the project are listed in Appendix 2. Reference material used for the course work is listed in Appendix 3.

Figure 1. Students at the Lincoln marine Science Centre, SA, examining live cultures of fish killing algae using microscopy to practice their taxonomic skills.

Objective 1 (to instruct industry in algal identification) was delivered as a series of lectures and 2 practical sessions. These practical sessions were provided for each group, to give the participants the opportunity to examine live cells in cultures of the problematic algal species (Fig. 1). Cultures were provided by the University of Tasmania's Harmful Algae Culture Collection, and have been isolated over a number of years from seawater samples sent in by research bodies, government bodies and industry during periods when problematic algal blooms have occurred.

Objective 2 (to hold a workshop on solutions to the algal problems) was delivered as a lecture on possible solutions and an interactive discussion on what would be practical to deploy in the farm situation, and how the algae are affecting farm productivity. Much of this information is discussed in the results section.

RESULTS AND DISCUSSION; WORKSHOP

Aquatic Animal Health Subprogram: Emergency Response Sampling for the Finfish Aquaculture Industry Course, 2003

Algal Bloom Mitigation and Management Workshop

Judi Marshall (University of Tasmania, School of Plant Science)
Kevin Ellard / Stephen Pycroft (DPIWE Fish Health Unit)
Colin Johnston (PIRSA)
Gustaaf Hallegraeff (University of Tasmania, School of Plant Science)

Discussion Topics

1. HAB risk assessment – transfer of knowledge within industry
2. Alert systems
3. Sampling techniques
   - Algal sampling
   - Fish sampling
4. Diagnostic fish behaviour
5. Practical mitigation strategies
6. Related fish health problems

Salmon Workshops, Hobart

Two discussion workshops were held in Hobart, involving industry and relevant government personnel from the Department of Primary Industry, Water and Environment, Marine Farming, Analytical Services Tasmania and Fish Health Unit.

Salmon Workshop 1

The initial workshop on Tuesday September 2nd 2003 involved mainly technical personnel from across the salmonid industry. The following topics were covered:

HAB risk assessment – transfer of knowledge within industry

It was concluded that there was no risk assessment of harmful algal blooms (HABs) within industry. Work to determine the risk levels of HABs would enhance the ability to manage stock in the event of increasing harmful algae cell counts.

Alert systems

The alert system within industry worked on a word of mouth system. All aquaculture companies maintained a positive and a co-operative relationship around HAB issues. However, there was agreement that a formal communication system using media such as fax or e-mail to circulate information about potentially threatening algal blooms would be valuable. This type of system would require an integrated industry-wide monitoring system.

Stephanie Fulton added that Analytical Services Tasmania ran a database of phytoplankton abundances for clients, which was capable of providing reports. This system was currently not utilised by industry. Agreement was made that a system such as this may be valuable as a management tool for an industry based algal monitoring system. Currently two farms, Aquatas at North West Bay and Tassal at Bruny Island, send regular samples to Analytical Services Tasmania.

It was agreed that further discussion on this matter should take place in the second salmon workshop which the majority of farm managers would be attending.

Sampling techniques; Algal sampling

Protocols for sampling of algae were provided by DPIWE Fish Health Unit. Industry agreed it would be appropriate to adopt such standards, if an industry based monitoring programme was adopted.

Sampling techniques; Fish sampling

Issues involving the quality and frequency of fish samples being sent for pathology were discussed. Problems involving the sampling of fish after the event, dead fish rather than morbid fish being sampled, the number of fish sampled and the lack of control fish sampled for pathology were raised. Industry indicated that it needed to be educated in the process of taking appropriate fish samples for veterinary pathology. The industry veterinarian Dr Kevin Ellard was developing continuing education on farm for these techniques. One area of concern was the lack of early notification to the Fish Health Unit of suspected algal induced fish mortalities.

Diagnostic fish behaviour
The group was very interested to know about diagnostic fish behaviour, but unable to contribute enough information to determine diagnostic fish behaviour patterns. The information discussed is presented in Table 1. Industry agreed that more research into the area of diagnostic fish behaviour and pathology was required. The point that comprehensive and competent fish sampling techniques and observations needed to be adopted by industry to help achieve this outcome was discussed in depth.

Practical mitigation strategies
The practical mitigation strategies presented by Dr Judi Marshall were discussed and are listed in Table 1. The group contributed that the use of tarpaulins with the current cage systems was prohibitive. However, the use of aeration through venturators was currently being used on farms. Industry was very interested to know the effectiveness of using aeration. This work strategy needs to be assessed by industry.

Related fish health problems
Not discussed

Table 1. Algal mitigation strategies as discussed in the workshop

Strategy	Salmon	Tuna
Monitoring	Strategy currently being developed	Strategy currently being developed
Venturation	Useful for some dinoflagellate blooms. Research now being undertaken on some farms	May be applied in extreme circumstances
Oxygenation	May be applied in extreme circumstances	May be applied in extreme circumstances
Airlift pump	Sites too shallow	Sites too shallow and exposed
Moving Pens	Last resort action	Not yet applied
Perimeter Skirts	Not developed. Thought to be too cumbersome.	Site too exposed
Alternative cage systems	Not considered	Not considered
Pre-emptive harvest	Not discussed.	Not discussed
Flocculating clay	Thought to be of use but needs local research to develop protocols	Not considered
Chemicals	Not considered	Not considered
Site selection	Not discussed	Not discussed

Salmon Workshop 2

The second workshop on Thursday October 9th 2003 involved mainly managerial personnel from across industry. The following topics were covered

HAB risk assessment – transfer of knowledge within industry

A current proposal for the Aquafin CRC on determining risk levels of HABs was presented. The workshop agreed that this information is critical to be able to provide a risk assessment for the salmon industry. The industry group was keen to see the transfer of this type of knowledge from researchers to industry to allow them to make management decisions. Using a similar course on an annual basis was considered to be an excellent forum to pass on this information.

Alert systems

As discussed in the first workshop, the alert system for HABs within industry worked on a word of mouth system. The possibility of an integrated industry-wide monitoring system incorporating the services of Analytical Services Tasmania (DPIWE) and using current data resourced from the Tasmanian Shellfish Quality Assurance Program (TSQAP) was discussed in depth. Currently only two farms send samples to AST, being Aquatas at North West Bay and Tassal Pty Ltd at Bruny Island. The other farms not presently using this system agreed to look into this form of monitoring.

This issue was perused and the outcomes are reported on in Further Developments, P18.

Sampling techniques; Algal sampling

Not discussed

Sampling techniques; Fish sampling

Veterinary pathologist Dr Stephen Pyecroft discussed issues involving the quality and frequency of fish samples being sent for pathology by farms. Problems involving the sampling of fish post event, dead fish rather than morbid fish being sampled, the number of fish sampled and the lack of control fish sampled for pathology was discussed. Industry indicated that it needed to be educated in the process of taking appropriate fish samples for veterinary pathology. From the previous salmon workshop, the industry veterinarian Dr Kevin Ellard was looking "to combine sample collection workshops (on farm) with ongoing education programs – provided by DPIWE".

Diagnostic fish behaviour

The group was very interested to know about diagnostic fish behaviour, but unable to contribute much information. It was agreed that more research into the area of diagnostic fish behaviour and pathology was required by industry. It was confirmed that comprehensive and competent fish sampling techniques needed to be adopted by industry to help achieve this outcome.

Practical mitigation strategies

The practical mitigation strategies presented by Dr Judi Marshall were discussed. Use of tarpaulins was thought not to be practical in the Australian situations due to the

depth of the leases and the prevailing currents. Alternative cage systems such as rafts used by Tassal Limited Bruny Island were discussed as possible alternatives in managing algal blooms. The rafts allow more movement of surface waters which may prevent the build up of algal cell numbers on the surface, such as occurs with *Noctiluca scintillans*. The use of aeration through venturators was currently being assessed by farms. Requests were made for more information to be supplied on the effectiveness and use of venturators in mitigating algal blooms. It was put forward that this research was required, but funding was needed to investigate these issues and no known data was available. The salmon indicated that research on mitigation strategies could be conducted on a farm by farm basis.

Related fish health problems
Fish health issues pertaining to historical blooms of *Chaetoceros* were discussed. It was ascertained that both algal records and histopathological slides were available from this and associated events. It was agreed that an investigation into the historical data available from both farms and the Fish Health Unit (DPIWE) might provide much needed data into algal related fish health problems. This information has been integrated into an ARC-Linkage funding proposal. See Further Developments.

Tuna workshop, Port Lincoln

A workshop in Port Lincoln was held on Friday October 3rd 2003 involving 8 personnel from across industry, members of SASQAP and the biotoxin monitoring programme in New Zealand. The following topics were covered:

HAB risk assessment – transfer of knowledge within industry
The workshop agreed that HAB risk assessments would be useful, but difficult to obtain in the tuna industry due to the inability to do experimental trials using tuna. Knowledge was transferred via word of mouth between 4 large companies which employed trained biologists. It was unknown if other smaller companies received word of mouth information. The workshop agreed that a more formalised approach to transfer knowledge about algal blooms and current risks would assist the industry greatly.
Problems identified from the attendees were

- Companies do not communicate about the problem of algal blooms and the probability of algal induced fish mortalities due to the culture within the tuna industry. However, most companies are receptive to more research on algal blooms and how to work together on this topic.
- The information about problems involving harmful algal blooms and algal induced fish mortalities / health problems was not being assimilated by middle management within the industry.

This season Tom Bayly was employed by the Tuna Boat Owners Association (TBOA) to screen microalgae, which historically have been shown to increase in abundance during the autumn months –. SASQAP kindly donated their database structure so that results from the industry could be compiled from those researchers with equipment and knowledge to count algae. Companies that did not have these resources donated vessels, planes and crews to perform sampling. Up to date reports were faxed or e-mailed to companies from water sampling/algae counts and aerial surveillance.

Samples from companies without a biologist were screened and the information provided with an update of knowledge in the vicinity of the lease area including fish mortalities and water quality.

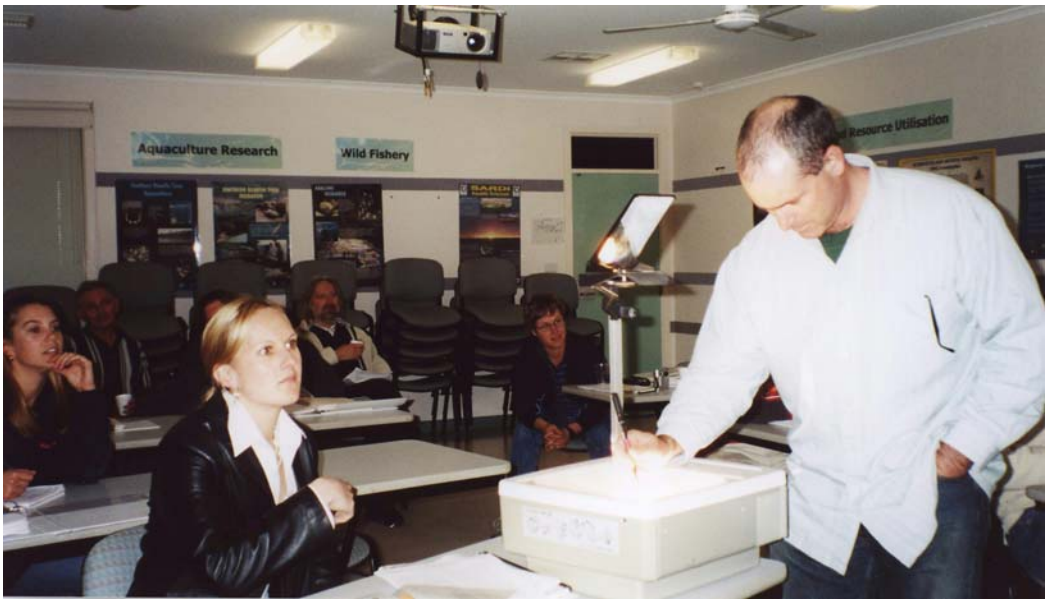

Figure 2. Dave Ellis discussing existing algal monitoring strategies with the group in the tuna workshop in Port Lincoln.

This season it is intended to streamline this process further but research needs to be performed to gather more comprehensive knowledge of microalgae in the farming area and provide an interactive data base for industry. The project aims to include information on what stimulates these algal bloom events, succession of algae and potential harmful algae.

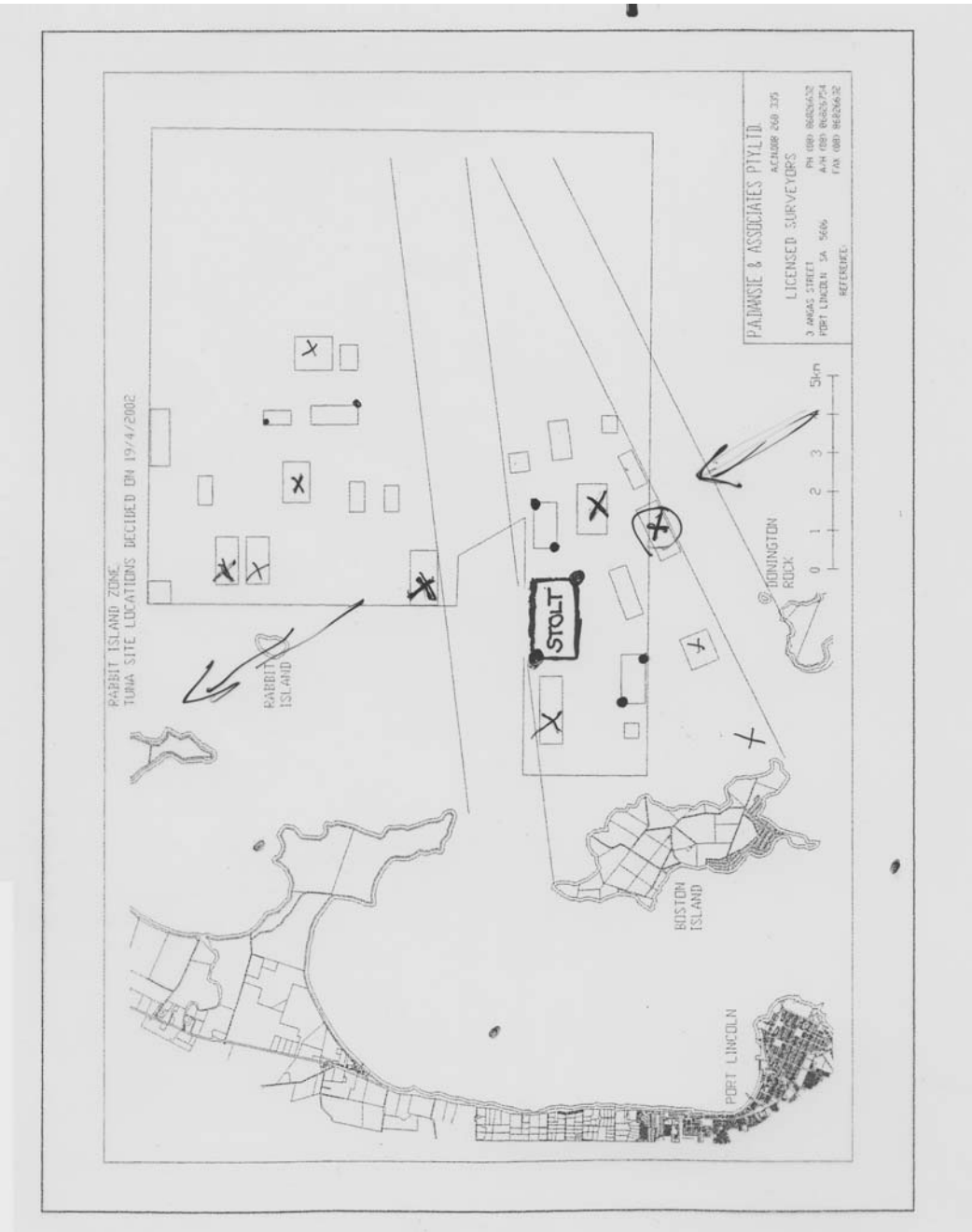

Figure 3. Lease sites for tuna farms and locations (X) sampled regularly by farm personnel. The arrows indicate the direction that prevailing algal blooms are thought to enter the lease site based on hydrological observations

Alert systems
No alert system for algal blooms was available for Port Lincoln fish farmers. An alert system integrated into a network was discussed. It was also considered that this system may be incorporated into the SASQAP monitoring program for some algal sampling sites. The need for all sites to be sampled was discussed (Figure 2). It was agreed that it may be possible to select 4-6 key sites in which industry-wide sampling may occur. These sites are shown in Figure 3. David Ellis will follow through the process of discussion about a more integrated approach for industry wide sampling. It was suggested that the tuna industry might also set its own alert levels for HABs based on examples in the literature and on farm observations of fish behaviour in the presence of algal blooms. The preferred method of communicating HAB information was by the faxing of maps of the area of an algal bloom determined by aerial flights. Research is required to set HAB levels which are part of the project being currently put forward on *in vitro* gill samples and finfish assaults to the Aquafin CRC.

Sampling techniques; Algal sampling
Sampling techniques within industry are not standardised. There is an issue with each farm using different techniques and net sizes. To be able to participate in an industry based monitoring program, the industry would need to standardise their techniques. The techniques used by SASQAP were supplied and would be valuable in resolving the issue concerning standardisation of techniques. It was suggested that future workshops could cover the teaching of standardised techniques to industry.

Figure 4. Dr Colin Johnston from PIRSA demonstrating to course participants how to correctly take samples of fish for diagnostic analysis.

Sampling techniques; Fish sampling
A fish dissection was demonstrated to the group by Dr Colin Johnston (Figure 4). It was agreed that this was a valuable session to help farm workers provide quality samples for diagnosis. It was put forward that future workshops should also include a component dealing with fish sampling techniques to update farm workers. Discussion occurred about the need for industry to seek veterinary advice on notifiable diseases and other fish health related problems as well HAB related fish mortalities.

Diagnostic fish behaviour
Little information was offered by the group on diagnostic fish behaviour in the presence of algal blooms. *Trichodesmium* was noted to cause oxygen depletion and reduce tuna feeding rates. *Karenia* and *Chaetoceros* species were noted to make fish jumpy. Participants from the tuna industry did not place fish behavioural response of tuna to algal blooms as an important diagnostic tool as did the salmon industry.

Practical mitigation strategies
Practical mitigation strategies were discussed. The physical algal mitigation strategies presented were not considered appropriate for the tuna industry due to

- The offshore environment of the farm leases leading to accessibility problems for the installation of plankton tarpaulins or aeration equipment etc.
- The decreased risk of HAB assault due to the position of the leases, when compared to previous site locations (eg. behind Boston Island).

Monitoring of algal blooms, including the integration of predictive abilities was discussed as the most appropriate and effective mitigation strategy for the tuna industry at the current time. Currently the industry uses plane spotting in peak periods of HAB occurrence (Feb – May) and some companies ground truth this information by taking algal samples. Concern was noted by the tuna industry that no minimum levels for algal abundance were available to act on the monitoring data. The towing of cages was identified as the second most preferred option in the case of HABs. Venturation was noted by Dr Colin Johnston as a preferred option to reduce respiratory distress in fish and has the most potential as an intermediate mitigation strategy in the event of a HAB. There was some interest in the flocculation methods. An understanding of the dynamics of the system is needed to fully appreciate HAB and the effects on tuna farming and the environment within. A predictive tool that encompasses water currents would play a vital role in farming for the future.

Related fish health problems
Fish health problems were only covered briefly. It was concluded that there was not enough conclusive or anecdotal evidence to be able to draw any relationships between algal blooms and fish health for tuna.

RESULTS AND DISCUSSION; COURSE QUESTIONAIRE

Course Questionnaire

Company/Organisation ……

Position ……

Course rating.

How satisfied were you with the course in the following respects?

	Very Unsatisfied				Very Satisfied
	1	2	3	4	5
Content	☐	☐	☐	☐	☐
Delivery	☐	☐	☐	☐	☐
Resource package	☐	☐			
Workshop	☐	☐	☐	☐	☐

Course Content

Did the course cover the topics you required? Yes / No

If no, what other topics would you like to see covered

……

……

Do you feel more confident in your ability to identify problematic microalgal species? Yes / No

Do you feel more confident in your ability to identify fish health problems? Yes / No

Do you think that it would be valuable to run a similar course on an annual basis? Yes / No

Was the practical session long enough? Yes / No

Would you be interested/available to attend a more detailed 2-3 day workshop in the future? Yes / No

What improvements would you like to see in this course?

……

Any other comments?

A questionnaire was provided to all course participants. The rating of the course was very high, with the tuna industry personnel giving 'very satisfactory' ratings for all components (Figure 5).

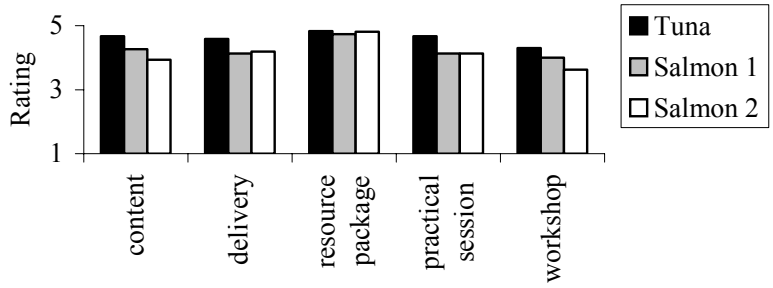

Figure 5. Questionnaire course ratings for the 2 courses held in Hobart for the salmon industry and 1 course held in Port Lincoln for the tuna industry. Ratings are as follows. 1 - Very unsatisfied; 3 – satisfied; 5 – Very satisfied.

The questionnaire also showed that there is less confidence in algal identification in the tuna industry than the salmon industry (Figure 6), which is most likely due to less accessibility to phytoplankton identification expertise in South Australia compared to the Tasmanian salmon farmers. The tuna farmers, did, however, have more confidence in the identification of fish health problems.

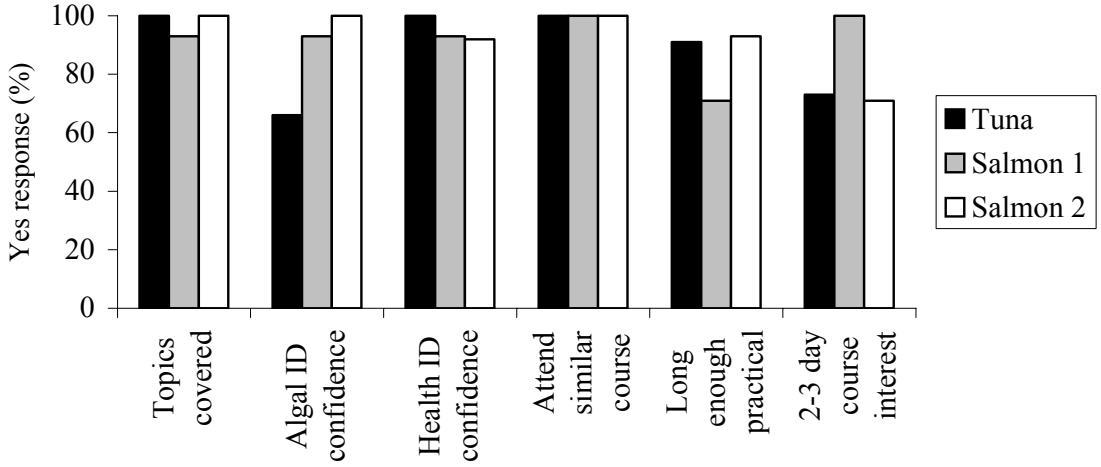

Figure 6, Affirmative response from course questionnaire for the 2 courses held in Hobart for the salmon industry and 1 course held in Port Lincoln for the tuna industry.

Suggestions and Comments

The suggestions and comments came from 30-40% of the group. The main comments from the first salmon course (2/9/03) were requesting a longer workshop and practical sessions. Example comments were as follows;

"Longer workshop – more opinions from different farm personnel with more ideas"

"Identification practical very useful. Course structured well and easily understandable."

The second salmon course (9/10/03), which mainly farm managers attended, requested a greater emphasis on mitigation strategies, particularly venturation, and the development of farm based monitoring and protective procedures, for example

"It may be worthwhile developing a group of less technical indicators for ramping up monitoring eg. changes in turbidity, colour index of samples, total cell counts. Also fish observations, environmental observations etc. Results used to trigger certain monitoring or protective procedures"

"Would have liked a bit more specific pathology associated with each algal species, maybe also plankton sampling techniques most appropriate for each species"

The tuna course (2-3/10/03) attendees had a greater range of skills, and therefore the suggestions were wider ranging from "Need to look at sampling and preparation techniques. Devise a simple key to get people started" to a greater emphasis on industry based expectations such as "Build up detailed document on the local algae around the Lincoln area". Having various people from other areas discussing their knowledge and experience presents other perspectives that you don't expect. It is a valuable source of information that would be great to continue over a period of time and build good, strong working contacts."

BENEFITS AND ADOPTION

The Tasmanian salmonid industry has acted upon some suggestions brought up during the workshop. Key advances have been in;

- Agreement between the major salmon companies Tassal Limited, Aquatas and Huon Aquaculture Company to contribute towards developing a industry based monitoring program, utilising the services and resources provided by Analytical Services Tasmania (DPIWE) with their NATA accredited microalgal identification service.
- Agreement between the major salmon companies Tassal Limited, Aquatas and Huon Aquaculture Company in making in-kind contributions (in excess of $50,000 per annum) towards an ARC-Linkage proposal by Marshall and Pycroft titled "Predictive ichthyotoxicity, Diagnostics and Risk Assessment of Harmful Algal Blooms for Finfish Aquaculture" (submitted Dec 2003).
- Closer links between the Tasmanian salmonid industry and other industry, research and governmental associates concerned about the issue of HABs, including the Tasmanian Shellfish Quality Assurance Program.

All companies in the South Australian tuna industry are receptive to research more so now and are eager to find out more information on algae and how to work together on these topics (David Ellis, pers. comm.). Key advances have been

- This season the TBOA intends to streamline the process of screening algae during autumn months. SASQAP kindly donated their database structure so

that results from the industry could be compiled from those researchers with equipment and knowledge to count algae. Up to date reports will be faxed or e-mailed to companies from water sampling/algae counts and aerial surveillance. Samples from companies without a biologist were screened and the information provided with an update of knowledge in the vicinity of the lease area.

However, further research needs to be performed to gather a more comprehensive knowledge of microalgae in the Port Lincoln farming area and an interactive database for industry needs to be created. This includes what stimulates algal bloom events, succession of algae and potential harmful algae.

FURTHER DEVELOPMENT

The use of the NATA accredited phytoplankton monitoring service offered by Analytical Services Tasmania (AST, Department of Primary Industries, Water and Environment, Tasmania) for routine monitoring, as suggested in the Hobart workshops, has been adopted by the salmonid industry for the 2003/2004 season. Finfish farmers can access reports and their own current data from this system. It is proposed in a current ARC-Linkage application (Hallegraeff and Marshall) that an integrated monitoring and predictive system for risk assessment of algal blooms would be able to be developed using this data. The Tasmanian Shellfish Quality Assurance Program (TSQAP, Dept of Health, Tasmania) have also agreed in principle and by in kind contributions to the above mentioned FRDC proposal to contribute currently assessed algal monitoring data (through AST) from the shellfish industry. The meta-database provided by these industries gives a comprehensive coverage of South Eastern Tasmania (Figure 7).

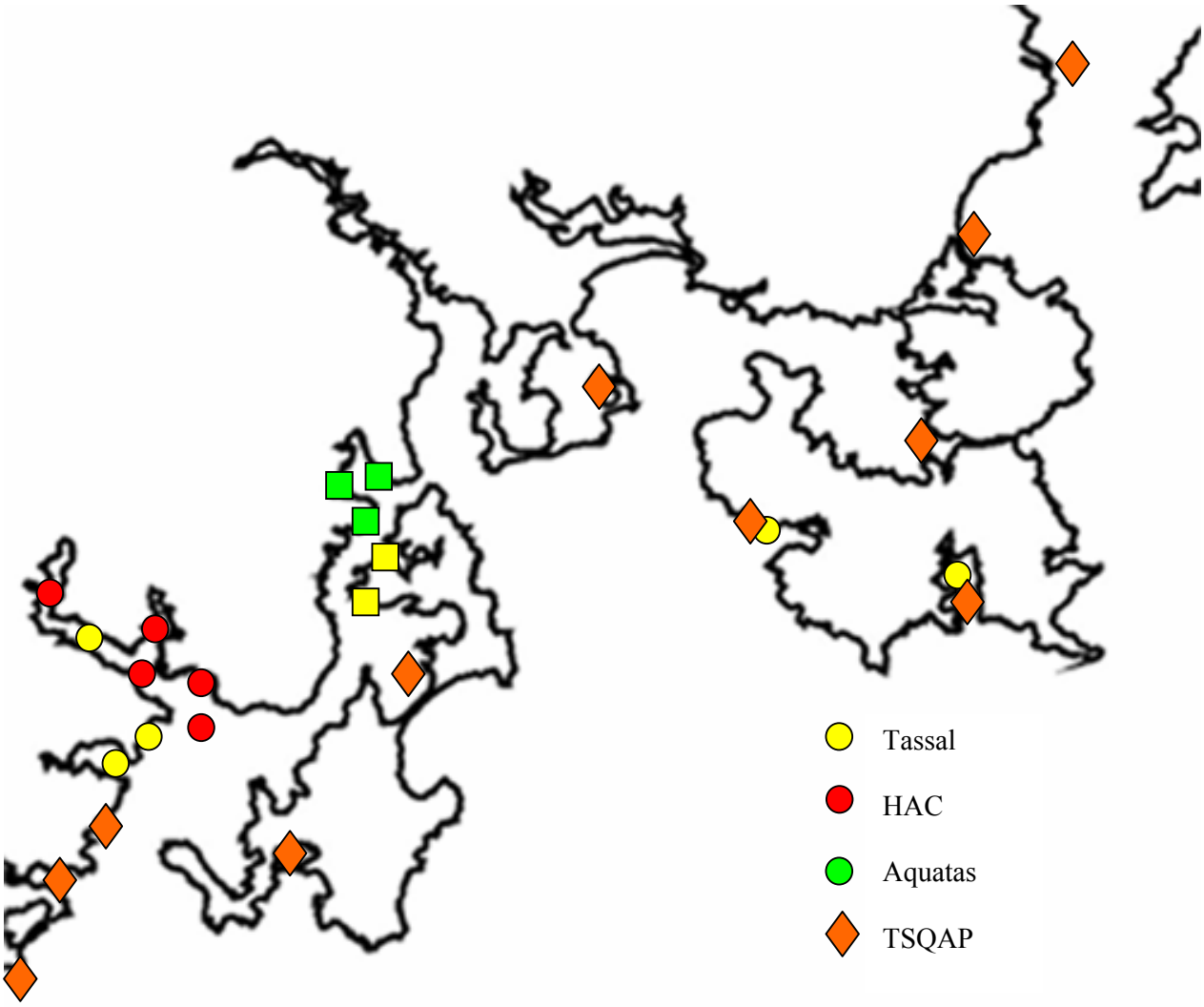

Figure 7; A selection of sites routinely sampled by the Tasmanian Shellfish Quality Assurance Program (TSQAP, orange diamonds) and finfish lease sites presently (squares) or proposed (circles) to be included in an algal monitoring program.

PLANNED OUTCOMES

The experience of getting industry representatives together under an educational course and workshop forum on harmful algal blooms has shown benefits to industry, researchers and government in a very short time scale. However, the outcomes of future courses such as this one is reliant on sourcing of external or industry funds for its continuation. Such funds are presently being pursued through the FRDC, Aquafin CRC and other avenues.

RECOMMENDATIONS

- "Emergency response microalgal identification for the finfish aquaculture industry" workshops should be run on an annual basis for both salmon and tuna aquaculture industries. Funding should be provided through either an industry based funding agency such as FRDC or ARC-Linkage, provided through a levy by the industry bodies or as the education and training component of the Aquafin CRC structure for the sustainable production of finfish aquaculture.
- Funding should be made available to determine the risk analysis of potentially damaging algal species for both industries. Minimum algal cell abundance, patterns of algal succession, gross, behavioural and histopathological diagnostic characters needs to be determined, to be used as a farm management tool (See Further developments)

Salmon

- The course should be integrated with the Tasmanian Fish Health Surveillance Program, to illustrate algal and fish sampling techniques in the context of algal blooms in a combined farm field day / industry workshop format.
- An industry wide sampling program should be adopted using the already available services offered by Analytical Services Tasmania.
- Funding should be provided for the analysis of predictive trends of HABs in southeast Tasmania using historical farm data and other data available.
- Historical algal data should be reconciled with fish mortality events and histopathological evidence available through the DPIWE Fish Health Unit slide library.
- An annual workshop should include the discussion of between companies on algal mitigation techniques. Industry managers have indicated that algal mitigation research needs to be resourced on a company wide basis.
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Tuna

- Future courses could be usefully run in conjunction with the PIRSA - Aquatic Animal Health Program to ensure dissemination of appropriate post mortem and sampling technique.
- The Tuna Boat Owners Association should initiate an industry based algal sampling program; incorporating samples form the SASQAP program, to cover the lease areas for the tuna industry. This information would give the industry greater predictive capability and reduce replication. Individual farms should still be encouraged to continue their own algal monitoring to be entered in a central database. Farms without algal monitoring resources could contribute in kind with the supply of boats, planes etc.

APPENDIX 1: COURSE PROGRAMMES AND ATTENDANCE LISTS

Course 1 Programme; Hobart, Tuesday 2nd September 2003

8:30-10:30	Microalgal taxonomy lectures	Gustaaf Hallegraeff (Utas)
10:30-11:00	Morning tea	
11:00-12:00-	Phytoplankton ecology lectures	Gustaaf Hallegraeff (Utas)
12:00-12:45	Lunch	
12:45-3:30	Microscope practical	Gustaaf Hallegraeff (Utas) Judi Marshall (Utas)
3:30-4:00	Afternoon tea	
4:00-4:30	Gross pathology of fish	Kevin Ellard (DPIWE)
4:30-5:15	Monitoring and mitigation strategies	Judi Marshall (Utas)
5:15-6:00	Workshop discussion (see sheet)	Judi Marshall (Utas) Kevin Ellard (DPIWE) Gustaaf Hallegraeff (Utas)

Course 1 Participants; Hobart, Tuesday 2nd September 2003

1.	David Cameron	Tassal Ltd
2.	Tim Withrington	Tassal Ltd
3.	Raymond March	Tassal Ltd
4.	Nigel Evans	Tassal Ltd
5.	Rauri Colquhuon	Tassal Ltd
6.	Arthur Miller	Tassal Ltd
7.	Josh McKibben	Huon Aquaculture Company
8.	Ron Marshman	Huon Aquaculture Company
9.	Hayden Pearson	Huon Aquaculture Company
10.	Ben Fazzioli	Huon Aquaculture Company
11.	Anthony Ingram	Huon Aquaculture Company
12.	Marcus Walkem	Huon Aquaculture Company
13.	Richard Gill	Van Diemen Aquaculture
14.	Paul Armstrong	Aquafin CRC/TAFI
15.	Susan Forbes	Aquafin CRC/TAFI
16.	Mick Attard	Aquafin CRC/TAFI

Fee paying attendees

1.	Ruth Erikson	(Analytical Services Tasmania / DPIWE)
2.	Stephanie Fulton	(Analytical Services Tasmania / DPIWE)

Course 2 Programme; Hobart, Thursday 9th October 2003

8:30-10:30	Microalgal taxonomy lectures	Gustaaf Hallegraeff (Utas)
10:30-11:00	Morning tea	
11:00-12:00-	Phytoplankton ecology lectures	Gustaaf Hallegraeff (Utas)
12:00-12:45	Lunch	
12:45-3:15	Microscope practical	Gustaaf Hallegraeff (Utas) Judi Marshall (Utas)
3:15-3:45	Afternoon tea	
3:45-4:15	Gross pathology of fish	Stephen Pyecroft (DPIWE/FHU)
4:15-5:00	Monitoring and mitigation strategies	Judi Marshall (Utas)
5:00-6:00	Workshop discussion (see sheet)	Judi Marshall (Utas) Stephen Pyecroft (DPIWE/FHU) Gustaaf Hallegraeff (Utas)

Course 2 Participants; Hobart, Thursday 9th October 2003

1.	Matthew McLean	Tassal Ltd
2.	Russell Timsar	Tassal Ltd
3.	Chris Coad	Tassal Ltd
4.	Matt Finn	Tassal Ltd
5.	Ray Furgusson	Tassal Ltd
6.	Guy Westbrook	Tassal Ltd
7.	Adam Norris	Tassal Ltd
8.	Dom O'Brien	Huon Aquaculture Company
9.	Adrian Steenholdt	Huon Aquaculture Company
10.	Dave Stockford	Huon Aquaculture Company
11.	Simon Holmes	Huon Aquaculture Company
12.	Rod Coughlan	Huon Aquaculture Company
13.	David Mitchell	Huon Aquaculture Company
14.	Craig Selkirk	Aquatas Pty Ltd
15.	Nick Murfett	Aquatas Pty Ltd
16.	Paul Mitchell	Aquatas Pty Ltd
17.	Peter Heard	Aquatas Pty Ltd

Guests and observers

1.	Colin Shepherd	DPIWE
2.	Stephanie Fulton	(Analytical Services Tasmania / DPIWE)

Course 3 Programme; Port Lincoln,

Thursday 1st October 2003

9:00-11:00	Microalgal taxonomy lectures Dinoflagellates and Diatoms	Gustaaf Hallegraeff (Utas)
11:00-11:30	Morning tea	
11:30-12:30-	Microalgal taxonomy lectures Flagellates	Gustaaf Hallegraeff (Utas)
12:30-1:30	Lunch	
1:30-3:30	Microscope practical Dinoflagellates	Gustaaf Hallegraeff (Utas) Judi Marshall (Utas)
3:30-4:00	Afternoon tea	
4:00-5:00	Microscope practical Flagellates	Gustaaf Hallegraeff (Utas) Judi Marshall (Utas)

Thursday 2nd October 2003

9:00-10:00	Phytoplankton ecology lectures	Gustaaf Hallegraeff (Utas)
10:00-11:00	Algal monitoring programmes & biotoxin analysis in New Zealand	Paul McNabb & Melissa Gladstone (Cawthron Institute, NZ)
11:00-11:30	Morning tea	
11:30-12:30-	Microscope practical Natural seawater samples	Gustaaf Hallegraeff (Utas) Judi Marshall (Utas)
12:30-1:00	Lunch	
1:00-1:30	Fish sampling techniques demonstration	Colin Johnston (PIRSA)
1:30-2:30	Gross pathology of fish	Colin Johnston (PIRSA)
2:30-3:30	Monitoring and mitigation strategies	Judi Marshall (Utas)
3:30-3:45	Afternoon tea	
3:45-5:00	Workshop discussion (see sheet)	Judi Marshall (Utas) Colin Johnston (PIRSA) Gustaaf Hallegraeff (Utas)

Course 3 Participants; Port Lincoln, 1 & 2nd October 2003

1.	Tom Bayly	Aquafin CRC/ Utas
2.	Christopher Pitney	Tony's Tuna
3.	Rachel Lawrie	Australian Fishing Enterprises
4.	Rebecca Patterson	Stolts Sea Farm Pty Ltd
5.	Mark Thyer	Sarin Marine Farm
6.	Marty Lang	AJKA
7.	David Ellis	TBOA
8.	Con Karaberidis	Sekol Farmed Tuna P/L
9.	Tim Brewer	Southern Star Aquaculture
10.	Travis Dymott	South Australian Aquaculture Management
11.	Dave Warland	
12.	Kirsten Rough	Kalis (Tuna) P/L
13.	Jeff Buchanan	PIRSA-SARDI
14.	Tim Flowers	SARDI
15.	Colin Johnston	PIRSA

APPENDIX 2: STAFF

Dr Judith-Anne Marshall B.Sc., Dip.Ed., Ph.D.
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Employed as a Research Fellow at the University of Tasmania, graduating with a PhD in algal toxicity, physiology and chemotaxonomy in 2003. Current research projects include the elucidation of the toxic principle of ichthyotoxic algae and determining diagnostic pathology for algal insult. Interests in determining algal bloom risk assessment for the aquaculture industry and developing algal bloom mitigation strategies.

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International expert in phytoplankton taxonomy and harmful algal bloom ecology. Editor-in Chief of the stage-setting 2003 UNESCO Manual on Harmful Marine Microalgae

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Graduated in veterinary medicine from Murdoch University 1992 and has worked as a government veterinary officer with the Departments of Agriculture and Fisheries before moving to Tasmania in 1999 to take up the present position with the Department of Primary Industry Water & Environment. Key areas of interest include the development of strategies to reduce incidence of disease in aquaculture and other livestock production.

Dr Stephen B. Pyecroft BVSc (Hons) MACVSc (Aquatic Animal Health)
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Graduated at Queensland University veterinarian school in 1984. After 8 years in general rural practice returned to the University of Queensland gained a post-graduate honours degree before embarking on a PhD. in the Department of Microbiology and parasitology. Since 1992 has been involved in aquatic animal health disease investigation and is currently supervising veterinarian pathologist at Mt Pleasant laboratories, DPIWE, Tasmania.

Dr Colin Johnston BVMS(Hons), MACVSc (Aquatic Animal Health)
(Aquatic Animal Health Veterinarian)
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Veterinarian working exclusively with aquatic animals. Current position as Manager, Aquatic Animal Health for the South Australian State government. Specific interests in histopathology, gross pathology and clinical pathology of marine and freshwater finfish and marine molluscs. Previous experience as veterinary services manager for large fish farming company in Scotland.

Mr Paul McNabb
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Paul is an analytical chemist with 7 years experience in food safety. For the past 4 years Paul has been part of a small team of international collaborators working towards viable and fully validated test method alternatives to the mouse bioassay for detecting marine biotoxins. Paul manages the Biotoxin laboratory at Cawthron where skilled staff routinely test all known shellfish toxins and use the latest technology including LCMS to solve problems associated with Harmful Algae.

Ms Melissa Gladstone
Section Head - Phytoplankton Section
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Melissa manages the Phytoplankton laboratory at Cawthron where skilled staff identify toxic phytoplankton in water samples taken around New Zealand. Melissa works closely with commercial and health sectors to provide an early warning system for Harmful Algal Blooms. Melissa joined the Phytoplankton lab, the only one of its kind in New Zealand, in 1999 after completing a Honours degree in Marine and Molecular Biology. She is paricularly interested in applying molecular techniques to aid identification of harmful microalgae.

Paul McNabb and Melissa Gladstone were in Port Lincoln as guests of Mr Ken Lee and the SASQAP program and gratefully donated their time to the workshop.

APPENDIX 3: Reference material provided in the resource package

Anon (2002). Emergency response sampling for harmful algae. DPIWE Fish Health Unit Fact Sheet 6.1. Extract from the DPIWE – Fish Health Unit Tasmanian Control Centre manual.

Ellard, K. (2003). Impacts of Algae Blooms on Salmon Farms in Tasmania. DPIWE Fish Health Unit course notes

Fukuyo, Y. HAB photograph sets and Atlas of Dinoflagellates. Harmful Algal Bloom Program of IOC and HAB project of WESTPAC/IOC. CD Rom

Hallegraeff, G.M. (2002). Aquaculturists' Guide to Harmful Australian Microalgae 2nd Edition. The Print Centre, Hobart. 136pp.

Hallegraeff, G.M. (2003). Harmful algal blooms: a global overview. *In*; Hallegraeff, G.M., Anderson, D.M. and Cembella, A.D. (eds). *Manual on Marine Microalgae.* Monographs on Oceanographic Methodology, 11 UNESCO Publishing, Paris, Chapter 1. pp 25-50.

Hallegraeff, G.M. and Hara, Y. (2003). Taxonomy of harmful marine raphidophytes. *In*; Hallegraeff, G.M., Anderson, D.M. and Cembella, A.D. (eds). *Manual on Marine Microalgae.* Monographs on Oceanographic Methodology, 11 UNESCO Publishing, Paris, Chapter 18. pp511-522.

Rensel, J.E. and Whyte, J.N.C. (2003). Finfish mariculture and harmful algal blooms. *In*; Hallegraeff, G.M., Anderson, D.M. and Cembella, A.D. (eds). *Manual on Marine Microalgae.* Monographs on Oceanographic Metholdology, 121 UNESCO Publishing, Paris, Chapter 25, pp 693-722.