Seafood Safety Scheme

Periodic review of the risk assessment

NSW/FA/CP064/1208

Contents

Executive summary

The previous risk assessment (NSW Food Authority, 2009) of the Seafood Safety Scheme was published in March 2009. The risk assessment was part of a comprehensive review of food safety schemes undertaken during the remake of Food Regulation 2004.

A review of influences on seafood safety since the 2009 assessment identified a number of issues for consideration. Those issues and two subject areas (parasites in raw fish for sushi/sashimi and non-*Vibrio* bacterial contamination of shellfish) identified during an expert review of the 2009 assessment have been considered in this report.

- For the years 2009 and 2010 OzFoodNet reported the following outbreaks attributed to seafood (reports are available at OzFoodNet, 2011):
  - Ciguatera, ten outbreaks from Queensland.
  - Scombroid/histamine poisoning, four outbreaks (ACT, NSW, Qld, Vic) and one suspected outbreak (NSW).
  - Escolar/rudderfish keriorrhoea, two outbreaks (ACT, Vic).
  - Salmonellosis, one outbreak, (multi-state) possibly linked to barramundi.
- The medical literature includes two reports of parasitic infection from Australian fish:
  - An incident (2 cases) of nematode infection following the consumption of fresh water fish from remote northern Western Australia (Jeremiah et al, 2011).
  - A woman of Tongan descent developed anisakidosis after eating raw, locally caught South Australian mackerel (Shamsi and Butcher, 2011).
- The Australian Seafood Cooperative Research Centre (Tamplin et al, 2011) completed a study that supports the liberalisation of storage temperatures for live Sydney rock oysters. The recommendations have been adopted by the NSW Food Authority.
- NSW has experienced several extensive potentially toxic cyanobacterial blooms in freshwater and brackish areas. These have resulted in a range of food safety interventions in the affected areas, including:
  - advising recreational fishers to gut, gill and wash fish prior to cooking,
  - advising recreational fishers not to collect yabbies or freshwater mussels,
  - industry voluntarily diverting commercially harvested seafood to bait,
  - industry voluntarily adopting gut and gill requirements for fish prior to sale, and
  - government mandating closure of areas to recreational and commercial harvest of seafood.
- As the result of toxic cyanobacterial blooms in Gippsland Lakes the Victorian Department of Health developed a health risk assessment for cyanobacterial toxins in seafood.
- International agencies have investigated the potential for human toxicity of pinnatoxin, a recently reported marine algal biotoxin.

The conclusions of the 2009 assessment remain valid. The updated assessment contains elements of the familiar and the new.

- Consumption of large predatory reef fish from ciguatera hot spots has risks that commercial and recreational fishers should recognise.
- Scombroid or histamine poisoning, which is generally linked to failures in the cold chain, remains an occasional problem.

- Escolar occasionally enters the commercial food chain without adequate warnings to consumers.
- Those preparing seafood for consumption raw or undercooked must be aware of the risk of parasites. Food safety is improved by the use of high value marine fish, buying sashimi grade product, checking the intestinal cavity for parasites, candling fish muscle for parasites, freezing fish prior to preparation according the guidelines issued by European Food Safety Agency (EFSA, 2010), and by using cooking processes that result in safety without overcooking fish (EFSA, 2010).
- The protection of shellfish harvest areas from contamination by sewage remains of critical importance for the prevention of shellfish-borne viral and bacterial illness.
- There is a role for the NSW Food Authority in the whole-of-government approach to the management of cyanobacterial blooms.
- Good science can assist food safety management with benefits for the food industry and consumers:
    - The studies of pathogens growth in the Sydney rock oyster at various temperatures allow for new and lower cost approaches to oyster safety.
    - Pinnatoxin studies prevent aberrant results in bioassays leading to unnecessary harvest closures and the associated costs.
    - Studies of cyanobacterial toxins provide a solid basis for the imposition of interventions to protect consumers and reduce the need for precautionary closures.

Introduction

The previous risk assessment (NSW Food Authority, 2009) of the Seafood Safety Scheme (the Scheme) was published in March 2009. The risk assessment was part of a comprehensive review of food safety schemes undertaken during the remake of Food Regulation 2004. At the completion of this process a simplified and refined Food Regulation 2010 was made. That regulation provides for continuation of a Seafood Safety Scheme.

Upon completion the NSW Food Authority commissioned an expert review of the 2009 assessment. The review resulted in a number of observations that spanned suggestions for improved clarity through to identification of technical issues for further investigation. Changes of a minor or editorial nature were included in a second edition of the assessment. The reviewer noted that two hazard/product pairs that had been studied by Ross and Sanderson (2000) were not considered in the 2009 assessment. Parasites in raw fish for sushi/sashimi and non-Vibrio bacterial contamination of shellfish have been addressed in this updated risk assessment.

A survey of significant influences on seafood safety in NSW since the 2009 assessment formed the major part of this periodic review.

Update of the 2009 assessment

A review of influences on seafood safety since the 2009 assessment identified a number of issues for consideration:

- For the years 2009 and 2010 OzFoodNet reported the following outbreaks attributed to seafood (reports are available at OzFoodNet, 2011):
    - Ciguatera, ten outbreaks, all from Queensland.
    - Scombroid/histamine poisoning, four outbreaks (ACT, NSW, Qld, Vic) and one suspected outbreak (NSW).
    - Escolar/rudderfish keriorrhoea, two incidents (ACT, Vic).
    - Salmonellosis, one outbreak, (multi-state) possibly linked to barramundi.
- The medical literature includes two reports of parasitic infection from Australian fish:
    - An incident (2 cases) of nematode infection following the consumption of fresh water fish from remote northern Western Australia (Jeremiah et al, 2011).
    - A woman of Tongan descent developed anisakidosis after eating raw, locally caught South Australian mackerel. (Shamsi and Butcher, 2011).
- The Australian Seafood Cooperative Research Centre (Tamplin et al, 2011) completed a study that supports the liberalisation of storage temperatures for live Sydney rock oysters. The recommendations have been adopted by the NSW Food Authority.
- NSW has experienced several extensive potentially toxic cyanobacterial blooms in freshwater and brackish areas. These have resulted in a range of food safety interventions in the affected areas, including:
    - advising recreational fishers to gut, gill and wash fish prior to cooking,
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    - industry voluntarily diverting commercially harvested seafood to bait,
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    - government mandating closure of areas to recreational and commercial harvest of seafood.
- As the result of toxic cyanobacterial blooms in Gippsland Lakes the Victorian Department of Health developed a health risk assessment for cyanobacterial toxins in seafood.
- International agencies have investigated the potential for human toxicity of pinnatoxin, a recently reported marine algal biotoxin.

Foodborne illness

Ciguatera poisoning heads the OzFoodNet 2009–10 list of foodborne illness incidents attributed to seafood. All reported outbreaks are in Queensland which reflects the consumption of large reef fish from tropical areas consistent with the known aetiology. Outbreaks were attributed to a mix of commercially caught and recreationally caught fish, including one fish that was caught by a recreational fisherman but then sold through a market. OzFoodNet last reported a ciguatera outbreak in NSW in 2002. The NSW Food Authority (2005) investigated a further suspected outbreak in 2005. Sydney Fish Market has imposed guidelines to restrict fish potentially contaminated with ciguatoxin from being sold at the wholesale auction. The restrictions include rejection of potentially contaminated fish from prohibited supply regions and the introduction of maximum size limits for some tropical reef fish. Since implementing these guidelines in 2005, there have been no known cases of ciguatera poisoning from fish sold through Sydney Fish Market (Sydney Fish Market, 2005;

2012). The marketing restrictions mean that ciguatera risk in NSW is better managed now than when Ross and Sanderson (2000) completed their assessment.

Scombroid/histamine poisoning is second on OzFoodNet's seafood list for the same period. NSW had one reported outbreak and one suspected outbreak in the period and there were six reports for the period 2001–08. With up to eight outbreaks over a ten-year period, it is considered that the hazard is fairly well managed. This is attributable to the use of an effective cold chain that uses ice and refrigeration to preserve both quality and safety. Guidance on control of histamine in seafood is available on the NSW Food Authority website (NSWFA, 2011a).

Escolar/rudderfish keriorrhoea is third on the list. OzFoodNet last reported a keriorrhoea incident in NSW in 2001 but there have been occasional anecdotal reports of keriorrhoea in the intervening period. Guidance regarding the sale and labelling of escolar is available on the NSW Food Authority website (NSWFA, 2011b).

An outbreak of salmonellosis associated with barramundi was also reported in the period. Consumption of a variety of foods and meals were associated with illness, with barramundi having the highest relative risk (RR= 3.8, 95% CI 1.0–14.2) for illness, but the cause of illness was not definitively identified (OzFoodNet, 2010). Five reports of *Salmonella* associated with seafood appear in OzFoodNet reports from 2001 to 2010, with two of the reports having 'suspected' status.

A husband and wife were infected with *Gnathostoma*, a nematode parasite, after eating a fresh water fish in remote northern Western Australia. The fish had been pan-fried whole over a camp fire, but the duration and thoroughness of cooking is unclear. Gnathostomiasis is a foodborne zoonosis resulting from ingestion of larvae. The larvae are unable to mature further in humans and they migrate through visceral and cutaneous tissues. Patients often develop fever, anorexia, abdominal discomfort, nausea and vomiting. The disease may show up in the skin (with red, pus filled or painful swellings) or the viscera (which may involve almost any part of the body including lungs, eyes or central nervous system) depending on the larval migration pattern. These are the first confirmed human cases of gnathostomiasis acquired in Australia, although there have been cases in other mammals (Jeremiah et al, 2011).

A woman of Tongan descent developed anisakidosis after eating raw, locally caught South Australian mackerel. Upon detailed microscopic examination the anisakid nematode, *Contracaecum,* was identified. Anisakidosis can result in severe gastrointestinal disorders, allergic reaction and even death. The allergic response can occur against live anisakids or food in which worms were killed by cooking or pasteurisation (Shamsi and Butcher, 2011).

Sydney rock oyster storage temperatures

Time and temperature have been identified as critical control points to reduce the risk of *Vibrio parahaemolyticus* in oysters. However, the time and temperature criteria that were being considered in international forums were developed using a model for the American oyster (*Crassostrea virginica*) grown in USA shellfish-growing waters. As this had the potential to disadvantage the Australian industry, the Australian Seafood Cooperative Research Centre (CRC) undertook a project to produce a validated and robust *V. parahaemolyticus* model that would be approved by regulatory authorities (Tamplin et al, 2011); the NSW Food Authority contributed funding towards the research.

The research project produced validated predictive models for *Vibrio* and standard plate count growth in both Pacific oyster (PO) and Sydney rock oyster (SRO). Microbial growth in PO was as expected based on international work for other shellfish species. However, the results for SRO demonstrated that microbial growth does not occur until storage temperatures reach above 25°C.

Additional work undertaken specifically on SRO assessed the growth of *E. coli* and *Salmonella* bacteria up to 35˚C. This work demonstrated that growth of these bacteria did not occur for storage temperatures up to 25˚C. Bacterial growth was observed above 25˚C.

The previous storage temperature requirement for SRO was:

a) <25˚C within 24 hours of harvest, then

b) <15˚C within 72 hours of harvest.

As a consequence of the study the storage temperature requirement for SRO was amended to:

a) <25˚C within 24 hours of harvest, then

b) <20˚C within 72 hours of harvest.

When considering the amended storage temperature regime, the provision of a safety factor of 5˚C was considered appropriate to account for variations in actual storage temperatures in commercial applications.

Cyanobacterial toxins in seafood

Guidelines for Managing Risks in Recreational Water (NHMRC, 2008) includes a comprehensive overview of cyanobacteria and their toxins. The following extracts are from that publication:

> *Cyanobacteria (blue-green algae) are bacterial photosynthetic autotrophs that form a common and naturally occurring component of most aquatic ecosystems. Cyanobacteria have some of the characteristics of bacteria and of algae. Their capacity to photosynthesise with the aid of green and blue-green pigments, and their size and tendency to occupy a similar habitat, make them look much like algae — hence the historical classification of the group as blue-green algae. They can occur singly or grouped in colonies and can increase to such large numbers that they colour the water (a 'bloom') and form highly visible thick scums.*
>
> *Cyanobacteria are of public health concern because some types produce toxins that have harmful effects on tissues, cells or organisms. These toxins are a potential hazard in waters used for human and animal drinking-water supplies, aquaculture, agriculture and recreation. Furthermore, production of toxins is unpredictable, making it difficult to identify the toxicity of waters and define the restrictions that should be placed on their use.*
>
> *The most common toxic cyanobacteria in Australia are:*
>
> Microcystis aeruginosa, Anabaena circinalis, Cylindrospermopsis raciborskii, *and* Aphanizomenon ovalisporum *in fresh water; and Nodularia spumigena and Lyngbya majuscula in estuarine and coastal marine water.*
>
> *The health problems associated with cyanobacteria are due to the cyanotoxins that they produce. The three main groups of cyanotoxins are:*
>
> - *the cyclic peptides — microcystins and nodularin*
> - *the alkaloids — such as neurotoxins and cylindrospermopsin; and*
> - *lipopolysaccharides.*

Cyclic peptides (Newcombe et al, 2010)

The microcystins and nodularin are known to cause liver damage (hepatotoxins). They block protein phosphatases 1 and 2a, which are "molecular switches" in all eukaryotic cells, with an irreversible covalent bond. For vertebrates, a lethal dose of microcystin causes death by liver damage within hours to a few days.

There are two potential mechanisms for long-term microcystin damage to the liver, progressive active liver injury as described above, and promotion of tumour growth. Tumour-promoting activity of microcystins is well documented in animals, although microcystins alone have not been demonstrated to be cancer causing. The literature indicates that hepatotoxic blooms of Microcystis aeruginosa *containing microcystins occur commonly worldwide.*

Alkaloids (Newcombe et al, 2010)

The alkaloid toxins produced by cyanobacteria include a range of compounds that interfere with nerve cell function (neurotoxins), including anatoxins and saxitoxins, as well as cylindrospermopsin, which is a recognised hepatotoxin, but which also causes general cell damage (cytotoxin).

While the neurotoxins have different modes of action, all have the potential to be lethal at high doses by inhibiting the ability to breathe - anatoxin-a and anatoxin-a (S) through cramps, and saxitoxins through paralysis. However, no human deaths from exposure to cyanobacterial neurotoxins are known.

The neurotoxic saxitoxins or paralytic shellfish poisons (PSPs) are one of a number of groups of toxins produced by dinoflagellates in the marine environment. Shellfish feeding on toxic dinoflagellates can themselves become toxic and hazardous if consumed, even causing human fatalities. Poisoning incidents usually coincide with the sudden proliferation of these organisms to produce visible blooms, the so-called "red tides".

Saxitoxins are also the neurotoxins present in Anabaena circinalis, *the only cyanobacterium yet found to be neurotoxic in Australia. The widespread occurrence of saxitoxins, especially in Australian neurotoxic* A. circinalis, *makes them a very important class of cyanobacterial toxins, at least in this country. In relation to* A. circinalis *in Australia, toxin profiles appear to be relatively constant and dominated by the C toxins. There is also some limited evidence that this cyanobacterium can produce both neurotoxins and hepatotoxins, a phenomenon which has been reported overseas with* Anabaena flos-aquae.

Cylindrospermopsin is an hepatotoxic alkaloid toxin that was first was isolated from C. raciborskii *and was therefore named after it. It is a general cytotoxin (cell toxin) with relatively slow onset of symptoms resulting in kidney and liver failure. Results suggest that cylindrospermopsin may also act directly as a tumour initiator, which has implications for long-term exposure.*

Lipopolysaccharides (Newcombe et al, 2010)

Lipopolysaccharides (LPS) are an integral component of the cell wall of all cyanobacteria (as well as other types of bacteria), and help to determine and maintain the size and shape of the cell. As LPS are always present in cyanobacteria it would appear to make LPS a potential issue of concern for exposure in recreational situations, relative to the other known toxins. These compounds have been shown to produce irritant and allergenic responses in human and animal tissues. They are pyrogenic (fever-causing agents) and toxic. An outbreak of gastroenteritis is suspected to have been caused by cyanobacterial LPS. Interestingly, however, cyanobacterial LPS are considerably less potent than LPS from some other types of bacteria such as Salmonella.

When toxins produced by cyanobacteria are present in the aquatic environment, seafood harvested from these waters may present a health hazard to consumers (Mulvenna et al, 2012). Table 1 below summarises evidence from the literature on cyanobacterial toxins in seafood.

Table 1: Literature reports of cyanobacterial toxins (tx) in seafood

Reference	Country	Toxin	Animal	Comment
Negri (1995)	Australia	PSP (*Anabaena*)	Mussel (freshwater)	Feeding trial; tx above regulatory limit; 95% of toxin in viscera
Vasconcelos (1999)	Portugal	Microcystin	Mussel (marine)	Feeding trials; tx was 10.5 ppm dry weight
(includes secondary sources)	Finland	Hepatotoxin	Mussel (freshwater)	Probable cause of muskrat mortality
	Finland	Microcystin	Mussel	Laboratory trial
	Australia	Nodularin	Mussel (marine)	From natural bloom
	Portugal	Microcystin	Crayfish (freshwater)	
	Portugal	Microcystin	Fin fish	Low in edible parts
Van Buynder (2001)	Australia	Nodularin	Prawn	Tx at 60% of health alert level in whole prawns. Suggested 60,000/mL closure. Tx stored in viscera, small amount enters flesh when cooked, 90% discarded in offal
			Mussel	Tx 1.5 ppm; derived health alert level. Exceeded health level cell count of 40,000/mL
			Finfish	Tx levels remained low and concentrated in viscera
Vasconelos (2001)	Portugal	Microcystin	Crayfish (freshwater)	Tx accumulated in viscera and no significant risk if gut removed
Yokoyama (2003)	Japan	Microcystin	Freshwater bivalve	Depurate slowly in winter. 250 ppm tx (dry wt) in hepatopancreas accumulated in 25°C water
Kankaanpaa (2005)	Australia	Hepatotoxins	Prawns farmed	Fed prawns accumulated tx – but not in muscle. Low natural tx in 2001–02

No confirmed reports of human illness have been found, however, Van Buynder (2001) reported anecdotal evidence that acute affects were observed in a bloom in the Gippsland Lakes after eating large quantities of prawns. Mulvenna et al (2012) report that there have been twelve cyanobacterial blooms in Gippsland since 1985. All three common bloom-forming cyanobacteria in the Gippsland lakes are toxic species.

In order to provide advice and to define acceptable levels of cyanobacterial toxins in seafood in Victoria, Australia, the Victorian Department of Health convened a scientific advisory group to carry out a risk assessment regarding commercial and recreational seafood safety in the Gippsland Lakes. The seafoods of concern were fish, prawns and mussels harvested from the lakes. The identified toxins for the risk assessment were microcystins, nodularin, saxitoxins and cylindrospermopsin, all of which have been found in Australian aquatic environments and are distributed worldwide.

A report of the scientific advisory group's findings has been published (Mulvenna, 2012). The health guidelines from the report are shown in Table 2. In November 2011 the NSW State Algal Advisory Group (a whole of government group that responds to algal issues in NSW, see Appendix 2) endorsed the recommendations for use in the event of cyanobacterial blooms NSW.

Table 2: Health guideline values for cyanobacterial toxins in seafood (based on consumption by 2–16 year age group)

Toxin	Health guideline value (µg/kg of whole organism sample)		
	Fish	Prawns	Mussels or Molluscs
Cylindrospermopsin and deoxycylindrospermopsin	18	24	39
Microcystin-LR or equivalent toxins, including Nodularin	24	32	51
Saxitoxins	800	800	800

The Gippsland Lakes experienced a *Nodularia spumigena* bloom from December 2011 to May 2012. Seafood samples were tested for nodularin and the results compared to the health guideline value. The results are available on-line (VicHealth, 2012) and an extract is included in Appendix 1. Table 3 is a summary of those results.

Table 3: Summary of nodularin toxin results of testing in seafood during Gippsland Lakes bloom 2011–12

Sample	Nodularin toxin µg/kg		
	Average[1]	Median[1]	Maximum
Black bream – whole	42.2	31	203
Black bream – gutted and gilled			<16
Black mussels	186.6	139.5	740
Prawns collected within the lakes	108.4	88	299
Prawns collected outside of Lakes Entrance	105.1	103	270

Note 1: Average and median values of samples where nodularin was detected.

The results are consistent with previous observations with toxin levels highest in molluscs, followed by prawns and then whole fish. Toxin was not detected in fish that had been gutted and gilled. Consumption of fish offal occurs in some communities and the sale of whole fish harvested from a bloom introduces an element of risk.

Prawns collected from oceanic waters (outside of Lakes Entrance) contain levels of toxin comparable to those collected in the lakes. Fishers were advised not to catch prawns in the lake or from Victorian oceanic waters from Wilson Promontory to the NSW border. Prawns are a migratory species and some species of Victorian prawns will migrate to the commercial prawn harvest areas in NSW (Montgomery, 2010). The risk to consumers of NSW caught prawns was thought to be low because the oceanic prawn trawl harvest areas are north of Newcastle, which is towards the upper limit of migration for Victorian king prawns, and oceanic king prawns are a mixed population that originates from a wide range of estuaries.

NSW also has cyanobacterial blooms. Parts of the Hawkesbury Nepean river system consistently have moderate levels of cyanobacteria and blooms are often reported in late summer or autumn. The Murray River experienced extensive blooms, impacting approximately 1000km of the river, in 2010 and 2011. Blooms occurred in the Myall Lakes in 1999 and 2012. Blooms are reported on the NSW Office of Water (2012) website.

The response to algal and cyanobacterial blooms in NSW is coordinated by a network of Regional Algal Coordinating Committees (RACCs). The committees include representatives of state and local governments, water utilities, community/tourism bodies and, where appropriate, federal and interstate governments. Each RACC maintains a contingency plan which sets out appropriate responses to alerts.

One key task of the RACCs is to keep their local communities informed of hazards arising from blooms. This is particularly important during Red Alerts which are described on the NSW Office of Water (2012) website as:

> *This alert level represents 'bloom' conditions. The water will appear green and may have strong, musty or organically polluted odours. Blue-green algae may be visible as clumps or as scums. The 'blooms' should be considered to be toxic to humans and animals, and the water should not be used for potable water supply (without prior treatment), stock watering, or for recreation.*

Media releases issued during red alerts include advice for recreational fishers that freshwater mussels and crayfish from areas affected by the bloom should not be eaten and fish should be gutted and thoroughly washed prior to cooking. Issues with commercial fisheries have usually been handled cooperatively between the Department of Primary Industries (DPI), the NSW Food Authority and the fishing industry.

During previous red alerts in the brackish prawn harvest areas of the Hawkesbury River, fishers have agreed to divert the catch to bait. When the 2012 Myall Lakes bloom was first recognised, higher value fish were gutted and gilled prior to sale and mullet was diverted to bait. These actions were recommended by the NSW Food Authority and endorsed by seafood marketers and representatives of professional fishers.

As the Myall Lakes bloom was widespread and cyanobacterial scums were present, a regulatory closure of recreational and commercial fishing was imposed by the DPI until the toxicity of the bloom could be determined. The closure was supported by industry because it protected both public health and the reputation of seafood. The fishery reopened promptly when toxin was not detected.

Overall it seems that risk to seafood consumers from cyanobacterial toxins is low. However, there is a hazard and management activities ranging from issuing advisory information through to recreational and commercial fishing closures is warranted during cyanobacterial blooms. The guidelines in Table 2 above will provide valuable assistance during blooms.

Pinnatoxins

In 2007 a batch of Australian shellfish submitted for biotoxin testing by mouse bioassay demonstrated toxicity. Subsequent studies isolated and determined the structure of several pinnatoxins associated with the incident (Selwood et al, 2010).

Pinnatoxins were discussed at the International Conference of Molluscan Shellfish Safety in 2011. The prevailing view at the time was that there is significant evidence that pinnatoxins don't cause acute illness in humans (A. Zammit, *pers comm* 17 May 2012). Internationally the issue of human toxicity remains under review. Progress will be monitored and any updated formation included in the next periodic review of the seafood safety scheme risk assessment.

Parasites in raw fish for sushi/sashimi

Walsh and Grant (1999) noted that parasites are only a seafood safety concern where fish is eaten raw or partly cooked. They acknowledged the growth in consumption of raw fish and recommended that the specific risks associated with the preparation and sale of raw fish for consumption raw should be investigated.

Ross and Sanderson (2000) assessed the risks of parasites in raw fish for sushi/sashimi in NSW. They stated the risk appears currently to be low, but the growth in consumption of raw fish suggests that increased incidence of seafood-borne parasitic infections might be expected. They assigned a Potential Risk (PR) score of 0.35–0.70 and overall ranking of 9th out of 10 hazards assessed. They suggested a PR score of less than one probably represents a risk that is currently well managed.

FSANZ (2005) undertook a relative risk ranking for seafood. Helminthic parasites in chilled/frozen fish and fish fillets and in marinated, pickled, brined, dried or fermented fish products ranked low. The report stated there were no epidemiological data indicating foodborne illness due to the presence of helminthic parasites in raw finfish products in Australia, however, two incidents have since been reported (see above; Jeremiah et al, 2011; Shamsi and Butcher, 2011).

Worldwide fish-borne parasitic zoonoses are responsible for large numbers of human infections. In the past these diseases were limited for the most part to populations living in low- and middle-income countries, but the geographical limits and populations at risk are expanding and changing because of growing international markets, improved transportation systems and demographic changes (such as population movements) (Chai et al, 2005).

Liver flukes (Chai et al, 2005)

> *Liver flukes have long been known to cause serious disease in certain areas of the world. Cholangitis, choledocholithiasis, pancreatitis, and cholangiocarcinoma are the major clinical problems, associated with the long chronic pattern of these infections.*

Intestinal flukes – heterophyids (Chai et al, 2005)

> *These minute intestinal flukes of the family Heterophyidae are parasites of birds and mammals. A large number of species have been reported from humans. However, because an extraordinary number of heterophyid species are zoonotic (about 35 species) and have very similar transmission patterns, this group is in the aggregate a very significant food safety and quality problem.*
>
> *Although generally not considered of significant clinical importance relative to the liver flukes, several heterophyid species, including* Stellantchasmus falcatus, Haplorchis *spp., and* Procerovum *spp., can cause significant pathology, often fatal, in the heart, brain, and spinal cord of humans.*

The intestinal flukes – echinostomes (Chai et al, 2005)

Trematodes of the family Echinostomatidae (Poche, 1926) are intestinal parasites of birds and mammals. At least 30 genera and more than 200 species are known; about 15 species infect humans. There are 11 reported fish-borne echinostome species. The disease is generally mild, but ulcerations and bleeding in the stomach or duodenum may occur.

Diphyllobothriasis (Chai et al, 2005)

This is the most important fish-borne zoonosis caused by a cestode (tapeworm) parasite. Although not generally considered a serious zoonosis, there are indications that its frequency and distribution is increasing in some regions, probably because of social and economic change. These tapeworms are among the largest parasites of humans, and may, as adults in the intestine, grow to 2–15 m in length.

Anisakiasis (Chai et al, 2005)

Anisakiasis (anisakidosis) refers to infection of people with larval stages of nematodes belonging to the families Anisakidae or Raphidascarididae. Although cases of human infection have been reported with worms from a number of species within these families the two genera most often associated with anisakiasis are Anisakis *and* Pseudoterranova. *Anisakiasis occurs when people ingest third stage larvae found in the viscera or muscle of a wide range of fish and cephalopod mollusc species. Humans are accidental hosts in the life cycle, and the parasites almost never develop further within the human gastrointestinal tract. Nevertheless, anisakiasis is a serious zoonotic disease, and there has been a dramatic increase in its reported prevalence throughout the world in the last two decades.*

Human anisakiasis can take a number of forms, depending on the location and histopathological lesions caused by the larvae. Larvae may remain in the gastrointestinal tract, without penetrating the tissues, causing an asymptomatic infection, which may only be discovered when the worms are expelled by coughing, vomiting or defecating. In invasive anisakiasis, larvae penetrate the gastric or intestinal mucosa, or more rarely other sites such as the throat. There is some evidence that gastric invasion is more often associated with infections by Pseudoterranova *spp. and intestinal invasion with infections by Anisakis spp. Symptoms of gastric anisakiasis usually appear 1–7 hours after consumption of fish, while intestinal anisakiasis usually manifests 5–7 days after fish consumption. In both cases, there is severe pain, with nausea and vomiting. Histopathological examination of invasive anisakiasis usually reveals the worm embedded in a dense eosinophilic granuloma in the mucosa, often with localized or diffuse tumours in the stomach or intestinal wall.*

In recent years, it has become clear that anisakiasis is often associated with a strong allergic response, with clinical symptoms ranging from isolated swellings to urticaria and life threatening anaphylactic shock.

Broglia and Kapel (2011) explore the themes of demographic change in relation to food generally. They contend that changing dietary habits in a changing word are emerging drivers for transmission of foodborne parasitic zoonoses. Among other things the authors point to:

- changing eating habits, such as the consumption of raw or lightly cooked food, and the demand for exotic foods, such as bush meat,
- rapid population growth, concentrating in urban areas,
- an increasingly global market in vegetables, fruit, meat, ethnic foods, and even farm animals, some of which originate from countries without appropriate food safety procedures,

- improved transport logistics and conditions, which enable parasites to survive on food products and reach the consumer in a viable form,
- an increasingly transient human population carrying its parasitic fauna worldwide, and
- the shift from low- to high-protein food consumption as nations develop economically with a concomitant and global greater dependency on meat and fish products.

There appears to be a clear consensus in parasitology literature about the hazards associated with eating raw and undercooked fish (for example see Dorny et al, 2009). However, a number of authors contend that traditionally prepared sushi or sashimi has a low level of risk. In his 1987 article *Anisakiasis – is the sushi bar guilty?,* Oshima suggests the risk is low and that rising reports of anisakiasis are due to advances in diagnosis rather than the commercialisation of sushi.

Nawa et al (2005) point out that sushi and sashimi served in Japanese restaurants and sushi bars are preferentially, but not exclusively, prepared from relatively expensive marine fish such as tuna, yellow tail, red snapper, salmon and flatfish/flounder. These species are less contaminated or are even free of *Anisakis* larvae, although salmon is an important intermediate host for the fish tapeworm *Diphyllobothrium latum*. In contrast, other popular and cheap marine fish, such as cod, herring, mackerel and squid, tend to be heavily infected with *Anisakis* larvae. Except for *Anisakis* and *D. latum*, marine fish transmit few parasite species that infect humans. The authors conclude that the risk of infection with fish-borne parasites by dining in Japanese restaurants and sushi bars is not as significant as is generally feared.

Nawa et al (2005) were writing about travel medicine and noted that raw or undercooked freshwater or brackish-water fish, frogs, land snails, snakes, backyard chicken and wild boar are served in rural Japan and many Asian countries as well. Thus, travellers dining in local restaurants or street shops can be expected to have much higher risks of infections with various parasites.

Chai et al (2005) reviewed the fish-borne parasitic diseases considered by the World Health Organisation to be most important. Their review provides a useful overview of the hazards.

Table 4: Trematodiases: a) the liver flukes (Chai et al, 2005)

Species	Molluscan and piscine hosts	Geographic distribution
Clonorchis sinensis	Freshwater fish and snails	Korea, China, Taiwan, Russia
Opisthorchis viverrini	Freshwater fish and snails	Thailand, Laos, Cambodia, Vietnam
Opisthorchis felineus	Freshwater fish and snails	Spain, Italy, Albania, Greece, France, Macedonia, Switzerland, Germany, Poland, Russia, Turkey, Caucasus
Metorchis conjunctus	Freshwater fish and snails	Canada, USA

Table 5: Trematodiases: b) the intestinal flukes – heterophyids (Chai et al, 2005)

Species	Molluscan and piscine hosts	Geographic distribution	Comment
Metagonimus yokogawai	Freshwater snails and fish	Korea, China, Taiwan, Japan, Russia, Indonesia, Israel, Spain	Infection prevented by not eating uncooked fresh water fish
Metagonimus takahashii	Freshwater snails and fish	Korea, Japan	
Metagonimus miyatai	Freshwater snails and fish	Korea, Japan	
Heterophyes heterophyes	Brackish water snails and fish	Egypt, Sudan, Palestine, Brazil, Spain, Turkey, Iran, India, Russia	Linked to salted or insufficiently baked fish
Heterophyes nocens	Brackish water snails and fish	Korea, Japan, China	
Haplorchis taichui	Freshwater snails and fish	Taiwan, Philippines, Bangladesh, India, Palestine, Egypt, Malaysia, Thailand, Laos, Vietnam, China	
Haplorchis pumilio	Freshwater snails and fish	Thailand, Laos, China	
Haplorchis yokogawai	Freshwater snails and fish	Taiwan, Philippines, China, Malaysia, Egypt Indonesia, Thailand, Laos, India, **Australia**,	
Pygidiopsis summa	Brackish water snails and fish	Korea, Japan	

The prevalence of liver flukes in endemic areas is related to the custom of eating raw fish or shrimps. Examples include: Congee with slices of raw freshwater fish (southern China and Hong Kong); raw freshwater fish with red pepper sauce; half roasted or undercooked fish in Guangdong Province; Koi pla in north-eastern Thailand and Laos. Korean immigrants in Canada ate wild-caught fish in undercooked traditional dishes not realising that *M. conjunctus* was endemic in fish in the area.

Table 6: Trematodiases: c) the intestinal flukes – echinostomes (Chai et al, 2005)

Species	Piscine hosts	Geographic distribution
Echinostoma hortense	Freshwater snail and fish	Korea, Japan, China
Echinochasmus japonicus	Freshwater snail and fish	Korea, Japan, China
Echinochasmus perfoliatus	Freshwater snail and fish	Japan, China, Taiwan, Hungary, Italy, Rumania, Russia
Echinochasmus liliputanus	Freshwater snail and fish	Egypt, Syria, Palestine, China
Echinochasmus fujianensis	Freshwater snail and fish	China

Chai et al (2005) provide information on another trematode, *Nanaphyetus salmincola*, which is associated with a fresh water snail and salmonid (trout, salmon) and non-salmonid fish. Human disease is endemic in the far-eastern part of Russia.

Table 7: Cestodes (tapeworms) Diphyllobothrium species reported from humans (Chai et al, 2005)

Species	Piscine hosts	Geographic distribution
Diphyllobothrium alascense	Burbot, Smelt	Kuskokwim Delta, Alaska
Diphyllobothrium cameroni	Marine fish	Japan
Diphyllobothrium cordatum	Marine fish	Northern Seas, Greenland, Iceland
Diphyllobothrium dalliae	Freshwater fish (*Dallia pectoralis*)	Alaska, Siberia
Diphyllobothrium dendriticum	Freshwater fish (Salmonids, Coregonids, Burbot, Grayling)	Circumpolar; introduced elsewhere
Diphyllobothrium hians	Marine fish	North Atlantic; North Sea?
Diphyllobothrium klebanovski	Salmonids	Eastern Eurasia, Sea of Japan, Sea of Okhostsk; Alaska?
Diphyllobothrium lanceolatum	*Coregonus*	North Pacific, Bering Sea
Diphyllobothrium latum	Pike, Burbots, Percids	Fennoscandia, western Russia, North and South America; reported from Cuba, Korea
Diphyllobothrium nihonkaiense	Salmon	Japan
Diphyllobothrium pacificum	Marine fish	Peru, Chile, Japan
Diphyllobothrium ursi	Red salmon	Alaska, British Columbia
Diphyllobothrium yonagoensis	Salmon	Japan, Eastern Siberia

Infection is linked to the consumption of raw or insufficiently cooked or marinated fish. The zoonosis occurs most frequently in communities that have food preferences for wild-caught prepared in ways such as: sushi, sashimi, gravalax (gravlax), strogonina, gefilte fisch, and ceviche. There is little to implicate farm-raised salmonids in transmission of diphyllobothriids to humans. Wild salmonids are at highest risk of becoming infected and represent a major reservoir of infection.

Chai et al (2005) discuss a third group of parasites, those responsible for anisakiasis. The two genera most often associated with anisakiasis are *Anisakis* and *Pseudoterranova*. Historically only two major zoonotic species were recognised; the 'herring worm' *Anisakis simplex* and the 'codworm' *Pseudoterranova decipiens*. Recent molecular genetic studies, however, have shown that both of these morphological species actually comprise a number of sibling species, genetically differentiated and often with distinct geographical and/or host ranges.

Live anisakid larvae may be ingested when people eat raw, insufficiently cooked, smoked or marinated fish or cephalopod molluscs. Human anisakiasis can take a number of forms depending on whether the parasite remains in the gastrointestinal tract or invades other organs. In recent years, it has become clear that anisakiasis is often associated with a strong allergic response, with clinical symptoms ranging from isolated swelling to urticaria (itching) and life threatening anaphylactic shock. Freezing and cooking might not provide protection against allergic response (Chai et al, 2005).

Anisakiasis occurs through the world. Of the total cases (about 20,000 when Chai et al published their report in 2005) over 90% are from Japan (where 2000 cases are diagnosed annually) with the majority of other cases from the Netherlands, Germany, France and Spain. As diagnostic methods improve, more cases are being reported from other areas of the world, including a report from New Zealand. Larval anisakid infections can be found in fish from Australian waters (for example Doupe et al, 2003 and Shamsi et al, 2011).

Overall it seems that higher risk factors in contracting seafood-borne parasitic illness are associated with:

- low and middle income countries,
- cultural traditions related to the consumption of raw and undercooked seafood,
- freshwater fish more than marine fish,
- wild caught marine fish more than farmed (pellet feed) marine fish, and
- lower cost marine fish more than higher value marine fish.

At this stage the risk from parasites from seafood served raw and undercooked remains low in Australia. However, Japanese food, including sushi and sashimi, is very popular in Australia and cultural diversity means that consumption of other forms of raw seafood is increasingly likely. If that increase leads to higher consumption of raw or undercooked wild caught, low value marine fish or freshwater fish the risk will increase. The recognition of anisakis related anaphylaxis could well change the risk rankings in the future.

Non-vibrio bacterial contamination of shellfish

Walsh and Grant (1999) found that bacterial pathogens of faecal origin to be high priority for risk assessment.

Ross and Sanderson (2000) assessed the risks of non-vibrio bacterial contamination of shellfish. They estimated the PR to be 0.25–1.35 for depurated shellfish and possibly 0.5–2.7 for shellfish that are not depurated and ranked the risk as sixth out of ten hazards assessed. They stressed that the interventions specified for control of viral contamination of shellfish are relevant and in particular the control of sewage pollution in shellfish growing areas.

FSANZ (2005) relative risk ranking for raw oysters with *Listeria monocytogenes*, *Escherichia coli* (non-EHEC), *Staphylococcus aureus*, *Salmonella* (non-typhoid), *Campylobacter* spp, *Shigella* spp. or *Yesinia* spp. were all low.

Shellfish harvesting controls stressed by Ross and Sanderson (2000) are central to the activities of the NSW Food Authority's Shellfish program. The requirements for sanitary surveys, microbial water and shellfish testing, and monitoring environmental parameters to inform the open or closed status of harvest areas provide substantial control of most faecal contamination issues. Oysters consumed raw are the main risk and yet there is little evidence of foodborne illness. OzFoodNet reports from 2001 to 2010 contain only one outbreak of bacterial illness where oysters were suspected to be the vehicle. The outbreak occurred in Victoria in December 2001. Six people were sick and the evidence of oyster involvement was 'descriptive' (other categories of evidence are 'statistical' after a formal epidemiological study, or 'microbiological' confirmation of the agent and cases).

Ross and Sanderson's conclusion: 'the presence of existing control strategies suggest that faecal bacteria in shellfish constitute a low risk to the health of NSW consumers relative to other identified hazards', still appears to be correct.

Conclusions

The conclusions of the 2009 assessment remain valid. The updated assessment contains elements of the familiar and the new.

- Consumption of large predatory reef fish from ciguatera hot spots has risks that commercial and recreational fishers should recognise.
- Scombroid or histamine poisoning, which is generally linked to failures in the cold chain, remains an occasional problem.
- Escolar occasionally enters the commercial food chain without adequate warnings to consumers.
- Those preparing seafood for consumption raw or undercooked must be aware of the risk of parasites. Food safety is improved by the use of high value marine fish; buying sashimi grade product; checking the intestinal cavity for parasites; candling fish muscle for parasites; freezing fish prior to preparation according the guidelines issued by European Food Safety Agency (EFSA, 2010), and by using cooking processes that result in safety (EFSA, 2010).
- The protection of shellfish harvest areas from contamination by sewage remains of critical importance for the prevention of shellfish-borne viral and bacterial illness.
- There is a role for the NSW Food Authority in the whole of government approach to the management of cyanobacterial blooms.
- Good science can assist food safety management with benefits for the food industry and consumers:
    - The studies of pathogens growth in the Sydney rock oyster at various temperatures allow for new and lower cost approaches to oyster safety.
    - Pinnatoxin studies prevent aberrant results in bioassays leading to unnecessary harvest closures and the associated costs.
    - Studies of cyanobacterial toxins provide a solid basis for the imposition of interventions to protect consumers and reduce the need for precautionary closures.

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Appendix 1: Results of seafood analysis during Gippsland Lakes bloom – Dec 2011 to March 2012

All results in this appendix are from the Victorian Department of Health website (VicHealth, 2012). Non detections are only included where they provide useful information. Results in bold face exceed the health guideline value.

Table 8: Black bream

Date of collection	Sample location	Nodularin toxin whole black bream µg/kg	Nodularin toxin G&G black bream µg/kg
07/12/2011	Point Turner	16	-
07/12/2011	Eagle Bay/ Split Jetties	**43**	-
07/12/2011	Tambo Bay	**47**	-
21/12/2011	Eagle Bay	**41**	< 16
21/12/2011	Tambo Bay	**52**	< 16
16/01/2012	Jones Bay	**111**	< 16
17/01/2012	Wattle Point	20	< 16
17/01/2012	Metung	**203**	< 16
25/01/2012	Eagle Bay	19	< 16
30/01/2012	Tambo Bay	19	< 16
30/01/2012	Jones Bay	**30**	< 16
31/01/2012	Metung	**27.4**	< 16
06/02/2012	Wattle Point	**44.4**	-
07/02/2012	Metung	**54**	< 16
08/02/2012	Eagle Bay	**40**	< 16
10/02/2012	Waddy Point	**74**	< 16
13/02/2012	Tambo Bay	**24**	< 16
13/02/2012	Eagle Bay	**39**	< 16
14/02/2012	Metung	**28**	< 16
15/02/2012	Waddy Point	**145**	< 16
21/02/2012	Tambo Bay	17	< 16
21/02/2012	Jones Bay	**39**	< 16
27/02/2012	Waddy Point	**42**	< 16
06/03/2012	Bancroft Bay	**25**	< 16
06/03/2012	Nungurner	**33**	< 16
07/03/2012	Eagle Bay	**32**	< 16
08/03/2012	Eagle Bay	17	< 16
13/03/2012	Jones Bay	18	< 16

Date of collection	Sample location	Nodularin toxin whole black bream µg/kg	Nodularin toxin G&G black bream µg/kg
13/03/2012	Eagle Bay	**30**	< 16
19/03/2012	Jones Bay	21	< 16
19/03/2012	Tambo Bay	**53**	< 16
26/03/2012	Tambo Bay	17	< 16
26/03/2012	Waddy Point	**28**	< 16
27/03/2012	Waddy Point	**32**	-
10/04/2012	Tambo Bay	20	< 16
23/04/2012	Tambo Bay	17	< 16

Table 9: Black mussels

Date of collection	Sample location	Nodularin toxin whole black mussels µg/kg
13/12/2011	Metung Jetty	36
13/12/2011	Nungurner Jetty	**63**
13/12/2011	Kalimna Jetty	**740**
18/12/2011	Metung Jetty	**102**
18/12/2011	Nungurner Jetty	**107**
18/12/2011	Kalimna Jetty	**506**
05/01/2012	Metung Jetty	**168**
05/01/2012	Nungurner Jetty	**170**
05/01/2012	Kalimna Jetty	**189**
11/01/2012	Nungurner Jetty	**71**
11/01/2012	Metung Jetty	**126**
11/01/2012	Kalimna Jetty	**330**
16/01/2012	Metung Jetty	**183**
16/01/2012	Nungurner Jetty	**215**
16/01/2012	Kalimna Jetty	**338**
30/01/2012	Metung Jetty	**187**
30/01/2012	Nungurner Jetty	**306**
30/01/2012	Kalimna Jetty	**525**
06/02/2012	Metung Jetty	**149**
06/02/2012	Kalimna Jetty	**334**
06/02/2012	Nungurner Jetty	**351**
13/02/2012	Metung Jetty	**73**

Date of collection	Sample location	Nodularin toxin whole black mussels µg/kg
13/02/2012	Kalimna Jetty	**100**
13/02/2012	Nungurner Jetty	**130**
20/02/2012	Metung Jetty	**77**
20/02/2012	Kalimna Jetty	**135**
20/02/2012	Nungurner Jetty	**249**
27/02/2012	Kalimna Jetty	**111**
27/02/2012	Metung Jetty	**241**
27/02/2012	Nungurner Jetty	**642**
05/03/2012	Kalimna Jetty	**152**
05/03/2012	Nungurner Jetty	**274**
05/03/2012	Metung Jetty	**328**
13/03/2012	Kalimna Jetty	**88**
13/03/2012	Nungurner Jetty	**133**
13/03/2012	Metung Jetty	**188**
19/03/2012	Metung Jetty	**62**
19/03/2012	Nungurner Jetty	**121**
19/03/2012	Kalimna Jetty	**144**
27/03/2012	Metung Jetty	34
27/03/2012	Kalimna Jetty	39
27/03/2012	Nungurner Jetty	39
02/04/2012	Kalimna Jetty	**64**
02/04/2012	Metung Jetty	**150**
10/04/2012	Nungurner Jetty	34
16/04/2012	Nungurner Jetty	31
16/04/2012	Metung Jetty	40
16/04/2012	Kalimna Jetty	**83**

Table 10: Prawns collected within the Gippsland Lakes

Date of collection	Species	Sample location	Nodularin toxin prawns from within the lakes µg/kg
13/01/2012	School Prawns	Gippsland Lakes	**88**
29/01/2012	School and King Prawns	Nungurner	**299**
06/02/2012	School Prawns	Nungurner	**102**
13/02/2012	King Prawns	Cunningham Arm	**75**
13/02/2012	King Prawns	Bell's Point	**91**
27/02/2012	King Prawns	Barrier Landing	**111**
06/03/2012	King Prawns	Nungurner	**77**
06/03/2012	King Prawns	Cunningham Arm	**77**
14/03/2012	King Prawns	Nungurner	**56**

Table 11: Prawns collected outside of Lakes Entrance

Date of collection	Species	Sample location	Nodularin toxin prawns from ocean outside the lakes µg/kg
30/12/2011	School Prawns	6.5 Nautical miles west of Lakes Entrance	30
10/01/2012	School Prawns	Eastern Beach	**124**
15/01/2012	School Prawns	Eastern Beach	**137**
17/01/2012	School Prawns	Eastern Beach	**270**
29/01/2012	School and King Prawns	Eastern Beach Channel	**224**
30/01/2012	School Prawns	Off Lake Bunga	**81**
30/01/2012	School Prawns	2 Nautical miles east of Lake Tyers	**107**
02/02/2012	School Prawns	Between 0.5 and 2.2 nautical miles east of Lake Tyers	**119**
04/02/2012	School Prawns	7 Nautical miles west of Lakes Entrance	**77**
04/02/2012	King Prawns	1.5 miles straight out from Lakes Entrance	**107**
04/02/2012	School Prawns	11 Nautical Miles east of Lakes Entrance 3.5 fathoms	**130**
06/02/2012	School Prawns	Lakes Entrance	**98**
16/02/2012	King Prawns	2 Nautical miles east of Lakes Entrance	**35**
16/02/2012	King Prawns	0.5 Nautical miles east of Lakes Entrance	**55**
16/02/2012	King Prawns	5 Nautical miles east of Lakes Entrance	**110**
26/02/2012	King Prawns	6.5 Nautical miles east of Lakes Entrance	**44**
27/02/2012	King Prawns	Eastern Beach Channel	**99**
27/03/2012	King Prawns	6 Nautical miles east of Lakes Entrance	**44**

Many of the locations listed in these tables may be found at:

http://maps.google.com.au/?ll=-37.907908,147.790489&spn=0.197202,0.491638&om=1&t=m&z=12

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Appendix 2: Algal management in New South Wales

These extracts from the NSW Office of Water website provide information on algal management in NSW (http://www.water.nsw.gov.au/Home/default.aspx).

Algal management strategy

In response to the occurrence of the largest recorded blue–green algal bloom in the Darling River in 1991, the NSW Blue–Green Algal Task Force was formed. The Task Force was made up of representatives from a number of key NSW government agencies. In 1992, the Task Force made 30 recommendations to the government which were developed into a comprehensive integrated Algal Management Strategy to minimise the occurrence and impact of algal blooms in New South Wales.

The NSW Algal Management Strategy integrated a large number of measures into five key elements: State Algal Contingency Plan; Management of Blooms; Land and Water Management; Education and Awareness Raising; and Research. The Strategy included Algal Contingency Plans to minimise the effects of blue–green algal blooms, and short to medium term measures to control the factors leading to algal bloom development. It also covered short to long term nutrient and water management measures to minimise nutrient inputs to waterways. These measures were strengthened by education and research, and by increasing community awareness. The Strategy involves Catchment Management Authorities, NSW Office of Water and other state government agencies, local government, communities, industry, researchers and landholders.

The NSW Algal Management Strategy forms the basis of the work of the Regional Algal Coordinating Committees.

NSW State Algal Advisory Group

The NSW Algal Management Strategy is administered by the NSW State Algal Advisory Group (SAAG) and the nine regional algal coordinating committees.

The State Algal Advisory Group provides the over arching policy advice and framework for the management of fresh water and marine blooms. Membership of the State Algal Advisory Group is made up of the relevant NSW State agencies, NSW local government and the Murray Darling Basin Authority.

While each member is responsible for a specific area of management and technical information, the NSW Office of Water is the lead agency for water management in NSW and coordinates both the State Algal Advisory Group and the Regional Algal Coordinating Committees

Technical Advisory Group

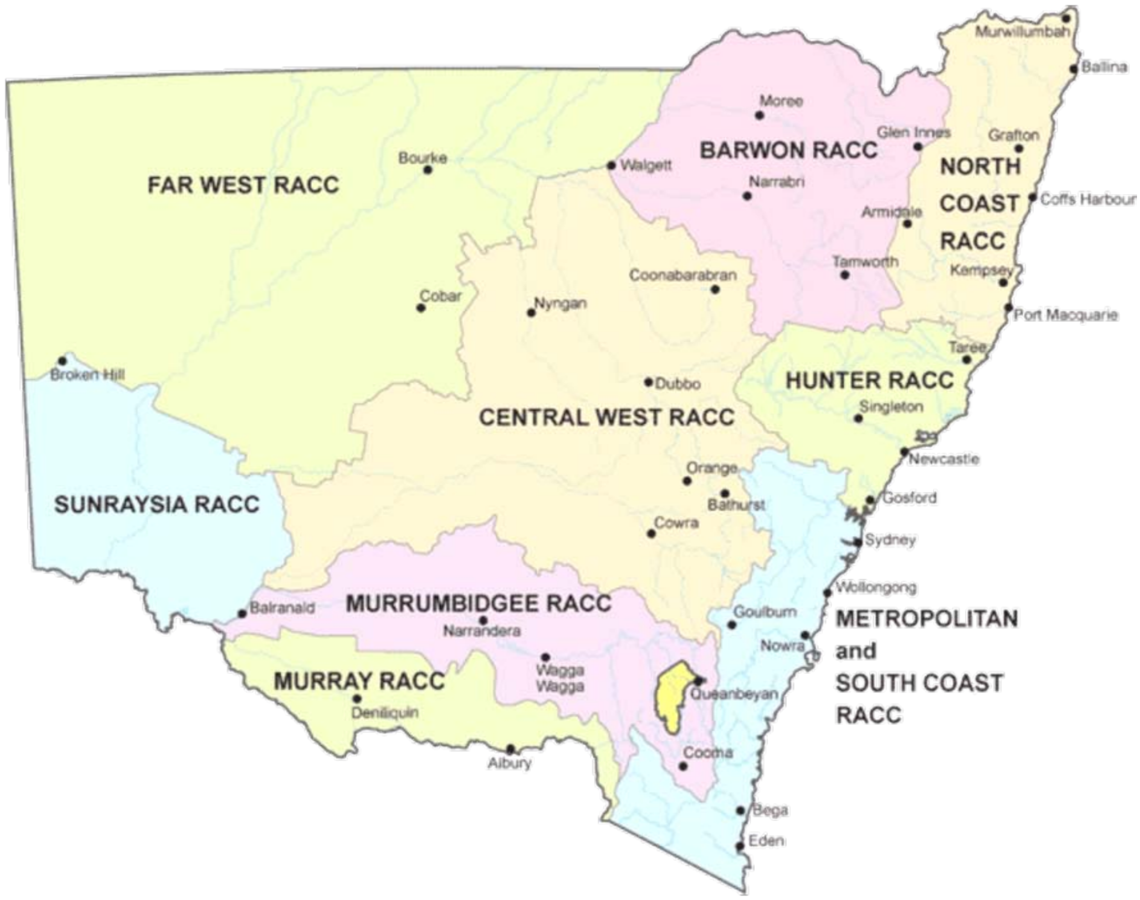
The Technical Advisory Group (TAG) of the SAAG is a panel of scientists who have expertise in various aspects of the ecology and management of nuisance phytoplankton blooms, in both freshwater and marine environments.

Current TAG membership comprises staff from several key NSW government agencies that have roles in the management of nuisance phytoplankton blooms and in protecting the public from the adverse health effects of these blooms: NSW Department of Primary Industries (Office of Water and NSW Food Authority), NSW Health, Office of Environment and Heritage and Sydney Catchment Authority, plus external expertise from universities and local government (University of New South Wales, Macquarie University, Port Macquarie–Hastings Council).

The TAG reports its findings to the SAAG, who can incorporate its findings into strategic responses to algal blooms. The TAG will also respond to questions from and report back to the nine Regional Algal Coordinating Committees (RACCs) and their stakeholders on technical issues confronting these RACCs and stakeholders. By these avenues, the TAG aspires to provide relevant and transparent advice to inform algal bloom management across NSW fresh and marine waters.

Regional Algal Coordinating Committees (RACC)

RACC details are available on the NSW Office of Water webpage http://www.water.nsw.gov.au/Water-Management/Water-quality/Algal-information/Algal-contacts/default.aspx#racc .



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