Government of Western Australia
Department of Health

Marine Biotoxin Monitoring and Management Plan 2016

WESTERN AUSTRALIA SHELLFISH QUALITY ASSURANCE PROGRAM

Marine Biotoxin Monitoring and Management Plan 2016

WASQAP 2016

Prepared by the WA Department of Health

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Version Control

Version	Date	Author	Reason	Sections
Draft Marine Biotoxin Monitoring and Management Plan 2015	May 2015	WASQAP	Updating Biotoxin Management Plan from WASQAP Manual 2011 following Biotoxin Risk Assessment carried out in 2014	All
Draft Marine Biotoxin Monitoring and Management Plan 2015	July 2015	WASQAP	Amendments following consultation	All
Marine Biotoxin Monitoring and Management Plan 2016	May 2016	WASQAP	Updated plan following outcome of Department of Agriculture and Water Resources Review. Annual Review	All

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1.0 Introduction

This document should be read in conjunction with the WASQAP Operations Manual and Australian Shellfish Quality Assurance Program (ASQAP) Manual (2016).

1.1 Purpose

This marine biotoxin monitoring and management plan (MBMMP) has been developed under the WASQAP to ensure regular industry monitoring within shellfish growing areas to gain a better understanding of the risk level and to mitigate the risk of contaminated shellfish. The management plan takes into account the inherent risk, the cost of managing the risk, whilst considering the legislative and financial burden on seafood producing businesses.

1.2 Scope:

This MBMMP is designed for the aquaculture and commercial shellfish harvesting industry, particularly bivalve molluscs harvested from the following areas:

- Cockburn Sound - Southern Flats and Kwinana Grain Terminal
- Mistaken Island
- Oyster Harbour
- Shark Bay

1.3 Background References to MBMMP:

This MBMMP is based on information provided in Part B of the Cawthron report (No. 645) entitled Australian Marine Biotoxin Management Plan for Shellfish Farming and the Report prepared by Centre of Excellence for Science, Seafood and Health (CESSH) in 2014 entitled “Review the Tasmanian paralytic shellfish toxin (PST) event and Safefish recommendations to determine an interim risk management approach for WA”.

CESHH report acknowledged that whilst filter feeding bivalve shellfish species (e.g. mussels, oysters) have a high capacity to accrue biotoxins, the report concluded that there is a low putative biotoxin risk in Western Australia's commercially harvested areas. Additionally, following the routine biotoxin sampling carried out as part of the biotoxin review during 2015/2016 only one sample was found to be on the regulatory limit. Therefore the sampling frequencies for phytoplankton and biotoxin testing have been set accordingly (i.e. twice monthly for phytoplankton testing and once a month for biotoxin testing).

It is acknowledged that the use of flesh testing is the cornerstone of the regulatory approach, and whilst phytoplankton provides a support role, (particularly in the early identification of impending blooms) together they provide a good risk management tool.

1.4 Roles and Administrative Responsibilities:

Roles and administrative responsibilities for the MBMMP are the same as for the WASQAP. When an algal bloom occurs in the vicinity of lease areas, additional management support may be provided by the Department of Water (DOW).

1.5 Growing Areas and Sampling Sites:

Harvest areas and sampling sites are shown in the WASQAP Operations Manual (section 2 details sampling locations for shellfish harvesting areas in WA). Phytoplankton sampling protocols and procedures for sample collection and dispatch to the analytical laboratory are also detailed in the Manual.

2.0 Monitoring & Sampling Procedure (This procedure applies to routine sampling and sampling undertaken in the event of an exceedance).

All sampling is performed in accordance with section 4 of WASQAP.

2.1 Biotoxin events are notoriously unpredictable, even when the best routine monitoring program is actively implemented it is possible that new biotoxin events and challenges will arise. Therefore aside from the mandatory sampling

programs, environmental factors should also be considered as useful indicators to a pending food safety biotoxin event. Such clues can be drawn from, but should not be limited to, fish kills, meteorological data, pollution spills (especially those involving nutrients) and obvious blooms (which may be noted on the WASQAP Sampling Program Information Sheet).

Phytoplankton sampling should be undertaken frequently and regularly, with the frequency remaining constant throughout the year, as potentially harmful species can occur at any time of the year (Cawthron Report No.646, Nov 2001). Therefore, phytoplankton water samples are collected bimonthly throughout the year as per the sampling program for growing areas. However, sampling is less frequent for Mistaken Island harvesting area as traditionally it is only harvested from a few months a year. For seasonal start-up two phytoplankton samples and one biotoxin sample is taken prior to the commencement of harvesting.

However, the frequency of phytoplankton sampling may increase in response to results of the regular monitoring program. Biotoxin flesh samples are taken when phytoplankton alert levels have been triggered (refer to Table 1). In addition to this, flesh samples for biotoxin screening for Amnesic Shellfish Poisoning / Diarrhetic Shellfish Poisoning / Paralytic Shellfish Poisoning (ASP/DSP/PSP) are routinely tested for every month. While potential Neurotoxic Shellfish Toxins (NST) producers have been identified occasionally they have never been detected at significant levels. Therefore, NSP toxins are currently not routinely tested for in WA, however the NSP risk in WA waters is currently being further assessed.

2.2 A water sample is taken by industry representatives and sent to the Laboratory for phytoplankton analysis for target species enumeration. If a phytoplankton sample is not received within one week of its scheduled date the businesses operating in the harvesting area should consider voluntary cessation of harvesting (unless prior arrangements have been made with DOH Food Unit).

Water samples are analysed within 72 hours of arrival at the laboratory. At the same time water samples are taken, a flesh sample is also collected and stored chilled at 5°C or frozen.

2.3 If no potentially toxic species are identified at levels that exceed the alert levels in Table 1 the sample is frozen and held in frozen storage for 6 weeks.

2.4 If potentially toxic species are identified at levels that exceed the alert levels ('to initiate flesh testing' in Table 1) the analyst will immediately notify (by phone and/or email foodsafety@health.wa.gov.au) the DOH Food Unit. Additionally notification containing the specified subject heading is also to be sent to the following email address: algalblooms@health.wa.gov.au

Subject: Algal Bloom Shellfish Hazard

Importance: High

2.5 If the phytoplankton count reaches the alert level to 'initiate flesh testing' for the particular species, the food business must arrange for the chilled/frozen sample of shellfish to be screened for biotoxins. The initial toxin analyses may be undertaken using the appropriate Jellett rapid kit, provided the testing is undertaken by a NATA accredited laboratory. If any toxin at all is detected then samples must be sent for quantitative analyses and the harvesting area may cease harvesting. (Additionally another water and flesh sample will be taken (seven days after the original sample was taken) and the water sample submitted for analysis and the flesh sample stored for possible biotoxin testing). The food business may decide to voluntary cease harvesting pending the biotoxin results (in line with Safefish Report 2013 recommendations 'regulatory decisions should be made on flesh results. Phytoplankton should be used to trigger further sampling". (Refer to Figures 1 and 2). If biotoxins are detected the sample must be submitted for biotoxin confirmation analysis.

2.6 If the phytoplankton alert levels are exceeded but are not at the level to 'initiate flesh testing', the phytoplankton Laboratory is to notify the DOH Food Unit and food business. An additional water and shellfish sample must be collected as soon as practicable and sent to the phytoplankton Laboratory for analysis.

If the subsequent sample shows that the phytoplankton levels for the particular phytoplankton species exceed the ‘alert levels to initiate flesh testing’, the frozen sample of shellfish (second sample) should be screened for biotoxins, and depending on the results undergo biotoxin confirmation. The food business may decide to voluntary cease harvesting pending the biotoxin results. (The initial toxin analyses may be undertaken using the appropriate Jellett rapid kit, provided the testing is undertaken by a NATA accredited laboratory. If any toxin at all is detected then samples must be sent for quantitative analyses and the harvesting area may cease harvesting. Refer to figure 1

2.7 If algal biotoxins are determined to be present at levels which exceed the maximum permitted concentrations specified in the Australia New Zealand Food Standards Code (*the Code*) Standard 1.4.1 Contaminants and Natural Toxicants (Table 2), the food business must close the harvesting area. Where a harvesting area is not closed the Department of Health would consider the provisions contained within its Compliance and Enforcement Policy to ensure no harvesting takes place. The protocols detailed in the WASQAP for surveillance, communication, media release and product recall will be carried out. The size and extent of the closure may be determined in liaison with DOW and Department of Fisheries (DOF).

The levels documented in Table 1 relate to discrete or composite samples. These levels were developed based on the WA biotoxin risk assessment and consideration of levels used internationally and in various states of Australia. They should be revised as further monitoring and research is undertaken that supports a change. The Laboratory remains vigilant for the wider spectrum of potentially toxic species and any novel species.

Table 1: Summarises the phytoplankton levels (in cells/L) that trigger management action.

Micro-algae species	Type of Toxin	Alert Level (refer to flow chart for actions)	Alert level to initiate flesh testing (cells/L)
***Alexandrium catenella*[1]**	PSP	100	200
***Alexandrium minutum*[1]**	PSP	100	200
***Alexandrium ostenfeldii*[1]**	PSP	100	200
***Alexandrium tamarense*[1]**	PSP	100	200
Gymnodinium catenatum	PSP	500	1,000 mussels 2,000 (other shellfish)
Dinophysis acuminata	DSP	1,000	1,000
Dinophysis acuta	DSP	500	1,000
Dinophysis caudata	DSP	500	1,000
Dinophysis fortii	DSP	500	1,000
Prorocentrum lima	DSP	500	500
***Pseudo-nitzschia* seriata group (*P.multiseries* and *P.australis*)[2]**	ASP	50,000	50,000
***Pseudo-nitzschia* delicatissima group[2]**	ASP	500,000	500,000
Karenia brevis	NSP	500	1,000
Karenia/Karlodinium/ Gymnodinium group[3]	NSP	100,000	250,000

N.B. The cell levels within each toxin group are cumulative. (For example 600 cells/L of both D.acuta and D. fortii would mean a total count of 1200 cells/L exceeding the critical level to initiate flesh testing. Example 2, Prorocentrum lima 400 cells/L and 150 cells/L Dinophysis acuminate would exceed the critical level to initiate flesh testing. Whereas 400 cells/L Dinophysis acuminata and 150 cells/L Dinophysis acuta would **not** trigger testing.

[1] *Alexandrium* species may be difficult to identify when numbers are low. If any doubt exists, they should be treated as potentially toxic.

[2]Species within the *Pseudo-nitzschia* groups are difficult to identify. The toxic species of most concern in each group are listed for those laboratories that have capacity to identify these algae to species level. Otherwise all algae within these groups should be considered potentially toxic. The *Pseudo-nitzschia seriata* group includes *P. australis, P. pungens* and *P. multiseries.* The *Pseudo-nitzschia delicatissima* group includes *P. turgidula, P. fraudulenta, P. delicatissima, P. pseudodelicatissima* and *P. multistriata*.

[3]The *Karenia/Karlodinium/Gymnodium* group includes *Karenia bidigitata, Karenia brevisulcata, Karenia mikimotoi, Karenia papilionacea, Karenia selliformis, Karlodinium micrum* and *Gymnodinium impudicum*. If there is evidence of fish kills near the growing area, NST testing should be considered.

A formal closure of a harvesting area may also be invoked after the reporting of cases of human illness consistent with the case definition for PSP, NSP, DSP, and/or ASP that have resulted from the consumption of shellfish from a particular area. Additionally, a formal closure may be invoked if the DOH Food Unit determines a closure is necessary for other reasons (e.g. toxins present in neighbouring areas, reporting of a potentially toxic phytoplankton species not previously reported from the harvest area etc.).

A summary of the WASQAP biotoxin detection and action process relevant to commercially produced shellfish is displayed below:

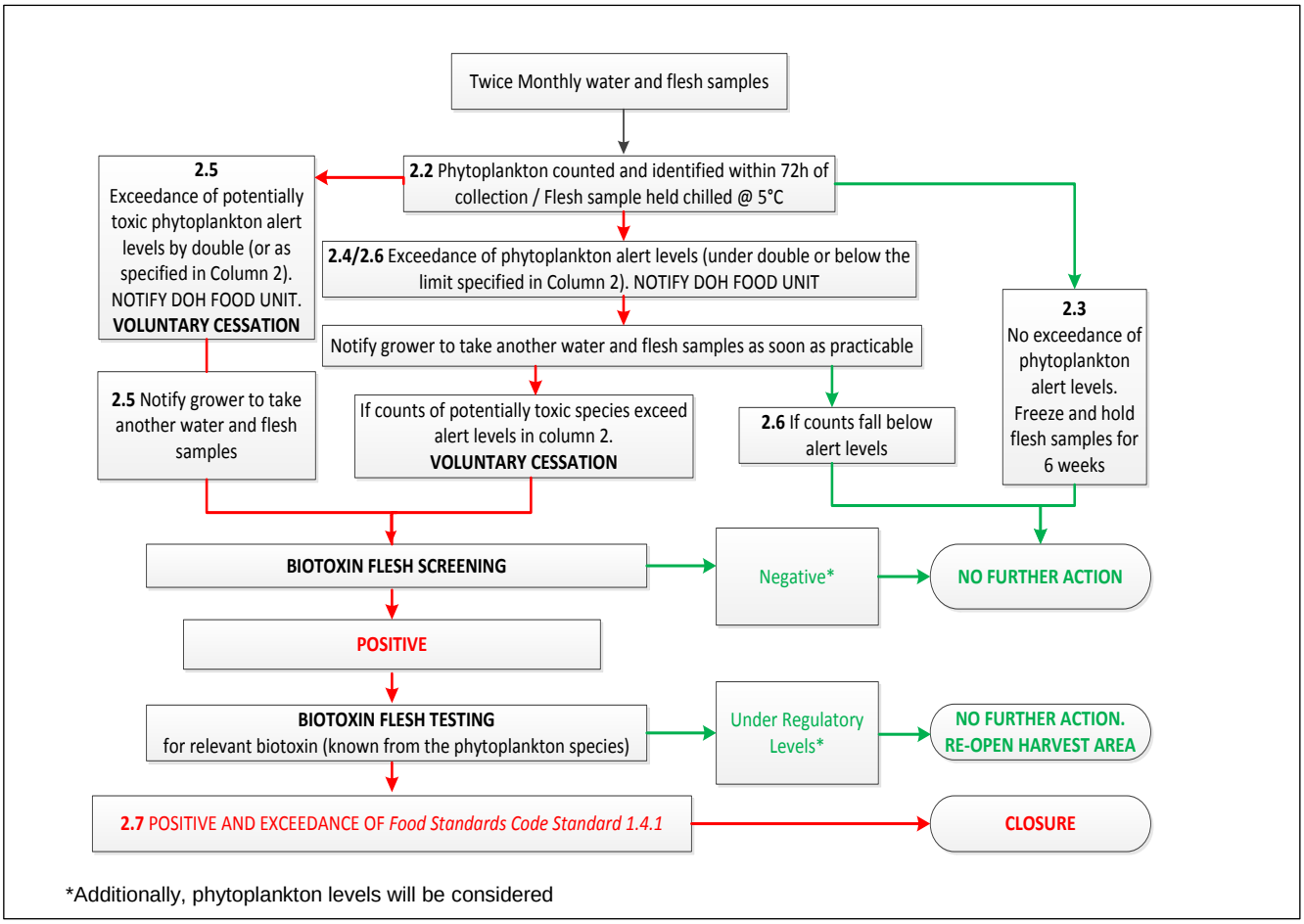

Figure 1 WASQAP marine biotoxin monitoring and management procedures. ***Note – further steps are required after an exceedance of the Australia New Zealand Food Standards Code Standard 1.4.1, refer to figure 2.***

Table 2 Marine Biotoxin Regulatory Closure Levels

A harvest area must be closed for the harvesting of shellfish when toxins in shellfish are found to be above the levels prescribed in the Australian and New Zealand Food Standards Code, Contaminants and Natural Toxicants Standard 1.4.1 as detailed below.

Analysis	Frequency	Maximum Level
Paralytic Shellfish Toxin (PST) (saxitoxins equivalent) High Performance Liquid Chromatography (HPLC)	Phytoplankton over trigger levels or routine biotoxin testing	0.8mg mg/kg saxitoxin equivalent
Amnesic Shellfish Toxin (AST) (domoic acid equivalent) Liquid Chromatography coupled with Mass Spectrometry (LCMSMS analysis)	Phytoplankton over trigger levels or routine biotoxin testing	20mg/kg Domoic acid equivalent
Neurotoxic Shellfish Poisoning (NSP toxins*)	Phytoplankton over trigger levels	200 MU/kg
Diarrhetic Shellfish Toxin (DST) (okadoic acid equivalent) (LCMSMS)	Phytoplankton over trigger levels or routine biotoxin testing	0.2 mg/kg Okadaic acid equivalent
YTX YESSOTOXINS (LCMSMS) **AZP Azaspiracids** (LCMSMS)		YTX is not regulated in Australia and although it is toxic to mice when applied intraperitoneally, its oral toxicity is questionable (Cawthron Institute, 2001).

NB: DSP toxins include okadaic acid, Dinophysis toxins (DTX1, DTX2, DTX3), Pectenotoxins PTX, PTX2.It does not include (PTX2-sa), yessotoxins, gymnodimine or azaspiracid.

*NSP toxins may now also be measured using chemical methodology (LCMS/MS). However, no mg/kg equivalence value or guidance is provided within the ANZFSC for this method. The US Food and Drug Authority acknowledge that 0.8 mg/kg brevetoxin-2 is equivalent to 200MU/kg.

3.0 Harvesting Area Re-Opening Criteria

The re-opening of a harvesting area following a biotoxin closure event shall only occur on the basis of bivalve shellfish meat test results (confirmed full profile of biotoxins). Phytoplankton results may be used to qualify meat testing requirements (refer to Figure 2).
If biotoxin tests on at least two successive meat samples taken a week apart show that the concentrations of biotoxin in the bivalve shellfish tissue are below the maximum level (ML) in the Code;

- AND water samples collected during the same period show levels of toxic algae at or below the alert levels; AND
- the algal levels are not increasing in number,

then re-opening of the harvest area may occur.

Should there be a toxin event in a harvest area then each individual shellfish species harvested shall be sampled. This will assist in determining the food safety risk of each species.

However, in the event that two consecutive shellfish meat samples taken a week apart are found to comply with the ML but phytoplankton samples collected during the same period show levels of toxic phytoplankton above the alert levels, re-opening may only occur after a 3rd consecutive compliant meat test result - which may be taken a further 48 hours or more after the second bivalve shellfish meat sample.

Following the re-opening of a harvest area the sampling requirements will be at a minimum weekly bivalve shellfish and phytoplankton samples for at least 2 weeks.

Harvest Area Re-opening Procedure

All those notified of the closure will be notified of the re-opening by the appropriate means. This will be initially by telephone followed by email. (Refer to opening procedure in WASQAP Operations Manual).

IF A SHELLFISH HARVESTING AREA IS CLOSED FOR OTHER REASONS BESIDES PHYTOPLANKTON/BIOTOXIN EXCEEDANCES (I.E. HIGH BACTERIOLOGICAL COUNTS) THE FOOD BUSINESSES SHOULD CONTINUE TO COLLECT PHYTOPLANKTON AND FLESH SAMPLES.

A summary of the WASQAP biotoxin detection and action process relevant to commercially produced shellfish is displayed below.

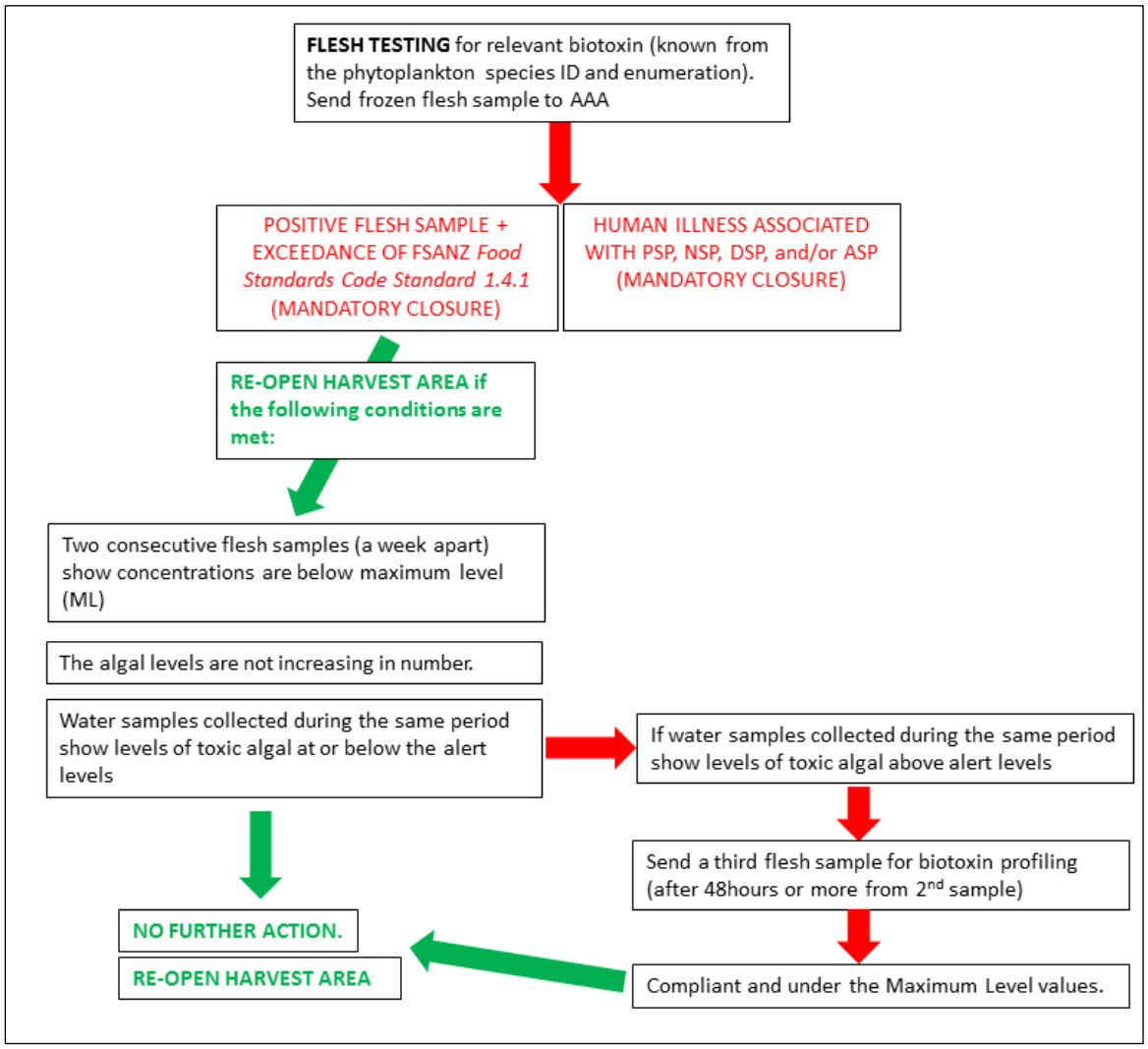

Figure 2: **Procedures** for re-opening commercial harvesting areas after experiencing an exceedance of the FSC standard 1.4.1 for biotoxins in the flesh of shellfish.

4.0 Recreational Shellfish Samples

It should be noted that recreational wild-capture of shellfish is not within the scope of WASQAP. It is impossible to guarantee the safety of eating wild shellfish without having a comprehensive monitoring program that tests the waterway concerned for harmful microorganisms and toxins. Such programs are extremely expensive and difficult to undertake. The DOH therefore recommends only eating shellfish harvested commercially under strict monitoring programs.

5.0 Review

The MBMMP will be reviewed to reflect changes in further monitoring and research in phytoplankton and biotoxins levels. Additionally it will be reviewed on scientific knowledge that supports a change.

Appendix 1- Phytoplankton species

Some name changes have occurred since original publication of the Cawthron report. These have been included in the list below and the list will be updated as new information is provided on toxigenic genera. The IOC (UNESCO) has a comprehensive and regularly updated list of harmful microalgae http://www.marinespecies.org/hab/. (Cawthron Report No 645 and NSW Shellfish Program Marine Biotoxin Management Plan 2014)

Category A – Species known to be present in Australian waters and proven to produce toxins either in Australia or internationally:

Alexandrium catenella (saxitoxin and derivatives)
Alexandrium minutum (saxitoxin and derivatives)
Alexandrium ostenfeldii (saxitoxin and derivatives, also produces spirolides in Canada)
Alexandrium tamarense (saxitoxin and derivatives, also has non-toxic strains)
Dinophysis acuminata (pectenotoxin, okadaic acid?, dinophysis toxins? and diol esters?)
Dinophysis acuta (pectenotoxin, okadaic acid?, dinophysis toxins? and diol esters?)
Dinophysis caudata (pectenotoxin, okadaic acid?, dinophysis toxins? and diol esters?)
Dinophysis fortii (pectenotoxin, okadaic acid?, dinophysis toxins? and diol esters?)
Dinophysis hastata (okadaic acid?, dinophysis toxins? and diol esters?)
Dinophysis mitra (okadaic acid?, dinophysis toxins? and diol esters?)
Dinophysis rotundata (okadaic acid?, dinophysis toxins? and diol esters?)
Dinophysis tripos (some strains produce okadaic acid, dinophysis toxins and diol esters)
Gymnodinium catenatum (saxitoxin and derivatives)
Gymnodinium cf breve (Karenia cf brevis) (brevetoxins)
Prorocentrum lima (okadaic acid?, dinophysis toxins? and diol esters?)
Pseudonitzschia australis (domoic acid)
Pseudonitzschia delicatissima (domoic acid)HNTA
Pseudonitzschia fraudulenta (domoic acid) HNTA
Pseudonitzschia multiseries (domoic acid)
Pseudonitzschia pseudodelicatissima (domoic acid) HNTA
Pseudonitzschia pungens (usually non-toxic, but toxic strains produce high concentrations of domoic acid per cell)
Pseudonitzschia turgidula (domoic acid)
Pyrodinium bahamense var. compressum (in tropical habitats) (saxitoxin and derivatives)
Note: HNTA Historically non-toxic in Australia

Category B – Potential toxin producing species (ie toxicity untested/unclear) known to be present in Australian coastal waters:

Alexandrium pseudogonyaulax (possible STX and derivatives, goniodomin)
Chattonella marina/antiqua (possible brevetoxins)
Fibrocapsa japonica (possible brevetoxins)
Heterosigma akashiwo (possible brevetoxins)
Pseudonitzschia cuspidata (possible domoic acid)
Pseudonitzschia heimii (possible domoic acid, non-toxic in New Zealand)
Pseudonitzschia lineola (possible domoic acid)
Pseudonitzschia multistriata (possible domoic acid, non-toxic in New Zealand)
Pseudonitzschia subfraudulenta (possible domoic acid)
Pseudonitzschia subpacifica (possible domoic acid)

Category C – Other potential toxin producing species world-wide that may be present in Australian waters:

Alexandrium angustitabulatum (possible saxitoxin and derivatives, identified in New Zealand waters)
Alexandrium acatenella (possible saxitoxin and derivatives)
Alexandrium cohorticula (possible saxitoxin and derivatives)
Alexandrium fraterculus (possible saxitoxin and derivatives)
Alexandrium fundyense (possible saxitoxin and derivatives)
Alexandrium lusitanicum (possible saxitoxin and derivatives)
Alexandrium tamiyavanichi (possible saxitoxin and derivatives)
Coolia monotis (produces cooliatoxin)
Dinophysis norvegica (Major DSP producer in Europe)
Gymnodinium aureaolum (possible brevetoxins)
Gymnodinium bidigitatum ((possible brevetoxins) found in New Zealand waters)
Gymnodinium galatheanum (Karlodinium micrum) (possible brevetoxins)
Gymnodinium impudicum (possible brevetoxins)
Gymnodinium mikimotoi (Karenia mikimoto) (possible brevetoxins)
Gymnodinium papillionaceceum Karenia papillonacea) (possible brevetoxins)
Gymnodinium pulchellum (Takayama pulchella) (possible brevetoxins)
Gymnodinium selliforme (Karenia selliformis) (gymnodimine, found in New Zealand waters)
Lingulodinium polyedra (yessotoxin producer in Japan)
Nitzschia navis-varingica (domoic acid was recently confirmed for an isolate from brackish Vietnamese waters)
Ostreopsis siamensis (produces palytoxin)
Pfiesteria piscicida Not possible to identify with routine monitoring. Culturing and immunolabelling required
Prorocentrum concavum (okadaic acid?, dinophysis toxins? and diol esters?)
Prorocentrum elegans (okadaic acid?, dinophysis toxins? and diol esters?)
Prorocentrum hoffmannianum (okadaic acid?, dinophysis toxins? and diol esters?)
Prorocentrum maculosum (produces prorocentrolides)
Prorocentrum minimum (Prorocentrum cordatum) (The toxin linked to this organism (185 fatalities in Japan) has not yet been elucidated, and the role of P. minimum is still in question)
Protoceratium reticulatum (yessotoxin producer in New Zealand)
(? Indicates this toxin has not been confirmed at the time of this report as being produced by Australian strains of this species)
Gonyaulax spinifera (possible yessotoxin)
Pseudonitzschia calliantha (domoic acid)
Numerous Karenia species have recently been described. Toxicity and applicability to the Australian program require more investigation.

Appendix 2 - Toxic Shellfish Poisoning Case Definitions

Paralytic Shellfish Poisoning (PSP)

Causative toxins: Saxitoxins (STX's), Gonyautoxins (GTXs) and C toxins (CTXs)

STXs have been recorded from Tasmania, Victoria, South Australia and New South Wales.

Microalgal sources: Gymnodinium catenatum, Alexandrium species (including A. minutum, A. catenella, A. tamarense, A. fundyense, A. ostenfeldii, plus others), Pyrodinium bahamense var. compressum, also freshwater species such as Anabaena spp., and Microcystis spp.

Symptoms:
•STXs block nerve conduction, manifesting as respiratory distress due to partial paralysis of the muscles necessary for breathing.
• Mild neurological symptoms encompass tingling or numbness around the lips or in fingers and toes (paraesthesias), sensations of floating or weightlessness (dysaesthesias), or gastrointestinal upset (nausea, vomiting, diarrhoea, gut pains).
• More severe poisoning may present with functional weakness (impaired grip strength, staggering gait), difficulty breathing and signs of acute respiratory insufficiency, e.g. cyanosis of the lips or fingernails.
• Severe STX intoxication can cause catastrophic acute respiratory failure and death by asphyxiation

Clinical Case Definition: The following neurological symptoms occurring within 12 hours of consuming shellfish:

- neurosensory;
- paraesthesia, i.e. numbness or tingling around the mouth, face or extremities;
- and one of the following neuromotor/neurocerebellar symptoms:
    - weakness such as trouble rising from seat or bed
    - difficulty in swallowing
    - difficulty in breathing
    - paralysis
    - clumsiness
    - unsteady walking
    - dizziness/vertigo
    - slurred/unclear speech
    - double vision

Amnesic Shellfish Poisoning (ASP)

Causative toxins: Domoic acid (DA) is a neurotoxin produced by a group of marine microalgae known as diatoms.

Microalgal sources: In Australia the known causative diatoms are from the *Pseudo-nitzschia seriata* group (*P. multiseries* and *P. australis*) and the *P. delicatissima* group.

No reports of illness attributable to DA poisoning have been received in Australia.

Symptoms:
• Mild intoxication may involve only gastro-intestinal upset (nausea, vomiting, diarrhoea, gut pains).
• Symptoms of neuro-intoxication include headache, convulsive seizures, myoclonus (involuntary, irregular muscle contractions), cognitive impairment and disorientation, anterograde amnesia (inability to lay down new memories following neurological damage), respiratory difficulty and coma.

Clinical Case Definition: Vomiting or diarrhoea or abdominal cramps within 24 hours of consuming shellfish;

- and no other probable cause identified by microbiological examination of a faecal specimen from the case or microbiological testing of left-over food;
- and/or one or more of the following neurological signs/symptoms occurring within 48 hours of consuming shellfish:

  - confusion
  - memory loss
  - disorientation
  - seizure
  - coma

Diarrhetic Shellfish Poisoning (DSP)

Causative toxins: Okadaic acid (OA), Dinophysistoxins (DTXs), Pectenotoxins (PTXs), Yessotoxins (YTXs) and Azaspiracids (AZAs).

NB. Pectenotoxin, an unrelated lipophilic toxin that is often detected with OA, is included in DST's for regulatory purposes in Australia, but there is some controversy over its toxicity to humans. Azaspiracids are not yet confirmed to be in this group.

Microalgal sources: DSTs are produced by marine microalgae known as dinoflagellates. In Australia the known causative species are *Dinophysis acuminata*, *D. acuta*, *D. caudata*, *D. fortii* and *Prorocentrum lima*. DST producing species are found in all states in Australia at various levels.

Symptoms:
• Nausea, diarrhoea, vomiting, abdominal pain and headache are the characteristic symptoms. The symptoms usually start between 30 minutes to a few hours after consumption.
• Usually resolves by three days following consumption of contaminated shellfish.
No fatalities have been reported.
• May present a risk of dehydration requiring fluid and electrolyte replenishment, particularly in young children or the elderly.

• *Okadaic acid* is a potent tumour promoter, which raises concerns about the possibility of harmful effects from chronic, low-dose exposure. Such exposures are difficult to measure, so the concerns of public health agencies are currently directed toward concentrations of OA in shellfish that cause acute gastro-intestinal illness.

There is no epidemiological evidence of human health effects from yessotoxin. However it is lethal to mice when administered intraperitoneally, and causes damage to heart muscles and livers in mice. Azaspiracids cause vomiting and diarrhoea in humans. In animal tests, these toxins have caused neurotoxic effects and severe damage to the intestine, spleen and liver tissues. The microalgal source is currently unconfirmed.

Clinical Case Definition: Vomiting or diarrhoea occurring within 24 hours of consuming shellfish and no other probable cause identified by microbiological examination of a faecal specimen from the case or microbiological testing of leftover food.

Neurotoxic Shellfish Poisoning (NSP)

Causative toxins: Brevetoxins (BTX's)

Microalgal sources: Karenia brevis (=Gymnodinium breve), K. cf brevis (=Gymnodinium cf breve), plus potentially K. papilionacea (=Gymnodinium papilionaceum), K. mikimotoi (=Gymnodinium mikimotoi) and similar species; Chattonella species, Heterosigma akashiwo and Fibrocapsa japonica.

Symptoms: The symptoms occur within 3-5 hours and are chills, headache, diarrhoea, muscle weakness, joint pain, nausea and vomiting. There can be altered perceptions between hot and cold, difficulty in breathing, double vision, trouble in walking and swallowing.

Clinical Case Definition: Two or more of the following neurological symptoms occurring within 24 hours of consuming shellfish:

- neurosensory:
  - paraesthesia, i.e. numbness or tingling around the mouth, face or extremities
  - alternation of temperature sensations such as a prickly feeling on the skin during a bath/shower or exposure to sun, or difficulty distinguishing hot or cold objects
- neuromotor/neurocerebellar:
  - weakness such as trouble rising from seat or bed
  - difficulty in swallowing
  - difficulty in breathing
  - paralysis
  - clumsiness
  - unsteady walking
  - dizziness/vertigo
  - slurred/unclear speech
  - double vision

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