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Four recent ciguatera fish poisoning incidents in New South Wales, Australia linked to imported fish

Alan Edwards, Anthony Zammit and Hazel Farrell

Abstract

Between 2015 and 2017, the NSW Food Authority investigated 4 ciguatera fish poisoning incidents linked to fish caught in tropical Australian and international waters and imported to New South Wales. Three of the implicated fish were caught near the Capel Bank Seamount, part of the Lord Howe Island Seamount Chain off the coast of Queensland. The fourth incident, in 2017, involved a fish caught between Cooktown and Lizard island, also off the Queensland coast. Thirteen individuals were affected. Early identification of potential Ciguatera fish poisoning (CFP) cases can facilitate a faster incident response, patient diagnosis and treatment. While different fish species were involved, and the severity and duration of symptoms varied between individuals, 3 of the 4 incidents were distinguished by those affected having consumed a fish meal prepared with the head of the fish. Affected individuals also described a sensation of hot/cold temperature reversal or a painful 'sharpness' when in contact with or drinking cold water. This paper outlines a series of incidents where a case's symptoms, which can vary substantially in conjunction with their previous exposure history, the type of fish consumed and how the fish was cooked, can be used to identify potential CFP cases and hence CFP risks that may need to be addressed.

Keywords: Ciguatera fish poisoning, ciguatoxins, seafood borne illness, New South Wales, Australia, Pacific ciguatoxin 1-B (P-CTX-1B).

Introduction

What is ciguatera fish poisoning (CFP)?

Ciguatoxins are naturally occurring micro algal toxins produced by the dinoflagellate genus *Gambierdiscus*. The accumulation of ciguatoxins through the marine food chain is the cause of ciguatera fish poisoning (CFP) in seafood consumers. More than 90 species of fish have been linked to CFP, most species originating from tropical or sub-tropical locations.¹ The possible indicators of CFP include a variety of gastrointestinal, neurological and cardiovascular symptoms.^{2,3} A key identifier of CFP, although it may not always be reported, is the sensation of hot/cold temperature reversal (temperature dysaesthesia).²⁻⁴ The manifestation of CFP symp-

toms will vary depending on the species of fish, size and type of portion consumed, the overall health of the consumer and if they have previously been exposed to ciguatoxins.^{4,5} As a result, CFP can be misdiagnosed as another type of seafood poisoning (e.g. histamine, saxitoxin or brevetoxin) or, in severe chronic cases, as a brain tumour, multiple sclerosis or chronic fatigue syndrome.^{4,6}

Where does CFP occur?

CFP is an illness commonly thought to be an issue in tropical or subtropical regions only, however, there has been an apparent increase in reported cases of CFP globally⁷ and in the geographic range of CFP cases along the Eastern coastline of Australia. Historical reports of CFP

in NSW mainly refer to large outbreaks (1984: 40 cases⁸, 1987: 63 cases⁹, 1994: >30 cases¹⁰, 1997 and 1998: 26 cases, 3 clusters¹¹) linked to fish originating from tropical areas. An outbreak in 2002 was linked to 2 Spanish Mackerel caught near Brunswick Heads, northern NSW.¹² Following this, 2 investigations into suspected CFP outbreaks were from fish sourced in Fiji (2005) and Queensland (NSW Food Authority, unpublished data¹³). Since 2014, there have been 5 CFP incidents associated with Spanish Mackerel caught in New South Wales (NSW) coastal waters.^{13,14} This article focuses on 4 recent CFP cases linked to fish sourced outside of NSW.

How is the risk of CFP managed?

Regulatory criteria for ciguatoxins have not been established. This is due largely to the limited availability of certified reference material, which in turn has limited the development of cost effective routine testing. There are, however, several interrelated strategies in place across Australia to ensure that seafood is both safe and suitable for human consumption.¹⁵ In addition, the risk of CFP to NSW consumers is addressed through 2 industry initiatives. The first is to limit the size and type of fish that can be sold wholesale (e.g. prohibited species include Chinamanfish (*Symphorus nematophorus*), Tripletail Maori Wrasse (*Cheilinus trilobatus*), Humphead Maori Wrasse (*Cheilinus undulatus*), Red Bass (*Lutjanus bohar*), Paddletail (*Lutjanus gibbus*), Giant Moray (*Gymnothorax javanicus*) and Mackerel over 10 kg). The second is to limit the sale of fish caught in “Ciguatera High-Risk Areas”, these are usually tropical regions where the risk of contracting CFP from certain fish species is high.¹⁶⁻¹⁹ In addition, the NSW Food Authority template food safety program published for seafood processors contains information regarding ‘Ciguatera control’, which refers to the industry controls above.²⁰ Complementing these strategies is the surveillance of foodborne illness complaints and reports to regulators. In NSW, this includes monitoring of local incidents by NSW Health and the state regulatory agency,

the NSW Food Authority.^{21,22} Similar monitoring occurs in all Australian states and territories, and is coordinated nationally by OzFoodNet.²³

Methods

Case investigations

This paper considers NSW Food Authority investigations into 4 recent (2015-2017) CFP complaints. These outbreak investigations were conducted under the Food Act 2003 (NSW) and thus ethics approval was not required. The illness complaints and notifications were received by the NSW Food Authority and investigation findings were provided to NSW Health in accordance with established protocols. The NSW Food Authority investigation involved:

1. obtaining supplier details and tracing the supply of the fish back to its catch location;
2. securing samples of leftovers (Incidents 1 and 4) or of fish from the same batch (Incidents 2 and 3);
3. submitting samples for analysis; and
4. obtaining details, where possible, of case symptoms, how the fish was cooked and served and how much fish was consumed by individuals.

Toxin analysis

Where available, fish/meal samples were screened for Pacific ciguatoxin-1B (P-CTX-1B) at the Australian Research Facility for Marine Microbial Biotoxins, Sydney, using an Orbitrap liquid chromatography mass spectrometry (LC-MS) system.²⁴

Results

All complainants reported symptoms that appeared to vary depending upon 3 factors: the amount of fish consumed; how the fish was

prepared for consumption; and, whether the complainant had previously been exposed to the toxin.

Incident 1: Red Throat Emperor - September 2015

This incident involved a Red Throat Emperor that weighed between 1.5 and 2 kg. The fish was part of a 150-250 kg batch caught off the Capel Bank Seamount, off the coast of Queensland, to the south west of New Caledonia. The fish was sold 'butterflied', in that the supplier had removed the spine of the fish in addition to eviscerating it. The fish was purchased, baked in a casserole and consumed on the same day. This incident resulted in 3 cases of CFP within the same family. Case 1 reported experiencing an onset of abdominal cramping and diarrhoea shortly after eating the head of the fish and that symptoms progressively worsened during the following week. Three days post consumption, case 1 reported to hospital with headaches, abdominal cramping, diarrhoea, some numbness to lips and paraesthesia to lower limbs with hot and cold temperature reversal. Cases 2 and 3 reported eating 'only a mouthful' of the meal, that they generally 'felt unwell' and experienced tingling of the lower lip and hypersensitivity to the legs. Symptom onset for cases 2 and 3 was approximately 48 hours post consumption. Cases 2 and 3 did not seek medical advice. None of the cases were aware of any prior exposure to ciguatoxins. Leftover food from the fish meal was collected and ciguatoxin was detected at 0.023 µg/kg P-CTX-1B in the flesh of this sample.

Incident 2: Purple Rock Cod - September 2015

This incident involved a Purple Rock Cod the size and weight of which is unknown. The fish was part of the same batch in which the Red Throat Emperor identified in incident 1 was caught. It is not known how the Purple Rock Cod was cooked. This incident involved a single case who reported their illness directly to the vendor of the fish. The consumer reported that they became lethargic after consuming only the

flesh of the fish. Samples of Purple Rock Cod from the same batch as that sold to the consumer were retained by the vendor and submitted for analysis. Ciguatoxin was detected at 0.069 µg/kg P-CTX-1B in the flesh of this sample.

Incident 3: Green Jobfish - August 2016

This incident involved a Green Jobfish that was approximately 80 cm long and one of 3 Green Jobfish purchased by the consumer. The 3 fish were caught off the Capel Bank Seamount, off the coast of Queensland, to the south west of New Caledonia. The fish were purchased in July 2016, transported to the purchaser's home, descaled, gutted (including removal of eyes and gills), portioned and stored frozen. One of these fish was used to prepare a fish soup on 30 August 2016. That soup was shared amongst 6 family and friends. Symptoms experienced by each of the consumers varied (Table 1). One of the cases described their symptoms as "Water bites tongue; tingling lips; heavy face; diarrhoea; at times shortness of breath". P-CTX-1B was detected in 3 of 3 uncooked portions of the remaining fish (0.006, 0.036 and 0.020 µg/kg).

Incident 4: Grouper - February 2017

This incident involved a 5.646 kg Grouper, reportedly caught between Cooktown and Lizard Island that was served by a restaurant at a family function. The fish was selected alive – from a fish tank in the restaurant – and cooked 3 ways: steamed; cooked in a hot-pot; and served as fillets. The hot pot contained the head and skin of the fish. The offal and gills of the fish had been removed and were not cooked. There were 5 containers of 'leftovers' which were taken home by the consumer. Four of those containers were of the hot-pot dish. The fifth container was the steamed fish dish. Four family members who consumed the hot pot fell ill. Those who did not consume the hot pot remained well. Two of the 4 cases who fell ill consumed the hot-pot during the function as well as some leftovers the next day. The remaining 2 cases only ate the hot pot during the function and had milder symptoms. Symptoms experienced by each of the consum-

ers are summarised in Table 2. P-CTX-1B was not detected in any of the 3 containers of leftovers which were available for analysis.

In summary, 13 individuals were affected across 4 CFP incidents between 2015 and 2017 (Table 3). Different fish species were implicated in each incident, 4 in total. Common to at least 3 of the 4 incidents was the consumption of the head of the fish. All 4 fish were caught in tropical regions. The fish involved in incidents 1-3 were caught in and around international waters near the Capel Bank Seamount, off the Queensland coast, south west of New Caledonia. The fish involved in incident 4 during 2017 was caught between Cooktown and Lizard Island within the Australian Exclusive Economic Zone.

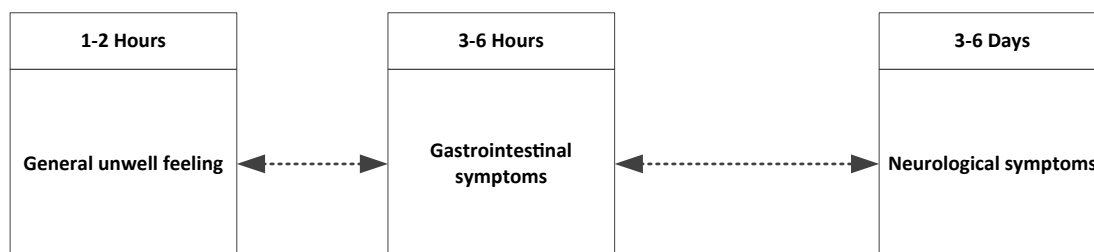
The severity and duration of symptoms varied across all cases. Common across all incidents was a progression of symptoms from an initial feeling of being unwell (1-2 hours), including gastrointestinal symptoms (3-6 hours), followed by neurological symptoms (3-6 days) (Figure 1).

Discussion

As demonstrated by the incidents outlined in this paper, the identification and confirmation of possible CFP cases can be complicated. Management of CFP risk is multifaceted and, as recently reviewed by Farrell et al.,²⁵ requires understanding of the reasons behind the apparent increases in illnesses and geographic range,

the ability to reliably detect CTX in seafood and to understand how toxin concentrations and consumption patterns relate to illness cases. The early identification and triage of CFP cases are invaluable to incident management for 2 reasons. They facilitate appropriate supportive treatment of those affected and provide industry with an opportunity to remove the implicated product from sale to reduce the risk to consumers of exposure to the toxin. Investigation of these 4 recent incidents highlights the issues faced in identifying and responding to cases of CFP. In NSW, foodborne-illness outbreak responses are used to address CFP incidents,²⁶ and typically involve 3 phases. The first is identification of potential cases. The second is a more detailed investigation leading, where appropriate, to regulatory action to address any potential risk to public health and safety. The final phase involves identifying and implementing any appropriate system changes to reduce the risk of a similar incident occurring in the future. With CFP incidents, the response process is limited for 2 reasons. The first is that cases of CFP can be easily misdiagnosed given the wide range of associated symptoms.^{4,5} As a result, despite the large number of cases worldwide, CFP is grossly underreported.^{4,5} The second reason is there is no specific diagnostic 'test' for the toxin in humans.²⁷ In addition, it should be noted that the availability of CTX standard reference material is limited P-CTX-1B was the only available reference material for the samples collected as part of these investigations. It is likely that other

Figure 1: Overview of progressive symptoms and estimated timeframes across four CFP cases (13 individuals) investigated by the NSW Food Authority (2015 – 2017).



Variable intensity and rate of progression of symptoms depending on:

- amount of fish consumed
- type of portion consumed
- concentration of ciguatoxin
- exposure history of individual

Table 1: Summary of reported symptoms from cases who consumed Green Jobfish (Incident 3).

Case	Prior exposure to CFP*	Age	Part of fish consumed	Symptoms (onset time)	Notes
1	Yes	63	Small piece of the head	Itchiness; diarrhoea; nausea; lethargy. (Unknown)	Case reported that they were generally unwell, with existing medical issues, prior to the meal.
2	Yes	30	Head	Itchiness; lethargy; heavy chest. (Unknown)	Case reported that they will 'suck' on bones during meal.
3	None reported	30	Flesh (fillet) only	Heavy chest. (12 hours post meal)	N/A
4	Yes	33	Mainly flesh (fillet)	No symptoms.	N/A
5	None reported	65	Not known	Disorientated. (Unknown)	N/A
6	Yes	62	Head	Felt generally unwell after the evening meal and woke with diarrhea at 3am the next morning. Described symptoms as: diarrhoea with sharp pain; numb face; swollen lips; Itchy arms and legs; lethargy; nausea; 'water bites' tongue; breathlessness. (From 5.5hrs post meal)	Case reported that they will 'suck' on bones during meal.

* reported by the affected individuals.

ciguatoxin analogues were present in the implicated fish samples. Improved testing methodology is required to enhance understanding and management of the risk of CFP. These factors highlight the need to improve identification of potential CFP cases. Although CFP incidents are difficult to identify, analysis of the 4 recent reports of CFP distinguished common indicators that could be used to improve identification of a potential CFP incident.

Two factors were identified as strong indicators of CFP following a fish meal.

1. Whether the complainant experienced a sensation of hot/cold temperature reversal. This can include burning sensation or skin pain on contact with cold water or a stinging sensation when drinking water. This sensation may also be identified as a painful 'sharpness';
2. Whether symptoms are associated with eating

the head or offal of the fish, particularly as a meal of fish soup or stew.

Associated indicators included:

1. Previous reported exposure correlating with more severe symptoms.
2. Two or more consumers of the same meal experiencing symptoms.
3. A progression from initial symptoms of itchy arms and legs, diarrhoea, nausea or lethargy followed 2 to 3 days later by any one or more symptoms that cases described as: heavy chest; sharp tongue (temperature reversal); breathlessness; diarrhoea with sharp pain; numb face; swollen lips; hot and cold sensations; racing heart and/or anxiety.
4. Persisting symptoms which could include: "heavy chest"; "sharp tongue" (temperature

Table 2: Summary of reported symptoms from cases who consumed Grouper (Incident 4).

Case	Prior exposure to CFP*	Part of fish consumed:	Symptoms (onset time)	Notes
1	None reported	Hot-pot: Head and skin on 2 consecutive days	<ul style="list-style-type: none"> • central dull chest pain • two episodes of diarrhoea • lack of energy and weakness • itchy and redness. (Reported 2 days after the second meal) • hot and cold sensations • racing heart • lethargy • anxiety (Ongoing 4 weeks after the second meal) 	Case reported that they ate the head of the fish but does not suck on bones during the meal.
2	None reported	Hot-pot: Head and skin on 2 consecutive days	<ul style="list-style-type: none"> • hot sensations with pain on one side • numbness in the legs and arms (Reported 2 days after the second meal) • hot and cold sensations • racing heart • lethargy • anxiety (Ongoing 4 weeks after the second meal) 	Case reported that they ate the head of the fish but does not suck on bones during the meal.
3	None reported	Hot-pot: Head and skin on 9/2	Diarrhoea. (Unknown)	N/A
4	None reported	Hot-pot: Head and skin on 9/2	Diarrhoea. (Unknown)	N/A

*reported by the affected individuals.

Table 3: Summary of reported CFP incidents linked to imported fish in NSW since 2015.

	Incident 1	Incident 2	Incident 3	Incident 4
Year	2015	2015	2016	2017
Fish species	Red Throat Emperor	Purple Rock Cod	Green Jobfish	Grouper
Origin of fish	Capel Bank Seamount. Same shipment as incident 2.	Capel Bank Seamount. Same shipment as incident 1.	Capel Bank Seamount.	Between Cooktown and Lizard Island off the Queensland coast.
Cases	3/3	1/1	5/6	4/11
Meal type	Fish casserole. Included eating the head of the fish.	Unknown.	Fish soup. Included eating the head of the fish.	Whole fish was prepared 3 ways: steamed, fillet and in hotpot.
Prior exposure to CFP*	None known.	None known.	4 cases.	None known.
Number of samples	1	1	3	2
Ciguatoxin test results	Positive meal sample: 0.023 µg/kg P-CTX-1B.	Positive fillet sample in a fish from the same batch: 0.069 µg/kg P-CTX-1B.	Positive fillet samples from the same batch: 0.006, 0.036 and 0.020 µg/kg P-CTX-1B.	Not detected.

*reported by the affected individuals.

reversal); breathlessness; diarrhoea with sharp pain; numb face; swollen lips; hot and cold sensations; racing heart and/or anxiety.

Conclusion

Improved diagnosis and reporting of potential ciguatoxin cases is essential in facilitating appropriate supportive treatment of those affected. The regulatory strategies used to address the risk of CFP, such as removal of the implicated product from sale, so as to reduce the risk to consumers of exposure to the toxin, rely on prompt identification of cases. Pending development of reliable, cost effective test methods for CTX, these incidents demonstrate that case symptoms, which can vary substantially in conjunction with their reported previous exposure history, the type of fish consumed and how the fish was cooked, can be used to identify potential CFP cases and hence CFP risks that may need to be addressed.

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