



## *Pseudo-nitzschia*, *Nitzschia*, and domoic acid: New research since 2011

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### ABSTRACT

Some diatoms of the genera *Pseudo-nitzschia* and *Nitzschia* produce the neurotoxin domoic acid (DA), a compound that caused amnesic shellfish poisoning (ASP) in humans just over 30 years ago (December 1987) in eastern Canada. This review covers new information since two previous reviews in 2012. *Nitzschia bizertensis* was subsequently discovered to be toxigenic in Tunisian waters. The known distribution of *N. navis-varingica* has expanded from Vietnam to Malaysia, Indonesia, the Philippines and Australia. Furthermore, 15 new species (and one new variety) of *Pseudo-nitzschia* have been discovered, bringing the total to 52. Seven new species were found to produce DA, bringing the total of toxigenic species to 26.

We list all *Pseudo-nitzschia* species, their ability to produce DA, and show their global distribution. A consequence of the extended distribution and increased number of toxigenic species worldwide is that DA is now found more pervasively in the food web, contaminating new marine organisms (especially marine mammals), affecting their physiology and disrupting ecosystems.

Recent findings highlight how zooplankton grazers can induce DA production in *Pseudo-nitzschia* and how bacteria interact with *Pseudo-nitzschia*. Since 2012, new discoveries have been reported on physiological controls of *Pseudo-nitzschia* growth and DA production, its sexual reproduction, and infection by an oomycete parasitoid. Many advances are the result of applying molecular approaches to discovering new species, and to understanding the population genetic structure of *Pseudo-nitzschia* and mechanisms used to cope with iron limitation. The availability of genomes from three *Pseudo-nitzschia* species, coupled with a comparative transcriptomic approach, has allowed advances in our understanding of the sexual reproduction of *Pseudo-nitzschia*, its signaling pathways, its interactions with bacteria, and genes involved in iron and vitamin B<sub>12</sub> and B<sub>7</sub> metabolism.

Although there have been no new confirmed cases of ASP since 1987 because of monitoring efforts, new blooms have occurred. A massive toxic *Pseudo-nitzschia* bloom affected the entire west coast of North America during 2015–2016, and was linked to a ‘warm blob’ of ocean water. Other smaller toxic blooms occurred in the Gulf of Mexico and east coast of North America. Knowledge gaps remain, including how and why DA and its isomers are produced, the world distribution of potentially toxigenic *Nitzschia* species, the prevalence of DA isomers, and molecular markers to discriminate between toxigenic and non-toxigenic species and to discover sexually reproducing populations in the field.

### 1. Introduction

Just over thirty years ago (December 17, 1987), domoic acid (DA) was discovered to be the toxin that killed at least three elderly people and sickened more than 100 others who consumed mussels (*Mytilus edulis*) from Prince Edward Island (PEI), eastern Canada (Bates et al.,

1989; Hanic, 2014). Since then, no additional deaths have been confirmed due to Amnesic Shellfish Poisoning (ASP), the syndrome caused by DA, although the prevalence of DA, its isomers, and toxic diatoms, has increased worldwide. This is because of increased monitoring, research and awareness, but is most certainly also due to limited medical awareness of ASP.

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