Environment

Mitigating the Impact of Harmful Algal Blooms Using Nuclear-Based Techniques

SUMMARY

- Harmful algal blooms (HABs) can contaminate fish, shellfish and other marine organisms, and pose a major threat to people's health, the livelihoods of fishermen and the environment.

- They are the seas' silent killers, toxin-laden patches of algae that amass along coastal shores and wreak havoc on marine ecosystems. Harmful algal blooms appear with no warning and such outbreaks have become more frequent.

- A nuclear-based technique using the receptor binding assay (RBA) is a quick and precise tool to identify the onset of HABs.

- The IAEA supports Member States with the identification of HABs using the RBA technique through various projects.

The IAEA supports Member States to track biotoxins and protect the marine environment using nuclear-based techniques.
(Photo: Joan Albernas/ Cuba)

INTRODUCTION

Harmful algal blooms are commonly known as 'red tides' because in some cases they are characterized by a massive red patch of water ominously approaching the shore, although most of the time it is rather difficult to see the blooms with the naked eye. They are also a major threat to the livelihoods of fishermen: the red tides can cause massive fish kills and thus significantly affect local and commercial fisheries, creating considerable financial hardship for coastal communities. This also increases the risk of contaminated sea products entering the human food chain.

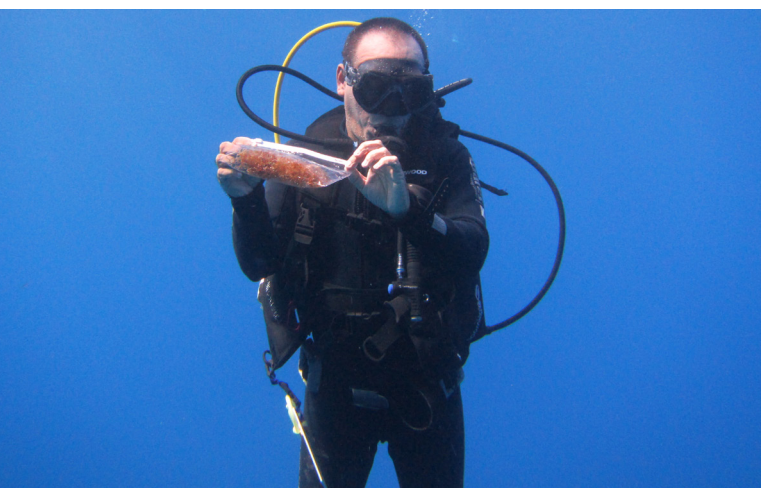Because of the impact that they can have on human health, economies and the marine environment, HABs are one of the most serious naturally occurring global coastal problems. As outbreaks of these poisonous blooms of algae become widespread and more frequent, the IAEA is stepping up efforts to help countries understand the phenomenon and use reliable nuclear-related methods for early detection and monitoring so as to limit HABs' adverse effects on coastal communities everywhere. With an effective emergency system, it is possible to minimize the risks to marine ecosystems, human health and economic stability.

WHAT ARE HARMFUL ALGAL BLOOMS?

Blooms of algae, ranging from microscopic phytoplankton to large visible seaweed, occur when light, temperature and nutrient conditions are ideal for plant growth. Not all algal blooms are harmful.

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A scientist collects seaweed as part of monitoring activities for harmful algal blooms.
(Photo: IAEA)

In fact, most of them sustain marine life, providing a vital source of nutrients for a host of sea creatures. However, these colonies of algae sometimes grow out of control and produce toxins that can poison fish, shellfish and other marine organisms, thereby posing a major threat to people's health and fishermen's livelihoods. Higher levels of nutrients in water as a result of coastal upwelling or agricultural run-off can contribute to these outbreaks. Paralytic shellfish poisoning, characterized by death through paralysis of the respiratory system, is one of the most common health threats from eating contaminated shellfish.

EARLY WARNING OF HARMFUL ALGAL BLOOMS USING NUCLEAR-BASED TECHNIQUES

Early detection of biotoxins is vital in protecting human health. Nuclear techniques can be used to identify promptly biotoxins in seafood or in the environment and to help to pinpoint outbreaks with more accuracy. This protects the food chain, and can help to limit the amount of time that fishing grounds must be closed.

For decades, testing for biotoxins from HABs has conventionally been done through the mouse bioassay method. Scientists in regulatory laboratories inject toxin extracts from suspect algal or shellfish samples into a laboratory mouse and measure how long it takes for the mouse to die. The mouse bioassay method is considered to have a low sensitivity, and is not able to precisely pinpoint levels of toxicity.

The nuclear-based technique using the receptor binding assay (RBA) is a far more sensitive and precise measuring method. It works by mixing a seafood sample with a radiolabelled toxin and then combining the mixture with membrane tissue. If the seafood is contaminated, the poisons compete with each other to 'bind' to the nerve cells of the tissue, with the radioactive toxin being 'bumped off' its receptors by poison already present in the shellfish. By measuring the amounts of radioactivity left in the tissue sample, scientists can then determine exactly the levels of toxins. RBA is used worldwide to complement or replace mouse bioassay. For years, the IAEA Environment Laboratories have been at the forefront of promoting the use of RBA for early detection and monitoring of HABs. Several successful applications have been reported and documented in Chile, El Salvador, Namibia and the Philippines, to name but a few.

EFFECTS OF HARMFUL ALGAL BLOOMS

Effect on human health

Consuming marine organisms that have fed on toxic algae may cause serious health problems. Among the worst consequences are different types of shellfish poisoning. These can be the result of ingesting any type of shellfish, such as mussels, oysters or scallops, with an accumulated toxin concentration. The symptoms vary from nausea to memory loss, brain damage and paralysis. In the worst cases, the toxin concentration can be lethal.

Effect on marine ecosystems

Algae are an important source of nutrition for oceanic life, and are at the base of the food cycle. The occurrence of HABs disrupts the marine food web, causing the intoxication and death of many marine mammals, birds and turtles.

Effect on the economy

Harmful algal bloom events that lead to the closure of aquaculture and recreational areas cause grave economic losses. These include a severe decline in fishery-related business, tourism activities and associated services. This is reflected in increased unemployment and insurance rates as well as in higher prices for marine products. In addition to seafood safety, HABs also affect seafood security. For example, fish regulations issued to deal with ciguatera poisoning most often involve the banning of selected species of certain sizes.

IAEA SUPPORT

The IAEA is helping countries use nuclear technology to identify HAB events, and to limit their impact. To date more than 40 countries have received technical assistance from the IAEA to address HAB-related problems, and the IAEA also supports several regional and national technical cooperation projects in this area.

Quick detection and assessment of HABs also help national authorities to adjust their fishing policies to protect marine organisms and wildlife, and to prevent dangerous neurotoxins from entering the human food chain.
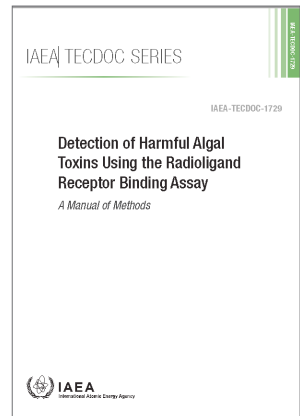
To deal with HAB emergencies and contribute to the sustainable management of fisheries and marine products, the IAEA, through its technical cooperation programme, has helped countries to establish a permanent monitoring system that provides early warnings of toxins in microalgae and seafood products. The IAEA also provides training on the use of specialized detection equipment for the monitoring of HABs.

The IAEA's objective is to build a support structure to allow countries to develop and implement strategies and programmes on HABs. Another goal is to upgrade regional capabilities for the use of the RBA technique through training and technology transfer.

GLOBAL PARTNERSHIPS

In order to help countries deal with the HAB menace, the IAEA collaborates with partners such as the US National Oceanic and Atmospheric Administration (NOAA). Under Practical Arrangements, the IAEA and NOAA support countries in the development and implementation of joint strategies and programmes on HABs that include developing capacities for HAB monitoring, toxin testing and technology transfer applicable to HAB investigations. A direct offshoot of this joint action is the IAEA Technical Document entitled *Detection of Harmful Algal Toxins Using the Radioligand Receptor Binding Assay: A Manual of Methods* (IAEA-TECDOC-1729). Issued in 2013, this manual serves as a useful guide for developing countries that wish to use the RBA method to monitor and respond to HAB events.

Another example of cooperation the tripartite agreement between the IAEA, the United Nations Environment Programme (UNEP) and the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO), signed on 25 February 2011, to build countries' capacity to monitor HABs. This collaboration resulted in regional initiatives in Africa, Latin America and Asia and the Pacific

Developing Member States receiving Technical Cooperation support for HABs
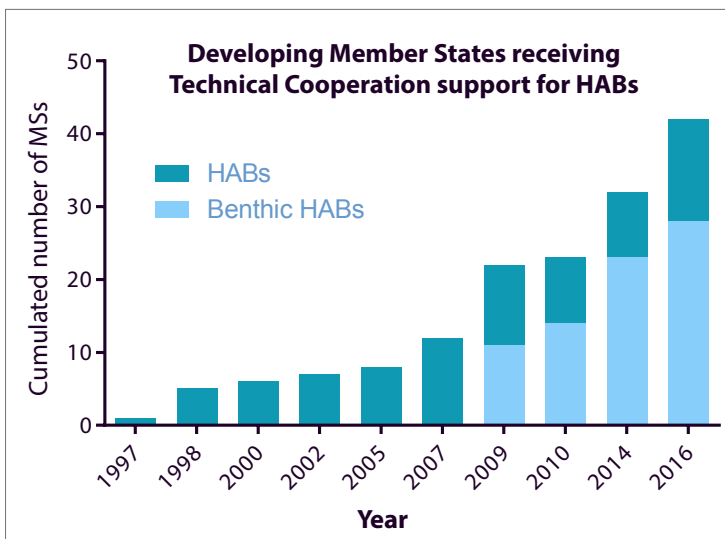
aimed at strengthening capacity to monitor HAB events. Another direct result of this collaboration was the production of a joint UNESCO/IOC–IAEA *Guide for designing and implementing a plan to monitor toxin-producing microalgae* (IOC Manuals and Guides No. 59).

The IAEA also works with marine institutes to handle the HAB threat. For example, the Laboratory of Marine Toxins of the University of El Salvador has received specialized detection equipment for HABs as well as training on its use through the IAEA technical cooperation programme.

The Philippine Nuclear Research Institute, which is currently the only IAEA Collaborating Centre in the field of HABs, works closely with the IAEA Environment Laboratories in Monaco to track the impact and fate of biotoxins in the marine food chain.

The IAEA signed in 2014 an agreement with the Louis Malardé Institute in French Polynesia concerning research on the impacts of HABs and contaminants on marine ecosystems and seafood safety.

Such partnerships are prime examples of the benefits of cooperation between the IAEA and Member States to protect national food security, public health and the economy. They contribute to the sustainable management of fishery products and the coastal economy, increase food security and provide valuable resources for scientific research institutions and governments.

To protect human health, early detection is vital. Nuclear techniques such as the radioligand binding assay (RBA) can be used to precisely and accurately detect biotoxins in seafood and in the marine environment.

(Photo: M-Y Dechraoui Bottein/IAEA)

RECOMMENDATIONS FOR CONSIDERATION

Member States are encouraged to collaborate with the IAEA to improve:

- Assessment of the problem of HABs using nuclear techniques.

- Capacity building in the use of nuclear techniques for effective monitoring of HABs and biotoxins, and in the development of strategies to limit the impact of HABs.