IAEA BRIEF 2017/8

Environment

Nuclear and Isotopic Techniques to Improve Seafood Safety

SUMMARY

1. Fish and shellfish are key sources of food for many people around the world, yet pollutants and biotoxins can jeopardize seafood safety.

2. Factors associated with climate change and ocean acidification can put added stress on organisms and have an impact on the transfer and accumulation of contaminants, and thus on the safety of our seafood.

3. The IAEA supports Member States in the use of nuclear and isotopic techniques to investigate these processes and to develop capacity to better detect and measure contaminants and biotoxins in the marine environment and in seafood.

Fish and shellfish are a source of food and income for millions of people around the world.
(Photo: M. Metian/IAEA)

INTRODUCTION

More than three billion people globally depend on the ocean as a source of income and food according to the United Nations. It is estimated that around 77% of pollution in the ocean comes from land sources, including agriculture, heavy industry, untreated sewage and plastics. Pollutants include trace metals such as mercury, radionuclides and persistent organic pollutants such as pesticides and polychlorinated biphenyls (PCBs).

In high concentrations, these contaminants can jeopardize seafood safety and even threaten human health. In recent years, there has also been an increase in the severity, frequency and geographical range of harmful algal blooms (HABs), which can produce biotoxins that can cause widespread foodborne illnesses.

Nuclear and isotopic tools provide an insight into the movement of pollutants and toxins in the marine environment, their transfer to marine organisms, and their increasing concentrations as they rise up the food chain from one organism to another, making their way, ultimately, on to our plates. Consumers need to be able to trust that the food they are eating is safe, that laboratories have the capability to precisely detect contaminants and biotoxins and that the information they are given is accurate.

IAEA SUPPORT

The IAEA Environment Laboratories work with Member States around the globe to ensure that they have the capability to detect and measure contaminant and biotoxin concentrations in the marine environment and in seafood, so that, in case of pollution incidents or toxic algal blooms, they can take the necessary measures. IAEA support includes

training in techniques and tools to sample, measure and monitor metals such as mercury or cadmium, radionuclides such as caesium and americium, organic pollutants such as PCBs or pesticides, and marine toxins such as saxitoxins or ciguatoxins.

Using nuclear techniques, researchers can gain a unique understanding of the ways contaminants move through the marine environment and through the food chain, from marine algae all the way to predator fish. Tracking of contaminants is important to keep populations safe, as contaminant concentration levels can increase higher up the food chain, potentially putting people's health at risk. This process is known as bioaccumulation. Research findings provide the science-based evidence needed to develop and maintain effective national seafood safety programmes.

The IAEA works with Member States to increase use of the RBA, a nuclear tool to quickly and precisely determine the presence of biotoxins in seafood and in the marine environment.

(Photo: S. Jones Couture/ IAEA)

MIMICKING THE HUMAN DIGESTIVE SYSTEM TO ASSESS CONTAMINATION RISK

IAEA Environment Laboratories researchers have developed an innovative way to replicate the human digestive process in the laboratory by creating a mix of various enzymes and a mechanical grinding mechanism. Fish tissue and samples are exposed to an artificial digestive mixture, in much the same way as they would be during actual digestion. Different ways of cooking fish are also examined, to see if this has an impact on contaminant levels. At the end of the experiments, IAEA researchers can accurately measure the remaining pollutants in different biological compartments (i.e. tissue and organs) using nuclear or isotopic techniques, thereby providing information on the ways contaminants and biotoxins are metabolized during digestion and food preparation and thus identifying the contaminants that remain to be potentially absorbed by our bodies.

TRACKING MERCURY IN SEAFOOD

The World Health Organization rates mercury as one of the top ten chemicals of major public concern owing, in part, to its persistence and tendency to accumulate in the environment and in organisms. In high concentrations, mercury can have devastating health effects, with impacts on the brain and nervous system. Since global seafood consumption has nearly doubled in the past three decades, monitoring of mercury concentrations in the ocean is of critical importance. The IAEA Environment Laboratories in Monaco work with Member States to develop better detection techniques and improve mercury monitoring in the marine environment, as well as studying the transfer of this toxic pollutant.

Mercury is released into the environment through industrial activities, coal-fired power plants and artisanal and small-scale gold mining. It makes its way into the marine environment via various pathways, such as rainfall and surface water. Bacteria in sediment change mercury to methylmercury, an extremely toxic compound, which can have serious negative effects on organisms and tends to bioaccumulate. Data from the 2013 UNEP Global Mercury Assessment suggest

that mercury emissions are continuing to rise with the increase in coal combustion and metal and cement production.

Many countries have established limits on the intake of mercury through the consumption of seafood. The IAEA Environment Laboratories work with Member States to increase their capacity to detect mercury and various mercury species, including the highly toxic methylmercury. They have developed and validated several analytical techniques for water, fish and sediment.

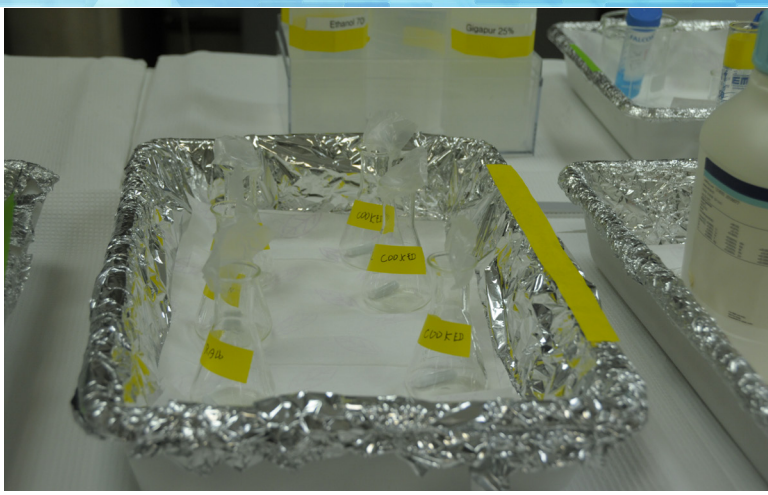
The IAEA Environment Laboratories also use tracers to study the accumulation of mercury in marine organisms and follow its transfer up the food chain. Specifically, they have studied mercury accumulation in important food sources such as clams, oysters, mussels and cuttlefish.

The Minamata Convention on Mercury highlights the importance of preventing and controlling mercury levels in the environment.[1] It has been signed by 128 countries and entered into force in August 2017. The Convention prohibits numerous mercury-emitting processes and products, calls for limits on mercury emissions and requires Member States to establish and strengthen their efforts to monitor environmental mercury.

TRACKING BIOTOXINS IN MARINE LIFE

Phytoplankton are microscopic algae at the base of the marine food chain that are responsible for more than half the earth's oxygen supply. Certain species are capable of producing toxic molecules which can make humans and marine animals severely ill, with symptoms including vomiting, diarrhoea, dizziness or, in extreme cases, even death.

Each year, toxin-containing phytoplankton are responsible for thousands of poisoning incidents all over the globe due to the consumption of contaminated seafood and respiratory issues in people who breathe in toxic aerosols released during blooms. These toxins have also been the cause of large-scale



IAEA Environment Laboratory researchers have developed a way to replicate the human digestive process by creating a mix of enzymes.

(Photo: S. Jones Couture/IAEA)

mortality among shellfish, fish, sea turtles, birds, endangered Mediterranean monk seals and whales.

The IAEA uses nuclear and isotopic techniques to gain a better understanding of HABs and to develop Member States' capacity to detect and quantify marine biotoxins.

The IAEA Environment Laboratories provide training in nuclear-based methods to detect HABs and associated biotoxins in seafood and marine environments. They work with Member States to increase the use of radioligand receptor binding assays (RBA), a nuclear tool used to determine quickly and precisely the presence of saxitoxins, ciguatoxins or brevetoxins, potent biotoxins in seafood.

In addition, new analytical methods to measure biotoxins and study the process of how these toxins are taken up by marine organisms and transferred up the food chain are also used. Such tools provide Member States with the information they need to impose restrictions when necessary to ensure the safety of their populations and seafood exports. These techniques can be used as part of regulatory monitoring activities to determine the presence of HABs in coastal waters and biotoxins in seafood.

[1] See www.mercuryconvention.org

Pollution and factors associated with climate change and ocean acidification can impact seafood safety and security.
(Photo: M. Metian/IAEA)

PRODUCING REFERENCE MATERIALS FOR QUALITY CONTROL

The IAEA Environment Laboratories also produce reference materials — samples that include marine biota (organisms) and sediment. These can be used as part of quality control procedures to check the analysis of samples, validate analytical methods and establish traceability to internationally agreed references. Reference materials play an important role in increasing the accuracy and certainty of environmental measurements. The IAEA Environment Laboratories organize proficiency tests and inter-laboratory comparison exercises to help laboratories around the world assess their capabilities and identify areas for improvement. They also provide training and capacity building in sampling methods and analytical techniques using various types of equipment.

FUTURE OF SEAFOOD SAFETY

In addition to contaminants and biotoxins, marine organisms are subject to other environmental stressors, such as changes in temperature, available oxygen and pH. The occurrence of these multiple stressors at the same time may impact seafood safety. Some interactions can occur between these global changes associated with climate change and ocean acidification and local pollutants (metals, organic pollutants, radionuclides and marine toxins) leading to their increased availability in the environment, potentially leading to higher concentrations of contaminants in certain seafood species. The IAEA Environment Laboratories are investigating the risks associated with the presence of multiple stressors on contaminant concentrations in seafood.

AREAS WHERE MEMBER STATES MAY BENEFIT FROM IAEA ASSISTANCE

- In strengthening and enhancing analytical capacities to precisely detect contamination in seafood through training.
- In improving research into HABs: knowledge about HABs and related toxins has increased greatly over the past few years, but key information gaps still remain, and analytical procedures for some toxins remain limited.
- In continuing to study the effect of multiple stressors on the bioaccumulation of contaminants in marine organisms in the context of seafood safety.

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