CODEX ALIMENTARIUS
INTERNATIONAL FOOD STANDARDS

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World Health Organization

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CODE OF PRACTICE FOR THE PREVENTION OR REDUCTION OF CIGUATERA POISONING

CXC 83-2024

Adopted in 2024

1. INTRODUCTION

Ciguatoxins (CTXs) are a class of toxins produced by marine dinoflagellates (motile unicellular algae). These toxins enter the marine food web when CTX-containing dinoflagellates/algae are consumed by herbivorous fish or shellfish, including some echinoderms. CTXs can bioaccumulate in these and higher trophic level marine organisms. Ciguatera poisoning (CP) is an illness resulting from consumption of marine organisms containing toxic levels of CTXs. Sub-chronic exposure to ciguatoxic fish or shellfish can also lead to toxic effects. CP has become a global health concern and is increasing in prevalence due to factors that likely include climate change. Coastal communities that rely on local fishing as a food supply and as a source of income are particularly at risk from increasing occurrences of CP. In 2018, FAO and WHO convened a joint expert meeting to perform an evaluation of CTX and provide guidance for development of risk management option.[1]

The benthic dinoflagellate genus *Gambierdiscus* is the main known producer of CTXs, and some species of *Fukuyoa* may also produce CTX-like toxins. These dinoflagellates tend to grow in tropical and subtropical marine environments and are typically associated with coral reefs. *Gambierdiscus* and *Fukuyoa* are known to attach to various substrates (e.g. turf algae, macroalgae, and coral, although they can also be detected in the water column). Recent reports have identified these organisms in more temperate regions as well, including the Republic of Korea, Japan, northern territories of New Zealand, southern Australia, the northern Gulf of Mexico, and the Mediterranean Sea. CTXs were initially categorized as belonging to one of three major classes that corresponded with their global location (Pacific P-CTXs, Caribbean C-CTXs and Indian Ocean I-CTXs); however, experts now recommend that toxins be categorized into four classes, derivatives of CTX4A, CTX3C, C-CTX, and I-CTX, according to their chemical structure (I-CTX structures have not been fully determined). CTXs are lipophilic, do not degrade under heat or mild pH changes, and are known to be resistant to degradation by cooking, freezing, or canning processes. They may undergo structural transformations as they are metabolized by marine organisms, often increasing in toxicity as they do so. More than 30 unique analogues of CTXs have been reported and many more have yet to be fully characterized.

The impact of CTXs to humans is primarily through the consumption of wild-caught herbivorous fish or predatory fish or shellfish that have accumulated CTXs. The risk of intoxication from aquacultured fish is considered to be low. The diet of the individual marine organism is the primary contributing factor for CTX accumulation; however, the size and age of marine organisms are believed to influence CTX accumulation as well. CTXs are lipophilic and may be present in tissues such as meat (flesh), head, liver, viscera, and roe (eggs). The *FAO/WHO Report of the Expert Meeting on Ciguatera Poisoning*[1] referenced more than 425 species of fish that have been identified as having been contaminated with CTXs, including examples such as barracuda, amberjack, grouper, snapper, and parrotfish. Many of these fish are territorial, which can help identify vulnerable fishing areas, though territories can overlap and change with time. CTXs do not appear to be fatal to fish and there are no outward signs that a wild-caught fish is contaminated with CTXs, such as change in behaviour, taste, odour, or texture; meaning that toxin analysis is required to confirm CTX presence and concentration.

Humans can experience CP when they consume fish or other marine organisms contaminated with CTXs. Generally, the signs and symptoms of CP are acute and can appear within several hours of consuming contaminated food or up to 48 hours after consumption. CP symptoms include gastrointestinal issues (e.g. vomiting, diarrhoea), neurological issues (e.g. paraesthesia, headaches), cardiovascular issues (e.g. hypotension, bradycardia), and some symptoms that are especially characteristic of CP, such as cold allodynia and dysesthesia. CP is rarely fatal, but exposure to CTXs may prove extremely debilitating and can exacerbate the impact of pre-existing cardiovascular or neurological conditions. There is no specific treatment for CP, but some symptoms can be managed if the illness has been correctly diagnosed.

Reports of CP have been made since the 1500s. At present, CP is believed to be the most common type of marine biotoxin-related food poisoning worldwide. The global prevalence of CP is estimated to be 10 000 to 500 000 cases per year. In general, CP prevalence may be underestimated due to a lack of mandatory incidence reporting, misidentification of CP symptoms, limited collection of epidemiological data on a global level, and other reasons. If clinicians do not know the characteristic symptoms, they may misdiagnose CP, leading to underreporting of the disease.

Consuming CTX-contaminated fish was once geographically limited to local residents and visitors to tropical and subtropical regions with suitable coral reef habitats, but global trade of fish and the impacts of climate change, including an increase in ocean temperature, prevalence of cyclones, and changes in currents, have caused CP illnesses to be observed among a wider range of individuals and reported in non-CTX endemic countries in temperate regions. Analogues of CTXs that were formerly found to be endemic to specific regions can now be found in other areas of the world. Some regions have been monitoring CP cases for many years, developing expertise in analysis and area management, and some are experiencing an increase in CP as an emerging issue and must learn how to develop monitoring programs, inspection protocols, and regulations to protect the public.

Successful surveillance and monitoring of CTXs depends on the availability of accurate epidemiological data and/or analytical methods validated according to international standards/guidelines. Presently, formal validation of analytical methods for CTXs is limited due to the lack of certified standards and certified or uncertified matrix reference materials. The analytical methods currently available for detection of CTXs are diverse and target different properties of the toxins (e.g. structure, cytotoxicity) and encompass both screening and quantitative measurements. Some analytical methods can simultaneously quantify individual CTX analogues, while others are more selective in the analogues that can be detected. However, there are no internationally agreed harmonized protocols to determine CTXs. Most CTX detection methods are suitable for analysing a variety of matrices (i.e. algae or seafood tissues) and some have sufficient sensitivity to detect CTXs at the levels that may be associated with adverse health effects in humans. CTX analogues are believed to vary depending on the species of toxin-producing algae, as well as the metabolism of marine organisms. CTXs can be extracted from CTX-producing algae or contaminated marine organisms; a limited number of CTX analogues have been synthesized (e.g. CTX1B, CTX3C, and 51-hydroxy-CTX3C). The dinoflagellates grow slowly in laboratory conditions and can be difficult to maintain; large quantities of ciguatoxic fish material are required for the isolation of toxins, which means production of CTX standards is limited. However, recent advancements in culturing, materials handling, and chemical characterization have significantly improved the capabilities to make reference materials. Toxins from cultured algae and fish with varying metabolite profiles are available.

In their 2020 report, FAO/WHO concluded that “effective and integrated risk management options would require definition of toxin profiles in each region, both in algal strains and in seafood to define risk evaluation protocols […] conclusions should be considered as of local or regional significance only […]” Some of the recommendations from the FAO/WHO report are included in the “Recommended Practices” sections below.

2. SCOPE

This document provides guidance on recommended practices to prevent or reduce CP for different types of stakeholders including competent authorities, fish sector operators (fishers, seafood processors, and seafood retail workers), health care professionals, and consumers. Because of differences in CTXs, analytical methods and standards, and regional prevalence levels of CP, not all recommended practices will be applicable in all situations or to all stakeholders.

3. DEFINITIONS

- **Analogue**: A compound that has a structure similar to another compound but differs from it in certain components, such as functional groups or substructures. When referring to CTX, analogues have similar backbone structures but different functional groups in specific locations.
- **Ciguatoxic**: Containing toxic levels of CTXs.
- **CTX-contaminated**: Containing levels of CTX which may or may not be considered toxic.
- **Fish sector operators**: People who work in the areas of fishing, seafood processing, and seafood retail.
- **Sentinel species**: An organism used to detect existing or emerging health hazards from the environment. Sentinel species are sensitive indicators of a chemical contaminant in the environment due to their ability to concentrate or integrate exposures within a food web or ecosystem, and they may provide early indication of potential adverse health effects and provide insight into toxic mechanisms of a given hazardous agent.
- **Surrogate**: a substitute species used to assess the quality of the environment when testing the target species is not feasible. In this case, testing of sentinel fish or water may be preferable to testing fish for consumption when determining if an area should be restricted to fishing.

4. RECOMMENDED PRACTICES

4.1 Government-sponsored surveillance and monitoring programs

As knowledge improves and reliable methods become available, competent authorities should consider establishing or strengthening programs to monitor outbreaks and CTXs in algae, sentinel fish species, and fish for consumption. Overall, the function of monitoring programs is to provide information that may be used to develop warnings of the potential for CP problems and provide feedback notices to the fishing industry or consumers to warn against fishing in certain areas. It is currently impractical (i.e. costly and labour-intensive) to test fish to a sufficient degree for the complete prevention of CP, but recommendations outlined below should help to reduce the prevalence of CP.

Environmental monitoring may be undertaken with a two-tiered approach: initial test of *Gambierdiscus* or *Fukuyoa* algae or fish using a functional biological screening method, then confirmation of any positive results using a chemical analytical method to identify well- known toxins and determine CTX content. Local officials should determine if there are sentinel species of fish that consume toxic algae and whether monitoring those fish as well as predatory fish that feed on affected fish in the area is appropriate. A non-exhaustive list of fish known or suspected to be associated with CP is included as Annex I. This list is provided as an example to users of the Code of Practice (CoP).

Competent authorities should define the causative organisms of CTX in their region. Monitoring of algae in the local region can be used to positively identify blooms of *Gambierdiscus* or *Fukuyoa* and characterize their toxin content when present in sufficient quantity. Passive sampling of toxins in the water column by Solid Phase Adsorption Toxin Tracking (SPATT) devices containing lipophilic resins can be used to collect toxins from water and have the potential to serve as an early warning tool but are not used routinely for CTX monitoring. More details on analyzing benthic algae are presented in the Analytical Methods section below.

Monitoring of both algae and fish is recommended, as the concentration and/or CTX profile of benthic dinoflagellates does not always correlate to contamination in fish; i.e. a high concentration of CTX in an algal bloom may not correlate to a high concentration of CTX in local fish, and certain species of fish may contain high concentrations of CTXs even though the density of dinoflagellates in the sea water is low. This relationship has been used by some competent authorities to set limits on size or species of fish permitted for consumption from a particular region.

Because toxin profiles typically differ in algae versus contaminated fish and humans (due to metabolism and behavior, for instance large migratory species that can feed in other areas), it is important to experimentally determine the correlation between environmentally sampled toxins and toxins isolated from fish and humans to enable traceback and targeted surveillance activities. It may be possible to identify the preferred substrate for dinoflagellates (e.g. seagrass and macroalgae) and if there is a selectivity or preference by herbivores for consumption of those substrates in a region.

Competent authorities could consider developing maps based on epidemiological data and identified prevalence of *Gambierdiscus* and *Fukuyoa* species in a region, and the associated food chains for toxin transfer in those areas. These maps may be useful to competent authorities when trying to determine if an area needs to be closed to commercial, subsistence, and recreational fishing. Maps indicating toxic fish or algae should be updated at reasonable intervals as blooms or migratory patterns may change season-to-season or with climate change, and results can be more precise as testing methods improve. Creating high-risk maps may not be appropriate for all regions, e.g. it may be difficult for countries or regions with many islands and coral reefs because high-risk areas are variable.

A more complex map could include information on the temporal and geographic toxin profiles of CTXs in the local area for both algae and fish. It may be possible to use information on the migratory patterns of reef fish (i.e. species of fish that migrate from an area with low *Gambierdiscus* or *Fukuyoa* density to one of high density) and the temporal swings in toxicity of the area and correlate them to possible toxin load, but this has not yet been practically demonstrated.

Competent authorities should consider developing and routinely updating an epidemiological database to collect information on human illnesses, which includes the species of the fish suspected of causing the illness and its original catch area if known (for countries reporting CP). Ideally, the data collected by these programs should include the origin and date of capture of contaminated fish, the fish species involved, CTX analogue profiles identified from meal remnants and patient samples, the concentration of toxins, severity of short and long-term symptoms experienced by the patient, the amount of fish consumed, the anatomical parts of the fish consumed, and other relevant information. Examples of monitoring programs that report information on CP are listed in the *FAO/WHO Report of the Expert Meeting on Ciguatera Poisoning.*[1]

Competent authorities could utilize social science approaches such as surveys and interviews to solicit information from local fishers about which areas yield toxic fish. Local fishers often possess knowledge about areas of CP risk, and this information represents a cost-effective way to supplement more costly surveillance of toxins in algae or seafood by analytical methods.

When competent authorities are notified of CP cases, it is important to first identify the species of seafood involved, locate the area and date of capture, determine the amount (weight) of fish the patient consumed, record the type and severity of symptoms, and recover any meal remnants (if available) for confirmation of CTXs. An initial risk assessment should include identification of whether the seafood was sourced locally or imported from another area. If the fish was captured locally, investigation of the concentration of CTXs in the algae, fish, and other animals in the capture area would be the next step to determine if an area should be restricted to fishing.

4.2 Other governmental activities

When sufficient data linking epidemiology and toxicology are available, competent authorities could consider developing maximum levels (MLs) for the concentration of CTXs permitted in susceptible fish. Because of current limitations in analytical methods and toxic equivalency factors of different CTXs, MLs may not be appropriate for all toxins or regions.

Examples of approaches some authorities have taken to reduce incidence of CP in their region are listed below. These approaches can be considered but may not be appropriate for all regions or all types of seafood.

- A list of banned fish species (forbidden to be imported or sold).
- A list of fish species recommended not to be eaten (but not forbidden).
- A list of banned species that can be imported only if the same species caught in the specific sea area of the exporting country are usually consumed in the exporting country, no CP has occurred, and it is tested and confirmed to be free of CTX.
- A size limit for some fish species depending on origin or previous link to CP cases.
- A positive list of species that may be sold at a regional or local market depending on place of origin and season.
- A protocol whereby listed species equal to or above a certain maximum weight must be checked at authorized points of first sale to discard CTX activity in flesh tissue.
- A positive list of certain marine fish species permitted for import.

If appropriate, competent authorities should develop regulations and voluntary guidelines to minimize the possibility that CTX-contaminated fish are caught or sold. Depending on the point of application, these may include requirements for food hygiene systems that include Hazard Analysis and Critical Control Point (HACCP) plans. In that case, authorities should conduct inspections to ensure that the HACCP plan contains the appropriate critical limits, monitoring procedures, and record-keeping elements, and is properly and consistently implemented.

If monitoring and surveillance is conducted, competent authorities should report the results of their monitoring to stakeholders and post warnings/fishing advisories in areas where fish species linked to CP may be caught.

When establishing regulations or other activities such as surveillance and monitoring protocols, it is recommended that authorities seek the advice of experts on CP. It may be beneficial to consult a committee with varied backgrounds and expertise to make the most informed decisions.

4.3 Analytical methods

Standardized protocols for testing of seafood matrices, algae, or passive water samples should be used so that results are comparable across laboratories or between regions and countries. This includes monitoring *Gambierdiscus* and *Fukuyoa* diversity (e.g. molecular approach vs. morphotaxonomy, how to approach inclusion of new species) or when collating epidemiological data. CTX sample collection and testing should be done using single or multi-laboratory validated methods to ensure comparability of results.

When possible, molecular techniques such as DNA barcoding should be used to determine the species of fish contaminated with CTXs (either at the time the fish is caught or as a meal remnant). Information on fish species can be used to help trace contaminated products back to their origin and to determine if follow-up CTX testing of other fish in the harvest area is necessary. Testing meal remnants for the presence of CTXs is important to link CP cases with the source of the CTXs.

Analytical methods with the capability to quantify toxins should be used, either methods that measure individual CTX analogues or methods that report the sum of all toxins present (i.e. cannot distinguish individual analogues). Because CTX profiles are known to vary by location or marine species, different reference materials may be needed based on the toxin profile observed and method used.

When possible, laboratories should consider storing aliquots of CTX-contaminated seafood or algae. These naturally contaminated samples can be used for development of reference materials or to share with other researchers performing method validations.

Entities with expertise in analytical methods and in developing reference materials are strongly encouraged to share knowledge and expertise and initiate collaboration with regions that are developing or improving their surveillance and monitoring activities.

Because analytical technologies will continue to evolve, it is not appropriate to recommend specific methods in a CoP. Detection of CTXs can be performed using a number of techniques, each with differing sensitivities, advantages, and limitations. Methods that have been reported in the literature are: the neuroblastoma assay (N2A), receptor-binding assay (RBA), enzyme-linked immunosorbent assay (ELISA), mouse bioassay (MBA), and liquid chromatography/(tandem) mass spectrometry (LC-MS or LC-MS/MS). The *FAO/WHO Report of the Expert Meeting on Ciguatera Poisoning* contains a list of methods that were available when the report was published in 2020.

As mentioned in Section 4.1, environmental monitoring may be undertaken with a two-tiered approach: initial qualitative screening of seafood or algae using a functional biological method (e.g. N2Aa) followed by quantitative analysis of positive samples to determine the overall concentration of CTXs. For CTXs where the structure is known and/or reference materials are available, confirmation of positive results can be performed using a method that can identify CTX analogues and determine their individual contribution to the overall CTX concentration (e.g. LC-MS). Stakeholders are encouraged to contact their competent authorities for assistance or consult with international agencies such as the International Atomic Energy Agency (IAEA) on method development and sharing of technology.

4.4 Fish sector operators

Fish sector operators (people who work in the areas of fishing, seafood processing, and seafood retail) should adhere to any national or regional legislation for food hygiene systems that include HACCP plans pertaining to CTXs or CP in relevant commodity species. If not specifically required by competent authorities, firms should consider adding CP to their HACCP plans to reduce the likelihood of CTX-contaminated fish entering the marketplace. These plans could include any relevant national, regional, or local limits on size or source of fish, traceability of fish products from fishing areas to retail, training on CP hazards and regulations, and criteria for rejecting shipments.

When possible, HACCP plans should contain limits on the areas or time of the year where and when fish can be caught, describe how monitoring will be conducted and how frequently, establish criteria for rejection of the commodity, and utilize an organized record-keeping system.

HACCP plans should include a hazard analysis; for CP, that would include local awareness of the species of fish caught which may be susceptible to CTX accumulation and an understanding of the location of the potentially toxic areas for avoidance. If appropriate, restrictions on the species and/or size of fish known to accumulate CTXs could be part of the HACCP plan. HACCP plans could include a requirement that fish known to accumulate CTXs and above a size limit are tested for CTXs before sale, but such wide-scale testing could be very costly or burdensome and access to analytical facilities might be restrictive.

Fish sector operators should institute policies for traceability of fish and accurate identification of the species being sold, especially for fish that are intended for export, so that the processing or retail firm can confirm that the product was not caught from a restricted area or is a locally restricted species.

Seafood processors who purchase fish directly from fishers should obtain information about fishing locations to determine the potential for ciguatoxic fish based on knowledge of the regions where CP occurs (comparing to risk maps from competent authorities where available). Primary seafood processors should avoid purchasing fish species associated with CP from established or emerging areas linked with CP.

Where MLs of CTXs in fish for consumption are established or recommended by competent authorities, fish sector operators could set critical limits on CTX concentrations in surrogates to reduce the likelihood that commercial fish are contaminated. Examples of surrogates are sentinel fish, algae, or water in a particular fishing area depending on what has been determined to be appropriate for the region (see Section 4.1).

CTXs are known to concentrate in fish viscera, liver, heads, and roe. Therefore, it is highly recommended that these organs or body parts from fish species linked to CP are not sold or consumed. Seafood processors should have policies and procedures for handling and disposal of seafood by-products and seafood-derived products to minimize risks to public and animal health and to protect the integrity of the food and feed chain.

4.5 Data sharing and training

Competent authorities are encouraged to share their guidance and best practices with interested parties, including for the purposes of training of scientists in relevant methodologies, to improve the global prevention of CP and encourage harmonization of data and reporting systems.

Entities wishing to begin or strengthen their surveillance and monitoring programs are encouraged to contact CP experts for consultation. International agencies such as IAEA and the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO) are promoting such work and could be contacted for assistance.

Competent authorities or other official institutions that have CP or CTX databases should be encouraged to share approaches on raising awareness of the risks of CP and to publish annual reports or other summaries on monitoring of illnesses to aid other regions in developing strategies for prevention and avoidance of CP.

4.6 Advice to Consumers and Healthcare Professionals

Competent authorities should provide advice on CP to consumers and healthcare providers. Some examples of consumer advice that have been used by competent authorities are:

- a fact sheet to consumers that contains information on the susceptible fish species, symptoms of illness, and how to preserve meal remnants for testing.
- advisory information for recreational fishers of areas where CP has been documented.
- a comic explaining the hazards for consumers.
- educational materials for patients and health professionals that includes a description of symptoms.

When preparing consumer advice, competent authorities should describe the signs and symptoms of CP. For example, that signs and symptoms of CP generally are acute and can appear within several hours of consuming contaminated food or up to 48 hours after consumption. CP symptoms include gastrointestinal issues (e.g. vomiting, diarrhoea), neurological issues (e.g. paraesthesia, headaches), cardiovascular issues (e.g. hypotension, bradycardia), and some symptoms that are especially characteristic of CP, such as cold allodynia and dysesthesia. CP is rarely fatal, but exposure to CTXs may prove extremely debilitating and can exacerbate the impact of pre-existing cardiovascular or neurological conditions. There is no specific treatment for CP, but some symptoms can be managed if the illness has been correctly diagnosed.

Consumers should be alert for advisories in regions where fish that may contain CTXs are caught, either commercially or recreationally.

Consumers must avoid eating fish caught from a restricted area identified by competent authorities. They should also consider limiting the portion size they consume from fish species that have been linked to CP, and avoid eating the liver, roe, head, or viscera of any CP associated species.

If a person suspects they have CP, they should seek medical attention and avoid eating additional portions of the suspect food. Certain beverages and food (mainly alcohol, fish, and nuts) can cause recurrent symptoms of CP in affected individuals and should be avoided for at least 6 months after experiencing CP.

If a food is suspected of causing CP, it is advisable to freeze any meal remnants or parts of the specific fish consumed and to contact the local food safety authority for further instruction.

Since CTXs may be transmitted through breastfeeding and unprotected sexual intercourse, individuals who are experiencing CP symptoms could refrain from these activities for the time being as a precautionary measure.

Competent authorities should advise healthcare professionals of the possibility of CP in patients, even in regions where CP is not endemic. If appropriate, authorities could offer training on how to identify CP in patients and how to notify a national or regional database of CP illnesses. Patients with symptoms of CP should be asked thoroughly about the types of fish they have consumed as well as consumption times and places.

4.7 Minimizing negative impacts of human activity

Correlations between human activity and increases in algal blooms/CP incidence have been suggested. Based on surveillance and monitoring, competent authorities could determine if changes to ecosystems are contributing to an increase in *Gambierdiscus* or *Fukuyoa* algae or CTX-contaminated fish in the area, and if steps can be taken to decrease these effects.

ANNEX I

List of marine organisms known or suspected to be associated with CP

This list was excerpted from the *FAO/WHO Report of the Expert Meeting on Ciguatera Poisoning*[1], it has not been updated further. This list is not exhaustive but rather provides examples of the variety of organisms and regions that may be associated with CP.

SCIENTIFIC NAME	COMMON NAME	LOCATION WHERE FOUND
Acanthurus dussumieri	Dussumier's surgeon fish (palani)	Hawaii (United States of America)
Acanthurus gahhm	Surgeonfish	Kiribati
Acanthurus leucopareius	Whitebar surgeonfish	French Polynesia
Acanthurus lineatus	Surgeonfish	Kiribati
Acanthurus maculiceps	Surgeonfish	Kiribati
Acanthurus nata	Surgeonfish	Kiribati
Acanthurus nigroris	Bluelined surgeon fish (maiko)	Hawaii (United States of America)
Acanthurus olivaceus	Orangeband surgeon fish (naenae)	Hawaii (United States of America)
Acanthurus striatus	Surgeonfish	Kiribati
Acanthurus xanthopterus	Yellowfin surgeon fish	Hawaii (United States of America), Nuku Hiva (Marquesas Islands)
Aphareus furca	Black forktail snapper (wahanui)	Hawaii (United States of America)
Aprion virescens	Blue-green snapper	French Polynesia, Enewetak Island, Bikini Island
Arothron nigropunctatus	Pufferfish	Kiribati
Bodianus bilunulatus	Tarry hogfish (a'awa)	Hawaii (United States of America)
Bodianus rufus	Spanish hogfish	Saint Barthélemy (Caribbean Sea)
Caranx ignobilis	Giant trevally (ulua)	Enewetak Island
Caranx latus	Horse-eye jack	French West Indies, Saint Barthélemy (Caribbean Sea), Bahamas, Saint Thomas (Caribbean Sea)
Caranx lugubris	Black jack	French West Indies, Enewetak Island
Caranx melampygus	Bluefin trevally	Nuku Hiva (Marquesas Islands), French Polynesia, Enewetak Island
Caranx papuensis	Brassy trevally	French Polynesia, Tubuai (Australes)
Caranx sp.	Trevally (ulua, papio)	Hawaii (United States of America)

SCIENTIFIC NAME	COMMON NAME	LOCATION WHERE FOUND
Cephalopholis argus	Blue-spotted grouper, roi	Nuku Hiva (Marquesas Islands), Hawaii (United States of America), French Polynesia, Kiribati
Cephalopholis argus	Large grouper	Enewetak Island, Kiribati
Cephalopholis miniata	Coral cod/coral grouper	Fiji, Arafura Sea (Australia)
Chaetodon auriga	Butterflyfish	Kiribati
Chaetodon meyeri	Butterflyfish	Kiribati
Cheilinus undulatus	Humphead wrasse	French Polynesia, China, Hong Kong SAR, Enewetak Island
Chlorurus frontalis	Pacific slopehead parrotfish	French Polynesia, Tubuai (Australes)
Chlorurus microrhinos	Steephead parrotfish	French Polynesia, Tubuai (Australes)
Cnidaria sp.	Jellyfish (omnivorous)	American Samoa
Conus spp.	Cone snails	Hawaii (United States of America)
Coris aygula	Clown coris (wrasse)	French Polynesia, Tubuai (Australes), Enewetak Island), Kiribati
Crenimugil crenilabis	Fringelip mullet	Nuku Hiva (Marquesas Islands), French Polynesia
Diodon hystrix	Porcupinefish	Kiribati
Diodon liturosus	Porcupinefish	Kiribati
Epinephelus coeruleopunctatus	Large grouper	Kiribati
Epinephelus coioides	Orange-spotted grouper	China, Hong Kong SAR
Epinephelus fuscoguttatus	Large grouper	Enewetak Island, Kiribati
Epinephelus hoedtii	Large grouper	Enewetak Island
Epinephelus lanceolatus	Giant grouper	China, Hong Kong SAR
Epinephelus maculatus	Large grouper	Enewetak Island
Epinephelus merra	Small grouper	Kiribati
Epinephelus microdon	Marble grouper	French Polynesia, Enewetak Island, Bikini Island
Epinephelus morio	Red grouper	Saint Barthélemy (Caribbean Sea)
Epinephelus multinotatus	Large grouper	Kiribati

SCIENTIFIC NAME	COMMON NAME	LOCATION WHERE FOUND
Epinephelus mystacinus	Misty grouper	Saint Thomas (Caribbean Sea)
Epinephelus polyphekadion	Large grouper	Kiribati
Epinephelus spilotoceps	Large grouper	Kiribati
Epinephelus spp.	Grouper	Canary Islands (Spain)
Epinephelus tauvina	Large grouper	Bikini Island, Kiribati
Forcipiger longirostris	Butterflyfish	Kiribati
Gymnosarda unicolor	Dogtooth tuna	Nuku Hiva (Marquesas Islands), French Polynesia, Enewetak Island
Gymnothorax flavimarginatus	Moray eel	Kiribati
Gymnothorax funebris	Green moray eel	Saint Barthélemy (Caribbean Sea)
Gymnothorax javanicus	Moray eel	Tuamotu Archipelago and Tahiti (French Polynesia), Tarawa, Kiribati, central Pacific Ocean, Hawaii (United States of America), Kiribati
Hippopus hippopus	Giant clam	Vanuatu
Hipposcarus longiceps	Parrotfish	Kiribati
Holothuria spp.	Sea cucumber	Hawaii (United States of America)
Kyphosus cinerascens	Blue sea chub	French Polynesia, Tubuai (Australes), Nuku Hiva (Marquesas Islands), Enewetak Island
Lethrinus miniatus	Trumpet emperor bream	French Polynesia, Enewetak Island
Lethrinus olivaceus	Longface emperor bream	Nuku Hiva (Marquesas Islands)
Liza vaigiensis	Thinlip grey mullet	Nuku Hiva (Marquesas Islands), Miyazaki (Japan)
Lutjanus argentimaculatus	Mangrove red snapper	China, Hong Kong SAR
Lutjanus bohar	Two-spot red snapper (red bass)	Mauritius, Minamitorishima (Marcus) Island (Japan), French Polynesia, Tubuai (Australes), Nuku Hiva (Marquesas Islands), Hawaii (United States of America), French Polynesia, Enewetak Island, Bikini Island, Kiribati, India, Indonesia, Viet Nam
Lutjanus buccanella	Blackfin snapper	Saint Croix, United States of America Virgin Islands
Lutjanus fulvus	Snapper	Kiribati

SCIENTIFIC NAME	COMMON NAME	LOCATION WHERE FOUND
Lutjanus gibbus	Humpback red snapper	Nuku Hiva (Marquesas Islands), French Polynesia, Enewetak Island, Bikini Island
Lutjanus griseus	Grey snapper	French West Indies
Lutjanus kasmira	Bluestripe snapper (taape)	Hawaii (United States of America)
Lutjanus monostigma	One-spot snapper	Nuku Hiva (Marquesas Islands), Enewetak Island, Bikini Island
Lutjanus sebae	Red emperor	Mauritius (Nazareth, Saya de Malha, Soudan)
Lutjanus spp.	Snapper	Antigua, Okinawa (Japan), West Africa, Baja California (Mexico), Saint Thomas (Caribbean Sea)
Lutjanus stellatus	Star snapper	China, Hong Kong SAR
Malacanthus plumieri	Sand tilefish	Saint Barthélemy (Caribbean Sea)
Monachus schauinslandi	Hawaiian monk seal	Hawaii (United States of America)
Monotaxis grandoculis	Big-eye bream, emperor	French Polynesia, Enewetak Island, Kiribati
Mugil cephalus	Mullet	
Mulloidichthys auriflamma	Goldstriped goatfish	Hawaii (United States of America)
Mulloidichthys martinicus	Yellow goatfish	Saint Barthélemy (Caribbean Sea)
Mycteroperca bonaci	Black grouper	Key Largo, Florida (United States of America)
Mycteroperca fusca	Island grouper	Canary Islands (Spain)
Mycteroperca prionura	Sawtail grouper	Baja California, Mexico
Mycteroperca venenosa	Yellowfin grouper	Guadeloupe and Saint Barthélemy, Caribbean Sea
Myripristis berndti	Soldier fish	Kiribati
Myripristis kuntee	Epaulette soldier fish (squirrelfish)	Hawaii (United States of America)
Naso brachycentron	Humpback unicorn fish	Nuku Hiva (Marquesas Islands)
Naso brevirostris	Spotted unicorn fish	Nuku Hiva (Marquesas Islands)
Oncorhynchus kisutch	Farmed salmon	Chile
Ophiocoma spp.	Ophiuroids (brittle stars) starfish	Hawaii (United States of America)
Oplegnathus punctatus	Spotted knifejaw	Miyazaki (Japan)

SCIENTIFIC NAME	COMMON NAME	LOCATION WHERE FOUND
Pagrus pagrus	Seabream (red porgy)	Selvagens Islands
Pamatomus saltatriz	Bluefish	Canary Islands (Spain)
Panulirus penicillatus	Lobster	Kiribati
Paracirrhites hemistictus	Hawkfish	Kiribati
Parupeneus bifasciatus	Goatfish	Kiribati
Parupeneus insularis	Twosaddle goatfish	Nuku Hiva (Marquesas Islands)
Plectropomus areolatus	Squaretail coral grouper	China, Hong Kong SAR
Plectropomus laevis	Blacksaddled coral grouper	China, Hong Kong SAR
Plectropomus leopardus	Coral trout/leopard coral grouper	French Polynesia, Tubuai (Australes), China, Hong Kong SAR, Tahiti, French Polynesia, Enewetak Island
Plectropomus melanoleucus	Grouper	Enewetak Island
Plectropomus sp.	Coral trout	Great Barrier Reef (Australia), French West Indies
Plectropomus truncatus	Squaretail coral grouper	Enewetak Island
Pomacanthus imperator	Angelfish	Kiribati
Pomadasys maculatus	Blotched javelin grunt	Platypus Bay, Queensland (Australia)
Pterois spp.	Lionfish	Guadalupe, Caribbean Sea
Pterois volitans	Lionfish	Virgin Islands
Sargocentron spiniferum	Sabre squirrelfish	Nuku Hiva (Marquesas Islands)
Sargocentron tiere	Squirrelfish	Kiribati
Scarus altipinnis	Filament-finned parrotfish	French Polynesia, Tubuai (Australes)
Scarus ghobban	Parrotfish	Kiribati, French Polynesia, Tubuai (Australes)
Scarus gibbus	Heavy beak parrotfish	French Polynesia, Tahiti, French Polynesia, Enewetak Island
Scarus rubroviolaceus	Ember parrotfish	Nuku Hiva (Marquesas Islands)
Scarus russelii	Parrotfish	Kiribati
Scomberomorus cavalla	King mackerel “Coronado” (king fish)	Florida (United States of America), Saint Barthélemy (Caribbean Sea), Guadeloupe
Scomberomorus commerson	Spanish mackerel	Hervey Bay, Queensland (Australia)

SCIENTIFIC NAME	COMMON NAME	LOCATION WHERE FOUND
Seriola dumerili	Greater amberjack/Kahala	Canary Islands (Spain), Madeira Archipelago, Hawaii (United States of America), Haiti, Saint Barthélemy (Caribbean Sea), Saint Thomas (Caribbean Sea)
Seriola fasciata	Lesser amberjack	Selvagens Islands (Madeira Archipelago), West Africa (Canary Islands)
Seriola rivoliana	Almaco jack/Kahala	Canary Islands (Spain), Hawaii (United States of America), Saint Thomas (Caribbean Sea)
Siganus argenteus	Rabbitfish	Kiribati
Siganus rivulatus	Marbled spinefoot rabbitfish	Eastern Mediterranean
Sphyraena barracuda	Great barracuda	Bahamas, Cameroon), Florida Keys (United States of America), French West Indies, Saint Barthélemy (Caribbean Sea), Guadeloupe, French Polynesia, Enewetak Island
Sphyraena jello	Pickhandle barracuda	Hervey Bay, Queensland (Australia)
Sphyraena spp.	Barracuda	California (United States of America)
Tectus niloticus	Gastropod	French Polynesia
Tridacna maxima	Giant clam	New Caledonia, French Polynesia
Variola albimarginata	Lyretail	China, Hong Kong SAR
Variola louti	Large grouper	Enewetak Island, Kiribati
Zancius cornutus	Moorish idol	Kiribati

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[1] FAO and WHO. 2020. *Report of the Expert Meeting on Ciguatera Poisoning. Rome, 19–23 November 2018.* Food Safety and Quality, No. 9. Rome.