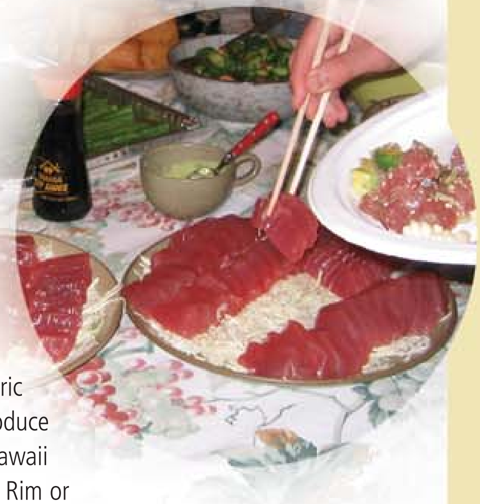
Keeping Hawaii Seafood

SAFE TO EAT

Fresh *island seafood*

Fresh island seafood is one of the things that makes living in Hawaii so special.

It is vital to the people of Hawaii for a healthy nutritious diet. It is also important to the island economy, because seafood is a key ingredient of the tourism "product" that Hawaii has to share with the world. Being in the middle of the Pacific Ocean means that Hawaii's fishermen can supply the islands with a variety of fresh, high quality, open ocean fish like *ahi* (bigeye and yellowfin tuna), *mahimahi*, and exotic deepwater snappers like *opakapaka* and *onaga*. Simply put, local seafood greatly enhances the visitor experience and the quality of life in the islands.



Hawaii Seafood is a premium product.

Hawaii has become a recognized source of premium fresh seafood that is presently featured in some of the best restaurants in the islands and across the country. This reputation has been earned through the combined efforts of Hawaii's hardworking fishermen, fresh fish auction, wholesalers and innovative chefs, and through generic seafood promotion efforts that have helped to introduce the country to fresh Hawaii seafood. High-profile Hawaii chefs have spearheaded the development of Pacific Rim or Hawaii Regional cuisine by featuring Hawaii seafood and other local products.

Cover: Fresh Hawaii longline-caught bigeye tuna sashimi *(chu toro)* prepared by Taketoshi Gibo, Take's Fish Market, Honolulu, Hawaii. (Photo by John Kaneko)

CONTENTS

Keeping Hawaii Seafood safe.

Preventing seafood-borne illness is vital to preserving the reputation of Hawaii seafood. Understanding the potential public health problems associated with some of our seafood products is the first line of defense. Establishing appropriate and effective control measures to prevent seafood-related illnesses is the next step. Finally, seafood safety is achieved when all of the people involved from the fishermen to the final consumer are aware of the potential hazards and their responsibilities in keeping Hawaii seafood safe to eat.

Seafood safety is a growing concern.

It is widely accepted that there are health benefits from including more fish in the diet. However, there are some food safety hazards associated with certain types of seafood products. Understanding the potential food safety risk is the key to prevention. The US government responded to the increased concern over seafood safety by implementing a new mandatory seafood inspection program in late 1997. The US FDA Seafood HACCP Regulation requires all seafood processors (domestic and overseas) and importers to implement HACCP-based seafood safety systems aimed at preventing specific seafood-related illnesses. HACCP which stands for Hazard Analysis Critical Control Point is a commonsense, science-based and methodical approach to food safety.

The HACCP approach depends on understanding the potential hazards, devising effective control measures, and monitoring critical steps in the harvesting and processing of seafood to control the hazard. HACCP is not a zero-risk system, but instead aims to minimize the risk of seafood safety hazards that are reasonably likely to occur unless controlled.

Seafood safety education and training.

Well-informed fishermen, processors and consumers each play a key role in the prevention of seafood-borne illnesses. This document has been prepared to help consumers enjoy fresh island seafood while protecting the reputation of Hawaii's important fishing and seafood industries by keeping our fish safe to eat.

Seafood Quality and Safety

Deciding whether or not a seafood product is safe to eat is based on an understanding of the factors that have the potential to increase the risk of illness. These factors include the species of fish, where the fish were harvested, how they were caught, how they were handled on the fishing vessel and how the catch was handled on shore.

Seafood SAFETY ISSUES of special importance to Hawaii.

SEAFOOD-BORNE ILLNESS	BRIEF DESCRIPTION	FISH SPECIES IMPORTANT TO HAWAII
SCOMBROID FISH POISONING	A.k.a. histamine poisoning. Pseudo-allergic reactions caused by histamine and possibly other biogenic amines in spoiled fish.	*Mahimahi*, tuna, marlin, *akule* and others.
CIGUATERA FISH POISONING	Ciguatoxin is a marine biotoxin. Causes mild to severe neurologic symptoms, reversal of hot and cold temperature sensation.	Tropical reef fish: *roi, kole, ulua, papio* and many others.
HALLUCINOGENIC REEF FISH POISONING	Unknown marine biotoxin. Causes severe nightmares and hallucinations. Source of toxin is unknown.	Nightmare *weke* (*Upeneus arge*), other *weke* (*Mulloidichthyes* spp) and striped mullet (*Mugil cephalus*).
MERCURY	An unavoidable natural contaminant in open ocean fish. No cases of poisoning reported from open ocean fish. Neurotoxic effects of high mercury concentrations are known in cases of industrial pollution or accidental poisoning.	Large tuna, marlin, swordfish and sharks contain mercury but at much lower levels compared with fish from polluted waters.
HERRING AND COD WORM INFECTION	A.k.a. *anisakiasis* caused by accidental herring and cod round-worm infection (*Anisakis simplex* or *Pseudoterranova decipiens*).	Fresh, raw wild Pacific salmon (*Onchorhynchus* spp), squid (all species), Pacific rockfish (*Sebastes* spp).
BROAD FISH TAPEWORM INFECTION	A.k.a. *diphyllobothriasis* caused by broad fish tapeworm infection (*Diphyllobothrium latum*).	Fresh, raw wild Pacific salmon (*Onchorhynchus* spp).
SALMON FLUKE INFECTION	A.k.a. *nanophyetiasis,* caused by accidental salmon fluke infection. This parasite (*Nanophyetus salmonicola*) causes salmon poisoning in dogs.	Fresh, raw wild Pacific salmon (*Onchorhynchus* spp).
ANGIOSTRONGYLIASIS	A.k.a. *eosinophilic meningitis* caused by accidental larval rat lungworm infection (*Angiostrongylus cantonensis*) of the central nervous system.	Fresh, raw freshwater prawn (*Macrobrachium* spp), slugs and snails.
INTESTINAL HETEROPHYSIASIS	Accidental intestinal fluke infection (*Stellantchasmus falcatus*).	Fresh, raw mullet (*Mugil cephalus*).

There are a variety of methods to detect indicators of an unsafe product. These methods include sensory examination, temperature measurements, and laboratory tests.

Sensory examination.

We naturally judge the quality of food using our senses to evaluate the visual appearance, smell and texture of the product. Seafood is highly perishable and off-odors are the main indicators of spoilage. While sensory experts apply a highly-evolved descriptive language to the range of odors that may be found in seafood, the ability to judge spoiled from non-spoiled food can be easily taught and this skill is largely instinctive.

Main seafood safety problems of importance to Hawaii include

- **Scombroid Fish Poisoning**
- **Ciguatera Fish Poisoning**
- **Hallucinogenic Reef Fish Poisoning**
- **Mercury**
- **Parasites**

When in doubt, throw it out.

Seafood SAFETY HAZARDS

and potential control approaches.

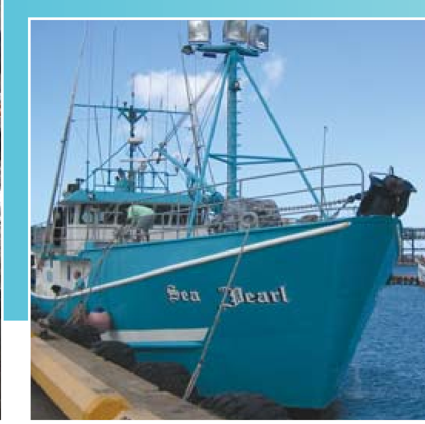
SEAFOOD SAFETY PROBLEM	CHILLING AND REFRIGERATION	FREEZING	COOKING	SPECIES AVOIDANCE
HISTAMINE	Effective only if chilling begins immediately after harvest and is rapid enough to prevent bacterial growth and enzyme action that form histamine.	Effective only if freezing is rapid enough to prevent histamine formation. Ineffective if histamine is allowed to form before freezing.	Ineffective if histamine is allowed to form before cooking. Toxin is not affected by cooking temperatures.	Unnecessary if histamine-forming fish are properly chilled and stored at <40°F and do not show signs of spoilage or mishandling.
CIGUATERA	Ineffective. Toxin is not affected by refrigeration temperatures.	Ineffective. Toxin is not affected by freezing temperatures.	Ineffective. Toxin is not affected by cooking temperatures.	Necessary precautions for fish species and fishing areas known to produce ciguatera.
MERCURY	Ineffective. Mercury content is not affected by refrigeration temperatures.	Ineffective. Mercury content is not affected by freezing temperatures.	Ineffective. Mercury content is not affected by cooking temperatures.	Necessary to reduce mercury exposure from the diet. But the known health benefits of eating fish should be carefully weighed against the undocumented health affects of low-levels of mercury in open ocean fish. Women of child bearing age and young children should follow their doctors' advice.
PARASITES	Ineffective. Parasites survive refrigeration temperatures.	Effective. Parasites are killed by deep freezing temperatures.	Effective. Parasites are killed by cooking temperatures.	Necessary precautions for species known to contain infective larvae only if fish are not frozen before being eaten raw.

Hawaii Fisheries

State of Hawaii, Hawaii Seafood Promotions Committee

Open Ocean (pelagic) Fishery

Ahi (bigeye and yellowfin tuna), *tombo ahi* (albacore tuna), *aku* (skipjack), swordfish, *kajiki* (Pacific blue marlin), *nairagi* (striped marlin), *hebi* (spearfish), *mahimahi* (dolphinfish), *ono* (wahoo), *opah* (moonfish), *walu* (escolar and oilfish), *monchong* (bigscale pomfret). Landed in Hawaii primarily by the pelagic longline fleet with some fish also caught by pole and line vessels (*aku* boats), trolling and handline boats.



Coral Reef Fishery

Ulua/papio (jacks), surgeonfish, *uhu* (parrotfish), *weke* and other goatfishes, *kaku* (barracuda), and assorted fish, shellfish and seaweed species. Hawaii has introduced species of shallow-water snappers and groupers. Small coastal schooling pelagic fish including *akule* (big eyed scad) and *opelu* (mackerel scad) are also extremely important food fish. Caught by net, hook and line and spearing methods.

Deep-slope Bottomfish Fishery

Onaga (long-tailed red snapper), *opakapaka* (pink snapper), *ulua* (jacks), *uku* (grey snapper), *hapu'upu'u* (seabass). Caught by bottomfishing boats using hook and line methods.

Histamine Poisoning

a.k.a. *Scombroid Fish Poisoning*

What is histamine poisoning?

Histamine poisoning is also known as *Scombroid Fish Poisoning*. It is caused when seafood containing high levels of histamine is eaten. Histamine levels in fish are naturally very low, but can increase to toxic levels in certain types of fish like *mahimahi* and tuna if they are not properly chilled. Histamine is generated in susceptible types of fish (histamine-formers) that are exposed to elevated temperatures for a prolonged period that allows bacterial growth and enzyme action. Certain types of bacteria are very efficient at converting *histidine* (a naturally occurring amino acid) to histamine (the toxin) in fish muscle. The conditions that allow spoilage also promote histamine production. Histamine can accumulate when fish are held on fishing vessels and while being handled by seafood processors, distributors, retailers and restaurants and finally in the hands of seafood consumers.

Is histamine poisoning a problem in Hawaii?

Histamine poisoning occurs, but cases are infrequent. However, it is one of the most common seafood-related illnesses reported in Hawaii and across the country. Hawaii people eat more seafood per capita than the rest of the US, and especially fish like *mahimahi*, tuna and other open ocean fish that are histamine-formers. The Hawaii Department of Health summarized the number of histamine poisoning cases reported between 1999 and 2003. During this 5-year period about 60 cases (illnesses) were reported each year for a resident population of roughly 1.2 million people. By comparison, the average number of cases of *campylobacteriosis* (a serious food-borne illness) mainly from chicken contaminated with the bacteria *Campylobacter jejuni*, was just over 800 per year. The risk of histamine poisoning in Hawaii is about 5 cases per 100,000 people per year, compared with 67 cases of *campylobacteriosis* per 100,000 people per year. The risk estimate is much lower if the large visitor population present in the islands is included.

What fish cause histamine poisoning in Hawaii?

Many of the important Hawaii fish species are potential histamine-formers including *mahimahi*, tuna (bigeye, yellowfin, albacore and skipjack) and other related open ocean fish species. In Hawaii, *mahimahi* caused 51% of the total number of reported cases of histamine poisoning followed by *ahi* (mostly yellowfin tuna and possibly bigeye) (32%), *kajiki* (blue marlin) (4%), *akule* (big eye scad) (4%), *ono* (wahoo) (3%) and the remaining species each at less than 1% of the total.

What are the symptoms of histamine poisoning?

Fish allergy or fish poisoning? Histamine poisoning occurs when people eat fish containing high concentrations of histamine and possibly other related biogenic amines generated during spoilage. Histamine poisoning can be misdiagnosed as a *"fish allergy"* because histamine causes *pseudo-allergic reactions*. Histamine is a mediator of the immune system. It is partly responsible for the reactions (swelling, itching and redness) people have to mosquito bites or symptoms people with allergies might have to dust or pollen.

The onset of symptoms is rapid, within minutes of exposure and symptoms usually subside in 8 to 12 hours. Over the counter anti-histamines can help alleviate symptoms. There are no reported fatalities associated with histamine poisoning.

The body reacts with some or all of the following symptoms:

- ITCHING ON THE FACE AND AROUND THE MOUTH
- BURNING SENSATION IN THE THROAT
- DRYNESS OF THE MOUTH
- DIFFICULTY SWALLOWING
- NAUSEA AND VOMITING
- WEAKNESS
- FLUSHING (REDNESS) OF THE FACE AND OTHERS PARTS OF THE BODY
- SEVERE THROBBING HEADACHE
- RAPID, STRONG HEART BEAT
- ABDOMINAL CRAMPS AND DIARRHEA

Top 10 fish species involved in reported cases of **histamine poisoning** in Hawaii during the 14-year period between September 1989 and October 2003.

RANKING	**FISH** (Hawaiian name and common name)	**OUTBREAKS** % and (n)	**ILLNESSES** % and (n)
No. 1	***mahimahi*** (dorado)	28.0% (81)	51.1% (353)
No. 2	***ahi*** (yellowfin & bigeye tuna)	45.3% (131)	31.5% (218)
No. 3	***kajiki & nairagi*** (blue & striped marlin)	5.9% (17)	3.8% (26)
No. 4	***akule*** (bigeye scad)	6.2% (18)	3.6% (25)
No. 5	***ono*** (wahoo)	3.8% (11)	2.6% (18)
No. 6	***walu*** (escolar & oilfish)	0.7% (2)	0.6% (4)
No. 7	***aku*** (skipjack tuna)	0.7% (2)	0.4% (3)
No. 8	***tombo ahi*** (albacore tuna)	0.4% (1)	0.3% (2)
No. 9	***hebi*** (shortnose spearfish)	0.4% (1)	0.3% (2)
No. 10	***opelu*** (mackerel scad)	0.4% (1)	0.1% (1)
TOTAL	***All fish implicated in reported cases of histamine poisoning.***	100% (289)	100% (691)

How can fish with high histamine content be detected?

Some victims of histamine poisoning have reported that they detected a sharp peppery or metallic taste in the fish. Others report that the fish had a strong taste, while some did not detect anything unusual about the fish they ate before becoming ill.

The detection of spoilage odors can be a useful indicator of mishandling, the risk of elevated histamine concentration and the relative safety of the product. Careful inspection of fish for spoilage odors is an extremely important and practical control measure because histamine is formed by a special type of bacterial spoilage.

Histamine does not by itself have a distinctive odor. However the conditions that allow spoilage also allow histamine to form. When bacteria grow, they give off odors characteristic of spoilage. These odors are useful practical clues about the possibility that fish were mishandled, that the fish are spoiled and may also contain an elevated concentration of histamine.

THE NOSE KNOWS. Studies in Hawaii have demonstrated the effectiveness of sensory examination to detect odors and visual cues of spoilage in preventing fish with high histamine levels from entering the market from commercial fishing vessels. A total of 1,065 histamine-forming fish delivered to the Honolulu fish auction were first inspected for spoilage, accepted or rejected when spoilage odors were present and then tested for histamine content. Only 15 fish exceeded the government limit for histamine and each of these fish was first rejected from the market because of spoilage. It is highly unlikely that representative sampling and testing could have been effective in culling 15 out of 1,065 fish with elevated histamine content. These studies demonstrated the value of careful screening of histamine-forming fish for odors and visual indicators of spoilage as an effective and practical histamine control measure in Hawaii. Sensory judgments are quick and for the Hawaii fishery products, have been validated for effectiveness as a practical histamine control measure.

Testing methods exist. The federal government has established a maximum histamine concentration of 50 ppm (parts per million) allowed in seafood. This limit has a built-in safety margin and is set well below the concentration that causes poisoning. Studies in Hawaii have shown that most fish contain much less than 1 ppm histamine. Histamine concentration in fish can be determined using laboratory tests. These laboratory methods are used routinely by canneries receiving frozen tuna to screen fish before canning. These tests take time and because the tuna can be stored in the freezer, canners have the time needed to utilize testing methods as an initial screening method. Loads of frozen tuna delivered by purse seine vessels to canneries often exceed 1,500 tons, and are broken into lots that can reach 100 tons containing thousands of individual fish. Handling high quality fresh seafood in much smaller lots is an entirely different situation. A typical Hawaii longliner delivers 7 to 8 tons of fish per trip and local trollers might deliver a single fish to the market. Fresh seafood is highly perishable and shelf life is limited. The routine use of histamine testing is not easily integrated into a fishery that catches, receives, processes and distributes the fresh high quality fish rapidly while maintaining cold temperatures.

How can histamine poisoning be prevented?

IT'S SIMPLE, keep fish cold and clean. Prevention relies on consumer and industry education and proper fish handling practices. Temperature control is the key to prevention of histamine poisoning. This is because bacterial growth and histamine production can be greatly reduced by rapid chilling and proper cold storage temperatures thereafter. Preventing the conditions that promote bacterial spoilage involve both temperature control and sanitary practices. All people involved in the harvesting, processing, distribution, preparation and consumption of susceptible fish play a role in the prevention of histamine poisoning. However, fishermen have the most important role because it is the initial cooling period after harvest that determines whether or not fish will be likely to form toxic levels of histamine. If fishermen understand the problem and consistently apply proper fish handling and icing of the catch, histamine control thereafter is achieved by maintaining proper storage temperatures. However, if the fishermen delay icing and do not properly store fish in ice or under 40°F, histamine control will be difficult.

FISHERMEN must do the right thing. Know what causes and prevents quality degradation, spoilage and histamine formation. Catching fish is only part of the job. Delivering a well-handled, top quality and safe product is the key to getting paid for all the hard work. Recreational and subsistence fishermen should also handle their fish carefully to preserve quality and make sure no one gets sick, including friends and family. Fish should be iced without delay, using enough ice to chill the fish quickly to below 40°F and then to near 32°F while stored in ice during the rest of the trip. Only new clean ice should be used on the fish. Sanitation is also important and the fish hold, brine tanks and fish boxes should be cleaned and sanitized between trips to keep the bacterial load to a minimum and to extend the shelf life and quality of the catch.

PROCESSORS must do the right thing. Know what causes and prevents quality degradation, spoilage and histamine formation. Proper handling and cold storage is the key to selling and getting paid for the processed seafood. Make sure fishermen ice the fish on the boat, then check the fish temperature to be sure the fish was well iced (less than 40°F), check carefully for signs of spoilage (appearance and odors) and then keep fish clean and cold (less than 40°F).

RETAILERS AND RESTAURANTS must do the right thing. Know what causes and prevents quality degradation, spoilage and histamine formation. Proper handling and cold storage is the key to providing your satisfied customers with good quality and safe seafood. Inspect fish deliveries carefully for signs of spoilage (appearance and odors), check the fish temperature (less than 40°F), and then keep fish clean and cold.

CONSUMERS must do the right thing. Learn what to expect of good quality fish and what odors and tastes indicate spoilage. If odd smells or tastes are detected, do not accept, buy or eat the fish. Learn about safe seafood handling. When buying fish, be prepared with a cooler and ice to keep the seafood cold while shopping and during the drive home, especially in warm weather. Seafood is highly perishable and should be treated with care, especially histamine-forming fish.

Marine Biotoxins: Ciguatera Fish Poisoning

What is ciguatera fish poisoning?

Ciguatera fish poisoning occurs when tropical reef fish containing *ciguatoxin* are consumed. Ciguatoxin is actually a complex of related marine biotoxins that have powerful neurotoxic effects. Ciguatoxin is formed by *Gambierodiscus toxicus*, and possibly other related single cell organisms known as dinoflagellates that adhere to marine algae and produce the toxin. Fish that eat the algae (herbivores) inadvertently ingest and accumulate the toxin. Fish that eat other reef fish (carnivores) further concentrate the toxin. This process is known as *bioaccumulation*. Fish do not appear to be affected by ciguatoxin, but people who eat fish containing ciguatoxin can suffer greatly.

Is ciguatera fish poisoning a problem in Hawaii?

Ciguatera is one of the most common seafood-borne illnesses in the US with the majority of the cases occurring in states and US associated regions that contain coral reef fisheries. These include Hawaii, Florida, Guam, American Samoa, Puerto Rico and US Virgin Islands. The people at greatest risk of ciguatera poisoning in Hawaii are recreational and subsistence fishermen that catch and eat susceptible reef fish.

Ciguatera cases are reported to the Hawaii Department of Health at about the same rate as histamine poisoning cases. A 5-year summary of ciguatera cases reported to the Hawaii Department of Health indicates that between 1999 and 2003 there was an average of 53 cases (illnesses) per year. By comparison, during this same period there were just over 800 cases of *campylobacteriosis* per year, mostly associated with eating contaminated chicken. The risk of ciguatera fish poisoning in Hawaii is about 4 cases per 100,000 people per year compared with the risk of *campylobacteriosis* of about 67 cases per 100,000 people per year.

What fish cause ciguatera fish poisoning in Hawaii?

There is a long list of reef fish that have been implicated in cases of ciguatera in Hawaii over the years. The ten most common species implicated in cases reported in Hawaii between 1999 and 2003 are presented on the following page.

What are the symptoms of ciguatera fish poisoning?

The onset of symptoms may occur within 10 minutes to 12 hours after exposure and symptoms can last from days to months.

Some or all of the following symptoms may occur:

- CHILLS
- ITCHING
- DIZZINESS
- SWEATING
- HEADACHE
- METALLIC TASTE IN MOUTH
- NAUSEA
- VOMITING
- DIARRHEA
- GENERALIZED WEAKNESS
- DECREASED SENSATION TO PAIN OR TOUCH
- TINGLING OR BURNING SENSATION IN AROUND MOUTH, HANDS AND LEGS
- PAINFUL MUSCLES
- REVERSAL OF TEMPERATURE SENSATION, COLD THINGS FEEL HOT, ETC.

Top 10 fish species involved in reported cases of **ciguatera fish poisoning** in Hawaii during the 5-year period between September 1999 and 2003.

RANKING	**FISH** (Hawaiian name and common name)	**OUTBREAKS** % and (n)	**ILLNESSES** % and (n)
No. 1	***roi*** (peacock grouper)	18.5% (23)	22.5% (56)
No. 2	***kole*** (gold ring surgeonfish)	15.3% (19)	15.7% (39)
No. 3	***ulua*** (large jacks mixed spp)	9.6% (12)	7.6% (19)
No. 4	***papio*** (small jacks mixed spp)	7.3% (9)	7.2% (18)
No. 5	***seabass*** (spp uncertain)	5.6% (7)	8.0% (20)
No. 6	***palani*** (eyestripe surgeonfish)	5.6% (7)	8.0% (20)
No. 7	***uku*** (green jobfish)	5.6% (7)	4.8% (12)
No. 8	***weke*** (goatfish)	5.6% (7)	4.8% (12)
No. 9	***wahanui*** (smalltoothed jobfish)	4.0% (5)	2.8% (7)
No. 10	***uhu*** (parrotfish)	1.6% (2)	1.2% (3)
TOTAL	***All fish implicated in reported cases of ciguatera poisoning.***	100% (124)	100% (249)

Roi (*Cephalopholis argus*) was implicated in 18.5% of the total number of ciguatera outbreaks and 22.5% of the ciguatera poisonings (illnesses) reported during this 5-year period. The *roi* is a type of grouper, a shallow-water reef predator.

Kole (*Ctenochaetus strigosus*) caused 15.3% of the outbreaks and 15.7% of the illnesses. The *kole* is a type of surgeonfish and is an herbivore.

Ulua (large jacks) and **papio** (small jacks) combined caused 16.9% of the outbreaks and 14.8% of the illnesses. Jacks (*Caranx* spp) are reef predators and these two categories are only differentiated by the size and age of fish within the same group of species. Larger sized predators are commonly thought to be more likely to be ciguatoxic. It is important to note that in the case of jacks (*ulua* and *papio*) and apparently with *roi*, that smaller-sized individuals are not always free of ciguatera toxin and larger individuals are not always ciguatera toxin positive.

Seabass (grouper) caused 5.6% of outbreaks and 8.0% of illnesses. "Seabass" and "grouper" are common market names for fish implicated in cases of ciguatera poisoning, but are non-specific to the species of fish. *Hapu'upu'u*, the deep-sea grouper (*Epinephelus quernus*) is listed as one of the groupers that cause ciguatera poisoning in Hawaii. The implication of *hapu'upu'u* is questionable because this fish is caught at great depths, well below 300 ft, although younger individuals may on occasion be found in much shallower water. Ciguatera toxic species in Hawaii are thought to range from the ocean surface down to about 200 ft (60 meters). Species substitution in the market occurs and may explain why this fish has been identified in cases of ciguatera poisoning in the past.

Uku (*Aprion virescens*) is another important bottomfish in Hawaii. This species has been implicated in 5.6% of the outbreaks and 4.8% of the cases of ciguatera poisoning. *Uku* are more likely to accumulate ciguatera toxin because they tend to have a shallower distribution than the other deep-slope bottomfish. The skinless fillet of this fish is similar in appearance to the higher priced *opakapaka* and *onaga* and species substitution in the market in the past may account for concerns about ciguatera in these deepwater snappers.

It is notable that during the five-year period between 1999 and 2003 that no cases of ciguatera poisoning were reported involving deepwater snappers, including *opakapaka* (*Pristipomoides filamentosus*) and *onaga* (*Etelis coruscans*). These fish are very important Hawaii market species and concerns have been raised about related species being potentially ciguatoxic. The reason that these fish are not implicated in cases of ciguatera poisoning is because these fish inhabit the deep waters between approximately 320 to 980 ft (100 and 300 meters) below the surface, well beyond the depths in which ciguatoxic fish occur.

How can fish containing high levels of ciguatera toxin be detected?

You can't smell ciguatera. Ciguatoxic fish cannot be detected by visual appearance or odors. Testing methods exist, but there are no validated, rapid methods that are suitable for commercial testing of fish lots for ciguatoxin. The FDA has not established an action level for ciguatoxin. Laboratory methods for detection of ciguatoxin in fish are used mainly for research and during disease outbreak investigations. A mouse bioassay is a generally accepted method for confirming the toxicity of fish samples.

A rapid enzyme-linked immunoassay ("stick test") for ciguatera toxin was developed in Hawaii by Dr. Y. Hokama of the University of Hawaii. This technology is now available to the public for the detection of ciguatoxin in reef fish (Cigua-Check® Fish Poisoning Test Kit by Toxi-Tec, Inc., Honolulu, Hawaii). It is useful especially for recreational fishermen, to screen individual fish prior to consumption.

There are other marine biotoxins generated in reef areas in Hawaii that can accumulate in reef fish and cause symptoms that can resemble ciguatera. These include *palytoxin*, *maitotoxin* and *scaritoxin*. These toxins appear to be related to ciguatoxin but may be generated by different organisms. Palytoxin and maitotoxin are the most powerful marine biotoxins and are toxic at much lower concentrations than ciguatoxin. Palytoxin was found to be the cause of an extremely rare and unfortunate seafood-borne fatality from the consumption of just three Marquesan sardines (*Sardinella marquesensis*) in Hawaii in 1978. These fish and the Goldspot sardine (*Herklotsichthys quadrimaculatus*) are introduced species, they are rarely eaten in Hawaii and consumers should be warned about the unpredictable potential palytoxin hazard.

How can ciguatera fish poisoning be prevented?

Know where your fish is coming from. Prevention essentially relies on consumer and industry education, varying levels of species avoidance and knowledge of reef areas that have produced ciguatoxic fish. Representative sampling and testing is of questionable value because some fish from a group of fish caught on the same reef may be safe to eat while others are not. Ciguatera problems may also be seasonal. These factors together with differences in individual susceptibility to the toxin make prevention of ciguatera difficult. People who are more frequent consumers of reef fish may have a much lower threshold for a ciguatoxic dose, while first-time consumers may tolerate higher initial doses of the toxin without symptoms. In commercial settings, most Hawaii seafood retailers and wholesalers refrain from selling potentially ciguatoxic fish species. Companies that supply the reef fish market niche must carefully select fish from reliable fishermen, make sure fishing is not in areas known to be producing ciguatera poisoning and keep abreast of state health advisories.

The majority of cases of ciguatera fish poisoning reported in Hawaii have come from recreational fishing, but some cases do occur from commercial sources of fish. Fishermen should be aware of the potential for ciguatera in Hawaii's reef fish and which species are frequently implicated. The risk of ciguatera toxin in reef fish is associated with not only the species, but conditions in individual reef areas. Therefore, it is important for fishermen to pay close attention to state health advisories regarding ciguatera and local knowledge of any cases that might have occurred in a particular reef area.

William Walsh/DAR/DLNR

Marine Biotoxins:
Hallucinogenic Reef Fish Poisoning

What is hallucinogenic reef fish poisoning?

Hallucinogenic reef fish poisoning occurs when people eat certain types of reef fish containing the toxin. This toxin is unknown chemically and its origin remains undetermined.

What are the symptoms of hallucinogenic reef fish poisoning?

Symptoms are limited to severe nightmares and hallucinations.

Is hallucinogenic reef fish poisoning a problem in Hawaii?

Yes, but cases are very rare. A 5-year summary of cases reported to the Hawaii Department of Health between 1998 and 2002 indicates an average of 2 cases (illnesses) per year for a resident population of roughly 1.2 million people. The risk is less than 1 case (0.33 cases) per 100,000 people per year. This rate estimate is for the general population and the people at greatest risk are consumers of reef fish, especially the species implicated in cases of hallucinogenic fish poisoning.

What fish cause hallucinogenic reef fish poisoning in Hawaii?

A type of goatfish known as the nightmare *weke* (*Upeneus arge*), other types of *weke* (*Mulloidichthyes* spp) and the striped mullet (*Mugil cephalus*) have been implicated in cases of hallucinogenic fish poisoning.

How can fish containing high levels of hallucinogenic reef fish toxin be detected?

No testing methods exist. The nightmare *weke* is easily identified by the sharp black and white striped color pattern of the tail fin. These fish should be avoided. Mullet and *weke*, however are food fish in Hawaii.

How can hallucinogenic reef fish poisoning be prevented?

Prevention relies on consumer and industry education and species avoidance. Nightmare *weke* should not be eaten. For mullet and other species of *weke*, local knowledge and avoidance of reef areas that have caused hallucinogenic fish poisoning are the primary means of prevention.

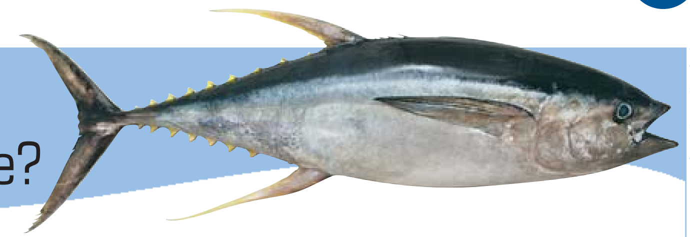
William Walsh/DAR/DLNR

Mercury

What is mercury poisoning?

Mercury poisoning can occur from exposure to mercury, a toxic metal. The most important toxic form of mercury in seafood is *methylmercury*. Mercury poisoning from eating fish is also known as *Minamata Disease*. This is in reference to the severe poisoning of people that ate seafood grossly contaminated with methylmercury originating from industrial pollution in Minamata Bay Japan in the 1950's. Another serious mercury poisoning event occurred in Iraq during the 1970's when mercury treated grain seeds meant to be planted were instead used to make bread and consumed directly. Much of what is known about the toxic effects of mercury is from studies of these two tragic accidental poisoning events. However, extrapolating the potential for methylmercury poisoning to open ocean fish like tuna, swordfish, and marlins remains highly controversial.

What about *ahi*, is it safe?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Yes. There are no reported cases of mercury poisoning associated with Hawaii's open ocean fish, including tuna, marlin and swordfish.

No adverse health effects were found in children born to mothers that ate 12 meals of fish (like Hawaii's fish) in the Seychelle Islands.

The known health benefits of fish in the diet appear to outweigh any potential adverse health effects of low-level mercury exposure from a diet of open ocean fish.

Is mercury poisoning a problem in Hawaii?

No single case of mercury poisoning from the consumption of Hawaii fish has been reported. Also, no cases have ever been reported that specifically implicated open ocean fish like swordfish, tuna or marlin anywhere in the world.

What fish cause mercury poisoning in Hawaii?

No Hawaii fish species are known to have caused mercury poisoning.

Where does mercury come from?

Mercury in the environment comes from two basic sources, those that are natural and those that result from human activity (pollution). The ocean is a natural mercury sink. Volcanic activity and the leaching of soil by rainfall deposit mercury into the ocean. Mercury vapors emitted into the atmosphere from coal fired power plants and incinerators, and mercury contained in industrial effluents are significant sources of manmade mercury pollution. Mercury enters the water from industrial discharge and from contaminated rain.

Mercury is transformed into the toxic form, methylmercury through the action of bacteria in the sediments. This is especially important in small, shallow bodies of freshwater exposed to significant amounts of mercury pollution. Fish from polluted water can quickly accumulate high levels of methylmercury from the aquatic life they feed on. The mercury cycle in the deep ocean is quite different from the relatively small volume, inland and nearshore waters.

What are the symptoms of mercury poisoning?

Mercury acts as a powerful neurotoxin. At high concentrations it kills nerve cells and can cause problems with vision, coordination, speech and in some cases death. Mercury at high doses during pregnancy can cause blindness, cerebral palsy, delayed development and other birth defects in children. By contrast, the effects of low-level mercury exposure from open ocean fish in the diet continue to be debated by scientists.

The following symptoms are described from cases of mercury poisoning from severely contaminated nearshore fish from polluted water and the accidental poisoning involving mercury treated grain, and not from open ocean fish like tuna, swordfish or marlin.

Symptoms of mercury poisoning at high concentrations may include:

- STUMBLING GAIT
- DIFFICULTY SPEAKING
- TUNNEL VISION
- IMPAIRED HEARING
- MUSCLE WEAKNESS
- FATIGUE
- HEADACHE
- IRRITABILITY
- TREMORS
- COMA
- DEATH

The potential for toxic effects of mercury on the developing fetus and young children is a major concern.

Studies of children born to Iraqi women in the early 1970's exposed to mercury from the consumption of mercury treated wheat seeds have drawn attention to the vulnerability of the fetus to mercury exposure.

Additional studies have been done on populations that eat fish to determine if lower levels of mercury exposure can also impact the fetus. One study followed women and their children who were exposed to mercury through the diet of fish in the Faroe Islands. This study found a statistical correlation between umbilical cord blood mercury and diminished scores on standardized tests of children. However, the "fish" source of methylmercury was primarily pilot whale, a marine mammal. These women periodically feasted on pilot whale meat and exposed their children to elevated levels of methylmercury as well as other toxic substances including cadmium and PCBs.

Pilot whales are not fish.

A more appropriate study of health effects from fish consumption involved a population of mothers in the Seychelle Islands that ate an average of 12 meals of fish per week. The general population in the Seychelles has one of the highest fish consumption rates in the world estimated at between 175 and 220 lbs per person per year. The Seychelle Island diet of fish includes yellowfin tuna, skipjack, bonito, wahoo, jacks and other fish similar to those found in Hawaii. Whale meat is not part of the diet. No adverse health effects from the high fish consumption levels and low-level mercury exposure were found in children during the 9 year study. It is quite possible that the known health benefits of eating fish outweighed the possible adverse effects of the low levels of mercury contained in the fish.

Why was the situation in Minamata Japan different?

The nearshore fish that caused mercury poisoning in Minamata Japan in the 1950's were contaminated with extremely high levels of mercury from industrial pollution. Average mercury concentrations in Minamata Bay seafood ranged from 9 to 24 ppm (parts per million), with some fish reaching 40 ppm. These values far exceed the US government methylmercury limit of 1 ppm and the levels found in Hawaii fish. In addition, the fish consumption rate in Japan (over 160 lbs per year) is estimated to be 10 times that of the average US consumer (16 lbs per year).

What about open ocean fish?

Open ocean fish like sharks, swordfish, marlins and tunas accumulate methylmercury from their diet. The larger, older individuals of these species have greater potential to build up higher levels of methylmercury. The source of the mercury in Hawaii's open ocean fish appears to be from natural sources and not directly from atmospheric mercury pollution from manmade sources. A Princeton University study found that between 1971 and 1998, while emissions from industry were estimated to have increased atmospheric mercury pollution by 10 to 25%, there was no change in the low levels of methylmercury (average 0.22 ppm in 1971 and 0.21 ppm in 1998) in the yellowfin tuna caught in Hawaii during the same period.

This study provides evidence that the mercury found in yellowfin tuna caught in the middle of the Pacific Ocean near Hawaii is not directly from atmospheric pollution, but more likely through the natural marine food web originating from deep ocean sediments. The mercury cycle in the ocean is distinct from shallow nearshore areas, lakes and rivers that are more rapidly and directly affected by mercury pollution because of the proximity to point sources and the much smaller volume and shallow nature of the water systems in which contaminated fish are found.

By contrast, the mercury cycle in the deep ocean may be a much longer process involving methylation of mercury in the deep ocean sediments followed by a prolonged period of time for mercury to be accumulated through the food web. The mercury accumulated by open ocean fish far from significant sources of mercury pollution is more likely to reflect naturally occurring environmental background levels of methylmercury.

Should the Iraqi mercury poisoning incident be used to derive recommendations on fish consumption?

This was a case of severe mercury poisoning and not a situation of low level mercury exposure. The people were poisoned by eating mercury contaminated grain and not fish. The data from the Iraqi incident that are being used to extrapolate the estimate of tolerable mercury exposure are very limited in numbers. The University of Rochester scientists that conducted the Iraqi studies have cautioned about the limitations of using the Iraqi poisoning event to determine the effects of mercury exposure from fish. As a result, they conducted the Seychelle Island study to focus on a more appropriate sentinel fish eating population and the children exposed to low mercury levels from ocean fish in their mother's diet during pregnancy.

How can fish containing high levels of mercury be detected?

Fish containing mercury do not have a characteristic appearance or odor.

Laboratory testing methods exist and are used in some settings to screen fish for mercury content. The US FDA has established a 1 ppm defect action limit for methylmercury in fish.

How can mercury poisoning be prevented?

There is no evidence that species of fish from Hawaii fisheries have ever caused mercury poisoning, or ever will at the concentrations that have been reported. The evidence is weak that the low levels of mercury contained in Hawaii open ocean fish pose a health risk.

Protecting the developing fetus and young children from mercury exposure from fish can be done by limiting mothers' and infants' consumption of contaminated fish, especially those caught in recreational inland fisheries where mercury may build up to unnaturally high levels. There are many watersheds and lakes across the country contaminated with mercury at levels that have prompted health advisories for specific bodies of water.

Is there consensus of what constitutes a safe daily intake of mercury?

No. Several organizations that issue health advisories and have conducted studies on methylmercury have drawn quite different conclusions about safe daily intake of mercury. Some of the differences result from the targeted population of consumers and the type of seafood that led to methylmercury exposure in studies of populations at risk. For example, in the Seychelle Islands study population, women ate a variety of nearshore and open ocean fish and are thought be more representative of fish eating populations. The joint EPA-FDA advisory is stricter because of the reliance on the results of studies of the Faroe Islands population that was exposed to methylmercury from periodic feasts on pilot whale, a marine mammal.

Guidance for pregnant women for safe fish (ex. yellowfin tuna steaks) **consumption aimed at reducing prenatal mercury exposure of their children.**

AGENCY OR SOURCE	GUIDANCE*
EPA-FDA Joint Advisory 2004	1 meal/week
World Health Organization (WHO)	2.3 meals/week
Agency for Toxic Substance and Disease Registry (ATSDR)	3 meals/week
Seychelle Island Child Development Study (Univ. Rochester)	12 meals/week**

** A "meal" is a 6 oz. portion of fish. **Average fish consumption without any adverse health effects.*

There are continuing efforts to weigh and compare the known health benefits of fish in the diet with the uncertain toxic effects of low levels of mercury intake associated with eating fish. It is clear that at much higher consumption rates of fish with much greater mercury concentrations (from polluted water) that poisoning can occur. However, it does not appear to be a significant risk when considering the naturally occurring background levels of mercury found in open ocean fish like tuna. A quantitative risk assessment that considers the risk and the benefits of eating fish is needed. Another mother and child cohort study is underway in the Seychelle Islands, thought to be the best sentinel population to study the effects of mercury from a true marine fish diet.

The World Health Organization (WHO) provides guidance of 5 ppm hair mercury concentration as the safe upper limit of mercury exposure. This value has a 10-fold safety factor built in. It is based on the finding of health effects at a minimum of 50 ppm hair mercury in studies of patients exposed to high levels of mercury contaminated food. University of Rochester scientists, studying the Seychelle Islanders found the average hair mercury concentration in young children was 7 ppm about 10 times higher than the US average. No harmful effects in children (the most sensitive population) were detected, even at 15 ppm methylmercury in hair, nearly 20 times the US average. While further studies are being completed, women should follow their doctor's advice.

Safe raw fish consumption

The consumption of raw fish is a traditional practice in Hawaiian, Pacific Island and Japanese cultures. Today, Hawaii consumers enjoy a variety of fresh, high quality fish that are eaten as *poke*, *sashimi*, *sushi* and a variety of other raw fish preparations. Seared tuna (cooked only on the surface and raw in the center) is a form of raw fish preparation with roots in the traditional Japanese preparation called *tataki*. A popular *tataki* preparation is made using raw *aku* (*katsuo* or skipjack).

The most popular fish species eaten raw in Hawaii include bigeye tuna, yellowfin tuna, skipjack, albacore tuna, blue marlin, striped marlin, *opakapaka* and *onaga*. These fish are **safe to eat raw.**

Parasites

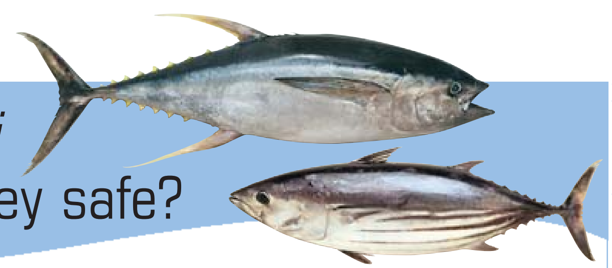
All animals including fish can have parasites, but only a few species of important food fish contain parasites that are potentially harmful to people. Most parasites seen inside some types of fish fillets are an aesthetic quality problem and not a health risk. Unsightly worms can destroy the value of fish fillets, but are only of public health importance if they are alive (viable), are infective (transmissible) to humans and if the fish are eaten raw. For example, the small white worms found in the muscle near the belly of *aku* (skipjack) are larvae of a species of shark tapeworm. These are not infective to people, but it is common practice to avoid eating the parasites for aesthetic reasons.

There are some fish that should not be eaten raw. Determining the fish species that are unsafe to eat raw requires an understanding of the biology of the parasite. Parasite-host fish relationships are highly-evolved and highly-specific. **As a general rule, freshwater fish should not be eaten raw** because of the greater potential for parasites harmful to people. Generally, it is the parasites that naturally occur in marine and land mammals and birds that have the greatest potential for parasites harmful to people. Certain marine fish should not be eaten raw because of the risk of parasite infections, while other species are free of parasites of public health importance and are safe to eat raw.

Most parasite life cycles involve multiple hosts coinciding with different life stages of the parasite. Only some of the stages are infective to humans. When people encounter infective parasite larvae in raw fish, they may become accidental hosts and suffer from parasitic infections. Knowing which fish are safe and which are unsafe to eat raw is the key to preventing fish-borne parasitic infections.

Fully frozen and fully cooked fish of any species are free of harmful parasites, because the two temperature extremes kill the parasite larvae, making them harmless. Freezing fish to kill parasite larvae requires holding fish at -4°F for at least 7 days or at -31°F for at least 15 hours. Cooking should be to an internal temperature of 140°F or greater (until it loses its translucent "raw" appearance). The trend towards undercooking fish is safe only if the fish species is free of harmful parasites or the fish was adequately frozen prior to cooking.

What about *ahi* and *aku*, are they safe?



State of Hawaii, Hawaii Seafood Promotions Committee

YES. The fish commonly eaten raw as *sashimi* or *poke* in Hawaii are safe to eat.

There have been no reported cases of parasite infections from *ahi* (bigeye, yellowfin or albacore tuna) or *aku* (skipjack) in Hawaii.

There are no reported cases of parasite infections from other fish eaten as *sashimi* or *poke* including *kajiki* (blue marlin), *nairagi* (striped marlin), *onaga* (long tailed red snapper) or *opakapaka* (pink snapper).

Parasites:

Herring and cod roundworms

What are herring and cod roundworm infections?

Infection by larvae of the roundworms, *Anisakis simplex* (herring worms) or *Pseudoterranova decipiens* (cod worms) is known as *anisakiasis*.

What are the symptoms of herring and cod roundworm infections?

In many cases, the patient feels a tingling sensation in the back of the throat and coughs up a worm. In more severe cases, the patient feels abdominal discomfort, which has led to the misdiagnosis of appendicitis.

Are herring and cod worm infections a problem in Hawaii?

Cases are extremely rare. In the late 1980's, it was estimated that a little more than 50 cases had ever been reported in the US. In Hawaii, where residents consume more fish per capita than other states with much of that fish eaten raw, there does not appear to be a problem with parasites from fish consumption. The only cases of anisakiasis in Hawaii in which the type of fish was confirmed involved wild Pacific salmon from Alaska or the Pacific Northwest and imported squid.

What fish can cause herring and cod roundworm infections when eaten raw?

Important species to Hawaii consumers include,

- Wild Pacific salmon (king, silver, sockeye, pink and chum)
- Pacific rockfish (*Sebastes* spp)
- Squid (all species)

Of particular concern is the use of salted salmon in the Hawaiian dish called *lomilomi* salmon. Salt does not kill the worm larvae. If the fish are not properly frozen to kill parasite larvae, consumers may become infected. The popularity of sashimi and cold smoked salmon made from farm-raised Atlantic and Pacific salmon may also be a factor leading to greater risk, if consumers do not make the distinction between farm-raised and wild-caught salmon. **Cultured salmon is known to be free of harmful parasites and can be eaten raw.** Wild-caught salmon should never be eaten raw unless it is first frozen to kill the parasite larvae.

How can fish with herring and cod worm larvae be detected?

Fish containing parasites of public health concern do not have a characteristic outer appearance or odor. Anisakid roundworm larvae can be seen with the un-aided eye in pale colored fish fillets. This allows them to be detected using a technique called *candling* in which a light is passed through the fillet from below, illuminating the parasites inside the muscle. Candling is not effective in dark colored fillets because larval parasites are more easily concealed than in less pigmented fillets. Artificial digestion and screening methods can be used to survey for anisakis-type roundworm larvae.

How can *anisakiasis* be prevented?

Prevention depends on consumer and industry education, species avoidance, and freezing certain species of fish if intended to be eaten raw or undercooked. Fish known to carry harmful parasite larvae should be completely cooked if not previously frozen. The tendency to cook seafood lightly and the growing trend to undercook fish may present new parasite concerns. When in doubt about parasite risk, freeze the fish before eating it raw or undercooked.

It is important to know the fish species and the associated risk and whether it was farm-raised or wild-caught. For example, cultured Atlantic salmon can be eaten fresh and raw because the parasite life cycle is broken by the use of artificial feeds in place of natural forage prey species that serve as intermediate hosts for parasites.

Parasites:

Broad fish tapeworm

What is broad fish tapeworm infection?

Fish-borne infections by tapeworms of the genus *Diphyllobothrium* are known as *diphyllobothriasis*. The broad fish tapeworm, *Diphyllobothrium latum* is the largest human tapeworm (reaching 30 ft in length) and most common species of the 8 *Diphyllobothrium* species that can parasitize people. The main (definitive) host is man, but other mammals can also serve as hosts including dogs, cats and swine. Adult tapeworms reside in the small intestine and shed eggs through the feces. Several larval stages occur in the complex life cycle, leading to the infective stage that is found embedded in the muscle of some types of freshwater and *anadromous* fish like salmon that hatch in freshwater, grow to adults in seawater and return to freshwater to spawn. People become infected by ingesting the larval tapeworms contained inside raw or undercooked fish.

Is broad fish tapeworm infection a problem in Hawaii?

Broad fish tapeworm infection are rare and not associated with fish from Hawaii.

What fish cause broad fish tapeworm infection when eaten raw?

Wild-caught Pacific salmon of the genus *Onchorhynchus* are the most important species of Pacific Northwest fish for Hawaii consumers. Other species including wild-caught trout, pike and perch are also important, but these fish are not normally eaten raw in Hawaii and are not generally available.

Pacific salmon are important in Hawaii because the popularity of *lomilomi* salmon made with salted wild-caught salmon. Pacific salmon can be infected with broad fish tapeworm larvae in addition to the larvae of herring worms that cause *anisakiasis*.

How can fish with broad fish tapeworm larvae be detected?

Infected fish cannot be identified by outward appearance or odors. Knowledge of the species and source of fish that have the potential to harbor broad fish tapeworm larvae is the best and most practical approach. It is not common to inspect fish for the presence of broad fish tapeworm larvae. Examination of thin slices of fish muscle under a microscope can be done to detect parasite larvae. Artificial digestion methods can also be used to screen for parasite larvae.

How can broad fish tapeworm infection be prevented?

Prevention relies on consumer and industry education and species avoidance. **Wild-caught and fresh (never frozen) Pacific salmon and other susceptible fish species should never be eaten raw or undercooked.** If fish that are known to be potential hosts of broad fish tapeworm larvae are to be eaten raw, they should be properly frozen first to less than -4°F for at least 7 days or to below -31°F for at least 15 hours.

What are the symptoms of broad fish tapeworm infection?

Infection can be prolonged and without symptoms other than weight loss, because the parasite is well adapted to man. Patients may first be alerted to the presence of the broad fish tapeworm when infective pieces of the tapeworm are seen in the stool.

Some clinical symptoms include:

- ABDOMINAL DISCOMFORT AND DISTENTION
- INTERMITTENT ABDOMINAL CRAMPING
- FLATULENCE
- DIARRHEA
- VOMITING
- WEIGHT LOSS
- ANEMIA

Parasites:

Salmon fluke infection

What is salmon fluke infection?

Salmon disease in dogs is caused by the parasitic fluke (trematode), *Nanophyetus salmonicola* that can be present in some freshwater fish like trout (*Salmo* spp) and *anadromous* fish like Pacific salmon (*Onchorhynchus* spp). This organism carries *Neorickettsia helminthoeca*, the *rickettsial* agent (a type of microbial pathogen) that causes salmon "poisoning" in dogs. Dogs should never be fed raw wild salmon for this reason. People are also vulnerable to accidental infection with the salmon fluke (*nanophyetiasis*), but do not appear to be susceptible to the *rickettsial* pathogen.

What are the symptoms of salmon fluke infection?

- NAUSEA
- ABDOMINAL DISCOMFORT
- DIARRHEA
- FATIGUE
- WEIGHT LOSS
- SOME CASES ARE ASYMPTOMATIC

Is salmon fluke infection a problem in Hawaii?

This disease is extremely rare in the US. Twenty cases of infection in people have been reported in Oregon. Cases in the US have involved raw, undercooked and inadequately processed smoked salmon and steelhead. The potential for Hawaii consumers to become infected is mainly related to the consumption of raw, fresh (never frozen) wild-caught Pacific salmon.

What fish cause salmon fluke infection when eaten raw?

Consumers should be aware that there is the potential for parasitic infection if wild-caught Pacific salmon or trout are eaten raw without first freezing the fish to kill the parasite larvae.

How can fish with salmon fluke larvae be detected?

No detection methods have been developed for the larvae of this fluke in fish. Artificial digestion and screening methods are probably useful in detecting larvae.

How can salmon fluke infection be prevented?

Prevention relies on consumer and industry education and species avoidance. Wild-caught, fresh (never frozen) Pacific salmon or trout should never be eaten raw or undercooked.

Parasites: Angiostrongyliasis

What is angiostrongyliasis?

Angiostrongyliasis is a rare accidental parasitic infection of people by larval rat lungworms, a type of roundworm. *Angiostronglysus cantonensi*s is the species known to be present in Hawaii. The larval worms invade the central nervous system in man and cause *eosinophilic meningitis* and *meningoencephalitis*. The definitive hosts are rodents, the intermediate hosts are mollusks (snails and slugs) and crustaceans (prawns), and man is an accidental host.

What are the symptoms of angiostrongyliasis?

The body reacts with some or all of the following symptoms:

- SUDDEN ONSET OF SYMPTOMS
- SEVERE HEADACHES
- NAUSEA
- VOMITING
- NECK STIFFNESS
- SEIZURES
- MODERATE BUT PROLONGED FEVER
- ABDOMINAL PAIN
- ANOREXIA

Is *angiostrongyliasis* a problem in Hawaii?

Cases in Hawaii are extremely rare. However, *eosinophilic meningitis* caused by *A. cantonensis* infection has recently become a reportable disease in Hawaii. Physicians are now required to report cases to the Hawaii Department of Health because of several recent cases and the possible increase in the prevalence of this disease in Hawaii.

What fish cause *angiostrongyliasis* in Hawaii?

The most likely route of this infection is through the consumption of inadequately washed fresh vegetables and fruits, either containing infected slugs or snails, or contaminated with their slime that may also contain infective larvae. Freshwater snails should not be eaten raw because of the parasite potential. African snails, *Anchatina fulica* are known carry *A. cantonensis* larvae. Accidental infections have occurred in American Samoa where raw and undercooked African snails were consumed. Another case was reported in Australia in which the patient confessed to eating live slugs on a dare and suffered greatly. Susceptible aquatic foods in Hawaii include freshwater prawn *Macrobrachium* spp which are eaten raw in some areas of the Pacific Islands (Tahiti) and in Southeast Asia. **Eating raw freshwater prawns is not a common practice in Hawaii.**

How can prawns with *Angiostronglysus cantonensis* larvae be detected?

Uncertain, but microscopic examination of prawn muscle should be able to detect encysted larvae.

How can *angiostrongyliasis* be prevented?

Prevention relies on consumer and industry education and species avoidance. **Freshwater prawns and snails should never be eaten raw or undercooked.** Also thoroughly wash and carefully inspect fresh fruits and vegetables, especially leafy greens, for slugs, snails or their slime. Never eat slugs or snails raw.

Parasites:

Intestinal Heterophysiasis

What is intestinal *heterophysiasis*?

Intestinal infection with the larvae of the trematode (fluke), *Stellantchasmus falcatus* that can be present in mullet (*Mugil cephalus*).

What are the symptoms of intestinal heterophysiasis?

The body reacts with some or all of the following symptoms:

- MOST CASES OF HUMAN INFECTION ARE BENIGN AND ASYMPTOMATIC
- SEVERE CHRONIC DIARRHEA
- WEIGHT LOSS
- IRRITATION OF THE INTESTINE
- COLIC
- NAUSEA

Is intestinal *heterophysiasis* a problem in Hawaii?

This disease is extremely rare but a few cases have been reported in the past. Mullet is not commonly eaten raw in Hawaii but may account for the rare occurrence of this infection. Consumers should be aware that the potential for parasitic infection is high if mullet are eaten raw because there is a high rate of infection of mullet by *S. falcatus* larvae in Hawaii.

What fish cause intestinal *heterophysiasis* when eaten raw?

Mullet are the only marine fish of public health importance in Hawaii in the transmission of *S. falcatus* larvae to humans.

How can fish with *Stellantchasmus falcatus* larvae be detected?

Uncertain, but microscopic examination of fish muscle should be able to detect larvae.

How can intestinal *heterophysiasis* be prevented?

Prevention relies on consumer and industry education and species avoidance.
Mullet should never be eaten raw or undercooked unless properly frozen.

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