Native fishermen gather specimens of poisonous fishes for Caltech investigators on Canton Island, in the South Pacific. Specimens are collected by fishing, netting, diving and spearing, poisoning the water, and sometimes even by blasting.

POISONOUS FISHES

In recent years fish poisoning has taken on world-wide medical significance. It's a problem that embraces important military, economic and investigative problems too.

by FINDLAY RUSSELL

FISH POISONING, or—to give it its technical name—ichthyotoxism, implies poisoning due to the ingestion of fish, quite exclusive of bacterial contamination. Of the hundreds of families of fishes about 15 are poisonous to man; by species, about 400. Not all the fishes of these 400 species are poisonous, however. Nor are all poisonous fishes toxic at the same time—or even in the same place at the same time. Toxicity may differ not only from species to species, but also from fish to fish, in the same virulent group. A species of fish that was edible five years ago may be toxic today. In some species only the gonads may prove to be poisonous, while in another —or even in the same species—the entire fish may be toxic.

Constantly confusing, the problem of fish poisoning embraces a number of important medical, military, economic and investigative problems. It has *been* a problem for centuries. In ancient Japan, for instance, it was known that one kind of tetraodon (commonly known as the puffer) was "absolutely mortal . . . no washing or cleansing will take the poison off . . . it is therefore never asked for but by those who intend to make away with themselves."

Fish poisoning is not always fatal, of course. In 1774 Captain James Cook, quite by mistake, ate a tetraodon liver and roe while off New Caledonia, and recorded his symptoms as follows:

"About 3 o'clock in the morning we found ourselves seized with an extraordinary weakness and numbness all over our limbs. I had almost lost the sense of feeling, nor could I distinguish between light and heavy bodies —a quart pot full of water, and a feather, being the same in my hand. We each of us took an emetic and after that a sweat which gave us much relief. In the morning one of the pigs which had eaten the entrails was found dead, he being swollen up to an unusual size."

A world-wide problem

By the beginning of this century and with the advent of modern communications the problem of fish poisoning had taken on world-wide medical significance. Over 500 deaths a year were being reported, and another 500 victims probably died undiagnosed. From 1913 to 1923 in Japan alone 6137 cases of fish poisoning were recorded. Of these, 906 were due to the tetraodon, with over a 64 percent fatality rate. Today less than 100 people die of fish poisoning each year, though it is safe to assume that there are as many as 2,000 or 3,000 non-fatal cases.

During the past five years the fisheries resources in the Central and South Pacific have expanded enormously. With this expansion has come a greater need for a more thorough study of where and when the commercial fisherman may take his haul. The danger of depleting some fishing grounds while leaving others relatively untouched because of a lack of ecological information on poisonous fishes has become a very real problem.

Military situation

During the war in the Pacific several occurrences of fish poisoning hindered the successful completion of military missions. In one report a 30-man crew of a Navy landing craft, after eating a 50-pound poisonous barracuda, became so ill that it was necessary for a relief crew to man their vessel. In another incident eight members of a U. S. Army ship were put to port and hospitalized after eating a poisonous snapper. Small wonder, then, that in the last three years the military has become one of the principal supporters of the research activity directed toward solving the more clinical aspects of the problem.

Lessons learned from the Japanese during the last war point to the importance of using fish as a basic food for combat units. Downed air men must often depend to a certain extent on fish if they are to survive. Some smaller naval units of the Japanese fleet are known to have increased their range from home base by almost a third by utilizing fish in place of stored foods. Isolated units, especially in the South Pacific, must often depend entirely on the sea for their source of fresh meat.

A daily problem

To the many island races that depend upon the oceans for fresh meat, poisonous fishes present a daily problem. These islanders have all kinds of ways of detecting which fish are poisonous and which are not. They range from studying the effects of moon rays on the skin of the fish, to the feeding of the suspected catch to another animal. As you might expect, the number of cases of poisoning is highest where the superstitions are greatest —though sometimes the islanders' superstitions are sufficient to protect them from a possibly toxic fish.

On the whole, poisonous fishes are not as tasty as non-poisonous ones. Often their smell or consistency is such that they are readily discarded on being caught. The most suitable information we have on how the islanders tell when a fish is poisonous is that which has been passed down through the decades, based an actual poisonings. Though this method has its limitations—since toxicity may change—it offers an adequate basis on which the islander may select his fish with a reasonable degree of safety.

In those areas where there is an abundance of rodents, the fish is often fed to these animals to determine the toxicity. Some islanders feel that they are able to identify a poisonous fish by the color of the palatine structures, or by the direction of the gill rakers. Others determine the toxicity by placing a silver coin on the skin of the fish and watching to see if the coin will turn black. Still others will throw a piece of the fish onto an anthill. If the ants refuse it, they do the same.

Of these varied methods, none are entirely satisfactory either for the individual or the commercial fisherman.

Identification

Thus the first barrier for the investigator is to determine which fish are poisonous and which are not. Oddly enough this is relatively a new problem and most of the attention directed towards solving it is being supplied by governments and industries interested in the economic productivity of the seas.

The job of identifying and classifying the hundreds of poisonous fishes is, of course, extremely complicated, but enough information has been collected during the past ten years to make present progress more rapid.

Fish poisoning is often designated, probably somewhat ambiguously, by area groupings of fishes causing the poisoning. There are three main groups. The Caribbean type of poisoning—which is the least virulent, incidentally—is most commonly caused by the giant barracuda, and the amberjack.

Dr. Findlay Russell examines and classifies various poisonous fishes before grinding them up and extracting toxins.

The second grouping is the Pacific type, often caused by the giant barracuda, trigger fish and snapper.

The third type is tetraodon poisoning, caused by the puffer or balloon fish. Puffers—not all of which are poisonous—are found in most of the warm seas of the world, but are most common about the isles of Japan.

A matter of taste

If, for example, one were to eat an ounce of the flesh of *Tetraodon hispidus*, a small puffer known to be highly poisonous, what could he expect to experience?

The immediate symptoms would be confined generally to complaints of perverted sensory function about the mouth—though several victims of tetraodon poisoning are known to have expired in less than twenty minutes after eating one of these fish. Within a period of three hours, complaints of nausea, abdominal pain, severe headache and difficulty in swallowing and articulating would be in evidence. There would be a marked weakness of the extremities, coupled with severe pain and tingling of the hands and feet.

Deep reflexes would probably be absent, as would the pupillary response. Difficulty would be experienced in co-ordinating walking movements, and symptoms of shock would probably develop. Within four or five hours after the onset of symptoms, death would result. Not all victims lapse into shock, however; some die in respiratory paralysis or from secondary complications.

If one were to eat of another unpleasant little creature of the snapper family, *Lutjanus gibbus*, he would probably become violently ill, though not a fatality. Again the symptoms of perverted sensory function about the oral cavity would appear, followed by vomiting and diarrhea. Severe pain in the extremities and an itchiness over the body would put the patient to bed, where all movement would be avoided. The chief complaint would concern an altered sensory function, which the patient might interpret as being an inability to perceive cold objects and to identify pain correctly. For several weeks the victim might complain of indisposition, weakness, loss of appetite, paresthesia and occasional dizziness. Complete recovery in most cases requires from two to six weeks, although some symptoms have been said to persist for as long as three months.

Treatment

As the exact nature of the poisonous substances is unknown, treatment tends to be symptomatic. Such measures as gastric lavage, intubation and oxygen administration and the combatting of secondary infections which often develop, are indicated. Combatting shock with intravenous solutions and appropriate medications as well as allaying the pain with calcium gluconate and Demerol is often necessary.

Why fish poisoning occurs

A good deal of speculation has gone into explaining why fish poisoning occurs. The Carribbean type of poisoning has been attributed to the eating of the poisonous manchineel berry which grows on a plant along the shorelines in that area. The seed is said to fall into the

water, where it is eaten by certain fishes which then become poisonous.

But the manchineel berry, rather locally distributed in the Caribbean, is certainly not responsible for the poison found in the tetraodons off Japan. It is not even certain that it is responsible for the poison in the fishes of the Caribbean. The berry has never been found in the stomachs of these poisonous Caribbean fishes—nor have the stomach contents of the poisonous and non-poisonous Caribbean fishes revealed any remarkable differences.

The proof or rejection of the theory would of course lie in a controlled feeding experiment, which, unfortunately, has never been undertaken. It can be noted too that the giant barracuda which is poisonous in the Caribbean is not a berry eater and, in an aquarium, cannot be induced to eat the suspected seed. In the case of the barracuda, at least, it seems likely that the maturity of the fish has more to do with the presence of the toxin than the diet.

Report from Fanning Island

A second theory frequently proposed and more recently discussed by S. G. Ross can be better substantiated. Ross was employed as the medical officer on Fanning Island in the Central Pacific from 1946 to 1948. According to him, there was a negligible number of fish poisoning cases on the island previous to 1945. In October of 1945 the allied governments dumped huge amounts of tank mines, ammunition, copper wire and other metals not far from the island. Four months later there were ten cases of fish poisoning within a thirty-day period. From February, 1946 to April, 1947, there were 95 cases in all. Ross reported these findings in November, 1947. Although no accurate records were kept, the number of cases of fish poisoning on Fanning Island gradually decreased after Ross's departure at that time.

Natural—or man-made?

There is no doubt that certain edible fish became inedible within the course of a few months in the vicinity of Fanning Island. This change *could* be accounted for by a natural unpredictable fluctuation. If it was due to the dumping of war materials, it is not at all clear whether it was caused specifically by copper, titanium or some other metal.

Unfortunately, there is no record as to whether or not large numbers of fish were killed in the dumping operation near Fanning Island. Nor are there any reports from other areas where similar war supplies were scuttled.

Another possibility

Still another theory concerning fish poisoning is that fish which feed largely on coral life become poisonous. This hypothesis would have to exclude a large number of poisonous fishes whose denticular anatomy is such that coral feeding would be impossible or at least highly improbable. There are, however, some poisonous species which feed almost entirely on coral animals, and in turn these animals have been found abundantly in their stomachs.

Of course, only controlled feeding experiments will indicate the importance of this theory. Many of the suspected molluscs on which some species of poisonous fish are known to feed have not proven poisonous to man. Coral itself has never been found to possess elements that are poisonous in their natural combination in the coral.

Food-chain relationship

The theory held in best repute among the remaining ichthyologists seems to be that the toxin is derived from a poisonous seaweed, alga or echinoderm, on which the fish feeds. As yet these suspected agents have not been identified, although several investigations at the present time seem to indicate that this food-chain relationship may play an important part in the etiology of the poisoning.

In spite of obvious criticisms to these presentations, they may all contribute significantly to the causation fact or factors. It is possible to divide these theories into two assumptions:

1. That toxicity is produced through factors of environment.
2. That toxicity is produced through food ingested by the fish.

Another influence which may prove to be more important than either of the above is related to the role of certain genetic factors. The alteration of several metabolic functions related to hormone production in certain poisonous fishes may play an important part in the production of these toxins.

Current investigations

Investigations pertaining to the poisonous fish problem are being conducted in several institutions at the present time. At the School of Tropical Medicine in Loma Linda, California, a very detailed study is being made into the taxonomy and ecology of these poisonous fishes. The work at Caltech is concerned principally with the physiological and pharmacological activity of these poisonous extracts. Studies will also be made into certain hormonal and enzymatic influences, as well as several genotype peculiarities in these fishes.

In retrospect, the significance of the problem can readily be seen. The questions that confront the investigator are numerous and perplex not only to the scientist but to the fisherman, the packer, the soldier, the doctor and the housewife. Within the next five years sufficient progress should be made towards solving the conflict in our existing data and perhaps establishing a firmer insight into the fish poisoning problems.