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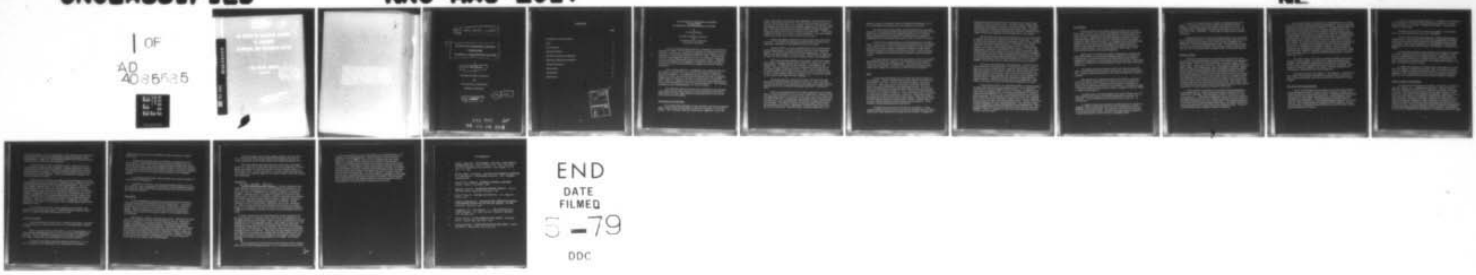

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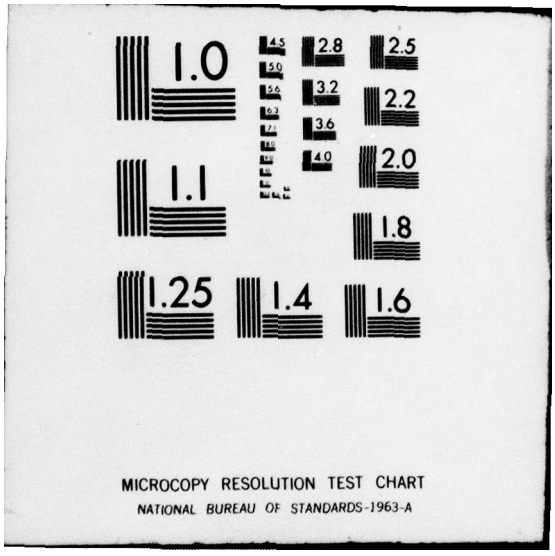
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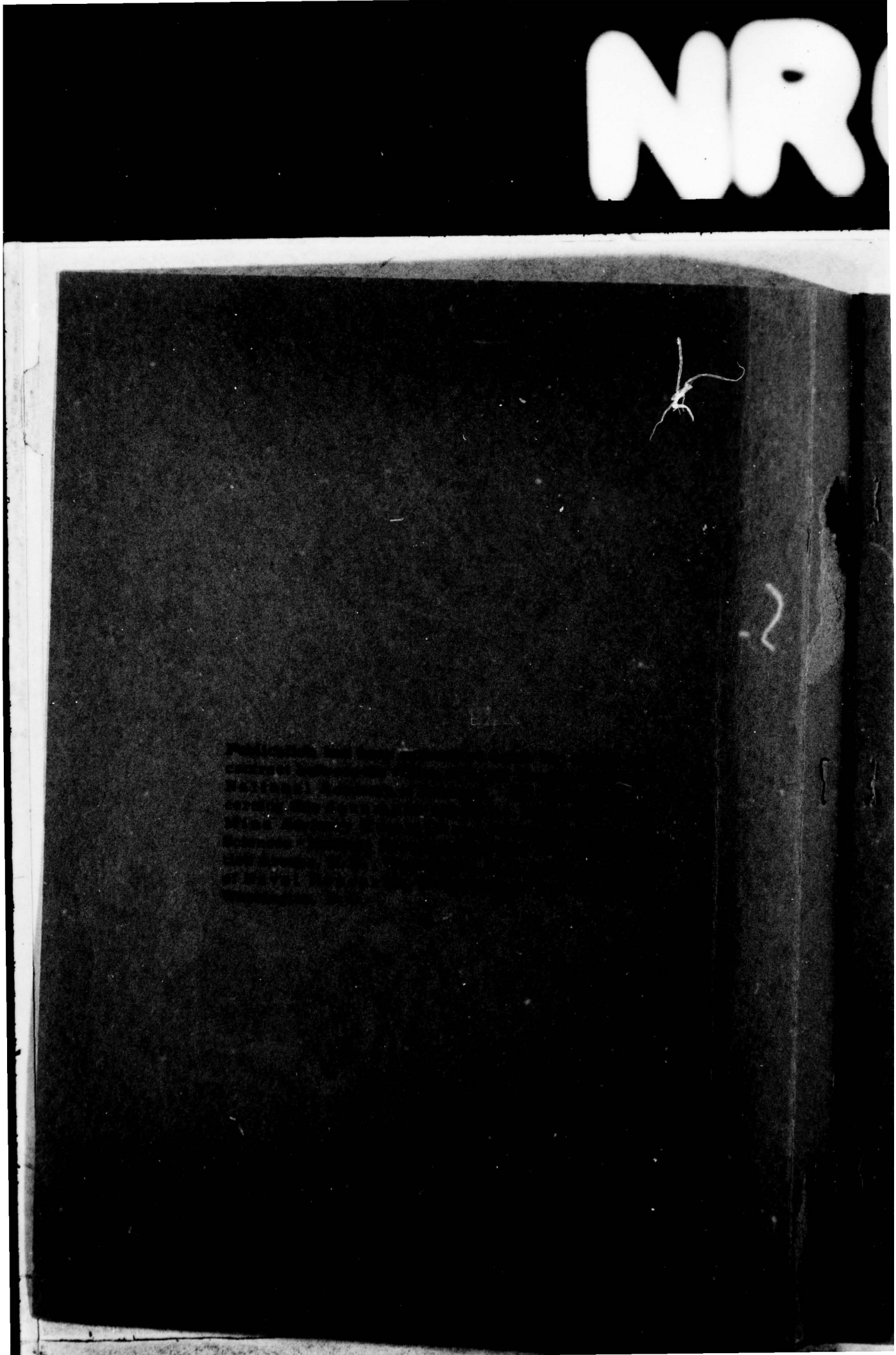

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# AN OUTLINE OF BIOLOGICAL HAZARDS TO SWIMMERS IN TROPICAL AND SUBTROPICAL WATERS

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The University of California

Berkeley, California

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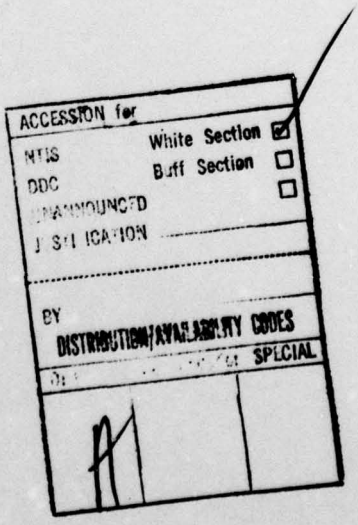

# AN OUTLINE OF BIOLOGICAL HAZARDS TO SWIMMERS IN TROPICAL AND SUBTROPICAL WATERS

by
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There are many biological hazards to swimmers in tropical and subtropical waters. As the number of persons entering such waters for scientific, recreational, and military purposes is increasing, it is perhaps useful to give a brief indication of some of these. The following references and suggested hazards are not to be considered exhaustive; a more complete listing would involve an extensive volume. Hopefully the following might provide suggestive thinking for anyone planning to enter such an area from which further reading could provide specific indications.

In the coming comments, cataloging is not by genus and species, but rather in a general way by the size of the creature causing the potential disturbance. It is assumed that the swimmer is involved in some sort of task, and therefore that the hazard is not due to misguided playing with sea animals or else due to eating infected or poisonous ones. However, cognizance is taken of the fact that swimming generally involves the swallowing of some of the surrounding water. The following problems are not insurmountable, *but should be known*.

The references listed at the end are not exhaustive but represent a few useful sources from which much of the following was abstracted. Discussions with Drs. Edgar Martin and Raymond Watten were further useful sources of information.

## Vertebrates other than Fish

In worrying about diseases one may overlook more obvious hazards. Thus in some areas, being mauled or eaten by a crocodile is a real possibility. These animals, and their relatives the alligators, occur over

most of the world in the areas we are discussing. On the shore they can inflict a sharp blow with the tail. They bite and then spin in the water, and thus are literally able to tear off legs. They live in fresh water (even including some of the oases in the southern Sahara) but go into salt water also. The regions most noted for human attacks are India and Egypt. Species in some countries are too small to be troublesome. The gavial, though often large, is not known to eat living humans. All these animals spend most of their time on river banks or in the water.

Tigers and jaguars (old and new world respectively) often swim by choice. The larger cats sometimes press attacks in shallow water, apparently realizing that land animals are there less agile.

In much of Africa, another possible hazard is the usually docile greater hippopotamus. They live in rivers and can move remarkably rapidly. On occasion they rush and destroy passing craft. They are able to bite clean through the torso of a man. Encountered at night when on their way back to water, one may charge and prove very dangerous.

The next mentioned animals are the snakes. Most water operations involve crossing a bank or beach, which can expose one to all the land hazards. In addition there are a number of sea snakes in the tropics. All are venomous, but they are generally docile and will not bite unless caught or disturbed directly. Also, they are small but do not always deliver much venom; a victim can become very sick but may not die. Certain islands which are completely free of poisonous snakes on the land have sea snakes in their fringing surf.

There are also eels, such as the moray, which are fish; they somewhat resemble snakes and thus are noted here. Some can inflict severe bites but they are not generally very troublesome unless bothered, and thus they can be avoided by examining holes before reaching into them.

There are land snakes which are rather aggressive and can swim. Thus it is quite impressive to see a cobra or king cobra crossing a canal. How aggressive they are in the water is not clear, but they are large and can inflict a fatal bite. Incidentally, the world's largest venomous snake, the king cobra, is a diurnal species which prefers a jungle environment near streams. The common cobra is a nocturnal snake which shows a decided fondness for water, occasionally entering brackish bays or the salt water of the ocean. Over the world, venomous snakes are in the

minority except in Tasmania, where all snakes are poisonous, and the rest of Australia where poisonous forms outnumber the others.

The giants of the snake groups, the boas and pythons, are good swimmers. The giant anaconda from South America is a creature of the rivers, and feeds primarily on animals and birds at the river banks. These large animals are perhaps not a special threat to swimmers, though the African python has been known to inflict terrible bite wounds.

A threat of awe-inspiring but uncertain importance is the killer whale, *Grampus orca*, which is found in all oceans and seas. Facetiously it has been said that no one has reported being bitten by a killer whale; authenticated cases of attacks on humans are unknown to this author, though the dispatch with which they attack sea lions, various cetaceans, and other magnificent swimmers leaves no doubt as to their potential danger.

On some shores one can encounter sea lions, which are normally charming and harmless. However, the old males have been known to nip at divers during the breeding season. The same can be said for certain species of seals. It should not be assumed that these animals cannot move rapidly over the shore, at least for short distances.

## Fish

Certain general problems are well known but there can also be local hazards. Thus in the Amazon is a small catfish locally known as the Candirú (*Vandellia cirrhosa* and others including *Urinophilus diabolicus*). Some swim up into the urethra of both men and women, where they spread their spines, with disastrous results. Also to be found in the Amazon are the piranha (four dangerous species) which are famous for their ability to attack *en masse* and reduce a living animal to a skeleton in a matter of minutes. Also in the Amazon are to be found the large electric eels (*Electrophorus electricus*) whose high voltage discharge (up to 600 volts) can stun a large animal. Other areas contain peculiar hazards which are no less exotic, and thus a detailed study of any given locality should be made in advance of an expedition, where possible, discriminating between myth and fact.

Probably the most feared of the fish are the sharks. This is probably justified since at least one tenth of the approximately 250 known species have been implicated in attacks on men or boats. Though such

attacks are known from cooler waters, they are most common from equatorial waters around the world. The bite of these animals often removes so much tissue that death of the victim follows. The skin of the animals is sufficiently tough and rough so that contact can cause severe abrasion. Foolproof repellents are not known, though the usual copper acetate plus nigrosine dye is probably better than nothing.

So much has been written about sharks that the interested reader is simply referred to the references at the end of this paper. It might be worth mentioning that sharks are sometimes found to swim upstream away from their more usual salt water. The Ganges river shark, *Carcharias gangeticus*, ascends fresh water rivers, attacking many bathers, and ranges from the Indian Ocean to Japan. The Lake Nicaragua shark, *Carcharinus nicaraguensis*, is a fresh water species which attacks humans and is confined to the fresh waters of Lake Nicaragua, its tributaries and outlet. When working on an ocean beach, one should not be lulled into a false feeling of security by the shallow water, as it is truly remarkable to note the maneuverability of a ten-foot shark in slightly over one foot of water, either with or without surf present.

The next most feared fish is the barracuda, of which there are about 20 species of differing habits. The great barracuda, *Sphyraena barracuda*, attains a length of six to eight feet, and is found in the West Indies and Brazil north to Florida, and in the Indo-Pacific from the Hawaiian Islands to the Red Sea. They move extremely rapidly, quite suddenly appearing and disappearing, and have an unnerving habit of following divers. Apparently they are attracted by anything that is bright or glittery. Barracuda wounds tend to be straight cuts, while those of the shark are often more curved in the shape of their jaws.

In the warmer waters, one finds fish capable of venomous stings, in many cases inflicted by spines along the back. In the associated references are included details of some of the types. It might be mentioned that the stingrays alone, which have representatives along both coasts of the United States, have a worldwide distribution in the areas being discussed. If the swimmer enters shallow water with a shuffling gait, he will often cause these fish to move on out of the way; stepping down onto one can lead to extremely painful results. Electric fish occur in many waters but few are a serious problem. The swimmer should avoid the temptation to grasp interestingly textured passing fish. Some of these tropical fish sit on the bottom of the ocean and are extremely difficult to discern. Stepping on a fish such as the stonefish *Synanceja horrida*, can prove fatal.

Invertebrates

Along the shores of the tropical oceans one finds the so-called killer clam, *Tridacna gigas*. These can weigh several hundred pounds and may be seen sitting unattached on a sandy bottom, or they may be in a mound of coral. Though their hazard is probably overrated, the author, while preoccupied with a piece of work, has had the end of his flipper grasped by such a clam by accident. If the animal closes upon something, release can only be affected by inserting a knife between the shells (which do not mesh perfectly) and cutting the two large transverse adductor muscle bundles. Cuts received from the sharp edges of these and other shells can become serious problems.

Some of the cone shells are capable of inflicting a venomous bite, which they might do to an extremely unlucky swimmer who chanced to step upon one. In tropical waters a few fatalities have been reported among shell collectors. The operculum of the scorpion shell, and several relatives, is whipped about during righting actions, and could conceivably inflict a cut.

An octopus can bite and deliver venom, but these are generally timid, retiring animals which tend to hide in holes, and pose little problem. Crabs can also bite and abrade, but cannot normally be considered a hazard.

Sea urchins are a ubiquitous hazard to swimmers in the ocean. It is all too easy to bump into one, or step on one, or be carried into their spines by the surf. Penetration by the spines can introduce a venom, and secondary infections are not uncommon. A large percentage of experienced divers report such an incident, though the result is usually a transient inconvenience.

A bristle worm is found throughout the tropical Pacific and in the Gulf of Mexico and contact can produce inflammation, swelling, and numbness. The use of gloves if one must turn over rocks, etc., is obvious here.

A number of species of starfish in tropical waters are capable of stinging, which is inconvenient but tends not to incapacitate a person. Similarly, some corals sting. More serious is the fact that coral cuts in the tropics tend not to heal, and this can in some cases incapacitate a person from further active work for a prolonged period.

A number of coelenterates are capable of administering severe stings. It is a good policy to avoid contact with jellyfish and other hydroids, unless one is completely protected by some sort of suit. In the Indian Ocean, Philippines, and northern Australia is found the sea wasp, *Chiropsalmus quadrigatus*, whose sting can cause death in humans in minutes.

Returning to the fresh water and swamp regions, there are a number of possible annoyances. In several portions of Africa and the Pacific region, particularly southeast Asia and the islands of Malaysia and Melanesia, leeches are annoying pests of man. Although these annelids are not vectors of human disease, their bites may cause extensive blood loss and, as with any skin lesion in jungle areas, often become infected.

## Parasitic Worms

Parasitic worms infect man in almost all regions of the world but they are especially abundant in number of both species and individuals in the tropics. One of the most spectacular is the yard long so-called guinea worm, *Dracunculus medinensis*, from a number of regions of Africa, India, Arabia, Iran, Afghanistan, Iraq, and Russian Turkestan. Human infection results from swallowing water containing copepods infected by larvae, which can easily happen while swimming in a stream or river. The parasite usually works its way into the veins of the leg, from whence the female extends part of her body through a lesion to lay eggs in water. One treatment is to wind this worm up on a notched stick over a period of several days; faster removal can break the worm, and release of this foreign protein into the bloodstream can cause death. Such worm types are unpleasant hazards which need not immediately interfere with activity, though they can cause extreme sickness at a later time.

Other parasitic nematodes can be acquired during swimming in contaminated waters, some through swallowing the water and some by penetration of the skin. Mention might be made of *Strongyloides* and *Trichostrongylus*. Resulting complications can be severe but usually do not appear for a month or more. Endemic regions are located in Africa, Central and South America, and southern Asia. The common hookworm (*ancylostoma*) larvae can penetrate the skin but do not usually produce any strong immediate effect unless there is an allergic reaction. They normally pass from skin to lungs to stomach to intestine.

An important hazard to swimmers in contaminated waters are the blood flukes of man commonly known as schistosomes. These trematodes penetrate the skin and need not be swallowed. The circariae penetrate the epidermis by forcing the anterior of their body through the skin, and penetration occurs within 30 minutes, aided by the lytic action of secretions of the penetration glands. An alternative name for schistosomiasis is bilharziasis, and it occurs throughout much of Africa, the Middle East, isolated areas of southern Europe, and the Far East. Distribution can be irregular; thus a human case has never been reported from Taiwan. This problem is most common where natives routinely relieve themselves in the water. All stages of the parasite in man can produce pathologic changes by the combination of mechanical effects, toxic secretions or excretions, and disintegration products. Possible results include fever, abdominal pain, diarrhea, bronchitis, various lesions and tumors, paralyses, unconsciousness, a condition resembling tuberculosis, cirrhosis of the liver, etc.

In a later section, there will be considered hazards from shores, beaches, and river banks. In these areas, animals and insects tend to gather, and it might be appropriate to mention here that mosquitos are the vector which transmits the nematode infection, filariasis. This problem is almost worldwide in the tropics, with the spectacular late complication, elephantiasis, sometimes appearing.

This section is far from complete. For example, no mention has been made of the tapeworm (cestodes), but should serve to indicate a type of problem that does exist and which should be considered in these regions.

## Waterborne Infectious Diseases

One of the important bacterial diseases is the often fatal cholera. Though perhaps best known in Asia, there is scarcely a country of the world that has not at some time been visited. Individuals entering endemic areas should be immunized, but immunity is of short duration, not exceeding four to six months. Maximal immunity is attained about the tenth day after immunization. Immunization against typhoid is much more effective, and certainly should be completed by all swimmers. In this last connection, it should be noted that there are over 50 strains of paratyphoid against which to guard.

There are various bacillary dysenteries. People are often immune to local bacterial strains, but suffer from severe diarrhea a few days after moving to a new location. Though often transient, this can prove extremely debilitating.

Amoebic dysentery may not come on as rapidly as the bacillary forms, but the lasting effects can be more damaging.

In connection with bacterial problems, mention might be made of tropical ulcer. Any abrasion can develop into a progressive sloughing ulcer that may extend deeply through the underlying structures as deep as the bone. Many micro-organisms are demonstrable in such tissues, and the process is complicated by watery environments. Antibiotics are helpful.

The leptospiral diseases (from spirilla) are distributed throughout the world, and infection of man results from direct or indirect contact with the contaminated urine of an animal carrier. Infection may occur through mucous membranes or through minute cuts or abrasions of the skin. Swimming in contaminated water can transmit these diseases, and death can result in one to two weeks.

Though these problems are minimal when swimming in the ocean, it is often difficult to judge when a harbor, lake, or stream is contaminated. (It might be mentioned that typhoid germs can occur in salt water mollusks.) When swimming in such an area, all available information about the above problems and their many relatives should be obtained.

## Hazards on Shores and Beaches

In connection with streams and swamps, it should be remembered that some insects, etc., congregate around water. Thus one may be bitten by a tsetse fly in the sun, or a mosquito in the shade, at any time of the day. One must beware of shelters for the latter reasons. Mosquitos can carry various viral diseases (encephalitis, dengue fever, etc.), and a swimmer may be more exposed to massive bites than a better covered person. (Problems that could otherwise be controlled can avalanche with massive exposure.) Insect repellents are useful, but they wash off and are not very effective when emerging after having been in the water for a while. The well known involvement of mosquitos transmitting the protozoa causing malaria remains a serious problem. Incidentally, in areas where filariasis has been killed off, mosquito attacks can be higher

because the filaria are fatal to mosquitos. Some mosquito borne diseases such as yellow fever are no longer serious problems because of good immunization. Dengue fever is sufficiently painful that victims sometimes jump off boats or otherwise kill themselves.

Mention might be made of blackwater fever, which is one of the most dangerous complications of malaria. Sudden destruction of blood cells occurs and such large amounts of hemoglobin products are released that the kidneys are clogged. It is said that this condition is sometimes associated with sudden chilling. This is something for a swimmer who has had malaria to consider.

Numerous other insects can produce medical problems both around inland waters and near ocean shores. Sandflies carry a number of diseases, including Kala azar and the other protozoal leishmaniases. Mites carry scrub typhus, spotted fevers, etc. Scrub typhus might be contracted while getting out of the water and cause extreme sickness in a few days, with perhaps a ten per cent chance of death; inoculation is not very effective. Typhus, a rickettsial infection, for which there is reasonable but not absolute immunization, is not usually spontaneous in the wild, unlike scrub typhus; it is louse borne and has been called the most important disease in history. One may encounter infected ticks. Though not necessarily more likely near water, one may suffer more by being highly exposed when prepared to swim.

Treatments for all these tropical diseases are not perfect, but something can be done about most. A possibly exposed swimmer should receive a careful examination following his activity.

## General Comments

Fungus diseases of the skin tend to explode in the tropics, especially if the skin is damp. This can lead to disability when discomfort becomes extreme.

Contact with sea urchin or fish spines, even if non-poisonous, can cause intense radiating pains that are very frightening to the improperly informed. Again it should be emphasized that any wound or abrasion in the tropics can become a serious problem by secondary infection.

A number of peripheral problems might be mentioned, including extreme sunburn, heat prostration, and entrapment by quicksand.

Casualties in general are more difficult to handle in areas of tropical wilderness.

One group of animals which is generally not troublesome is the lizard family. Though sometimes quite impressive looking, these are generally inoffensive. The only two poisonous species known are confined to the deserts of southwestern United States, Mexico, and Central America. Occasionally a lizard will be seen fording a stream; the only ones regularly entering the ocean are the harmless marine iguanas of the Galapagos Islands.

It is assumed that sirens in human female form along the banks are treated with circumspection.

In addition to the above, the usual physiological hazards to divers are involved. Thus a knowledge of the danger of breath holding is assumed. (It is said that some ancients would hyperventilate and then fall into water as a method of suicide.)

## Precautions

In the accompanying references are mentioned numerous precautions and treatments concerning the specific hazards cited. A few brief comments are included here from the author's experience. In general, the feet should be covered over-all with some form of sturdy shoe or flipper. This will help prevent entrance into the foot of various mud-dwelling worms, and will also protect against coral abrasions and sea urchin spines.

With regard to sharks, much has been written. The writer is aware that there is no perfect defense, but has found the use of a "shark billy" the most satisfying. This prod was fitted with blunt points to minimize slippage on tough skins, and had a purpose of fending off approaching animals without wounding or irritating them. The use of bright fluorescent bathing suits is to be avoided since such cloth has been used for bait, and was involved in one known shark attack at Eniwetok. Though a knife does not give much of a feeling of security in the presence of sharks, it should be carried for use in cases of entanglement, and to cut the muscle in a killer clam in the unlikely event of being caught.

Protection against the various stinging jellyfish, and their relatives, is afforded by the simple expedient of wearing a suit of knitted woolen underwear, which can also afford some protection against cold.

Protection against burrowing larvae is afforded by a watertight diving suit. However, a leaky suit could prove more dangerous than none. Such a suit might rub larvae into the skin, and the intimate contact result in extra harm. In this connection, it should be noted that high moisture density in a relatively tight suit can cause the skin to swell and become more penetrable.

Conclusions

THIS REPORT POINTS

~~The previous has attempted to point~~ out that the tropics are not a simple paradise just because some of the familiar local hazards are absent. Even the foregoing partial list of potential hazards is rather distressing. However, though there is a greater abundance of biological hazards in tropical areas, it is useful to compare the situation in one's home country. Thus a list of hazards around the continental United States of America might include killer whales, sharks, stingrays, Portugese men-o-war, swamps with snakes and malaria, poison oak, nettles, "swimmer's itch," schistosomes, hookworm, sea urchins, alligators, etc. Some of these may seem less offensive than several of the items above, but it should be clear that the previous is not completely different from the more familiar, and hence to some, less intimidating hazards at home.

These matters have been discussed with various physicians who have had experience in tropical areas, and there is not unanimity as to the actual magnitude of the threat. However, after considering the various possibilities, the following might be said. With regard to swimmers near tropical beaches, a reasonably cautious and well-informed individual should expect generally to survive unscathed. Part of the bad reputation of the tropics, but only part, is due to the fact that there are more human swimmers there to be affected. Thus there are also dangerous sharks in the Aleutians, but one does not normally hear of shark attacks from that area. But it is well to be out of the water if, for example, sharks start circling, and certainly a bleeding swimmer is in danger near tropical beaches.

If one chooses or is forced to go in water which is heavily contaminated, then one will probably get sick, e.g., if one swims in water known

over

to contain schistosomes, then he will probably get schistosomiasis, with possibly fatal results. However, some feel that it is not much more dangerous to be in the water than to be in a tropical area near water. This is very probably true if the water is relatively uncontaminated, though if an epidemiological problem does develop, it may be more acute in a swimmer. With regard to work in the tropics in general, the literature indicates that there are hazards and annoyances, but that even people who have grown up in foreign cold climates can function there if they persistently observe precautions. In a short exposure, a few per cent will become sick, especially when away from centers of population in the jungle where drinking water and food are less well controlled. But if one has a task in such an area, and informs himself of the local hazards in detail, it is possible to avoid unfortunate results most of the time.

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