

Improving Safety for Divers Working in Port Security Polluted Water Issues in Harbor Environments

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Abstract:

Since the terrorist attacks of September 11, 2001 in the United States, the challenges of port security have become of increasing concern to both public safety and military divers around the world. In order to protect the health of divers working in these environments, dive teams will need to re-examine their thinking, particularly in regards to divers performing hull searches on large vessels. Aside from the usual biological hazards and chemical pollutants found in most harbors, these ships may be painted with toxic bottom paints containing organotin paint compounds, i.e., tributyltins, which pose a serious threat to the health of the divers who must search them. In addition to these hazards, divers working in warm water ports may be exposed to *Pfiesteria piscicida*, a toxic dinoflagellate that is suspected of causing lesions, shortness of breath, and symptoms of dementia. This paper will examine the risks involved in this type of diving as well as recommended countermeasures that should be taken to mitigate these hazards.

Key Words

polluted water diving, organotin paint compounds, tributyltins, toxic dinoflagellate, *Pfiesteria piscicida*, dry suits, full-face masks, diving helmets, hull searches

Introduction

In the early 1980s, the National Oceanic and Atmospheric Administration (NOAA) in the United States was one of the first public agencies to recognize and address the issues of contaminated water as they affect divers.¹ Although the problems they identified were serious, it took many years before other government agencies and private firms began to develop procedures for dealing with this problem.

Since the horrific events of September 11, 2001, the issue of port security has become of major concern for divers with government agencies in countries around the world. In the past, police divers would occasionally conduct hull searches looking for contraband. Today in all major ports across the United States, divers from public safety agencies are conducting hull searches on a daily basis looking for evidence of terrorist planted explosives or other items that may be used in conducting attacks on civilian populations. While public safety divers do not routinely check bridges for explosives, this is an area that will no doubt be of concern at some point in time.

These searches are motivated not only by a concern to protect the safety of the population, but also because so much commerce moves by ship. The ports of San Diego, Los Angeles, and San Francisco, had \$446 billion dollars (22% of U.S. trade) of freight pass through these gateways by ship in the year 2000.² Any action that would disrupt the traffic through these or any other major ports would result in millions of dollars in lost revenues.

The military has always taken a keen interest in port security. In certain countries, such as Canada, divers are always dispatched to perform a hull inspection each time a ship docks and again before it sails. These inspections are conducted to search for mines which might be planted on the ships' hulls. While most people think countries such as Canada have beautiful clean harbors, reports from Canadian military divers are that many of the ports where their ships routinely dock are as polluted as many of the most industrialized cities in the world.

Recent research by Richter *et al* has for the first time established a positive correlation between diving activities in polluted water and cancer.³ Richter studied a population of 682 Israeli Navy divers who had been diving in the Kishon River over a period of 47 years. The Kishon River has long been recognized as a seriously polluted body of water. A disproportionate number of the divers working in the Kishon developed cancer.

There have also been numerous anecdotal reports of police dive teams in the U.S. who have experienced unusually high rates of cancer among their divers. Police divers in San Diego, California brought lawsuits against an electronics firm, Teledyne Ryan, that deliberately dumped PCBs (polychlorinated biphenyls), a known class of carcinogens, into Mission Bay.^{4,5} An unusually high number of the divers who were members of this team developed cancer following dives in the area where these chemicals were discharged. While this group was probably too small to provide much useful scientific evidence, it does present a graphic example of the issues divers face.

Over the past few years, a new threat has been identified which may pose a serious risk to the long term health of many divers. Many large ships have their hulls painted with bottom paints that contain tributyltins. The organotin compounds used in these paints are designed to kill any marine growth that might attach itself to a vessel's hull. These chemicals move through an organism's tissues at the cellular level and are extremely effective in killing marine growth such as algae, worms, and barnacles.

The Environmental Protection Agency (EPA) and numerous other organizations in the United States have identified tributyltin as extremely toxic.⁶ Divers who conduct hull searches are placing themselves in direct physical contact with tributyltin, especially if they are diving without the benefit of the proper equipment.

Typical Harbor Pollutants

Due to the physical design of harbors, the water inside most ports does not readily flush out with each tidal change, so any chemicals which have a tendency to sink remain in the bottom sediments. Divers who work inside harbors are potentially exposed to all of the pollutants that may be present in the water including human fecal matter, gasoline, diesel fuel, oils, and any other chemicals that are intentionally or accidentally dumped into the water.

It is generally recognized that the largest source of pollution in any densely populated area is what is known as "non-point source" pollution.⁷ This includes the fertilizers that people use on their lawns and gardens; antifreeze, oil, and tire dust from automobiles; fecal wastes from pets; and any other materials that run off streets and into the local waters.

Following a heavy rain, many harbors collect higher than usual levels of pollutants, which usually become obvious to the naked eye and may produce offending odors. This phenomenon is often referred to as the "first flush" in popular literature. In addition, the capacity of many sewage treatment plants is overwhelmed during periods of high rainfall and results in spills of raw sewage.

Mission Objectives for Harbor Dives

Divers have always had to work in harbors to perform a variety of work, but today there is more emphasis on harbor work than at any time in the past. This is particularly true for public safety divers and commercial divers, particularly in the United States.

In addition to performing hull searches, military divers also perform ship repairs, usually when the ships are in port. They conduct routine training dives in these locations on a regular basis.

Divers who work for public transportation agencies routinely perform engineering safety inspections of bridges that cross harbors and other waterways. Examples of agencies in the U.S. who perform this type of work include the California Department of Transportation (Caltrans) and the North Carolina Department of Transportation.

Commercial divers work in harbors to tackle many different types of jobs, including dock and wharf repair, pipeline and cable work, ship repairs and maintenance, etc.

Potential Danger in Hull Searches

There are many physical dangers in conducting a hull search of a large vessel, which include seawater intakes and propellers. In some cases, the sheer physical size of the vessel can be a risk to the untrained and poorly equipped diver who can become "lost" underneath the ship and find himself unable to discern which way to go to reach the surface, particularly in an out-of-air emergency.

Another serious hazard in many waterways along the southeastern and Gulf coasts of the United States is the presence of *Pfiesteria piscicida*, which was first identified by Burkholder in 1992.⁸ This toxic dinoflagellate is suspected of causing body lesions, shortness of breath, and symptoms of dementia.

The hidden danger in hull searches is the presence of tributyltins in the paints coating the hull. In its liquid form, tributyltins are toxic, according to the EPA.⁹

Once the paint has cured on the hull of a ship, it is no longer acutely toxic to humans, but it is lethal to encrusting marine organisms that attempt to establish themselves on hull surfaces painted with this compound. However, since tributyltin is a suspected carcinogen, and since by design it migrates through tissues, it is not unreasonable to suspect that divers who have repeated contact with surfaces coated with tributyltin may be absorbing this chemical into their bodies. The paint is designed to continuously leach from the hull over a period of several years before it must be reapplied.

In most harbors, the visibility is so poor that the only way to conduct a hull search is for the diver to continuously run his hands over the hull of the ship. In addition, as the diver conducts his search it is not unusual for him to brush his head or arms against the ship's surface. On a large ship the diver may be in direct physical contact with the vessel for more than an hour at a time. In a busy port, the divers may be diving on visiting ships on a daily basis.

Wetsuits and ordinary scuba equipment do not provide any protection from the pollutants found in most harbors. The suits allow skin contact with the contaminants as the water enters at the neck, waist, ankles, and wrists, as well as through the zipper. Scuba regulators allow water to enter the diver's mouth around the lips and backflush through the exhaust valve.

Ordinary scuba face masks which only cover the eyes and nose are easily dislodged and leak wherever mustache hair or head hair breaks the seal. Once the water enters the mask it can be inhaled through the nose or make contact with the eyes.



Fig. 1 – The hulls of most large ships have been painted with compounds containing tributyltins.

Recommended Equipment

Although the military has diving medical officers, public safety divers and commercial diving firms usually do not have full-time medical personnel to oversee their operations and make recommendations on the precautions that should be taken in contaminated environments. Even in the military, the recognition of the threat of contaminated water has often been downplayed under the assumption that divers are “tough” and are expected to work in conditions that the average person might find unacceptable.

Most of the teams who dive in contaminated water have been doing this type of work for so long that there is little thought given to the fact that this type of diving might present any serious health hazard. A common attitude among some divers is a refusal to acknowledge that there might be a problem, because once the problem is recognized they would have to deal with it. Dealing with the problem of polluted water almost always means additional equipment, further training, procedural changes, and increased expense.

The basic system recommended for diving in polluted water is a full-face mask, and a dry suit with attached boots, a dry hood, and attached dry gloves. This is the minimum level of protection recommended for diving contaminated water for public safety divers in the United States as specified by the National Fire Protection Association (NFPA) Standard #1670 on Operations and Training for Technical Search and Rescue Incidents.¹⁰ Unfortunately, there are many public safety dive teams who do not adhere to this minimum standard. There are also a number of teams who recognize the need for even greater protection when conditions are demanding, and have equipped themselves appropriately with diving helmets that mate directly to dry suits with attached boots and dry gloves.

The commercial diving industry in the United States operates under the auspices of the Association of Diving Contractors International (ADCI), and has included specific instructions for diving in contaminated water in its Consensus Standards for Commercial Diving and Underwater Operations, Fifth Edition, issued in 2003.¹¹ For the situations where a diver is called upon to dive in conditions where exposure may cause long-term health risks or death, they specify the use of surface-supplied diving equipment, including a dry helmet mated directly to a dry suit with attached boots and gloves and a return-line (reclaim) diving system.

Various military groups around the world are dealing with the issue of contaminated water diving, but to date, most military organizations have not issued a standard document on this matter. As of this writing, the U.S. Navy has produced a short manual on contaminated water diving, but has not publicized any detailed protocol or published this document in a formal fashion. The Canadian Forces also include some information on contaminated water diving in their diving manual, but there is disagreement among their divers about what level of precaution should be taken in certain circumstances.

In selecting equipment, it is especially important to select gear that has been tested for its chemical compatibility with a variety of chemicals. The U.S. Navy has conducted some testing, on various pieces of equipment, that has been made publicly available.¹² Some manufacturers have hired third party firms to test their gear, or have their own in-house testing facilities. It is essential to check any manufacturer’s claims against the appropriate test standards to ensure the compatibility of the gear to be used.



Fig. 2 – The equipment recommended for most contaminated water dives includes a dry suit, attached dry gloves, and a mating dry helmet.

Thermal Hazards

Whenever a diver is encapsulated there is almost always a danger of overheating when surface temperatures are above 65 degrees F, (18.3 degrees C) particularly if the diver must serve as a standby diver. In these circumstances some type of provision must be made to help ensure that the diver remains at a comfortable temperature. This may be accomplished using a cool source of fresh water or by using chemical cooling packs.

Insulating underwear must be adjusted for the water temperature and anticipated diver work load during the dive. Most divers will need at least two different sets of dry suit underwear, as well as liners and vests to adjust their insulation over the course of a year in temperate waters.

In some cases in warm weather, it will be impractical to have a diver serve as a standby diver for an extended period of time and then expect him to take his turn in the water immediately following his duty as a standby diver. In these situations it may be more prudent to have another diver dress in to make the dive and allow the standby diver time to recover from any heat stress. Although this will increase the crew requirement for this type of operation, this is essential to help ensure the safety of the divers.

Decontamination

Decontamination for any contaminated water dive must be planned, and the appropriate preparations must be made, well in advance of the dive itself. Everything required for decontamination must be in place before the diver enters the water.

Planning for decontamination includes considerations regarding the type of contamination, what chemicals will be needed for decontamination, ensuring there is an adequate supply of fresh water, brushes, hoses, and capture pools for used decontamination fluids.¹³ There also must be a procedure for disposing of these fluids.

All personnel who assist in decontamination must be properly trained and equipped with the appropriate level of personal protection. For further details on decontamination equipment and procedures, see *Diving in High-Risk Environments* by Barsky¹³.



Fig. 3 – Decontamination must be planned well in advance of the dive.

Summary

Diving in contaminated water rarely exposes a diver to biological or chemical agents that are "immediately dangerous to life and health." In most cases, a diver may only be exposed to contaminants that make him temporarily sick or uncomfortable. However, the long term effects of repeated exposures to many chemicals and some organisms present risks that are unacceptable.

Diving medical officers need to take a pro-active stance in regards to protecting the safety of the people entrusted to their care, and it may be best to assume that in most situations the water is polluted unless proven otherwise.

In regards to the dangers posed by hull searches and exposure to tributyltins it would be prudent to err on the side of caution until further research is done to prove or disprove the risks to the working diver.

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