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Cold Shock and Swimming Failure

The real danger of cold water is not in the slow descent into hypothermia, but in the sudden symptoms of cold shock.

by Chris Brooks

It is well known by most sea kayakers that hypothermia is a serious risk. Getting chilled by exposure to water even as warm as 70°F (21°C) can eventually lead to a number of serious and even life-threatening physical and mental symptoms. Many kayaking books focus on the various stages of hypothermia, and while it is important to recognize them, the most serious and dangerous effects of cold water aren't in a slow deterioration of abilities. For kayakers, a more realistic approach to the risks of cold-water immersion is to focus on the effects that happen in the first seconds of immersion and the following few minutes.

Water does not need to be drastically cold to kill you. You can drown very quickly if you are not mentally and physically prepared for sudden immersion. Since early times, the Inuit understood this danger. The waterproof paddling jackets—*tuiliqs and kamleikas*—used by early kayakers sealed together with their kayaks to provide full body coverage. Inuit whalers even developed dry suits. They consisted of sealskin or seal gut stitched together to form a complete covering that was worn by harpooners hunting whales from *umiaks*. The danger of exposure to cold water was well understood by the Arctic maritime peoples.

The presence of icebergs makes it obvious that kayakers should dress for cold water. On a warm summer day, when it may be comfortable to paddle in shorts and T-shirts, the risk of cold water may still be present, and dressing for the water is essential.

The Greek author Herodotus wrote about hypothermia back in 450 BC during the Persian/Greek wars commenting on mariners who died in sea battles in the Mediterranean Sea: "Those who could not swim perished from that cause, others from cold." The first human experiment in cold water to test out the value of protective clothing, however, was not done until 1922. A doctor working for the Merchant Shipping Advisory Committee on lifesaving appliances, named Dr. Hill, immersed his laboratory assistant, Mr. Pergarde, in 62°F (16.6°C) water and concluded: "That the coverings wet or dry, protect a body from cooling down, and also that a rubber skin outside such coverings is a further great protection."

The four stages where death can occur as a result of sudden cold-water immersion have been recognized by the scientific community since before World War II. These are: Cold Shock—kills in 3–5 mins. Swimming Failure—kills in 5–30 mins. Hypothermia—kills after 30 mins. Post-Rescue Collapse—kills during or hours after rescue.

The first two stages of immersion—cold shock and swimming failure—kill more than half the people who drown. It's especially important to protect yourself from those first two stages, and to do that effectively, you need to know something about cold-water physiology and survival psychology. It's also important to understand the denial of risk that is built into us all and causes many sea kayakers to paddle without wearing protective clothing or fail to make good plans and preparation prior to -launching. Up until about 50 years ago, no one really understood the reason why people suddenly immersed in cold water died. It was attributed to an inability to stay afloat and vague terms such as "exposure." The steady loss of lives was simply accepted as fate and an occupational hazard.

As long as cold shock and swimming failure were considered only of academic interest, mariners and government regulators—and later survival training schools, outdoor-sportswear manufacturers and PFD manufacturers—concentrated their efforts on protecting people from the more protracted process of hypothermia. As a result, hypothermia is widely recognized and understood; however, even with today's well established teaching programs, good regulations and much improved life-saving equipment, the two stages of immersion have often been overlooked. These are what I want to address.

Cold Shock

Over 15 years ago, Moulton Avery wrote an excellent article in this magazine ("Cold Shock," *SK*, Spring '91), noting that "immersion in cold water kills more sea kayakers than any other factor in our sport." Cold shock has been observed in people sensitive to cold at water temperatures as high as 77°F (25°C). In water below 60°F (15°C), the effects of immersion become significantly life-threatening to everyone. The lower the temperature, the more severe the symptoms. The effects of cold shock are completely out of your conscious control. If you don't protect yourself from cold water, they will happen to you whether you like it or not. If you really don't believe that it *will* affect you, the next time you take a shower, turn the cold water on full blast and aim it at your belly button. You will soon be a believer.

Cold shock is caused by rapid skin cooling and can kill within three to five minutes after immersion. On initial immersion, you make a huge inspiratory gasp. Being immersed in near-freezing cold water is also extremely painful, and the sudden sensation of acute pain can accentuate the inspiratory gasp. The gasp is followed by severe hyperventilation: a fourfold increase in your breathing rate. It is not uncommon for you to be panting at a breathing rate of up to 65 times a minute in this critical stage, so there is no chance to hold your breath. Indeed, in water below 60°F, your breath-holding ability is reduced by 25–50 percent. If the water is near

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freezing, even after the effects of cold shock have settled, you'll only be able to hold your breath for about 12–17 seconds.

The rapid breathing rate on its own can cause muscle spasms of the limbs and chest. All of these breathing irregularities increase the risk of drowning if you dip underwater or have a wave splash over your face. It only takes an inhalation of about five ounces (150 ml) of water to cause drowning. Drowning is a combination of cardiac arrest and suffocation. Your heart stops beating within one to two minutes after you have inhaled a significant amount of either fresh- or seawater. Water in the lungs compromises your ability to exchange oxygen, and because respiratory movements may occur for up to five minutes when underwater, water can continue to be drawn into your lungs.

Cold shock also causes a massive increase in heart rate and blood pressure. These cardiac responses may cause death, particularly in older, less healthy people.

The intense effects of cold shock last two to three minutes and will settle down after about five minutes of immersion. This period of involuntary reactions is just at the critical stage of sorting yourself out after your kayak has flipped and you're working to adjust to the wind and waves and avoid inhalation of water.

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Swimming Failure

Swimming failure is caused by rapid cooling of the muscles and nerves and can kill within about 5–30 minutes after immersion. It is much more common than you'd think. It's often poorly diagnosed by investigators because it usually isn't possible to delve into the precise history of what happens to a victim immediately after immersion. The cause of death listed on the death certificate is commonly reported as drowning. To be sure, drowning follows the inhalation of water, but it is swimming failure that leads to drowning when the mouth and nose can no longer be kept above the surface and slip underwater.

It's very dangerous to swim in cold water, and it doesn't need to be that cold (just 60°F) to cause a swimming failure that will drown you. Newspaper reports about drownings often mention that the victim was "an outstanding swimmer, yet he only swam 50 yards and drowned." Your swimming ability in warm water bears no relationship to your swimming ability in cold water. Professor Mike Tipton of the University of Portsmouth, U.K., and his colleagues in Sweden demonstrated quite clearly that your angle of attack while swimming (without a PFD) increases from 18 degrees to 24 degrees, and on swimming failure, just prior to drowning, the angle of your body becomes more upright at 35 degrees.

The drag on the body as it moves through the water at an increasingly upright angle is increased, your stroke rate is increased, and consequently your stroke length is decreased. The cold causes ineffective swimming strokes and a poor synchronization of them to breathing. This all adds up to an exhausted swimmer floating nearly vertical in the water. As you raise your arms above the water over your head to signal for help, there is a further loss of buoyancy. A cry for help expels air from your lungs (as much as four liters), removing the last vestige of buoyancy keeping your mouth above the water. The result is that you sink beneath the waves and never resurface.

While swimming failure doesn't apply directly to kayakers who maintain contact with the kayak after a wet exit, the "failure" is just a manifestation of physical symptoms that do apply. Swimming failure will manifest itself in compromising whatever physical tasks you need to do: holding onto the kayak, setting up a paddle-float outrigger, lunging onto your back deck and so on. Within a few minutes after immersion, you get a cold-induced anesthesia that causes a disconnect between your brain and your limbs and their position in the water—you don't know where your arms are. Your fingers grow numb and paralyzed, so your fine motor skills deteriorate. Grip strength is reduced, and cramps disable your limbs. Shivering further impairs movement, and panic compromises mental functions.

The Psychology of Survival

Survival schools have only recently started teaching lifesaving survival psychology. It's as important to know about the psychology of survival as it is to know about cold-water physiology. The work in this field has been pioneered by Professor John Leach, of Lancaster University, in the U.K.

The brain usually manages to function very successfully even in a whirlwind environment. What psychologists refer to as "human information processing" is capable of handling a lot of decisions in quick fashion. Unfortunately, however, in life-threatening situations, our brain is very limited in its ability to process information and to respond quickly and correctly.

Our brain uses an input selector (also called a "register") to process all the information received by our sensory organs. All the sensations, such as vision, hearing, taste, smell, temperature, vibration, pain and posture, are constantly being fed into this register or input selector by nervous system "telephone lines." Here the information is encoded and put into a central processing unit, which is your short-term or working memory. The number of "telephone lines" to the central processing unit is very limited, and in any survival situation, you should assume that you only have one line. This makes the processing system essentially a single-channel analyzer. This explains, for instance, why people will swear that they did not hear an alarm sound when they were completely engaged in some other complex task, even if the alarm was very loud. They will be telling the truth because their internal "telephone lines" were busy processing the other information and could not process any more information.

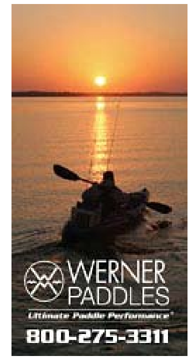
The limitation of the input selector is one of the primary reasons it's not easy for a single person to deal with a complex problem on his/her own under emergency conditions, and why working as a team provides a much better chance of survival. Commercial airlines have recognized this limitation and have introduced cockpit resource management for their flight crews to share in the decision-making process once borne solely by the captain. Kayakers should also adopt this approach of sharing the responsibilities required by emergency situations. Any rescue or capsize recovery should be a group effort. The person who capsized is likely to be under the greatest stress and the most likely to overlook protocols and to take inappropriate actions toward recovery. Kayakers who aren't directly assisting with a reentry can monitor drift or traffic, gather other members of the group, look for places to go ashore, etc.

From the brain's input selector, information is entered into the short-term or working memory where it is compared with other similar experiences that may already have been encoded in long-term memory as schemas or routines. The stored schemas—routines that have been learned and reinforced by practice—are available for comparison to any new information entering into the working memory. The connection with the schema provides a quick path to deciding upon an appropriate response to the emergency. If no schema is present, a plan of action has to be formulated using working memory alone. That's a very time-consuming process and has a limit on how much information it can hold and process in a given time.

With each new situation, a schema is developed and a response is generated. This response is then stored in long-term memory for a more rapid future response.

As we go through life, experiences from the benign to the dangerous are entered into our long-term memory as separate schemas. We have millions of schemas logged into our brain. Most are quite ordinary and automatic: turning the alarm clock on before you go to sleep at night, locating your toothbrush and brushing your teeth first thing in the morning, unlocking the car and putting the keys in the ignition and so on. Some, like defensive driving techniques, fire drills, CPR and kayak rescues, are all created as schemas and reinforced by regular practice. If there is no rehearsal of these emergency schemas to get them fully established in long-term memory, then the fine detail in them fades, and it's not remembered for later use when it may be lifesaving. That is why critical skills in our daily work and play require regular refresher training.

This process of decision making in normal, nonstressful circumstances takes about a tenth of a second to happen. If no schema has been developed for such ordinary situations, then the information processing is done by the supervisory attentional system (SAS) in the brain. The SAS takes care of planning, decision making, troubleshooting, error correction and solving novel problems. It also helps us perform in technically difficult or dangerous environments and overcome strong habitual responses. The SAS kicks in when we need to respond to an unplanned capsize, decide whether to swim to shore or wait to be rescued or assist an injured buddy crying for help. However, under stress and with no schema to follow, the SAS is slow and takes 100 times longer to process information compared to information stored as normal schemas. In an emergency, it can be quickly saturated with information and, as a result, be disabled just when it is most needed.



Self-Denial

Going hand in hand with our human information processing system, we also have a psychological protective mechanism that "shields" us from some of the stresses in life but sometimes doesn't do as good a job as it should do. This is called self-denial. When kayaking accidents make the news, it's often the same story: Paddlers didn't dress for the water and weren't prepared for the weather. With the risks so easily perceived, why did these kayakers ignore the clear threat to their lives? Professor Leach has an explanation for this. If your life is routinely comfortable and uneventful, your perception of a threat may be minimized by a feeling of having the odds in your favor—"It will never happen to me." The response to an imminent threat is generally, and surprisingly, one of inactivity and a failure to take any positive protective action.

People tend to reduce their awareness of personal threat to a level that they feel comfortable with. They will also ally themselves with other people in their group who appear similarly unconcerned about the threat. A consensus that something is not a serious risk produces a strong desire to conform to the group. This failure to acknowledge a risk is often made worse because preparation for dealing with a threat is often considered to be boring, inconvenient and costly.

Kayaking in water under 60°F is potentially very dangerous, and if you don't make the appropriate plans and preparations, it constitutes taking a very serious risk.

Know Your Enemy

You must dress according to the water temperature, not according to the air temperature. What you are wearing at the time of immersion is critical. If it is not on you or if it's not zipped up and ready for the water, it won't do the job you need it to do. If you wind up in the water, your immediate enemy is not hypothermia but drowning. Respiratory distress leading to water inhalation is most likely in the first few minutes of exposure to cold water and occurs well ahead of any symptoms of hypothermia. If you are well protected from the cold, the symptoms of cold shock should be minimal. If you experience any of its symptoms, your objective for the first 30 seconds to three minutes is to keep your nose and mouth out of the water. In those first few minutes, you should be very cautious about making decisions about what course of action to take.

Precautions

You can avoid paddling in cold water, but for most sea kayakers this is not really an option. Just remember: Once you start paddling in water 60°F or lower, you have entered the danger zone.

You can, in fact, acclimatize yourself to the cold water by taking daily cold showers for about three weeks, which will reduce the symptoms of cold shock for up to about one year. For some kayakers, that may be part of preparing for cold water. It is interesting to note that prisoners at Alcatraz were allowed to take only hot showers. By eliminating the possibility of acclimating to cold water, the prisoners were prevented from being able to prepare for a swim to escape. Be prepared for the effects of cold shock when you capsize. Hold onto your kayak for support until you can control your breathing before attempting a self-rescue or assisted rescue. You don't want to risk having your head get submerged if you can't hold your breath.

Always wear a flotation device. The buoyancy it provides is especially important immediately after a capsize and wet exit because it helps you keep your mouth above water while your breathing is erratic. The Canadian Red Cross has reported that 88 percent of canoe-related drowning victims and 67 percent of kayak-related drowning victims in the last 10 years were not wearing PFDs. Wear the best-performing PFD or life jacket you can find. Make sure that it fits well enough to keep from riding up when you are in the water. If you can't get the waist belt to cinch up under your rib cage, add a crotch strap to the PFD. Immersion clothing ranging from neoprene wetsuits to full dry suits will be needed depending on the trip. A neoprene cap will offer a useful measure of protection—a full hood even more, as it protects neck and ears. If you get too hot, you can always splash water on yourself and make use of evaporative cooling.

Practice capsizes regularly, starting in warmer water, then—with caution and very close to shore with a buddy, if not a group of kayakers—repeat the exercise in colder water. Practice a broad range of capsize recovery techniques. The more often you practice each technique in safe but realistic conditions, the more effective and reliable that particular schema will be when you need to resort to it in an emergency.

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Recommended reading: Essentials of Sea Survival, by Frank Golden and Michael J. Tipton (Human Kinetics, 2002); Survival Psychology, by John Leach (Macmillan Press, 1994).

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