CARE OF THE WILDERNESS ATHLETE

Pre-Participation Medical Evaluation for Adventure and Wilderness Watersports

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A request for a preparticipation medical evaluation for wilderness watersports may be made by guiding agencies, instructional camps, or by patients presenting for an annual visit. Although guidelines have been published regarding preparticipation physical evaluation for traditional competitive high school and collegiate sports, little has been written about medical evaluations for those wishing to engage in wilderness and adventure watersports. In this article, we offer guidance based on literature review and expert opinion. Watersports are among the most common recreational activities in the United States and are generally safe. Drowning, however, is a significant risk, particularly in small, self-propelled craft, and among children. Medical counseling before participation in watersports should include screening for medical conditions which may impair swimming ability, including a history of seizures, heart disease, and lung disease. Physicians should also promote preventive health measures such as use of lifejackets and sun protection, as well as alcohol avoidance. Swim testing tailored to specific activities should be strongly considered for children and those with questionable swimming ability.

Key words: kayaking, canoeing, sailing, surfing, injury, injury prevention, drowning

Introduction/Overview

The last 150 years have witnessed a rapid increase in participation in wilderness watersports on rivers, lakes, and oceans. Engaging in these sports is not without risk and athletes and adventurers alike may present to physicians before participation for consultation on risk reduction. Although the spectrum of watersports is broad and continues to expand, these sports can be loosely categorized by means of propulsion (eg, paddle, sail, hand) or by the environment in which they take place (eg, river, ocean, lakes).

Although guidelines have been published regarding preparticipation physical evaluation (PPE) for athletes competing in traditional high school and collegiate sports,¹ little has been written about such evaluations

for those wishing to engage in outdoor watersports. In this article, we provide guidance for physicians and athletes based on literature review and expert opinion.

Injury rates for most watersports are relatively low in comparison with many land-based sports.² This is likely due to the fact that water provides significant cushioning from impact, and because in watersports there are few collisions between athletes or between the athletes and the ground. Mechanisms of injury vary widely by watersport, but examination of the literature reveals a number of recurrent themes. Injuries from collisions with one's own equipment such as a surfboard after a wipeout, or the boom of a sailboat are common.^{3,4} Impact with submerged objects such as rocks can occur in white-watersports and in the surf.⁵ Finally, environmental exposures such as cold water, solar exposure, and hazardous marine animals also pose risks.⁴

Although overall injury rates in wilderness watersports are low, the risk of death, predominantly from drowning, is higher than that of many traditional competitive sports.⁶ The aqueous environment leaves little margin for error among aquatic athletes because humans have

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little natural buoyancy, limited breathholding capacity, and inadequate insulation from cold water.

The unique risks associated with wilderness watersports mandate that a preparticipation evaluation should focus on assessing acute and chronic medical conditions that may impair swimming ability, placing athletes at increased risk of drowning. The PPE is also an opportune time for physicians to encourage risk-mitigating behavior such as the use of life-jackets, wetsuits, and sunscreen, as well as avoidance of drugs and alcohol in and around the water. In sports such as offshore sailing or river rafting, where participants may be days or weeks away from definitive medical care, the consulting physician may also be asked to provide prescriptions to treat medical problems that commonly arise during these journeys such as seasickness, skin infections, and regional infectious diseases.

The aquatic athlete also bears significant responsibility for his or her own wellbeing. They must insure that their physical fitness, skill level, and swimming ability are commensurate with the physical challenges they are likely to face. They should be aware of current forecasts for relevant information regarding wind speed and direction, tide, wave height, water temperature, and river flow. As with other wilderness endeavors, the athlete should mentally work through worst-case scenarios and develop contingency plans for self-rescue. Ultimately, after medical consultation, the decision to participate in watersports rests with the athlete, who needs to consider not only the risks to their own health, but also the risks they may impose on would-be rescuers should they encounter trouble on the water.

The scope of this article is limited to nonmotorized watersports and does not include scuba diving.

Methods

Authors searched the MEDLINE database from 1980 to present via PubMed and OVID with the terms sailing,

surfing, rafting, kayaking, kitesurfing, canoeing, immersion hypothermia, as well as swimming and injuries. Studies were limited to the English language. Although most studies were descriptive and retrospective in nature, where possible, authors selected large-scale, prospective studies.

Discussion

EPIDEMIOLOGY OF WATERSPORTS INJURIES AND FATALITIES INJURY RATES, COMMON INJURIES AND MECHANISMS OF INJURY

For a summary of injury rates from selected sports see [Table 1](#). Please note that cross comparison between sports remains difficult because of heterogeneous definitions of injury, methods of data collection, and study design.¹³

SAILING

Rates of injury and severe injury in a survey of sailors were estimated to be 4.6 and 0.57 per 1000 days of sailing, respectively.¹⁰ Falls and injuries while handling lines and winches were the most common mechanisms of injury. Among professional sailors competing in large keelboats in the America's Cup, the injury rate was 5.7 injuries per 1000 hours of sailing.⁹ Most of these injuries were overuse sprains and strains of the back and shoulder. A study of the 635 nautical mile Newport-to-Bermuda race found an injury rate of 12 per 1000 races per sailor.¹⁴ Hand injuries were most common, followed by lacerations to the head. Among novice dinghy sailors, abrasions, contusions, and lacerations to the lower extremity and head were most common. These were mostly due to blows from the boom or occurred while the boat was being rigged.³ Many studies have found a strong positive correlation between wind speed and injury rates.^{3,14,15}

Table 1. Injury rates for selected watersports

<i>Sport</i>	<i>Population</i>	<i>Injury Rate</i>
Surfing	Competitive	6.6 significant injuries per 10 000 h ⁵
	Recreational	3.5 significant injuries per 1000 d ²
Kitesurfing	Heterogeneous group	7 injuries per 1000 d ⁷
Windsurfing	Recreational windsurfers	1 injury requiring medical care per 1000 d ⁸
Sailing	America's Cup	5.7 injuries per 1000 h ⁹
	Novice Dinghy Sailors	0.29 injuries per 1000 d ³
	Heterogeneous group	4.6 injuries per 1000 d, 0.57 significant injuries per 1000 d ¹⁰
Kayaking/canoeing	Whitewater	3.6-5.9 injuries per 1000 d ¹¹
		1.9 injuries requiring medical care per 1000 kayaking days ¹¹
Rafting	Commercial whitewater	0.26-0.44 injuries per 1000 d ¹²

Table 2. Boating fatality rates in 2011

Boat Type	Exposure Hours		Fatality Rate
	(In Millions)	Fatalities	per 100 Million Hours
Kayak	133	68	51
Canoe	90	66	73
Sailboat	71	26	39
Row/inflatable	194	82	42

Adapted from 2011 USCG National Recreational Boating Survey.⁶ Adaptations are themselves works protected by copyright. So in order to publish this adaptation, authorization must be obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.

SURFING

A study of recreational surfers reported an injury rate of 3.5 per 1000 days.² Another study of recreational surfers found that the most common injuries were lacerations (42%) and contusions (13%) predominantly to the head and lower extremities. Sixty-seven percent of injuries were caused by collisions with a surfboard and 17% by contact with the sea floor.⁴ Most lacerations were due to impacts with sharp edges of the board such as fins, nose, and tail. Competitive surfers have been shown to have higher rates of injuries, with rates of 4 injuries per 1000 surfing days and 6.6 per 1000 competitive surfing heats.^{5,16}

WHITEWATER KAYAK, CANOE, RAFTING

Injury rates for whitewater kayaking have been reported to be 3.6 to 5.9 per 1000 paddler days with half of the injured kayakers seeking medical care.¹¹ The incidence of injury among commercial rafters was found to be lower, with 0.26 to 0.44 injuries per 1000 days.¹² Among competitive slalom paddlers, the incidence of injury was found to be 10 times higher during competition than during training.¹⁷ Although hand blisters were the most common minor injury among whitewater kayakers, with an incidence of 30% to 90%,¹¹ shoulder dislocations, caused by paddling with the arm in an overhead position are the most common major injury with 15% of respondents to a survey reporting at least 1 dislocation.¹⁷ Most rafting injuries are lacerations and contusions caused by collisions between rafters or with paddles. Approximately 40% of injuries occur when rafters are ejected from the raft and collide with rocks in the riverbed while swimming.¹²

FATALITY RATES

With the exception of boating, there are dearth of data regarding watersports fatalities and fatality rates. The National Recreational Boating Survey reported 758

boating- related fatalities in US waters in 2011 (including power boats).⁶ Eighty percent of those fatalities occurred in boats less than 21 feet in length. Risk factors for fatal boating accidents include boater inexperience, stormy weather, strong currents, and alcohol use.^{6–8,15} Fatality rates and annual numbers of fatalities for canoes, kayaks, sailboats, and rowboats/ inflatable boats are listed in [Table 2](#).

PERSONAL HEALTH HISTORY

The PPE for watersports should screen for conditions related to the reasons for morbidity and mortality across the different watersports, such as cold water immersion, or personal health issues that would impair swimming ability including seizures, syncope, and cardiopulmonary disease. See [Table 3](#) for potential health screening questions.

Clinicians should adjust history questions to the individual sports and activities athletes will be engaging in based on the information presented in the sections on specific topics below. Beyond health-specific history questions, it is helpful to assess planning, training, knowledge, and skill regarding activity-related risks, emergencies, and mechanisms of injury and death.

SEIZURE DISORDERS

For individuals with seizure disorders, the risk of drowning is increased 15-fold to 19 fold compared with

Table 3. Questions for preparticipation evaluation of watersports

<i>Potential Health History Screening Questions</i>
How well can you swim?
Are you comfortable swimming in the open ocean?
Do you have a history of seizures?
When was your last seizure?
How long have you been on your current dose of medication?
Do you have a history of syncope or fainting episodes?
Do you have heart disease, angina, or a family history of heart disease?
Do you have a family history of sudden death in relatives who were 40 yrs old or younger?
Do you cough, wheeze, have difficulty breathing during or after exercise or have a history of asthma or other breathing disease?
Have you ever used an inhaler or taken an asthma medication?
Do your symptoms get worse with activity or exercise?
Do your symptoms get worse in the cold?
Do you have a history of neck problems, injury, or surgery?
Do you have a history of shoulder dislocations or surgery?
Do you have a history of motion sickness?

the general population.¹⁸ Individuals with uncontrolled seizure disorders should be prohibited from participating in swimming sports. For other watersports such as sailing, they should be given restrictions (eg, no solo-sailing, must wear life jacket). Individuals with epilepsy who have been seizure-free for 5 years and are not taking antiseizure medications may be allowed to participate in watersports, but should be informed to avoid hyperventilation as this may increase the risk of seizure.¹⁹

CARDIAC CONDITIONS

A history of risk factors for heart disease should prompt consideration of a cardiac workout as myocardial infarction (MI) is known cause of drowning, particularly in cold water. Individuals with a recent cardiac event should not participate in vigorous watersports activity until cleared for equivalent exertion in land-based activities.

Individuals with a history of unexplained syncope should be evaluated for channelopathies including long QT syndrome or other arrhythmias, as this may be a cause of some cold-water immersion deaths.²⁰

LUNG DISEASE

Patients with asthma should be questioned carefully on triggers. A cold-induced trigger should prompt further evaluation and/or limitations on activity (eg, no solo swimming and having an inhaler nearby). Other breathing problems such as chronic obstructive pulmonary disease (COPD) must also be carefully evaluated for stability before participation. In general, individuals with pulmonary function tests more than 2 SD below normal should not participate in scuba diving or other strenuous water sports.²¹

IMMUNE COMPROMISED CONDITIONS

Wounds acquired in the marine environment are at high risk of becoming infected with gram-negative bacteria such as *Vibrio vulnificus*. These bacteria can cause serious illness if not promptly treated, even in immunocompetent individuals. Physicians should counsel immunocompromised individuals and those with liver disease who will be going into water-based environments about infection prevention and signs of early infection. They should also consider prescribing a course of antibiotics (ciprofloxacin, doxycycline) to be carried by the patient while traveling, particularly to locations with limited medical services.²²

MUSCULOSKELETAL CONDITIONS

A history of cervical spine problems or surgery and age more than 40 years increase the risk of spinal cord injury in sports that take place in the surf.²³ Individuals with a

history of either recurring shoulder dislocations that have not been surgically repaired or of a recent dislocation face an increased risk for shoulder dislocations in overhead sports such as swimming, surfing, and kitesurfing, which may make return to shore difficult. In addition, any other orthopedic condition that potentially impairs the ability to swim should be assessed.

OTHER CONDITIONS

A history of motion sickness may be relevant particularly for sailing. Individuals with a history of severe motion sickness should be encouraged to trial anti-motion sickness medications while still on land to assess the severity of sedating and anticholinergic side effects that are common with transdermal scopolamine and to a lesser extent dimenhydrinate.

PHYSICAL EXAMINATION

A general preparticipation physical examination such as described in PPE 4th edition is recommended.¹ However, a face-to-face encounter may not be practical as in the case of a physician reviewing health history forms for a guided expedition. Referral to a specialist or swimming instructor for fitness testing may be relevant if concerns arise in the history. Swim testing, tailored to the planned activity, should be considered for children, and those of questionable swimming ability.

Special attention should be given to potential problems found on the PPE history as described above. Areas that merit attention include the following: (1) the shoulder for stability, range of motion, and rotator cuff strength; (2) cervical spine range of motion, upper extremity neurological examination; (3) ears for perforated tympanic membrane and external auditory canal lesions, especially important for participants in cold water activities who are at increased risk for surfer's ear; (4) lungs for wheezing, airflow limitation, and obstruction; (5) heart for murmurs; and (6) skin for any open sores or infections so appropriate precautions may be taken. The inclusion of testing such as an electrocardiogram in the presence of coronary disease risk factors is controversial, with the US Preventive Services Task Force (USPSTF) and the PPE Monograph 4th edition stating that insufficient evidence exists to determine the benefits and harm of exercise stress testing before exercise programs and recommending against any screening tests in the absence of risk factors.^{1,24}

DROWNING

Drowning is a major cause of morbidity and mortality in watersports. It is the fifth leading cause of accidental

death in the United States in all age groups and second among children. According to a 2013 US Coast Guard report, drowning accounted for 77% of all boating fatalities, and 84% of victims were not wearing a life jacket.²⁵ A formal discussion of this topic highlighting known risk factors for drowning will be helpful to an evaluator performing a PPE for watersports.

TERMINOLOGY

The term “drowning” is commonly used, but the definitions used to describe such an event can be confusing. In 2002, the World Health Organization defined drowning as the “process of experiencing respiratory impairment from submersion/immersion in liquid.”²⁶ The publication further clarifies that the only outcomes of drowning are death, morbidity, or no morbidity. The terms fatal drowning, nonfatal drowning, and drowning incident are acceptable descriptions of these 3 different types of events. Other terms such as near-drowning, dry drowning, and secondary drowning should be abandoned because they are not standardized and lead to confusion.^{27,28}

PATHOPHYSIOLOGY

The drowning process begins with respiratory impairment as the person’s airway goes below the surface of the liquid (submersion) or water splashes over the face (immer-sion).²⁷ If another breath cannot be obtained in the next few minutes, involuntary gasping will lead to aspiration of fluid and/or laryngospasm. Aspiration causes washout of surfactant, which leads to alveolar collapse, increased pulmonary shunt, and decreased lung compliance. Aspirated water also causes damage to capillary membranes resulting in severe pulmonary edema and bronchospasm. Both laryngospasm and aspiration can rapidly lead to hypoxia and subsequent unconsciousness over the next few minutes.

The general paradigm for rescuers should be to aid victims without placing themselves at extreme risk. A panicking victim can easily turn a rescuer into a second drowning victim if caution is not used. Therefore, if possible, a stick or paddle should be extended to a victim within reach, and lines or flotation devices can be thrown to victims out of reach. In-water rescues are notoriously dangerous and should only be attempted by trained individuals equipped with a flotation device.²⁹

RISK FACTORS

A number of factors can increase the risk of drowning. One phenomenon is described as shallow water blackout. Many swimmers and free divers hyperventilate to

prolong underwater breath holding with the mistaken belief that they are increasing oxygenation. In fact, hyperventilation improves breath-holding times because it induces hypocapnia. When swimming underwater after hyperventilating, oxygen may become depleted before rising CO₂ levels (which largely control respiratory drive) give the free diver a strong urge to breathe. Severe hypoxia can lead to underwater syncope among free divers, spear fishermen, or other swimmers trying to increase the time between breaths.³⁰ An explanation of the physiology behind shallow water blackout during the PPE may prevent this dangerous behavior.

Another important message is that no one is “drown proof.” Although the risk of drowning decreases substantially in individuals who have successfully completed swimming lessons, 35% of drowning victims are accomplished swimmers.^{31,32} Other risk factors for drowning include alcohol, as well as medical issues such as seizure, syncope, hypoglycemia, MI, COPD, and asthma.³³

SPECIFIC CONDITIONS AND ENVIRONMENTS

Wilderness watersports take place in a wide variety of settings, many of which can pose unique health threats to the aquatic athlete. Clinicians performing PPEs need to be aware of the following environmental considerations when assessing athletes who wish to engage in outdoor watersports. Knowledge of these areas will help guide clinicians in assessing preparation, knowledge, skill, and conditions or injuries that may threaten safe participation.

COLD WATER

Cold water, usually defined as <10°C (50°F), conducts heat 25 times as quickly as air of the same temperature and presents 2 life-threatening problems to those who fall into the water without proper gear: (1) the “cold-shock response” and (2) hypothermia.

COLD-SHOCK RESPONSE

The cold-shock response is mediated by skin-temperature receptors that trigger an adrenergic surge upon immersion in cold water resulting in uncontrollable hyperventilation and panic lasting for 1 to 2 minutes. Many cold-water immersion victims, unable to hold their breath for more than a few seconds, aspirate water at this stage and drown. Those with underlying cardiac disease can develop fatal arrhythmias or MI, a condition termed “immersion syndrome.”³⁴

Immersion victims who survive the initial cold-shock response have approximately 10 to 15 minutes of functional swimming time before their muscles cool off, their extremities become stiff, and they are no longer able to

swim or keep their heads above water. These facts have led to the “1 to 10 to 1” rule for cold-water survival. A victim falling into cold water has 1 minute to control their breathing, 10 minutes of meaningful swimming activity, and 1 hour before they lose consciousness from hypothermia.³⁵

HYPOTHERMIA

Hypothermia, defined as a core temperature of $<35^{\circ}\text{C}$ (95°F) occurs when the body's ability to produce heat is overwhelmed by heat loss to the environment.³⁶ Watersports enthusiasts are at high risk of hypothermia if they are not wearing appropriate insulating garments and fall into cold water or are exposed to cold, wet, and windy conditions for prolonged periods of time. Presuming flotation is not an issue, an adult male of average size who is immersed in ice-cold water can survive for approximately 45 minutes before succumbing to hypothermia. Survival time in water of $50^{\circ}\text{F}/10^{\circ}\text{C}$ is 2 to 5 hours, depending on body habitus, clothing, wind speed, and other factors.³⁷

Early symptoms of hypothermia include shivering, incoordination, and loss of fine motor skill, making it difficult to perform life-saving tasks such as tying a knot or fastening a buckle.³⁸ With moderate to severe hypothermia, the victim ceases shivering, loses strength, and displays poor judgment. Untreated, this progresses to stupor, and a decline in heart rate, respiratory rate, and blood pressure. Death is often preceded by ventricular fibrillation.

Sport-specific insulating clothing significantly prolongs survival times in cold water and effectively blunts the cold-shock response. In-water athletes (eg, surfers and swimmers) should wear wetsuits designed for ambient water temperatures. Cold-water kayakers, canoeists, and dinghy sailors should dress in preparation for capsize and wear lifejackets as well as dry suits or wetsuits that will allow them to remain functional in the water and facilitate self-rescue. Offshore sailors should carry immersion survival suits on board and practice donning them quickly should they be forced to abandon ship.

Potentially life-saving advice that should be incorporated in the PPE for cold-water sports includes the facts that (1) small boaters should always be prepared to fall into the water, and (2) when falling into cold water, it is critical to maintain one's airway above the surface during the initial phase of uncontrollable hyperventilation. These symptoms will subside in 1 to 2 minutes, followed by 10 or more minutes of functional activity.

TROPICAL REEF ENVIRONMENT

Tropical waters are home to a wide variety of hazardous marine animals capable of stinging, puncturing or biting

surfers, and ocean swimmers. Jellyfish are the most commonly implicated stinging animals, but with rare exceptions cause nothing more than painful wheals that are self-limited. Jellyfish stings can be avoided by wearing wetsuits or “rash guards.” Wounds suffered in tropical waters have a high incidence of infection due to the fact that warm seawaters harbor high bacterial counts and many wounds are contaminated with coral fragments, sand, and other organic material.²²

Individuals with a history of severe allergic reactions to jellyfish should be given prescriptions for oral diphenhydramine, steroids, and auto-injectable epinephrine.²²

NEAR-SHORE SURF

A wide range of sports including bodysurfing, stand-up paddle surfing, and surf kayaking take place in the surf. Within the surf zone are a number of powerful, dynamic, hydraulic forces that can create hazards for the inexperienced athlete.

The biggest threats in the surf come from being forcefully held underwater by a wave's turbulence and drowning, or from being sucked up by the lip of a breaking wave and then slammed onto the sea floor. Hollow plunging waves created by a steeply sloping sea floor are more dangerous than gradual, crumbling waves produced by gently inclined bottoms.²³ Novice surfers more than 40 years or those with a history of cervical spine problems should be advised to avoid hollow shore breaks as they are associated with increased risk of cervical spine fracture due to forced neck hyperflexion and hyperextension.²³

More than 80% of lifeguard rescues at US beaches occur seaward flowing river-like currents known as rip currents.³⁹ Swimmers attempting to swim ashore against outflowing rips can easily tire and drown. Those caught in a rip should swim parallel to the shoreline until they encounter an area of breaking waves where they will be pushed shoreward.

Beginner surfers often become overly dependent on their boards as a flotation device. Surfboard leashes (tethers) can break under the strain of big waves, often leading to a long swim back to shore. Before engaging in surf sports, novices should be encouraged to become strong, confident swimmers, become familiar with rip currents, and be reminded of the Hawaiian lifeguard mantra “when in doubt, don't paddle out.”

WHITEWATER

According to the Outdoor Foundation, approximately 1.9 million Americans went whitewater kayaking and 3.7 million went whitewater rafting in 2012.⁴⁰ The whitewater environment can be dangerous for both the

newcomer attempting to run rapids that are too difficult and the advanced paddler taking on more dangerous rapids.⁴¹ Common hazards include hydraulics, strainers, and flash floods.⁴¹

Hydraulics (also known as holes, reversals, rollers, suck holes, and pour overs) are formed where water flows over an object and curls back on itself, forming a strong upstream current. The water is often white and aerated, decreasing buoyancy, and hiding potential rocks in the riverbed. Especially dangerous, are concealed undercut rocks and low-head dams whose currents can trap a swimmer underwater and hold rafts, canoes, and kayaks upside down. Although most hydraulics release swimmers, others may require that the swimmer escape by swimming down toward the riverbed where the current will push them downstream.⁴¹

Strainers are objects such as tree branches or bridge pilings that allow water to pass through but can pin boats and boaters. Due to the enormous hydraulic forces created by strainers, paddlers are often unable to extricate themselves and drown. Often there is little water surface warning of the danger.⁴¹

In addition to obstacles, weather can play a large factor in whitewater. Heavy rains, snow melt, or planned dam releases can rapidly increase water flow, increasing a river's speed and power, raising the difficulty of most rapids.⁴²

Whitewater neophytes should be encouraged to learn about hazards associated with rapids and practice self-righting maneuvers (ie, Eskimo rolls) in a supervised setting before attempting any rapids.

Conclusions/Recommendations

A preparticipation evaluation for watersports may be requested by guiding agencies, instructional camps, or by patients presenting for an annual visit. This evaluation can serve an important role in decreasing the risk of morbidity and mortality among athletes and adventurers participating in watersports. Drowning is the major life threat; therefore, the evaluation and counseling should emphasize issues to decrease the risk of drowning. The status of chronic health conditions that may impede swimming ability, such as epilepsy, cardiovascular disease, and asthma should be reviewed. A functional assessment of swimming ability, tailored to specific activities should be considered, particularly among those new to watersports, or those with questionable swimming ability. Clinicians should also reinforce preventive health measures such as the use of life jackets and sunscreen, and the avoidance of alcohol and narcotics. Screening for orthopedic conditions, which increase risk of shoulder dislocation and cervical spine injury, is also

important. Watersports enthusiasts should be strong swimmers, dress appropriately for ambient water temperatures, and be in tune with local weather forecasts and water conditions for optimal safety and enjoyment.

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