does not cease until after the seaplane has passed out of the critical range by a degree or two.

If porpoising occurs due to a nose-low planing attitude, stop it by applying timely back pressure on the elevator control to prevent the bows of the floats from digging into the water. The back pressure must be applied and maintained until porpoising stops. If porpoising does not stop by the time the second oscillation occurs, reduce the power to idle and hold the elevator control back firmly so the seaplane settles onto the water with no further instability. Never try to "chase" the oscillations, as this usually makes them worse and results in an accident.

Pilots must learn and practice the correct pitch attitudes for takeoff, planing, and landing for each type of seaplane until there is no doubt as to the proper angles for the various maneuvers. The upper and lower limits of these pitch angles are established by the design of the seaplane; however, changing the seaplane's gross weight, wing flap position, or center of gravity location also changes these limits. Increased weight increases the displacement of the floats or hull and raises the lower limit considerably. Extending the wing flaps frequently trims the seaplane to the lower limit at lower speeds, and may lower the upper limit at high speeds. A forward center of gravity increases the possibility of high angle porpoising, especially during landing.

SKIPPING

Skipping is a form of instability that may occur when landing at excessive speed with the nose at too high a pitch angle. This nose-up attitude places the seaplane at the upper trim limit of stability and causes the seaplane to enter a cyclic oscillation when touching the water, which results in the seaplane skipping across the surface. This action is similar to skipping flat stones across the water. Skipping can also occur by crossing a boat wake while taxiing on the step or during a takeoff. Sometimes the new seaplane pilot confuses a skip with a porpoise, but the pilot's body sensations can quickly distinguish between the two. A skip gives the body vertical "G" forces, similar to bouncing a landplane. Porpoising is a rocking chair type forward and aft motion feeling.

To correct for skipping, first increase back pressure on the elevator control and add sufficient power to prevent the floats from contacting the water. Then establish the proper pitch attitude and reduce the power gradually to allow the seaplane to settle gently onto the water. Skipping oscillations do not tend to increase in amplitude, as in porpoising, but they do subject the floats and airframe to unnecessary pounding and can lead to porpoising.

TAKEOFFS

A seaplane takeoff may be divided into four distinct phases: (1) The displacement phase, (2) the hump or plowing phase, (3) the planing or on the step phase, and (4) the lift-off.

The displacement phase should be familiar from the taxiing discussion. During idle taxi, the displacement of water supports nearly all of the seaplane's weight. The weight of the seaplane forces the floats down into the water until a volume that weighs exactly as much as the seaplane has been displaced. The surface area of the float below the waterline is called the wetted area, and it varies depending on the seaplane's weight. An empty seaplane has less wetted area than when it is fully loaded. Wetted area is a major factor in the creation of drag as the seaplane moves through the water.

As power is applied, the floats move faster through the water. The water resists this motion, creating drag. The forward portion of the float is shaped to transform the horizontal movement through the water into an upward lifting force by diverting the water downward. Newton's Third Law of Motion states that for every action, there is an equal and opposite reaction, and in this case, pushing water downward results in an upward force known as hydrodynamic lift.

In the plowing phase, hydrodynamic lift begins pushing up the front of the floats, raising the seaplane's nose and moving the center of buoyancy aft. This, combined with the downward pressure on the tail generated by holding the elevator control all the way back, forces the rear part of the floats deeper into the water. This creates more wetted area and consequently more drag, and explains why the seaplane accelerates so slowly during this part of the takeoff.

This resistance typically reaches its peak just before the floats are placed into a planing attitude. Figure 4-14 shows a graph of the drag forces at work during a seaplane takeoff run. The area of greatest resistance is referred to as the hump because of the shape of the water drag curve. During the plowing phase, the increasing water speed generates more and more hydrodynamic lift. With more of the weight supported by hydrodynamic lift, proportionately less is supported by displacement and the floats are able to rise in the water. As they do, there is less wetted area to cause drag, which allows more acceleration, which in turn increases hydrodynamic lift. There is a limit to how far this cycle can go, however, because as speed builds, so does the amount of drag on the remaining wetted area. Drag increases as the square of speed, and eventually drag forces would balance the power output of the engine and the seaplane would continue along the surface without further acceleration.

Seaplanes have been built with sufficient power to accelerate to takeoff speed this way, but fortunately the step was invented, and it makes further acceleration possible without additional power. After passing over the hump, the seaplane is traveling fast enough that its weight can be supported entirely by hydrodynamic lift. Relaxing the back pressure on the elevator control allows the float to rock up onto the step, and lifts the

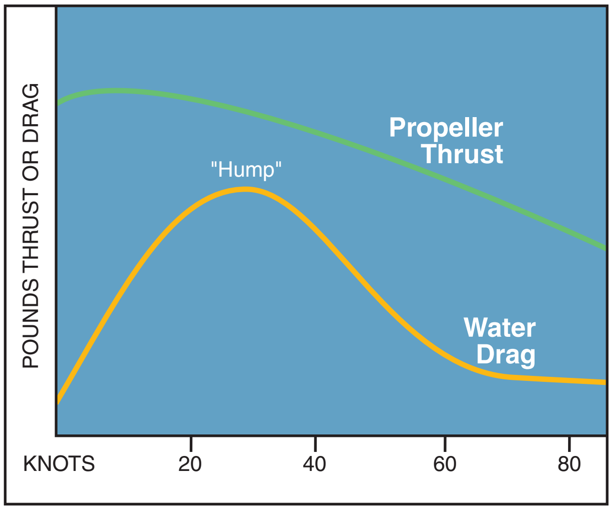

Figure 4-14. This graph shows water drag and propeller thrust during a takeoff run.

rear portions of the floats clear of the water. This eliminates all of the wetted area aft of the step, along with the associated drag.

As further acceleration takes place, the flight controls become more responsive, just as in a landplane. Elevator deflection is gradually reduced to hold the required planing attitude. As the seaplane continues to accelerate, more and more weight is being supported by the aerodynamic lift of the wings and water resistance continues to decrease. When all of the weight is transferred to the wings, the seaplane becomes airborne.

Several factors greatly increase the water drag or resistance, such as heavy loading of the seaplane or glassy water conditions. In extreme cases, the drag may exceed the available thrust and prevent the seaplane from becoming airborne. This is particularly true when operating in areas with high density altitudes (high elevations/high temperatures) where the engine cannot develop full rated power. For this reason the pilot should practice takeoffs using only partial power to simulate the longer takeoff runs needed when operating where the density altitude is high and/or the seaplane is heavily loaded. This practice should be conducted under the supervision of an experienced seaplane instructor, and in accordance with any cautions or limitations in the AFM/POH. Plan for the additional takeoff area required, as well as the flatter angle of climb after takeoff, and allow plenty of room for error.

Use all of the available cues to verify the wind direction. Besides reading the water, pick up clues to the wind's direction from wind indicators and streamers on the masts of moored boats, flags on flagpoles, or rising smoke. A boat moored to a buoy points into the wind, but be aware that it may have a stern anchor as well, preventing it from pointing into the wind. Waterfowl almost always align themselves facing into the wind.

Naturally, be sure you have enough room for takeoff. The landing distance of a seaplane is much shorter than that required for takeoff, and many pilots have landed in areas that have turned out to be too short for takeoff. If you suspect that the available distance may be inadequate, consider reducing weight by leaving some of your load behind or wait for more favorable weather conditions. A takeoff that would be dangerous on a hot, still afternoon might be accomplished safely on the following morning, with cooler temperatures and a brisk wind.

In addition to wind, consider the effects of the current when choosing the direction for takeoff. Keep in mind that when taxiing in the same direction as the current, directional control may be reduced because the seaplane is not moving as quickly through the water. In rivers or tidal flows, make crosswind or calm wind takeoffs in the same direction as the current. This reduces the water forces on the floats. Suppose the seaplane lifts off at 50 knots and the current is 3 knots. If winds are calm, the seaplane needs a water speed of 47 knots to take off downstream, but must accelerate to a water speed of 53 knots to become airborne against the current. This difference of 6 knots requires a longer time on the water and generates more stress on the floats. The situation becomes more complex when wind is a factor. If the wind is blowing against the current, its speed can help the wings develop lift sooner, but will raise higher waves on the surface. If the wind is in the same direction as the current, at what point does the speed of the wind make it more worthwhile to take off against the current? In the previous example, a wind velocity of 3 knots would exactly cancel the benefit of the current, since the air and water would be moving at the same speed. In most situations, take off into the wind if the speed of the wind is greater than the current.

Unlike landplane operations at airports, many other activities are permitted in waters where seaplane operations are conducted. Seaplane pilots encounter a variety of objects on the water, some of which are nearly submerged and difficult to see. These include items that are stationary, such as pilings and buoys, and those that are mobile, like logs, swimmers, water skiers, and a variety of watercraft. Before beginning the takeoff, it is a good practice to taxi along the intended takeoff path to check for any hazardous objects or obstructions.

Make absolutely sure the takeoff path ahead is free of boats, swimmers, and other water traffic, and be sure it will remain so for the duration of the takeoff run. Powerboats, wind-surfers, and jet-skis can move quickly and change direction abruptly. As the seaplane's nose comes up with the application of full power, the view ahead may be completely blocked by the cowling. Check to the sides and behind the seaplane as well as straight ahead, since many watercraft move much faster than the normal taxi speed and may be passing the seaplane from behind. In addition to the vessels themselves, also scan for their wakes and try to anticipate where the wakes will be during takeoff. Operators of motorboats and other watercraft often do not realize the hazard caused by moving their vessels across the takeoff path of a seaplane. It is usually better to delay takeoff and wait for the swells to pass rather than encountering them at high speed. Even small swells can cause dangerous pitching or rolling for a seaplane, so taxi across them at an angle rather than head-on. Remember to check for other air traffic and make any appropriate radio calls.

Be sure to use the pre-takeoff checklist on every takeoff. All checks are performed as the seaplane taxies, including the engine runup. Hold the elevator control all the way back throughout the runup to minimize spray around the propeller. If there is significant wind, let the seaplane turn into the wind for the runup. As r.p.m. increases, the nose rises into the plowing position and the seaplane begins to accelerate. Since this is a relatively unstable position, performing the runup into the wind minimizes the possibility of crosswinds, rough water, or gusts upsetting the seaplane. Waste no time during the runup checks, but be thorough and precise. Taxi speed will drop as soon as the power is reduced.

Water rudders are normally retracted before applying takeoff power. The buffeting and dynamic water pressure during a takeoff can cause serious damage if the water rudders are left down.

As full power is applied during takeoff in most seaplanes, torque and P-factor tend to force the left float down into the water. Right rudder pressure helps to maintain a straight takeoff path. In some cases, left aileron may also help to counter the tendency to turn left at low speeds, by increasing drag on the right side of the seaplane.

Density altitude is particularly important in seaplane flying. High, hot, and humid conditions reduce engine power and propeller efficiency, and the seaplane must also attain a higher water speed in order to generate the lift required for takeoff. This increase in water speed means overcoming additional water drag. All of these factors combine to increase takeoff distances and decrease climb performance. In high density altitude conditions, consider not only the length of the water run, but the room required for a safe climbout as well. The land area around a body of water is invariably somewhat higher than the water surface. Tall trees are common along shorelines, and in many areas, steep or mountainous terrain rises from the water's edge. Be certain the departure path allows sufficient room for safe terrain clearance or for a wide climbing turn back over the water.

There are specific takeoff techniques for different wind and water situations. Large water areas almost always allow a takeoff into the wind, but there are occasionally circumstances where a crosswind or downwind takeoff may be more appropriate. Over the years, techniques have evolved for handling rough water or a glassy smooth surface. Knowing and practicing these techniques not only keep skills polished so they are available when needed, they also increase overall proficiency and add to the enjoyment of seaplane flying.

NORMAL TAKEOFFS

Make normal takeoffs into the wind. Once the wind direction is determined and the takeoff path chosen, configure the seaplane and perform all of the pre-takeoff checks while taxiing to the takeoff position. Verify that the takeoff will not interfere with other traffic, either on the water's surface or in the air.

Hold the elevator control all the way back and apply full power smoothly and quickly, maintaining directional control with the rudder. When the nose reaches its highest point, ease the back pressure to allow the seaplane to come up on the step. Establish the optimum planing attitude and allow the seaplane to accelerate to lift-off speed. In most cases, the seaplane lifts off as it reaches flying speed. Occasionally it may be necessary to gently help the floats unstick by either using some aileron to lift one float out of the water or by adding a small amount of back pressure on the elevator control. Once off the water, the seaplane accelerates more quickly. When a safe airspeed is achieved, establish the pitch attitude for the best rate of climb (V_Y) and complete the climb checklist. Turn as necessary to avoid overflying noise-sensitive areas, and reduce power as appropriate to minimize noise.

CROSSWIND TAKEOFFS

In restricted or limited areas such as canals or narrow rivers, it is not always possible to take off or land directly into the wind. Therefore, acquiring skill in crosswind techniques enhances the safety of seaplane operation. Crosswinds present special difficulties for seaplane pilots. The same force that acts to lift the upwind wing also increases weight on the downwind float, forcing it deeper into the water and increasing drag on that side. Keep in mind that the allowable crosswind component for a floatplane may be significantly less than for the equivalent landplane.

A crosswind has the same effect on a seaplane during takeoff as on a landplane, that is, it tends to push the seaplane sideways across the takeoff path, which imposes side loads on the landing gear. In addition, wind pressure on the vertical tail causes the seaplane to try to weathervane into the wind.

At the beginning of the takeoff roll in a landplane, drift and weathervaning tendencies are resisted by the friction of the tires against the runway, usually assisted by nosewheel steering, or in some cases even differential braking. The objective in a crosswind takeoff is the same in landplanes and seaplanes: to counteract drift and minimize the side loads on the landing gear.

The sideways drifting force, acting through the seaplane's center of gravity, is opposed by the resistance of the water against the side area of the floats. This creates a force that tends to tip the seaplane sideways, pushing the downwind float deeper into the water and lifting the upwind wing. The partly submerged float has even more resistance to sideways motion, and the upwind wing displays more vertical surface area to the wind, intensifying the problem. Without intervention by the pilot, this tipping could continue until the seaplane capsizes.

During a takeoff in stiff crosswinds, weathervaning forces can cause an uncontrolled turn to begin. As the turn develops, the addition of centrifugal force acting outward from the turn aggravates the problem. The keels of the floats resist the sideways force, and the upwind wing tends to lift. If strong enough, the combination of the wind and centrifugal force may tip the seaplane to the point where the downwind float submerges and subsequently the wingtip may strike the water. This is known as a waterloop, and the dynamics are similar to a groundloop on land. Although some damage occurs when the wingtip hits the ground during a groundloop, the consequences of plunging a wingtip underwater in a seaplane can be disastrous. In a fully developed waterloop, the seaplane may be severely damaged or may capsize. Despite these dire possibilities, crosswind takeoffs can be accomplished safely by exercising good judgment and proper piloting technique.

Since there are no clear reference lines for directional guidance, such as those on airport runways, it can be difficult to quickly detect side drift on water. Waves may make it appear that the water is moving sideways, but remember that although the wind moves the waves, the water remains nearly stationary. The waves are simply an up-and-down motion of the water surface—the water itself is not moving sideways. To maintain a straight path through the water, pick a spot on the shore as an aim point for the takeoff run. On the other hand, some crosswind techniques involve describing a curved path through the water. Experience will help determine which technique is most appropriate for a given situation.

CONTROLLED WEATHERVANING

In light winds, it is easy to counteract the weathervaning tendency during the early part of the takeoff run by creating an allowance for it from the beginning. Prior to adding takeoff power, use the water rudders to set up a heading somewhat downwind of the aim point. The angle will depend on the speed of the wind—the higher

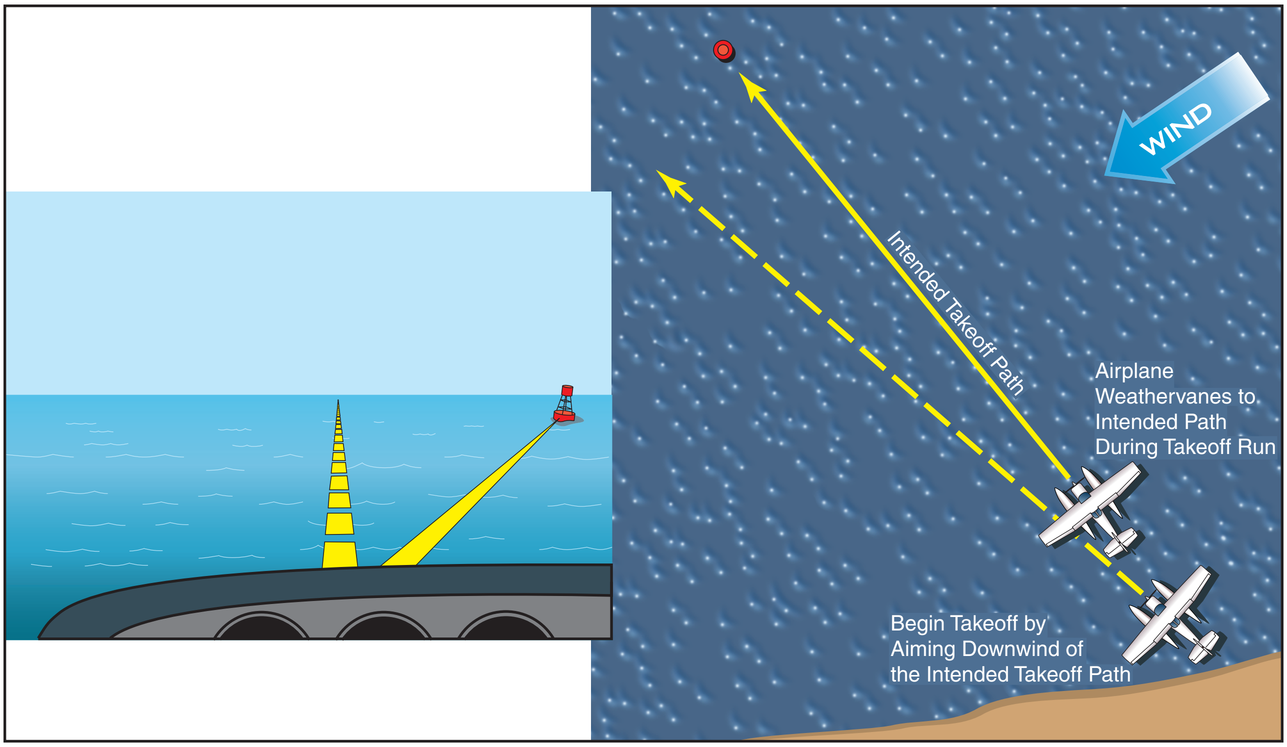

Figure 4-15. Anticipate weathervaning by leading the aim point, setting up a somewhat downwind heading prior to starting the takeoff. Choose an aim point that does not move, such as a buoy or a point on the far shore.

the wind, the greater the lead angle. Create just enough of a lead angle so that when the water rudders are raised and power is applied, the seaplane weathervanes to the desired heading during the time it gains enough speed to make the air rudder and ailerons effective. As the seaplane transitions to the plowing attitude, the weathervaning tendency decreases as the fronts of the floats come out of the water, adding vertical surface area at the front of the seaplane. Use full aileron into the wind as the takeoff run begins, and maintain enough aileron to keep the upwind wing from lifting as airspeed builds. [Figure 4-15 on previous page]

USING WATER RUDDERS

Another technique for maintaining a straight takeoff path involves leaving the water rudders down to assist with steering. Using the water rudders provides added directional control until the aerodynamic controls become effective.

To use this technique, align the seaplane with the aim point on the shore, hold full aileron into the wind, and apply takeoff power. As the seaplane accelerates, use enough aileron pressure to keep the upwind wing down. The downwind float should lift free of the water first. After lift-off, make a coordinated turn to establish the proper crab angle for the climb, and retract the water rudders.

This takeoff technique subjects the water rudders to high dynamic water pressures and could cause damage. Be sure to comply with the advice of the float manufacturer. [Figure 4-16]

DOWNWIND ARC

The other crosswind takeoff technique results in a curved path across the water, starting somewhat into the wind and turning gradually downwind during the takeoff run. This reduces the actual crosswind component at the beginning of the takeoff, when the seaplane is most susceptible to weathervaning. As the aerodynamic controls become more effective, the pilot balances the side loads imposed by the wind with the skidding force of an intentional turn, as always, holding the upwind wing down with the ailerons. [Figure 4-17]

The pilot plans a curved path and follows this arc to produce sufficient centrifugal force so that the seaplane tends to lean outward against the wind force. During the run, the pilot can adjust the rate of turn by varying rudder pressure, thereby increasing or decreasing the centrifugal force to compensate for a changing wind force. In practice, it is quite simple to plan sufficient curvature of the takeoff path to cancel out strong crosswinds, even on very narrow rivers. Note that the tightest part of the downwind arc is when the seaplane is traveling at slower speeds.

The last portion of a crosswind takeoff is somewhat similar to a landplane. Use ailerons to lift the downwind wing, providing a sideways component of lift to counter the effect of the crosswind. This means that the downwind float lifts off first. Be careful not to drop the upwind wing so far that it touches the water. When using a straight takeoff path, keep the nose on the aim point with opposite rudder and maintain the proper step attitude until the other float lifts off. Unlike a landplane, there is usually no advantage in holding the seaplane on the water past normal lift-off speed, and doing so may expose the floats to unnecessary pounding as they splash through the waves. Once airborne, make a coordinated turn to the crab angle that results in a straight track toward the aim point, and pitch to obtain the desired climb airspeed.

Again, experience plays an important part in successful operation during crosswinds. It is essential that all seaplane pilots have thorough knowledge and skill in these maneuvers.

DOWNWIND TAKEOFFS

Downwind takeoffs in a seaplane present a somewhat different set of concerns. If the winds are light, the water is smooth, and there is plenty of room, a downwind takeoff may be more convenient than a long downwind taxi to a position that would allow a takeoff into the wind. In any airplane, the wing needs to attain a specific airspeed in order to fly, and that indicated airspeed is the same regardless of wind direction.

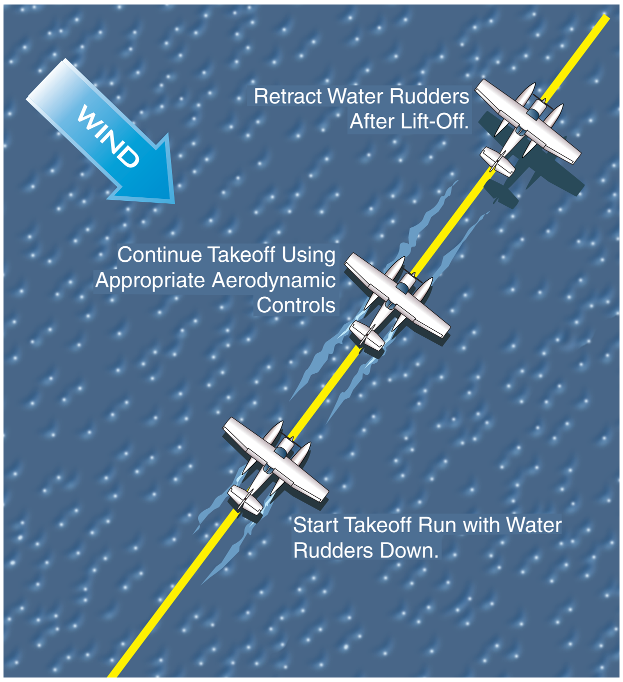

Figure 4-16. Remember to retract the water rudders after takeoff to avoid damage during the next landing.

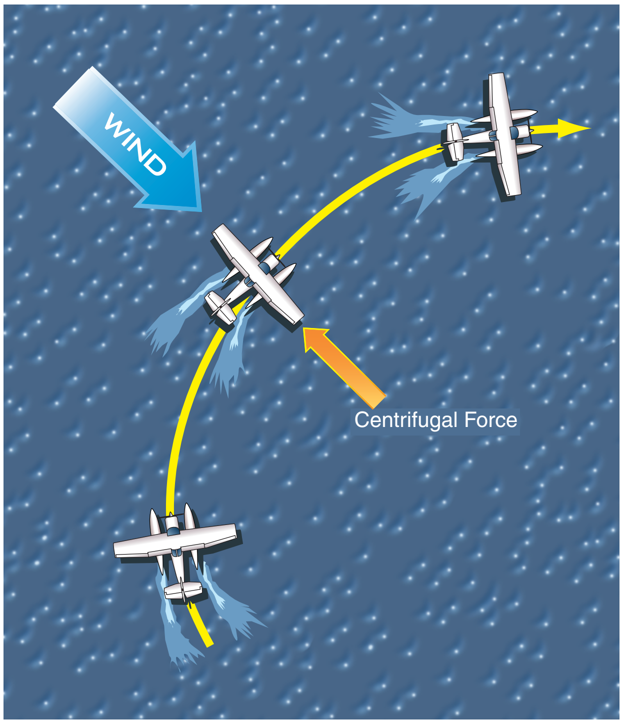

Figure 4-17. The downwind arc balances wind force with centrifugal force.

However, when taking off downwind, obtaining the airspeed means accelerating to a proportionately higher groundspeed. Naturally, the takeoff run is longer because the wings must first be accelerated to the speed of the wind, then accelerated to the correct airspeed to generate the lift required for takeoff. So far, this is identical to what occurs with a landplane during a downwind takeoff. But in addition, a downwind takeoff run in a seaplane is further lengthened by the factor of float drag. The speed of the floats in the water corresponds to the higher groundspeed required in a landplane, but the drag of the floats increases as the square of their speed. This increase in drag is much greater than the increase in rolling resistance of tires and wheel bearings in a landplane. A tailwind may lengthen the seaplane's takeoff distance much more dramatically than the same tailwind in a landplane.

Nevertheless, there are situations in which a downwind takeoff may be more favorable than taking off into the wind. If there is a long lake with mountains at the upwind end and a clear departure path at the other, a downwind takeoff might be warranted. Likewise, noise considerations and thoughtfulness might prompt a downwind takeoff away from a populated shore area if plenty of water area is available. In areas where the current favors a downwind takeoff, the advantage gained from the movement of the water can more than compensate for the wind penalty. Keep in mind that overcoming the current creates far more drag than accelerating a few extra knots downwind with the current. In all cases, safety requires a thorough knowledge of the takeoff performance of the seaplane.

GLASSY WATER TAKEOFFS

Glassy water makes takeoff more difficult in two ways. The smoothness of the surface has the effect of increasing drag, making acceleration and lift-off more difficult. This can feel as if there is suction between the water and the floats. A little surface roughness actually helps break the contact between the floats and the water by introducing turbulence and air bubbles between water and the float bottoms. The intermittent contact between floats and water at the moment of lift-off cuts drag and allows the seaplane to accelerate while still obtaining some hydrodynamic lift, but glassy water maintains a continuous drag force. Once airborne, the lack of visual cues to the seaplane's height above the water can create a potentially dangerous situation unless a positive rate of climb is maintained.

The takeoff technique is identical to a normal takeoff until the seaplane is on the step and nearly at flying speed. At this point, the water drag may prevent the seaplane from accelerating the last few knots to lift-off speed. To reduce float drag and break the grip of the water, the pilot applies enough aileron pressure to lift one float just out of the water and allows the seaplane to continue to accelerate on the step of the other float until lift-off. By allowing the seaplane to turn slightly in the direction the aileron is being held rather than holding opposite rudder to maintain a straight course, considerable aerodynamic drag is eliminated, aiding acceleration and lift-off. When using this technique, be careful not to lift the wing so much that the opposite wing contacts the water. Obviously, this would have serious consequences. Once the seaplane lifts off, establish a positive rate of climb to prevent inadvertently flying back into the water.

Another technique that aids glassy water takeoffs entails roughening the surface a little. By taxiing around in a circle, the wake of the seaplane spreads and reflects from shorelines, creating a slightly rougher surface that can provide some visual depth and help the floats break free during takeoff.

Occasionally a pilot may have difficulty getting the seaplane onto the step during a glassy water takeoff, particularly if the seaplane is loaded to its maximum authorized weight. The floats support additional weight by displacing more water; they sink deeper into the water when at rest. Naturally, this wets more surface area, which equates to increased water drag when the seaplane begins moving, compared to a lightly loaded situation. Under these conditions the seaplane may assume a plowing position when full power is applied, but may not develop sufficient hydrodynamic lift to get on the step due to the additional water drag. The careful seaplane pilot always plans ahead and considers the possibility of aborting the takeoff.