DOL-Fin Orca Mk-2

Owner's Manual (Rev. 1)

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Safety: Before using the DOL-Fin, read this owner's manual.

Always dive with a dive buddy qualified to perform a diver rescue in the case of an emergency, and be qualified yourself to perform a rescue for your dive buddy if needed. For your safety and the safety of your dive buddy you should receive dive training from a recognized training organization for the level and complexity of the dives you are planning. Significant and life threatening risks exist for freedivers and scuba divers that require training to understand how to mitigate those risks. Remember, industry safety standards for diving still apply when using a DOL-Fin for swimming propulsion and it is important to have a viable plan for dealing with equipment failures or medical emergencies of any kind at any time during a dive.

The DOL-Fin is not life saving equipment. When learning to use the DOL-Fin, swimmers should train in confined water with lifeguard supervision. For your own safety, only venture into open water after you have mastered use of the DOL-Fin. Swimming with the DOL-Fin in open water or in any unsupervised conditions is done entirely at the swimmer's own risk.

Before each use, always perform a Pre-Dive Checkout (page 7) of the DOL-Fin equipment to verify the structural and mechanical integrity of the unit to the swimmer's own safety and risk standards. Even easy dives can become dangerous when equipment unexpectedly fails. Never attempt to stand with both feet engaged into the DOL-Fin as you will be unstable which can cause you to fall over and can lead to injury. Be careful when using your DOL-Fin around others, as the fin can injure others if you hit or jab them with it. Make sure you leave appropriate safety clearances between yourself and others in the water so that it does not contact anyone else while you are swimming. Do not use your DOL-Fin without the fin tips installed. Use caution when handling the DOL-Fin that you do not pinch your fingers in the action of the hydrofoil.

The DOL-Fin is a unique and EXPERIMENTAL piece of swimming equipment. Venturing into the water with unfamiliar equipment can result in injury or death. Understanding and being competent with the operation of the DOL-Fin is crucial for its safe use. Reading this manual can assist a user of the DOL-Fin to become competent. However, it is the sole responsibility of the swimmer to determine whether or not they are competent to use any particular diving/swimming equipment, including a DOL-Fin, and to evaluate safety and mitigate risk.

Swimming is hazardous in and of itself which can result in serious injury including drowning. Users of the DOL-Fin should be good swimmers who are comfortable in the water, and not prone to panic. Swimming with fins can be physically demanding. Therefore, users of the DOL-Fin should be physically fit. If a potential user has any doubt about their fitness level, he/she should consult medical advice before venturing into open water.

Parts & Assembly:

The DOL-Fin Orca Mk-2 monofin consist of the following parts:

- Foot Binding Straps (1 matched set)
  a. Strap Spacers (2)
- Orca Body (1)
  a. Fairing Top (1)
  b. Fairing Bottom (1)
  c. Foot Plate (1)
  d. Orca Bracket (1)
  e. Internal Float (1)
- Suspension Straps (2)
- Top PE Suspension Guide* (2)
- Bottom PE Suspension Guide* (2)
- High Aspect Ratio Fin
  a. Aluminum Hydrofoil (1)
  b. PE Fin Tips* (2)
  c. Internal Bungee System (2)
- Hardware
  a. 12x1.5" SM Screws (6)
  b. 1/4x1/8 Isolation Washers (6)
  c. 6-32x1.125" Machine Screws (8)
  d. 6-32x0.5" Machine Screws (5)
  e. 6-32 Nylon Locking Nuts (11)
  f. PE Twin Screw Washer Plates* (2)
  g. Al Twin Screw Washer Plates* (2)

*** Note:** PE is short for Polyethylene and Al is short for Aluminum, the material the parts are made from.

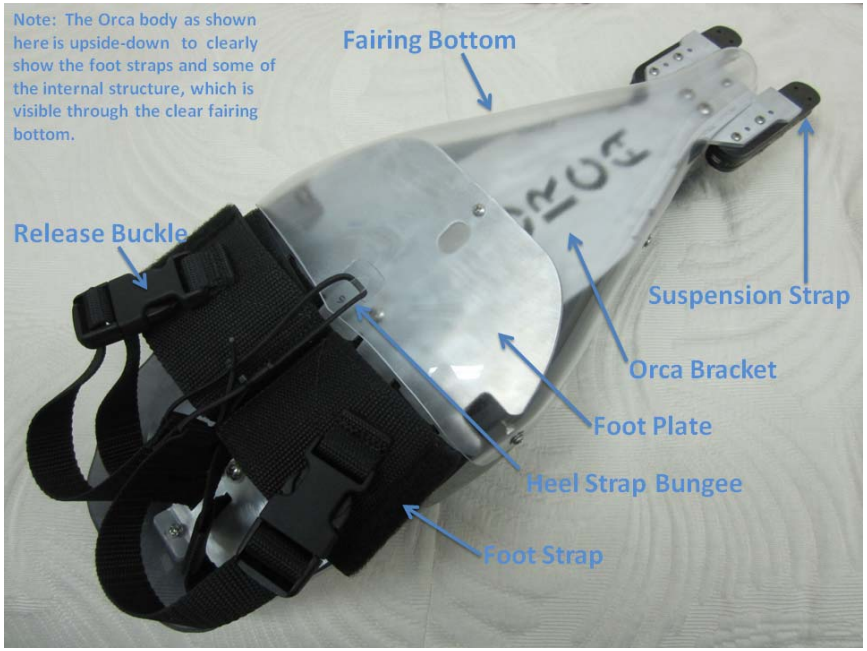
The DOL-Fin Orca Body is the structural support between the high aspect ratio fin and the swimmer's feet. **Figure 1** shows the Orca Body as seen from its underside with the fin suspension systems installed and labels some important features. As it is shown in Figure 1, only the fin needs to be attached to complete the monofin.

DOL-Fin
Dynamic Oscillating Lateral Fin

Installing the Foot Binding Straps:

The Foot Binding Straps are user replaceable and can easily be removed by disassembling the Orca Body and removing the aluminum Foot Plate. To install new Binding Straps, feed the straps through the strap slots in the foot plate and adjust as needed for a proper fit. Strap Spacers are provided to shorten the effective length of the straps for smaller feet. Once adjusted, screw the Foot Plate into the Internal Float. This action locks the Foot Straps into position on the Foot Plate. YouTube video **"DOL-Fin Orca Mk-2 Monofin - Foot Strap Tutorial"** shows this entire assembly process: http://youtu.be/U7iPuo9tnmg

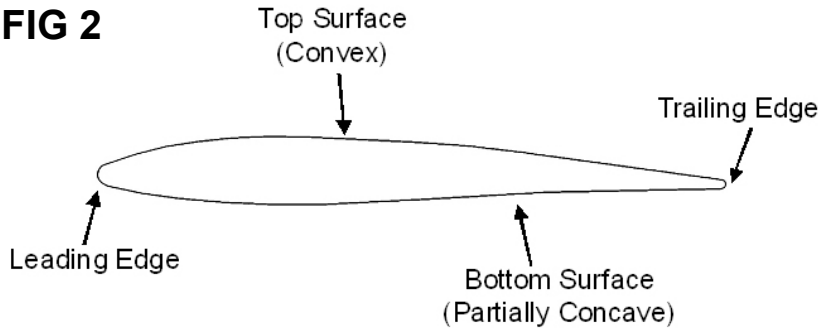
FIG 1



Fin Mounting:

The High Aspect Ratio Fin uses a custom non-symmetrical hydrofoil section. This fin has a top and a bottom as defined in **Figure 2** which shows an end profile of the fin's cross section. The top of the fin can be identified by its completely convex shape, while the bottom is partially concave.

FIG 2



When properly assembled, the fin mounts to the Exo-Skeletal Frame with the fin's leading edge and top facing pointed back end of the fairing top and the bottom of the fin against the suspension straps as shown in **Figure 3**. An improperly mounted fin will severely decrease fin performance.

Suspension Straps:

The Suspension Straps are made of an elastomer & nylon composite material configured to give the fin suspension a non-linear response. To achieve this characteristic, the nylon laminations are offset from the centerline of the Suspension Strap. This offset is visible by looking at the side edge of a Suspension Strap. To properly mount the Suspension Straps to the Orca Bracket, the nylon laminations should be offset away from the Mounting Tabs on the bracket and close to the fin as depicted in **Figure 3**. Mounting the Suspension Straps upside-down will affect the fin's angle-of-attack control and thus affect the overall performance of the DOL-Fin.

DOL-Fin
Dynamic Oscillating Lateral Fin

Hardware:

Eight screws (of which 4 come pre-assembled) fasten a sandwich of components together to form the DOL-Fin's hydrofoil suspension system. Do not over tighten these screws. Over tightening will compress the suspension straps and can cause misalignment of the trim plates or can damage the PE Twin Screw Washer Plates. These screw/nut sets should be tightened lightly. The proper assembly of the suspension system components set up mounted through the forward mounting holes in the Orca bracket can be seen in **Figure 3**.

FIG 3

The entire suspension system and fin assembly can be moved aft to the second set of holes in the Orca Bracket if more length is desired to give the fin a little more leverage to the fin.

Pre-Dive Checkout:

Before each use, visually inspect your DOL-Fin for damage and/or loose hardware. Never use a DOL-Fin that has loose hardware or shows signs of structural damage or cracking. A small fatigue crack can propogate quickly and result in a potentially catistrophic part failure during a dive. One of the great benefits of your DOL-Fin is its modular design that makes part repairs and replacement very easy to perform. So, if a visual inspection shows that something on your fin is loose, broken or compromised, don't just dive it as is; **fix it!**

Inspection Checklist:

(1) Check the hardware. Make sure that all the nuts are appropriately tightened and that the nut locking mechanisms are properly engaging the screw threads such that none of the hardware can come apart during use. Visually inspect the hardware for corrosion. Replace any screws, nuts or washers that show signs of weakening.
(2) Visually inspect the aluminum structural parts for damage from fatigue, cracking or corrosion. Cracked structural components must be replaced.
(3) Visually inspect the suspension straps and suspension guides for cuts, cracks or signs of weakening. The suspension action should be pliable and responsive. Replace any suspension componants that show damage or that seem degraded, as that can diminish the DOL-Fin's performance.
(4) Check that the Foot Binding Straps are in good shape and that the shoe's Velcro straps have adequate holding strength.
(5) Extend the fin tip bungees to visually inspect the fasteners and materials of the bungee assembly for wear or broken parts. Insert the fin tips into the foil ends in swimming configuration, and inspect them for desired shape, curvature and twist. If necessary, massage the fin tips with the hands until they hold the desired shape.

Use and Operation:

Your DOL-Fin is a revolutionary swimmer propulsion device and works differently from traditional swimming fins. It is important that you read this section before using your new DOL-Fin.

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Dynamic Oscillating Lateral Fin

The Orca2 monofin is designed to be used with dive socks. To provide the maximum level of energy transfer to the monofin, the straps do not have any padding attached to them and instead rely on padding worn on the foot to eliminate chaffing of the straps on the foot. If a dive sock is not available, a cotton gym sock will do almost as well. The more padding between the foot and the strap, the more movement is possible and the less connected the foot will be to the fin. So, adding strap padding on top of the dive sock would be counterproductive and it was therefore not included.

YouTube video (http://youtu.be/Mpwvsch6hQk) shows some useful information on how to adjust the binding straps to get a good fit for your feet. If diving with thick dive socks, you can often get a better connection with the Orca2 by diving down about 6 to 7 meters and pulling the heel straps again to snug your feet into the binding straps while the dive socks are compressed.

Selecting a Trim Setting for the DOL-Fin:

The DOL-Fin can be configured with different settings for the lateral fin's suspension system through the use of different suspension guides and the mounting holes selected. These suspension guides modify the rotation range of the fin relative to the frame and the different mounting options modify the length of the lever arm to the fin. Changing these settings affect the dynamics of the hydrofoil and the overall thrust and feel of the fin. Your DOL-Fin can essentially become many different monofins through selection and use of different trim options.

Start with the short arm configuration and the shorter stock length top suspension guides. If you feel like you want more thrust from the downstroke relative to the upstroke, you can replace the top suspension guide with a longer suspension guide that will produce a higher angle-of-attack of the fin blade during the down stroke, resulting in more thrust. Then try moving the entire fin and suspension system assembly to the aft set of mounting holes to configure the fin on the longer arm and see if you like that setting better or worse. Select the combination that feels best to you. In general, a longer top suspension guide will provide both more thrust and more resistance on the fin's down stroke, whereas the extended suspension/fin mounting will provide more thrust and more resistance on both of the fin's strokes. As the top and bottom suspension guide parts are the same parts trimmed to different lengths, it is easy to make a custom length top guide by trimming the part for a

longer bottom guide to a preferred length to make a new custom top suspension guide. A disk sander works well for this. Just make sure to trim them square and with even lengths.

The length of the top suspension guides is largely a biometric fit to match the flexibility of a person's ankles. Therefore, most individuals will find a particular length set that they most prefer and will not change it after that. However, there may be times when a diver may want to change settings of their fin, such as when changing from performance freediving to spear-fishing or photography where the swimmer's drag profile is increased. Selecting a suspension guide may optimize the fin to better accommodate swimming configurations with more drag.

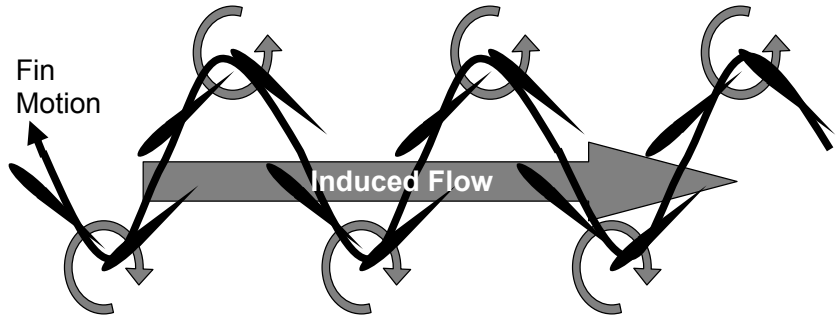
Swimming With the DOL-Fin:

The DOL-Fin Orca is more forgiving of a knee kick technique than are other monofins. However, good monofin technique with straight knees and proper core undulation will improve your overall efficiency and swimming performance. One important tip for freedivers is to not over-kick the fin. Keep the amplitude of the fin strokes relatively small and don't over-bend the knees. It is interesting to note that your fin will produce a surprising amount of speed from nothing more than flexing the ankles. Experiment with this ankle only method, as the best stroke techniques incorporates ankle flexing with the calf muscles in synchronization with the body undulation that is common to monofin use. The DOL-Fins are capable of producing more thrust on the return stroke than other monofins and if you don't master the calf/ankle movements, you will be missing out on a significant portion of the DOL-Fin's capabilities. Continuous low amplitude motions of the fin will help to keep the swimmer's body more streamline for drag reduction and speed.

The fin motion produces alternating patterns of starting vortices of the oscillating fin, which forms a reverse Kármán vortex street to focus a powerful jet of water flowing through the volume affected by the fin as illustrated in **Figure 4**. The fin motion is shown in black. The reverse Kármán vortex street and resulting flow of water are shown in grey. This flow of water provides an efficient generation of hydrodynamic thrust. In general, faster DOL-Fin swimming requires a higher frequency cycle rather than a larger amplitude cycle.

DOL-Fin
Dynamic Oscillating Lateral Fin

FIG 4



Propulsive efficiency can be of benefit at any swimming speed and sometimes slowing down has significant advantages. Particularly for freediving, incorporating two fin kicks followed by a glide period in a repeating pattern is an effective and commonly used method for reducing energy consumption. The two kicks together maintain the appropriate vortex spacing illustrated in Figure 6 to focus the water flow, but it also reduces the total power input and provides time for the muscles to relax and conserve energy. Since the power required for propulsion rises to the third power of the speed attained, an intermediate swimming speed is the best way to maximize economy and distance covered on a single breath. For example, if a swimmer is to double his/her swimming speed, he/she will have to produce eight times the power needed at the slower speed. This high power requirement can rapidly exhaust the available air supply. Swimming fast is fun, but it unfortunately comes at a cost.

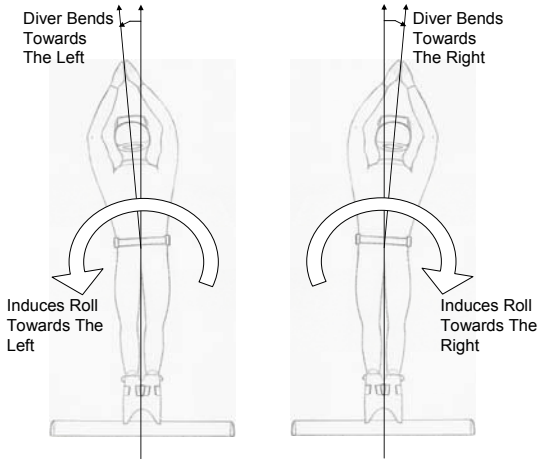
Streamlining becomes increasingly important as a swimmer's speed increases. For freediving, a swimmer can substantially reduce his/her frontal cross section area and therefore drag, by extending his/her arms in front with hands overlapping, and tucking the shoulders in tight around the ears with the chin tucked lowering the position of the head.

Control:

Diver Steering and Roll Control

Roll-trim buoyancy is a process by which a swimmer can control their roll orientation in the water. A swimmer, extended horizontally in the water, can control roll orientation by simply bending his/her body from side to side as illustrated in **Figure 5**. A swimmer's heavy legs at one end and the heavy head and arms at the other end will sink in relation to the more buoyant chest area. Therefore, if the swimmer bends his/her body reaching toward the right, the swimmer's body will roll to the right. If the swimmer bends his/her body reaching to the left, the swimmer's body will roll toward the left. In this way, roll trim buoyancy can be used to control ones roll orientation in water. This is also how steering is accomplished while under propulsion with the DOL-Fin. As a user becomes proficient with the DOL-Fin, they will learn how to use roll-trim buoyancy for control without interrupting the swimming stroke.

FIG 5



Controlling Fin Twist and Side-Slipping

A common problem many people have when first using the DOL-Fin is avoiding fin twist and side-slip when stroking the fin. Don't get discouraged. It is a little like learning to ride a bicycle. It takes some practice, but once you know how to do it, it feels completely natural.

The important thing to remember is that the DOL-Fin is a "Dynamic Oscillating Lateral-Fin", not a "Dynamic Oscillating Skewed-Fin". The fin should always be stroked in a direction that is orthogonal (90 degrees) to the span (i.e. – long axis) of the hydrofoil fin. If the fin is twisted in roll relative to the diver's upper body, and the diver inappropriately strokes the fin orthogonal to his upper body rather than orthogonal to the fin's span, the fin may side-slip and tend to increase the amount of roll misalignment in the fin with each down-stroke.

To become proficient at swimming with the DOL-Fin, the diver will need to learn to sense the fin's orientation through their feet and stroke the fin in the direction orthogonal to that sensed fin orientation. This may take a little practice to become proficient, but before long, the desired body motions will become automatic and happen without having to consciously think about it.

Adhering to this method will stabilize the fin and prevent it from deviating from optimum orientation. Until even kicking is learned, a twisted fin can be corrected by a coast period where roll-trim buoyancy can be used to pull the fin back into position. With continued practice, the coast can be eliminated and smooth even kicking will become completely natural.

Deploying and Folding Fin Tips

The fin tips deploy by simply plugging them into the ends of the aluminum hydrofoil, which places the fin in swimming configuration. To fold, simply unplug the fin tips from the foil ends and fold over the topside of the foil. The fin tips can be secured in the folded position by slipping rubber bands over the fin tips and foil.

Entering and Exiting the Water:

Shore Diving

If you are facing a long walk just to get to the shore, the DOL-Fin X carries comfortably in one hand much like a briefcase. There is enough room between the fin's suspension straps to act as a finger hold. Also, the fin extensions on either side of the central support can serve as a rack for your mask & snorkel and even a towel allowing you to offset the fin's weight and create a balanced handhold on the opposing fin extension. Everything you need to go freediving can be transported in one hand as a single easy to carry package.

When shore diving, always assess conditions of entry and exit, waves, surge and current as they can be dangerous and even deadly. Remember that the shoreline intersection of land, sea and air can be one of the most violent environments on Earth.

When shore diving, the DOL-Fin should be carried into and out of the water. To make it easier to put on, the heel straps should be lengthened prior to entering the water such that you can quickly slip your feet into the foot straps and clip the heel strap buckles. Then, a quick pull on the heel straps to take up the slack is all that is required to start swimming. When conditions allow, you can then take the time to retighten the heel straps for optimum connectivity and comfort and stow the heel straps by attaching the heel strap bungee to the hook on the fairing as shown in figure 1. If conditions permit, the fin should be put on and removed in water shallow enough to stand in. However, the DOL-Fin is put on and removed while floating in a crowched position in the water with your feet pulled up of the bottom.

Boat Diving:

When boat diving, it may be possible to use the rolling back entry. With this entry, the DOL-Fin is secured to the swimmer's feet while sitting on the edge of the boat where the rolling back entry will be performed. With all gear set up and ready to go, the diver can then roll back into the water and start swimming. Since all of the diver's gear is ready prior to entering the water this is the safest way to dive. Be sure that you have appropriate clearances around you before starting your rolling back entry. You don't want to injure others as you roll back or get your fin caught on anything in the boat.

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If the rolling back entry is not used, an entry similar to a shore diving entry can be used, whereby the diver first enters the water and then dawns the monofin.

Never attempt to stand up on dry land with both feet engaged into the DOL-Fin as you will be unstable which can cause you to fall and lead to injury. Never attempt to jump or dive from the end of a platform, dock, diving board or similar structure with both feet engaged in the DOL-Fin.

When exiting the water, as with other fins, the DOL-Fin should not be removed until the swimmer has a firm hold of the boat or a safety line. Never leave yourself exposed to water currents without an effective means of propulsion.

Care & Maintenance:

The DOL-Fin should be rinsed with fresh water after use to keep it clean and reduce corrosion. Rinse the hollow sections of the High Aspect Ratio Fin and rinse the area inside the fairing as well. The DOL-Fin should be stored out of direct sunlight to avoid ultraviolet light degradation of materials.

Always perform a pre-dive checkout of the DOL-Fin before using it. See the "Pre-Dive Checkout" section of this owner's manual for the inspection checklist.

Replacement parts for your DOL-Fin can be ordered from Smith Aerospace Corp.

Fin Assembly:

The DOL-Fin series monofins incorporate large foldable performance enhancing raked fin tips. An Orca with missing fin tips will suffer a significant performance penalty the Orca with the fin tips installed. Damaged, deformed or misshapen fin tips can also affect and degrade the fin's performance and balance. It is important to maintain the fin tips in good operating form for the fin to function properly and as designed.

The shape of the fin tips can be maintained by storing the monofin with tips extended in swimming configuration and with the fin leaning against a wall with the trailing edge of the fin on the floor and the top of the fairing against the wall as is shown in **Figure 6**. The trailing edge of the foil resting on the floor will place an appropriate amount of curvature

on the raked fin tips to maintain an appropriate shape for good performance. If the fin will not be stored in this manner, or if the fin is packed in a gear bag for transportation, fold the fin tips over the topside of the aluminum foil and secure them in place with rubber bands. This will help prevent them from becoming deformed. Fin tips that have become misshapen can be worked back into shape by massaging the plastic with the hands until the desired curvature has been achieved.

The fin tips are held in place by a bungee system internal to the hydrofoil. If this internal system breaks, the fin tips will be free to come out of the foil which would have a significant degrading effect to the monofin's performance. The ends of the bungee system that attach to the fin tips should be visually inspected prior to diving and compromised parts should be replaced. This system is comprised of bungee, nylon cord and plastic zip-ties. The parts are inexpensive and easy to replace. A foil without fin tips can suffer about a 50% performance reduction, so do not allow simple, easily repaired hardware to become a safety hazard. Maintain the redundant bungee system for the fin tips so that they are not lost while swimming at depth. With redundancy in place, if either bungee fails on a dive, the monofin's performance will be unaffected unless and until the other remaining bungee also fails. New fin tips and bungee systems can be ordered from Smith Aerospace Corp. and can be installed by the owner to an existing fin, or installed at the factory on a new fin.

When replacing worn bungee systems, make sure to return the fin tips to the same ends of the foil from where they came or the curvature in the fin tips will be opposite from the desired curvature. When installing new replacement fin tips take care to install them with any preset curvature aligned in the desired direction relative to the foil to avoid extra work shaping the tips. When new tips are installed it is recommended to begin storing the fin as described above and shown in **Figure 6,** to get the proper shape set into the plastic. The longer it sets with the proper shape the more permanent the shape will become to the plastic. Divers can play with changing the amount of curvature and twist the fin tips have in order to customize the feel and balance of their individual monofin. This is a subtle method by which divers can optimize their fin's performance to their individual swimming style.

Youtube video "DOL-Fin X-20 Fin Tip and/or Bungee Replacement" provides a complete tutorial on how to replace fin tips and/or bungee assemblys. This video can be accessed here: (http://youtu.be/pJzDBW7KE2c). The following explains the process in words.

To install a new bungee system, begin by fastening one end of the bungee to one of the fin tips with the loop string and plastic zip tie. Thread the loop string through the loop in the end of the bungee and then through the forward hole in the fin tip. With the loop string threaded through these two parts, bring the free ends of the loop string together and then fasten them together with the zip tie tightened to form about a 1 cm loop. Trim the excess tail from the zip tie. Adjust the loop such that the zip tie is biased closer to the bungee than to the fin tip so that it will not interfere with folding the fin tips later on. This can also be adjusted after assembly if you find that things moved around on you. For the redundant bungee system, repeat this step using the aft hole in the fin tip. The next step is to pull the bungee assembly through the aft hollow of the hydrofoil. This can be accomplished using a wire, or a string, to pull the bungee(s) through the foil. Then, with the already fastened fin tip installed into one end of the foil and the free end of the bungee(s) stretched through and exposed on the opposite end of the foil, use the remaining loop string and plastic zip tie to fasten the remaining fin tip the same as the first fin tip was fastened. A useful trick is to insert a pencil through the loop ends of the bungees to restrain them in place to keep them from receding back into the foil while the second fin tip is being installed. Once the strings are looped through the bungees and fin tip holes and zip tied in place, the pencil can be removed and the fin tips inserted into the foil ends.

Warranty:

As the DOL-Fin series monofins are Experimental, there is no warranty expressed or implied. This is primarily for liability reasons. We have done our best to make this hardware as tough and durable as possible. If your DOL-Fin should prove to be defective, we will assist you in finding solutions to get your hardware back into functioning order, so please do not hesitate to contact us and let us know your situation. Each case will be different, but historically, we have often supplied replacement parts at no cost to the customer, or for the price of the shipping.