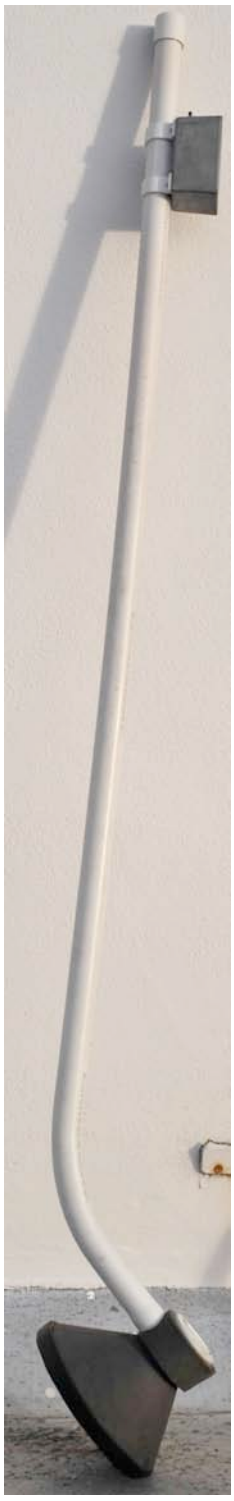
Building the “CETOS” directional hydrophone

You’ll need:



Glues & Resins
PVC cement
Contact adhesive (Ados F2 or similar)
Epoxy filler, or epoxy resin, hardener and “Q” cells (or glue power)
Polyester resin and catalyst
RTV Silicone glue

To build cone
Plastic funnel (about 220mm diam)
Fibreglass chopped strand mat
Release agent (car wax or silicone spray works well)
Paintbrush
Acetone (for cleaning up)

For shaft
32mm PVC electrical conduit, length to suit.
Polystyrene beads

For mounting and finishing hydrophone and cone
25mm PVC 1 way junction box
32/25mm PVC screwed reducer
Balcom PCBU32 32mm bush (female)
32mm Plain/screw coupler
32mm screwed plug

10mm thick closed cell foam (sleeping mat)
~60cm edge moulding (Para Rubber type S24)
small piece polystyrene foam

For potting hydrophone element
Benthos AQ-4 hydrophone element
Hard urethane potting compound (e.g. Smooth-on ClearFlex 95, or Devcon Flexane 80)
18mm ID test tube
High-quality wire core coax (Not solid core)
Disposable cup and clean mixing stick
Silicone paste or release agent

Tools needed
Heat gun
Electric drill and bits (32mm holesaw ideal)
Round file
Screwdriver
Pliers
Soldering iron and solder
One sheet of sandpaper (160 grit is ideal)
Round-tip knife or teaspoon

This hydrophone was designed for tracking sperm whales, but works well for many highly vocal species, including dolphins. Building one is well within the capability of anyone with reasonable practical skills. All the parts are cheap (except for the hydrophone element

(~NZ$200). None of the steps is difficult, but building it does take a while; and has to be done in stages. The finished product, if you do it right, will be reliable and very effective.

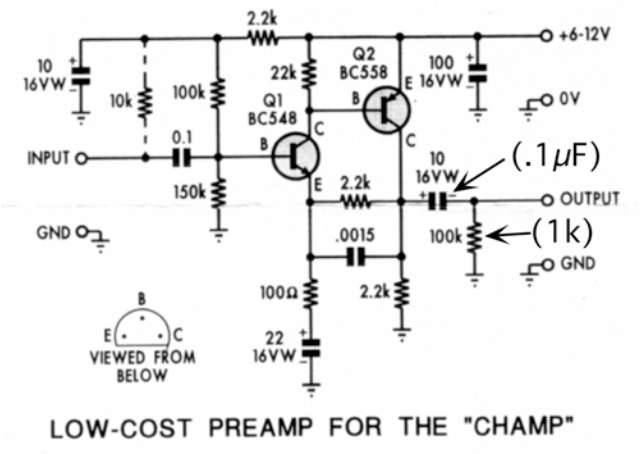
The electronics

We and others have found over many years that complex, sophisticated directional hydrophones provide little if any improvement over very simple ones. This applies particularly to the electronics.

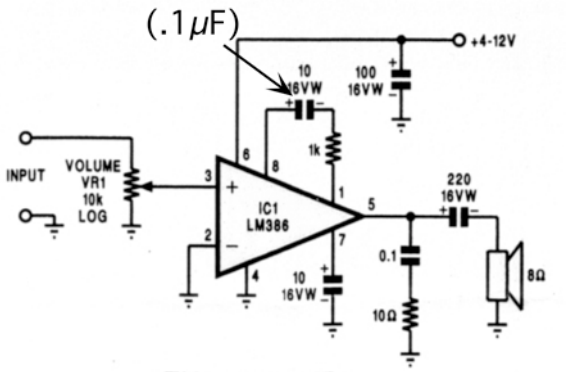
We use slightly modified kitsets which are available very cheaply (<$10 for each kit) from Jaycar Electronics.

Get the “Champ” amplifier (KC5152: 0.5 watt headphone amp) and “PreChamp” preamplifier (KC5166). All components, nicely printed circuit boards and building instructions are included in the kits (even solder).

We make two small changes (shown below in brackets, which provide about 6dB of low-cut filtration at 750Hz, and 10dB at 500Hz (corner frequency is 1592Hz).



LOW-COST PREAMP FOR THE "CHAMP"



THE "CHAMP"

The filtration reduces handling noise, and works excellently for sperm whales. With these changes, the amp produces 42dB of gain. If more gain is needed, you can replace the 1k resistor at pin 1 of the champ amplifier with a wire link. This will, however, change the filtration characteristics.

For other species you could stick with the original values. Alternatively, you could build a simple active filter[1] and have it so you can switch the filter in and out.

[1] For example, see www.calculatoredge.com/electronics/sk%20high%20pass.htm

We house these boards, with a switched 9v battery, headphone socket and volume control (the 10k variable pot on the output of the champ), in an aluminium box.

You can use a plastic box but whenever someone uses a VHF radio nearby you will fry your ears, and you may also faintly pick up nearby radio stations. Not ideal. Having all the electronics inside an aluminium box does a great job of shielding from radio frequencies.

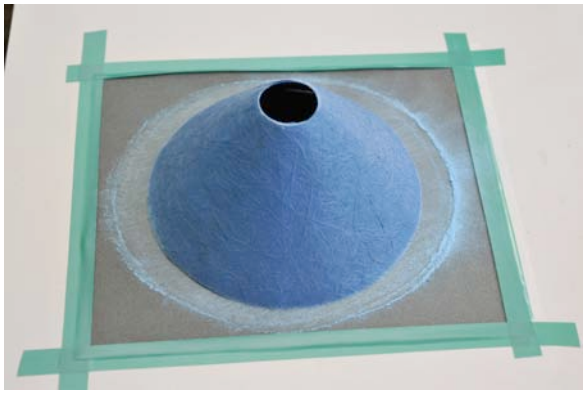
Note that this directional hydrophone will not record sounds with high fidelity. This is chiefly because of the relatively small dimensions of the cone. The cone will also cause phase changes at some frequencies, and the whole setup will not have a linear frequency response. The hydrophone is fine for recording vocalisation *rates*.

To build cone

The best cones are made in fibreglass. Cut chopped strand mat into D-shaped pieces that fit nicely around the funnel, and which will give you a diameter of about 200mm. Wax the funnel, or spray it with silicone spray, and wipe down.

One piece at a time, wet out mat pieces with paint brush and mould onto funnel, working resin through cloth with the paintbrush. Slightly overlap the next piece, and work around the cone until it is at least 2 layers thick all around. For cosmetic reasons I tinted the resin used on this cone.

When the cone is semi-hard, pop it off the funnel, and trim wide end with sharp scissors.



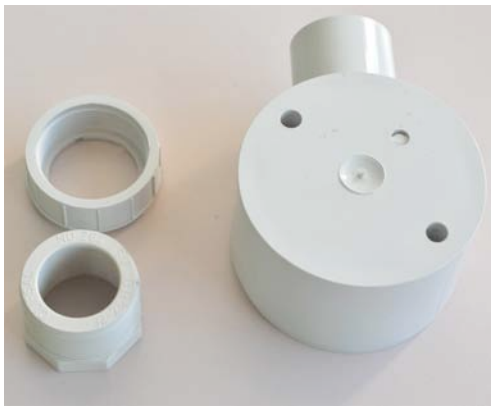
When fully hard, sand both ends of cone flat with sandpaper on a flat surface.

You can use a normal plastic funnel instead of building a fibreglass cone, but it will not be as rugged.

For shaft

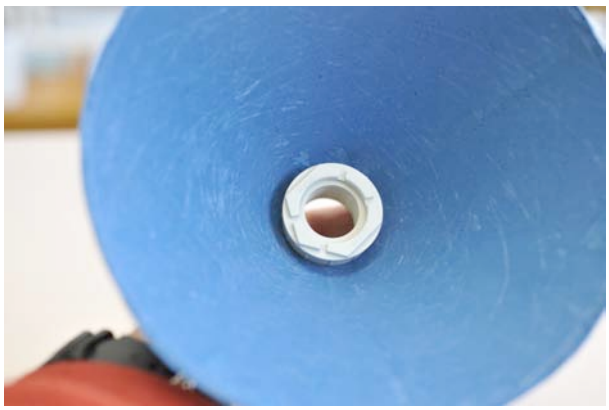
About 30-40 cm from one end, heat evenly with a heat gun, and bend gently over a wide radius. Make sure that the bend is smooth, and not too sharp. A sharp bend will be weak. Don't let the tube kink.

Mounting for hydrophone and cone
These are the parts you'll need for the base.

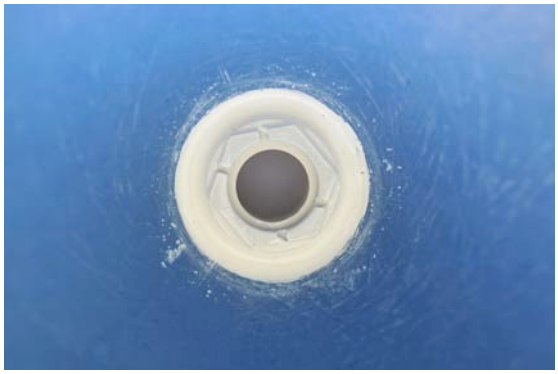


File out internal flange on the screwed reducer (bottom left).

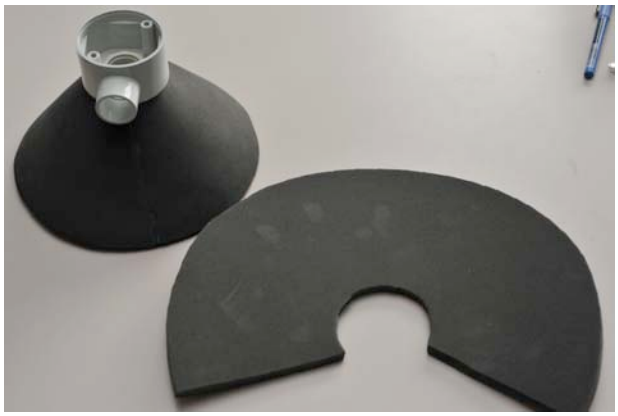
Cut a hole in the junction box so that the screwed reducer fits neatly into it. Fit the cone over threaded end, and screw on the threaded bush (round nut at top left) to attach the cone to the junction box.

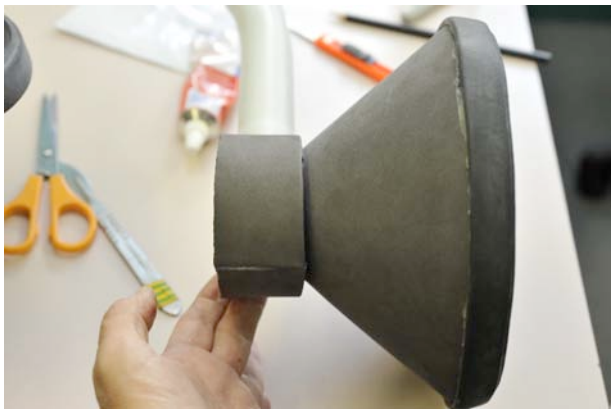


Epoxy filler will stick to the PVC components much better than polyester resins will. Fill the junction between the cone and the junction box with a smooth cove of epoxy filler (either the already-made stuff or epoxy resin made into a stiff paste with Q cells or glue power). The rounded tip of a kitchen knife, or a teaspoon is ideal for this. Do the same on the inside of the cone, between the outside of the PVC bush and the inside of the cone. Doing this ensures that the cone/junction box join is strong and waterproof.



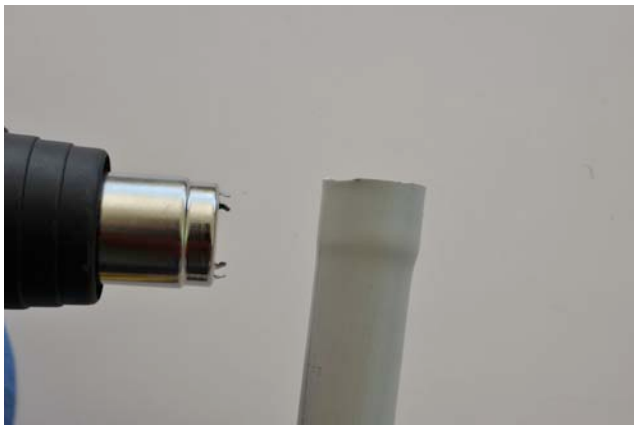
Fitting the insulating foam.





The hydrophone will not be directional without closed cell foam glued the rear of the cone and around the junction box. The foam is the same material as used in cheap sleeping mats. Cut to shape. Coat it, and the cone with contact adhesive (Ados or similar), and leave to go tacky. Press foam into place so that the back of the cone is completely covered. Do the same with the junction box. Leave the rear cover uncovered with foam. If you want it tidy, fit a rubber moulding around the edge using contact adhesive.

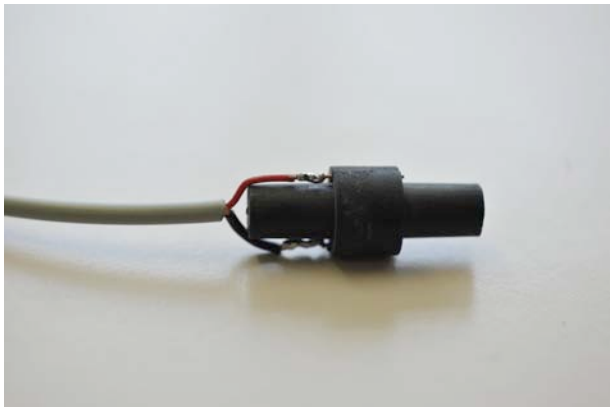
About now it makes sense to dry-fit the shaft to the junction box. Heat the very end of the bent conduit with a heat gun. Push shaft onto the junction box, and let cool. Take apart.



Potting up the hydrophone element

The Benthos AQ-4 elements have a collar around a central piece with an air-space between. Fill this space with glue or resin (epoxy resin is ideal, but PVA glue is more convenient) to prevent air bubbles forming when the hydrophone is potted. Work the resin/glue into the collar with a pin so that no air bubbles are trapped. Do this on both sides.

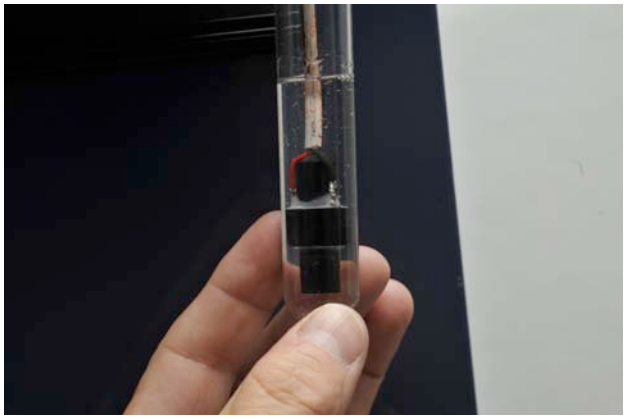
For the wire from the hydrophone element, any good coax will do, but it is easier to use coax that is quite stiff – this makes it easier to ensure that the element is not too close to the edge of the mould when you pot it up.



Solder the coax to the pins of the hydrophone element, so the shield goes to one pin and the core to the other. Make sure the two cannot short. Snip off the two pins on the other side. Abrade the outer jacket of the coax with sandpaper so that the potting compound will stick to it. Straighten the coax so that it and the element are as straight as possible.

Make up a foam spacer that fits neatly into the test tube top, with space for the wire to fit snugly down the middle. This is so the wire is held in the centre of the test-tube.

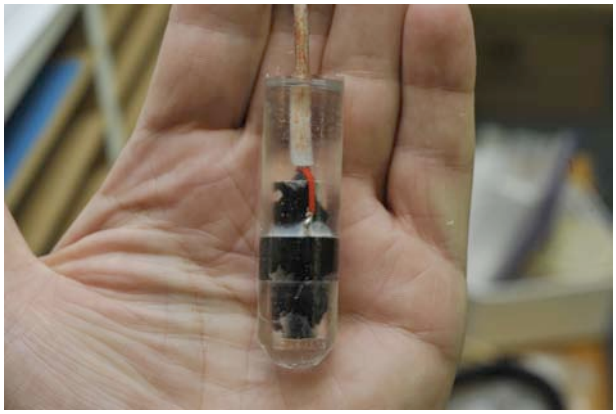
Coat the inside of the test-tube thinly with urethane release agent (silicone paste also works, but not as well). Mix up the potting compound. Be sure proportions are exact, or it may not set properly. You will need access to a decent balance, ideally one that reads to 0.1 of a gram. If you use the test tubes specified above, 15 grams will pot one hydrophone element. For Clear-Flex 95 Urethane, this means 6.0g of Part A, and 9 grams of Part B. Ideally, suck out the bubbles with a vacuum pump. This step is not crucial for directional hydrophones (it does not matter if fidelity is not perfect)



Pour 15 grms into the test tube, then insert the hydrophone element and coax. Work it up and down a bit to dispel air bubbles. Top up if necessary – the potting compound should completely cover the bare wires. Insert the foam spacer to ensure the wire exits from the middle of the moulding, not one side, and push down until just above the level of the potting compound. Tape top of test tube to cable and hang vertically for potting compound to go off.

Before the potting compound “gells”, ensure the hydrophone element is not against the wall of the test tube, and is completely covered by the Urethane. Leave for two days.

If you have used very good release agent you might be able to gently pull the potted hydrophone out of the test tube. If you’ve used silicone paste, you will need to ***very*** gently break the test-tube off with pliers. The silicone paste should have prevented the potting compound sticking to the glass. You now have a potted hydrophone. Don’t worry about small air bubbles in the potting compound. For a directional hydrophone they don’t matter.



Mounting the hydrophone

If the hydrophone is rigidly bonded to the body of the directional unit, it will be very sensitive to handling noise and water noise. Make a polystyrene collar to fit snugly over the hydrophone, and shape the outside to fit snugly into the bush inside the cone. Gently push into place inside the bush, then push the hydrophone through (from the rear). Then seal with a smear of Silicone RTV inside cone and inside the junction box.

Fitting it all together.

When you are ready to glue it all together (fit the foam and hydrophone first), coat inside of shaft end and fitting on junction box with PVC cement, and push together. Get the alignment right – this stuff sets quickly! Now cut the shaft and cable to length, and thread the cable up the shaft. Fit your electronics box to the shaft, and connect the wiring.

Mount the aluminium box near the top of the tube, and seal around it with RTV. If you've used a waterproof switch and volume pot, the only place not splash proof is the headphone socket. We work from open boats, and simply put a plastic bag over the amplifier box when the hydrophone is not being used.

One advantage of the electronics being based on simple commercially available kits is that it is easy to make up a spare amp and preamp. So, if a mishap happens, you can swap them out and get tracking again.

Now pour polystyrene beads down the shaft from the junction box end, until the shaft is completely filled. Check from the top end too. Filling the shaft with polystyrene beads stops the cable flopping around on the inside of the shaft, which creates noise, and puts some strain on the soldered connections at the top. When full, make a foam collar that fits around the hydrophone's wire at the bottom and push this into place where the wire goes up the shaft. This will keep the beads from going everywhere if you have to open the junction box at some later time. I also seal this comprehensively with RTV, because eventually the junction box may leak and you don't want water travelling up to the

electronics. We reseal the junction box every couple of field seasons. Glue the plain/screw coupler to the top of the shaft, and seal it with the screw-in cap.

Coat the sealing edges of the back of the junction box with RTV, and screw into place.

You now have a completed directional hydrophone. If you've done it right it will work great!

Use only alkaline batteries.

Dr Steve Dawson
New Zealand Whale and Dolphin Trust
Department of Marine Science
P.O. Box 56
Dunedin

Email: steve.dawson@otago.ac.nz