HYDROPHONES FOR MONITORING MARINE MAMMAL SOUNDS

For a chart comparing water and air power levels for various sounds send email to joeblue@earthlink.net and ask for Power Level Comparison chart as an attachment. The chart has LFA levels, Saturn Rockets, manatee hearing threshhold, snapping shrimp, etc. for easy comparison. For those who cannot open my attachment, I have provided a copy at the end of this site.

Dr. Joseph E. Blue collects information on hydrophones and posts an edited version of that information here as a community service. Please call my attention to links that do not work and new material as it change rapidly.

THIS SITE IS UNDER CONTINUOUS CONSTRUCTION

Last revised: 17 July 2003

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3313 Northglen Drive	**Phone: (407) 851-4105**
Orlando, FL 32806	**Fax: (407) 850-2075**

RANGE OF INTEREST

- **Frequency range of interest is from a low of 5 Hz to cover the low frequency range of the great whales up to about 200 kHz to cover the upper frequency range of the echo-locating dolphins.**
- **Sound pressure range of interest is from 10 dB below Sea State 0 up to 235 dB re 1 μPa at 1 meter, a level achieved by dolphins.**

SOLICITATION OF HYDROPHONE INFORMATION

In order for these postings to be more useful to the hydrophone user community I am soliciting your help in calling errors to my attention and in providing information on other hydrophone types. Non United States citizens are encouraged to submit products from their countries so this document may have wider use. Please use e-mail or fax to contact me.

Send user comments on hydrophones to:
joeblue@earthlink.net ***for posting.***

I have 42 years of underwater acoustics experience including 16 years as Director, Underwater Sound Reference Division (USRD), Orlando, Florida. USRD develops and builds standard hydrophones that set the national standards in underwater acoustics. It also develops and builds underwater sound projectors primarily for use in calibration. I am available for limited no cost consultations on hydrophones for particular applications to assist you and to help me understand your needs better. I also have 13 years experience in working on acoustic causes and mitigation of marine mammal/watercraft collisions.

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ABOUT HYDROPHONES

Hydrophones are essentially underwater microphones. They are usually composed of piezoelectric ceramic elements. Most of these devices, without preamplifiers, are reciprocal. That means they can both transmit and receive sound. Preamplifiers are often used as an integral part of a hydrophone to boost the piezoelectric ceramic signal near the element that lessens the effect of noise contamination from other parts of the receiving system. They also allow long cables to be used without decreasing the hydrophone sensitivity due to the added capacitance of the cable. Additional cable generally can be added without affecting the sensitivity of hydrophones with preamplifiers provided the preamplifiers are sufficiently powerful to drive the additional cable.

Hydrophone sensitivity is given in dB referenced to 1 Volt/µPa (dB re 1 V/µPa). A µPa is 1 µnewton/meter-squared. In some older literature sensitivity may be given in dB re 1 µbar. To get from µbars to µPa's you subtract 100 dB. The hydrophone you choose should be carefully chosen for your particular application. One is often tempted to choose a hydrophone with the largest bandwidth so it can be used in many applications. That choice can affect your signal-to-noise ratio or even cause acoustic overload of the preamplifiers. Hydrophones have a maximum sound pressure level to which they can be exposed before the preamplifiers overload or starts clipping the signals, which we call acoustic overload pressure. This acoustic overload pressure is dependent on the hydrophone sensitivity and the magnitude of the preamplifier's supply voltage (usually called B+). For example, a hydrophone with a 9 volt B+ and a sensitivity of -160 dB re 1 V/µPa will overload at a signal voltage rms level of about 2/3 B+ or 6 volts rms (14 dB) which corresponds to a sound pressure level of 174 dB re 1 µPa. Clearly, one should not choose a hydrophone with that much sensitivity to monitor an echolocating dolphin at close range when dolphins have been known to emit at level of 235 dB re 1 µPa at 1 meter.

LISTINGS OF HYDROPHONES

This list is continuously under construction. Please call errors to my attention. The specifications given are meant to assist you in your selection. Prices may be out of date. For the latest and more complete information contact the organization or manufacturer of the hydrophones you think may meet your requirements. For some suppliers I have included Web Site link and/or e-mail addresses to facilitate your choices and orders. I believe that most of these hydrophones can be used over -2 to 35 degrees C although they must survive a wide range of hot and cold temperatures to which they may be exposed in shipping, etc.

I.A. STANDARD HYDROPHONES (USRD)

These standard hydrophones are available for a service fee (rent) from the Underwater Sound Reference Division (USRD) of the Naval Undersea Warfare Center (NUWC) which has been relocated from Orlando, Florida to Newport, Rhode Island. These hydrophones may seem to be expensive but they will be recalibrated annually and replaced should they fail or be inadvertedly damaged during the length of the service fee agreement. Also, if you need a hydrophone in a hurry, USRD can usually supply one within a week. If you intend to publish quantitative acoustic data in a refereed journal,

these hydrophones provide an excellent link in the traceability of your measurements to the National Institute of Science and Technology (NIST).

Point of Contact for USRD Standards

Mr. Kirk Jenne	Phone: (401) 841-4336
	Fax: (401) 841-4989
	E-mail: jenneke@npt.nuwc.navy.mil

HYDROPHONES

TYPE	H52	H56
Frequency Range in kHz	0.02 to 150	0.01 to 65
Free-field Voltage Sensitivity in dB re 1 V/µPa	-187	-171
Cable Length Supplied (meters)	23	23
Maximum Operating Depth (meters)	5200	690
Operating Temperature Range (degrees C)	-2 to 35	-2 to 35
Preamplifier Gain (dB)	10	11
Power Requirement	12 Vdc, 10 ma	24 Vdc, 7 ma
Weight with Cable (kg)	4.3	6
Overload Acoustic Pressure (dB re 1 µPa)	206	195
Size: Element (max. dimension in cm)	5.1	2.5
Service Fee (Rent))		

Notes: The H52' s hydrophone' s self-noise is slightly above Sea State 0. At 100 kHz it becomes highly directional in the xz-plane (~ 10 deg).

The H56 has good self-noise characteristics (~ 10 dB below Sea State 0). It also has rather broad vertical directivity to 35 kHz and is omnidirectional in the horizontal plane to 60 kHz.

USRD RECIPROCAL TRANSDUCER TYPE F42, MODELS A, B, C and D

TYPE F42, MODEL	A	B	C	D
Frequency Range (kHz)	0.001 to 40	0.001 to 50	0.001 to 90	0.001 to 160
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-194	-197	-206	-208
Cable Length Supplied (meters)	1	1	1	1
Maximum Operating Depth (meters)	690	1030	3500	3500
Operating Temperature Range (deg C)	-2 to 35	-2 to 35	-2 to35	-2 to35
Preamplifier Gain (dB)	N/A	N/A	N/A	N/A
Power Requirement	N/A	N/A	N/A	N/A
Weight with Cable (kgm)	5	4.5	2.5	0.5
Overload Acoustic Pressure (dB re 1 µPa)	>240	>240	>240	>240
Size: Element (max. dimension in cm)	5.0	3.81	2.54	1.27
Service Fee (Rent)				

Notes: These transducers are equipped with Type RM2MP underwater connectors to which up to 100 m of cable can be added. They are omnidirectional in all directions at low frequencies and come with both transmit and receive calibration curves.

USRD RECIPROCAL TRANSDUCERS TYPES F36, F37, F40 and F50

TYPE	F36	F37	F40	F50
Frequency Range (kHz)	0.01 to 20	0.01 to 37	0.001 to 20	0.001 to 70
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-201	-204	-189	-205
Cable Length Supplied (meters)	30	30	30	23
Maximum Operating Depth (meters)	270	275	690	690
Operating Temperature Range (deg C)	-2 to 35	-2 to 35	-2 to 35	-2 to 35
Preamplifier Gain (dB)	N/A	N/A	N/A	N/A
Power Requirement	N/A	N/A	N/A	N/A
Weight with Cable (kgm)	4	4	4	4.3
Overload Acoustic Pressure (dB re 1 µPa)	>240	>240	>240	>240
Size: Element (max. dimension in cm)	19.4	16.45	10 dia. sphere	4.12
Service Fee (Rent)				

Notes: These reciprocal transducers all have omnidirectional patterns in the horizontal plane. They come with both transmit and receive calibration curves.

The USRD also maintains a stock of moving coil projectors that are relatively broadband. The reciprocal transducers can be used as projectors.

I.B. COMMERCIAL STANDARD-GRADE HYDROPHONES

The International underwater acoustics community has recognized the manufacturers of these hydrophones for many years for their capability of producing standard-grade transducers. The manufacturers have repeatedly produced quality products. Other manufacturers listed as producers of Utility-Grade hydrophones may also be producing high quality products at much cheaper prices. The prices I have listed may be out of date. I would appreciate up-dated prices if you have them. My experience with delivery time is that they are highly variable from the ones quoted. You should allow plenty of lead time in ordering.

I.B.1. Engineering Acoustics, Inc.

Phone: (407) 645-5444
1490 Gene Street Fax: (407) 645-4910
Winter Park, FL 32789 E-mail: ensign@eaiinfo.com
Internet: http://www.eaiinfo.com

MODEL	TH608S	TH608Q	E100A Dual Sensitivity
Frequency Range (kHz)	.010 to 40	0.010 to 120	0.005 to 5

Free-field Voltage Sensitivity (dB re 1 V/µPa)	-160	-180	-176 (high gain) -216 (low gain)
Cable Length Supplied (meters)	specify	specify	Specify
Maximum Operating Depth (meters)	600	600	1000
Operating Temperature Range (deg C)	-2 to 35	-2 to 35	-2 to 35
Preamplifier Gain (dB)		??	??
Power Requirement	24 V dc	+/-24 vdc	18 to 28 Vdc 10 ma max.
Weight with Cable (kgm)		??	??
Overload Acoustic Pressure (dB re 1 µPa)	176	196	185 (low gain) 225 (high gain)
Size: Element (max. dimension in cm)			
Price		??	??

Notes: Self-noise levels are below Sea State 0. Custom designs are available for your application. Speak with Tom Ensign at (407) 645-5444 ext. 203. I generally use him as I can drop by his office

I.B.2. Reson, Inc. Phone: (805) 964-6260
300 Lopez Road Fax: (805) 964-7537
Goleta, CA 93117 E-mail: grava@reson.com (Josh Grava)
Internet: http://www.reson.com

TYPE	TC4013	TC4014	TC4027	TC4032
Frequency Range (kHz)	0.01 to 170	0.015 to 480	0.01 to 10	0.07 to 120
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-211	-187	-180	-170
Cable Length Supplied (meters)	6	10	1	10
Maximum Operating Depth (meters)	700	900	200	900
Operating Temperature Range (deg C)	-2 to 35	-2 to 35	-2 to 35	-2 to 35
Preamplifier Gain (dB)	N/A	26	20	10
Power Requirement	N/A	12 to 24 Vdc, <50 ma	6.4 Vdc, <3ma	12 - 24 Vdc, <50 ma
Weight with Cable (kgm)	~ 1	~ 3	~ 2	~ 3
Overload Acoustic Pressure (dB re 1 µPa)	>240	~ 197	~ 186	~ 198 for 24 Vdc
Size: Element (max. dimension in cm)				
Price	??	??	??	??

TYPE	TC4033	TC4042
Frequency Range (kHz)	0.001 to 160	0.005 to 85
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-205	-173
Cable Length Supplied (meters)	10	

Maximum Operating Depth (meters)	900	1000
Operating Temperature Range (deg C)	-2 to 35	-2 to 35
Preamplifier Gain (dB)	N/A	20
Power Requirement	N/A	12 or 24 v
Weight with Cable (kgm)	~ 3	
Size: Element (max. dimension in cm)		
Overload Acoustic Pressure (dB re 1 µPa)	>240	
Price	??	

Notes: TC 4013 is a small reciprocal transducer that is relatively insensitive. It may be useful in monitoring high level dolphin echolocation clicks.

TC 4014 is a very small hydrophone with low sensitivity that may be useful in some higher frequency dolphin echolocation monitoring.

TC 4027 is a small hydrophone designed with a preamplifier that is close phase matched, such that, over the 10 Hz to 10 kHz range it is suitable for high fidelity sound recording.

TC 4032 is a low noise hydrophone suitable for measuring low ambient noise and low level marine-life sounds.

TC 4033 is a reciprocal transducer that is useful in high-signal level dolphin echolocation monitoring.

EC6070 Audio Amplifier covers the range of 10 hz to 700 kHz with two hydrophone inputs is available with a sonar detector that is actually an AM radio receiver that allows listening to dolphin. The frequency range makes it useful for a variety of listening applications. I t comes with two loudspeakers and headphones.

I.B.3. Bruel and Kjaer E-mail: info@bk.dk
Address: See internet for address Phone: (800) 332-2040
nearest you. Fax: (770) 8087818
Internet: http://www.bk.dk

TYPE	8103	8104	8105	8106
Frequency Range (kHz)	0.0001 to 180	0.0001 to 120	0.0001 to 160	0.007 to 30
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-211	-205	-205	-174
Charge Sensitivity (pC/Pa)	0.12	0.44	0.42	N/A
Cable Length Supplied (meters)	6	10	10	10
Maximum Operating Depth (meters)	250	250	1000	1000
Operating Temperature Range (deg C)	-2 to 35	-2 to 35	-2 to 35	-2 to 35
Preamplifier Gain (dB)	??	??	??	10
Power Requirement	??	??	??	??
Weight with Cable (kgm)	~ 3	~ 3	~ 3	??
Overload Acoustic Pressure (dB re 1 µPa)	??	??	??	??
Size (cm)	5x0.95 dia.	12 x 2.1 dia.	9.3 x 2.2 dia.	??
Price	??	??	??	??

TYPE	8101
Frequency Range (kHz)	0.0001 to 60
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-184
Cable Length Supplied (meters)	10
Maximum Operating Depth (meters)	400
Operating Temperature Range (deg C)	-2 to 35
Preamplifier Gain (dB)	0
Power Requirement	12 to 24 Vdc 12 to 24 ma
Weight with Cable (kgm)	3
Overload Acoustic Pressure (dB re 1 µPa)	191
Size (cm)	24.8 x 2.4 dia.
Price	??

Note: Bruel and Kjaer is very well known in the field of acoustic measurements. Their extensive use of charge amplifiers may be well justified from a purely technical viewpoint. Most underwater acousticians are habituated to voltage preamplifiers and seem reluctant to use charge amplifiers.

I.B.4. Benthos, Inc. Phone: (508) 563-6100 1-800-446-1222
49 Edgerton Drive Fax: (508) 563-6444
North Falmouth, MA 02556 Internet: http://www.benthos.com
E-mail: info@benthos.com

TYPE	AQ-18
Frequency Range (kHz)	0.0001 to 10
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-169
Cable Length Supplied (meters)	??
Maximum Operating Depth (meters)	1800
Operating Temperature Range (deg C)	-2 to 35
Preamplifier Gain (dB)	26
Power Requirement	12 Vdc, 0.3 ma
Weight with Cable (kgm)	??
Overload Acoustic Pressure (dB re 1 µPa)	181
Size (cm)	
Price	$893 1999 price

Notes: Omnidirectional in the horizontal plane. Well tested by USRD for temperature and pressure stability.

I.B.5. Wilcoxon Research, Inc. http://www.wilcoxon.com
21 Firstfield Road 1-800-WILCOXON
Gaithersburg, MD 20878

Model	H505L	H507A

Frequency Range (kHz)	2 to 10	10 to 100
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-160	-188
Cable Length Supplied (meters)	10	3
Maximum Operating Depth (meters)	250	1000
Operating Temperature Range (deg C)	-2 to 35	-2 to 35
Preamplifier Gain (dB)	10	10
Power Requirement	24 vdc	24 vdc
Weight with Cable (kgm)	??	??
Overload Acoustic Pressure (dB re 1 µPa)	167	195
Size (cm)	5.5 dia x 3.3 t	2.25 dia x 1.75 h
Price	??	??

Models H505L is a low noise hydrophone useful for ambient noise surveys and low level marine mammal listening.

I.B.6. Massa Products Corporation Phone: 1-800-962-7543
290 Lincoln Street Fax: (781) 749-2045
Hingham, MA 02043-1790 E-mail: mpc@massa.com
Internet: http://www.massa.com

Model	H-115	TR-1016	TR-1025C
Frequency Range (kHz)	.02-100		
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-190	-209	-296
Cable Length Supplied (meters)			
Maximum Operating Depth (meters)		700	700
Operating Temperature Range (deg C)	-2-25	-2-25	-2-25
Preamplifier Gain (dB)	selectable	N/A	N/A
Power Requirement		N/A	N/A
Weight with Cable (kgm)		4.4	5.5
Overload Acoustic Pressure (dB re 1 µPa)			
Size (cm)	3.75 dia 28.25 L	6.25 dia 22.5 L	3.125 dia 25 L
Price			

TR models are reciprocal and can tramsmit as well as receive.

I.B.7. Neptune Sonar Limited
Model D140H
o INTEGRAL PRE-AMPLIFIER
o OMNI-DIRECTIONAL RESPONSE
o LOW NOISE PERFORMANCE
o BROADBAND OPERATION
o MARINE MAMMAL AUDIO SENSOR
o MAXIMUM CABLE LENGTH 300 MTS

The D/140/H is a

I.B.8. ITC
International Transducer Corp. Phone: (805) 683-2575
869 Ward Drive Fax: (805) 967-8199
Santa Barbara, CA 93111 E-mail: bashforth-itc@channeltech.com Internet:
http://www.itc-transducers.com

Model	ITC 6050C	8212	8201
Frequency Range (kHz)	0.02 - 75	0.001 - 30	0.010 – 65
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-157	-160	-160
Cable Length Supplied (meters)	specify	3	
Maximum Operating Depth (meters)	~1000	~750	~1000
Operating Temperature Range (deg C)	-2 to 25	-2 to 25	-2 to 25
Preamplifier Gain (dB)	20	20	20
Power Requirement	24 vdc	12 vdc	+/-15 vdc
Weight with Cable (kgm)			
Overload Acoustic Pressure (dB re 1 µPa)	181	169	170
Size (cm)	5 dia x 30	5 dia x 5	5 dia x 37.5
Price			

The ITC 6050C has a very good low noise preamp making it highly suitable for low ambient noise measurements. ITC 8212 convenient for operation off 12 v boat battery. ITC 8201 has a differential output making it useful at times to reduce 60 Hz pickup.

I.B.9. High Tech, Inc. Phone: (601) 868-6632
1390 29th Avenue Fax: (601) 868-6645
Gulfport, MS 39501 E-mail: hightechinc@worldnet.att.net
Internet: http://home.att.net/~hightechinc/

Hydrophone HTI Model	90-U	96-MIN	94-SQQ
Frequency Range (kHz)	.002 to 20	.002 to 30	.002 to 30
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-155	-165	-165
Cable Length Supplied (meters)	??	??	??
Maximum Operating Depth (meters)	6096	3048	6096
Operating Temperature Range (deg C)	-2 to 35	-2 to 35	-2 to 35
Preamplifier Gain (dB)	21	36	33
Power Requirement	24 vdc	24 vdc	24 vdc
Weight with Cable (kgm)	??	??	??
Overload Acoustic Pressure (dB re 1 µPa)	173	183	183
Size (cm) length x diameter	10.16 x 3.81	6.3 x 1.91	3.81 x3.18

I.C. UTILITY-GRADE HYDROPHONES

Most of the hydrophones listed here are not well known to me. They are generally less expensive than those listed above. Some may be of equal quality to those that I have designated accepted standards, but they have not generally undergone extensive testing. I would most likely use one of these for comparative rather than quantitative measurements. I have had some luck with one in particular but shall refrain in this document from any endorsements.

I.C.1. VEMCO Limited Phone: (902) 852-3047
100 Osprey Drive Fax: (902) 852-4000
Shad Bay, Nova Scotia, Internet; http://www.vemco.com
Canada B3T 2C1 E-mail: support@vemco.com

VCHLF low frequency, low noise hydrophone	
Frequency Range (kHz)	0.01 to 20
Free-field Voltage Sensitivity (dB re 1 V/µPa)	??
Cable Length Supplied (meters)	??
Maximum Operating Depth (meters)	??
Operating Temperature Range (deg C)	??
Preamplifier Gain (dB)	??
Power Requirement	??
Weight with Cable (kgm)	??
Overload Acoustic Pressure (dB re 1 µPa)	??
Size (cm)	??
Price	??

Notes: No information received yet.

I.C.2. Sensor Technology Limited Phone: (705) 444-1440
P. O. Box 97 Fax: (705) 444-6787
Collingwood, Ontario, Canada L9Y 3Z4 Email: iwchadwick@sensortech.ca
Innternet: http://www.sensortech.ca

BM024 Hydrophone	
Frequency Range (kHz)	0.01 to 7.5
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-195 +/- 1
Cable Length Supplied (meters)	3
Maximum Operating Depth (meters)	300
Operating Temperature Range (deg C)	-2 to 35
Preamplifier Gain (dB)	N/A
Power Requirement	N/A
Weight with Cable (kgm)	0.3
Overload Acoustic Pressure (dB re 1 µPa)	>240
Size (cm)	??

Price	??

Notes: Omnidirectional in the horizontal plane.

I.C.3. Cetacean Research Technology
7309 26th Avenue NW Phone: (206) 297-1310
Seattle, WA 98117 Email: info@cetaceanresearch.com
Internet: http://www.cetaceanresearch.com

Model	20a	50a	300a
Frequency Range (kHz)	0.018 to 35	0.018 to 200	0.018 to 300
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-161	-161	-164
Cable Length Supplied (meters)	10	10	10
Maximum Operating Depth (meters)	1000	1000	1000
Operating Temperature Range (deg C)	-2 to 35	-2 to 35	-2 to 35
Preamplifier Gain (dB)	34	34	34
Power Requirement	5 to 15 Vdc	5 to 15	5 to 15
Weight with Cable (kgm)	0.8	0.8	0.8
Overload Acoustic Pressure (dB re 1 µPa)	166 to 175	166 to 175	169 to 178
Size (cm)	10 x 2.5 dia	10 x 2.5 dia	7Lx4Wx1T
Price	$367	$417	$567

Notes: Models 20a and 50a are cylindrical hydrophones which are omnidirectional in the horizontal plane. Model 300a is a plate hydrophone that becomes very directional (~ 10 deg at 250 kHz). Price includes water resistant battery/breakout box on all models. Models C300b and c differ only a few dB in sensitivity from C300a. Prices without the water resistant box are about $60 cheaper. None of the hydrophones are electromagnetically shielded (recommended) but can be on request for an extra charge. Model C20r is a recreationnal model with a water-resistant box and headphones. Model C20rk is a kayak version with waterproof connectors. Both of these recreational models cost $399.97.

I.C.4. Thomson Marconi Sonar Phone: 612 809 97 77
Faraday Park Fax: 612 809 97 51
Railway Road E-mail: ajdeac@gecms.com.au
Meadowbank
New South Wales, Australia 2114

Spherical Hydrophone SH101X	
Frequency Range (kHz)	0.001 to 100
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-201
Cable Length Supplied (meters)	??
Maximum Operating Depth (meters)	??
Operating Temperature Range (deg C)	-2 to 35
Preamplifier Gain (dB)	N/A
Power Requirement	N/A

Weight with Cable (kgm)	??
Overload Acoustic Pressure (dB re 1 µPa)	>240
Size (cm)	??
Price	AUS $400

Notes:

I.C.5. Bioacoustics, Inc. Phone: (508) 758-4270
3 Noyes Avenue
Mattapoisett, MA 02739

Fish Fone	
Frequency Range (kHz)	0.008 to 4
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-148
Cable Length Supplied (meters)	1.5
Maximum Operating Depth (meters)	??
Operating Temperature Range (deg C)	-2 to 35
Preamplifier Gain (dB)	??
Power Requirement	6 to 12 Vdc, 2 ma
Weight with Cable (kgm)	0.113
Overload Acoustic Pressure (dB re 1 µPa)	~ 160
Size (cm)	??
Price	$195

Notes: Highly variable sensitivity with depth. I would use this hydrophone for comparative measurements and casual listening.

I.C.6. Offshore Acoustics Phone: (604) 929-0470
5454 Indian River Drive E-mail: jkford@interchange.ubc.ca
North Vancouver, FAX: (604) 929-0470
B. C. , Canada V67G 1L3

Hydrophone	
Frequency Range (kHz)	0.006 to 10
Free-field Voltage Sensitivity (dB re 1 V/µPa)	-154
Cable Length Supplied (meters)	10
Maximum Operating Depth (meters)	340
Operating Temperature Range (deg C)	-2 to 35
Preamplifier Gain (dB)	??
Power Requirement	9 Vdc, 2 ma
Weight with Cable (kgm)	1
Overload Acoustic Pressure (dB re 1 µPa)	~ 164
Size (cm)	5 x 2.5 dia.
Price	$360

Speaker Amplifier - $20.00, Extra Cable - $3.00/m , Shipping in North America - $15.00

I.C.7. Gearing-Watson Electronics Ltd. Phone: 44(0)1323 846464
South Road FAX: 44(0) 1323 847550
E. Sussex BN 27 3JJ England Internet: http://www.gearing-watson.com

Hydrophone	B1/200	D/11	D/17P	D/26	D/70	D/140	D/300
Frequency Range (kHz)	0.1-150	0.1-20	0.1-30	0.1-45	0.1-100	0.1-200	0.1-500
Free-field Voltage Sensitivity (dB re 1 V/µPa)	??	??	??	??	??	??	??
Cable Length Supplied (meters)	??	??	??	??	??	??	??
Maximum Operating Depth (meters)	??	??	??	??	??	??	??
Operating Temperature Range (deg C)	-2 to 35	-2 to -35	-2 to 35	-2 to 35	-2 to 35	-2 to 35	-2 to 35
Preamplifier Gain (dB)	??	??	??	??	??	??	??
Power Requirement	??	??	??	??	??	??	??
Weight with Cable (kgm)	??	??	??	??	??	??	??
Overload Acoustic Pressure (dB re 1 µPa)	??	??	??	??	??	??	??
Size (cm)	??	??	??	??	??	??	??
Price	??	??	??	??	??	??	??

I.C.8. Burns Electronics PTY LTD.
316 Soldiers Point Road.
Salamander Bay.
N.S.W. 2317.
Phone/Fax 61+ 2 4982 7483
E-Mail: robbie@burnselectronics.com.au
Internet: http://www.burnselectronics.com.au/

Hydrophone	HP-A1	sh-4x
Frequency Range (kHz)		0.01 to80
Free-field Voltage Sensitivity (dB re 1 V/µPa)		-201
Cable Length Supplied (meters)		10
Maximum Operating Depth (meters)		400
Operating Temperature Range (deg C)		-2 to 35
Preamplifier Gain (dB)		??
Power Requirement		??
Weight with Cable (kgm)		??
Overload Acoustic Pressure (dB re 1 µPa)		??
Size (cm)		3.5 dia.
Price	$AU899	$AU575

Notes: Can be purchased with a preamplifier ($AU650) and hydrophone for $AU1125 total.

Price	??	??	??

I.C.9. Arrtec Phone:
P. O. Box 3098 Fax: 011 44 190 864 5387
Bletchley E--mail: jackie@dolphinear.com (jack butler)
Milton Keynes MK2 2AD Internet: http://www.dolphinear.com
United Kingdom

Model	DolphinEar	Dolphin Phone
Frequency Range (kHz)	0.18 to 20	
Free-field Voltage Sensitivity (dB re 1 V/µPa)		
Cable Length Supplied (meters)	6	
Maximum Operating Depth (meters)		
Operating Temperature Range (deg C)		
Preamplifier Gain (dB)		
Power Requirement	7 ma, 9 v.	
Weight with Cable (kgm)		
Overload Acoustic Pressure (dB re 1 µPa)		
Size (cm) length x diameter		
Price	$159	$99

DolphinEar comes with headphones and free spectral analysis software. Sensitivity not given.

I.C.11. AFAB Enterprises
5762 Chico Way NW
Bremerton, WA 98312
(360)698-4872
afab@is-design.com
PH1 Personal Hydrophone System http://www.afabsound.com has specifications. This is the most inexpensive system I have seen for recreational purposes. It is easily integratable into the public address system of whale watching vessels.
Price: $94.50

I.C.12. Planning Systems Inc.
Long Beach Engineering Center
21294 Johnson Road
Long Beach, MS 39560
(228) 853-0007
http://frankenstein.psilongbeach.com/products/hydrophones/

II. Hydrophone Manufacturers Submitting No Data (Addresses Only)

II.A. Specialty Engineering Phone: (408) 465-9000
3155 North Porter Street Fax: (408) 465-9001

Soquel, CA 95072-2217 E-mail: selfridge@ultrasonic.com
Internet: http://www.ultrasonic.com/

II.B. EDO Acoustic Products Phone: (801) 486-7481
2645 South 300 West Fax: (801) 484-3301
Salt Lake City, UT 84115-2968 E-mail: sales@edoipd.com
Internet: http://edocorp.com/indust/acoustic/products/acouprod.html

II.C. Geospace Phone: (713) 939-7093
7334 N. Gessner Fax: (713) 937-8012
Houston, TX 77040 E-mail: geospace@worldnet.att.net

II.D. GRAS (Scan Tech) Phone: (301) 495-7738
Fax: (301) 495-7739

II.E. USRD - Underwater Science, Research & Development, Inc.
Dick Hugus - President Internet: http://www.usrd.com
Phone/Fax: 407-812-5478
Email: gdh3@netpass.com
Larry Ivey - Vice President
Phone/Fax: 407-894-1855
Email: leivey@netpass.com
Business office contact
Dennis Bulin - Vice President
37150 Chancey Rd.
Zephyrhills, FL 33541
Phone: 813-715-0423
Fax: 813-782-5569
This company is not to be confused with USRD-NUWC at Newport, RI.
From Dick Hugus: We will provide you a quote on 7-10 F42B transducers as requested. We have built F42s and other transducers for the Navy and other companies such as the F40 and H52 and can build the equivalent to most of the NUWC-USRD standards. Larry Ivey and Dick Hugus ran the USRD Orlando transducer services before it was transferred to Newport, RI.

LINKS OF INTEREST TO BIOACOUSTICIANS

Equipment Links
Sonotronics - Ultrasonic Tracking Systems: http://www.sonotronics.com Sonotronics makes acoustic tags for fish and marine mammal tracking; also electronics and hydrophones for tracking.

OCEANEARS, INC: http://www.oceanears.com -- Oceanears makes inexpensive underwater sound projectors that give fair fidelity below 10 kHz which are basically ceramic rod and cone types.
Lubell Labs: Lubell supplies a line of underwater speakers that are widely used in the sports and underwater entertainment business: http://www.lubell.com

Lubell Labs: Lubell supplies a speaker that delivers a maximum SPL of 193dB/uPa/1m (~ 100 watts). Model LL-1424 has a useful frequency range of 200Hz - 9kHz, a +/-3db response of 430Hz - 4kHz. http://www.lubell.com/LL1424.html

Sonobuoys from Sparton http://www.sparton.com/buoys.htm

Datasonics Inc. - Underwater acoustic modems for data transmissions: http://www.datasonics.com/PRODUCTS/MODEMS/Telesonar.htm

NPL: Measurement Services List 16 - Acoustics in water UK standards: acoustic calibration services: http://www.npl.co.uk/npl/services/measurement/mserv-16.html

BIOACOUSTICS PAGE **by Dave Mellinger with links to ASA:**
http://asa.aip.org/ani_bioac/index.html

Saul Mineroff Electronics, Inc.
Link to recorders. The SME PMD650 Portable Minidisc Recorder is available through Saul. I find it particularly suitable for recording marine mammal sounds up to 20 kHz because of its manual input option. This allows one to record sounds for accurate calibration of sound pressure levels. http://www.mineroff.com

Newleap Ltd, (http://www.newleap.com, e-mail paul@newleap.com) specializes in preamplifiers and echolocation ' click' detectors that we have developed over years of active research in marine bio-acoustics.
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Links Courtesy of Joe Olson at: http://www.cetaceanresearch.com

Marine Mammal Research, Education & Conservation sites
Accademia del Leviatano
The Leviathan Academy

Acoustical Society of America

American Cetacean Society

Anne & Dave' s Adventures With Orcas

The Call of the Siren

Center for Bioacoustics

Center for Coastal Studies

Center for Whale Research

Centro Interdisciplinare di Bioacustica e Ricerche Ambientali

Cetacean Society International

The Cousteau Society

Cruzada por la Vida
For the protection of dolphins in Peru

The Dolphin Institute

The Dolphin Society

Dolphin Study Group Online

The European Cetacean Society

Great Whales Foundation

The International Whaling Commission

Lolita Come Home
She's the last orca from Puget Sound still in captivity!

Marine Life Care Group (Malta)

Marine Mammal Acoustics

Other Acoustics Related Sites

Project Delphis

The Society for Marine Mammalogy

Song of the Whale

Whale and Dolphin Conservation Society

Whale Conservation Institute

The Whale Museum

Whalenet
Whales on the Net

Whalesong

The Whale-Watching Web

Wild Dolphin Project

Woods Hole Oceanographic Institution

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Leviathan Legacy, Inc.
Underwater Acoustics and Bioacoustics Research and Consulting
Joseph E. Blue, PhD President joeblue@earthlink.net
Edmund R. Gerstein, PhD Vice President President gerstein2@aol.com
PHONE: (407) 851-4105 (561) 338-9185
FAX: (407) 850-2075 (561) 338-9185

Comparison of Water and Air Sound Power

Created by Joe Blue

In this Table, I have the level in dB (approximately) such that 170 dB in water is 1 watt and 120 dB in air is 1 watt. No direct comparison between the air and water sounds in the same row is intended or possible. Because SPL in dB has so many meanings (at least 3 in this Table) no comparisons can be accurately made without more knowledge of the measurement procedures.

WATER	WATER	EITHER	AIR	AIR	
Power in watts	Sounds peak spectral	Sounds in half-power band at 1 m	Level dB	Sounds A-weighted by a Sound Level Meter	Sounds in half-power band at 1 m	Power in watts
10 exp(7)	x	x	240	x	x	10 exp(12)
x	x	x	x	x	x	x
10 exp(6)	x	Loud Dolphin Click (peak)	230	x	x	10 exp(11)
x	x	x	x	x	x	x
10 exp(5)	x	x	220	x	x	10 exp(10)
x	x	LFA	x	x	x	x
10 exp(4)	x	x	210	x	x	10 exp(9)
x	x	x	x	x	x	x
10	x	x	200	x	x	10

exp(3)						exp(8)
x	x	ATOC	x	Saturn Rocket	x	x
100	x	x	190	x	x	10 exp(7)
x	x	20 Hz Whale 25 w	x	x	x	x
10	x	x	180	x	x	10 exp(6)
x	x	x	x	x	x	x
1	x	20 Hz Whale	170	x	x	10 exp(5)
x	x	x	x	x	x	x
0.1	x	Delaware Bay Test full power at 1 m	160	Ram Jet	x	10 exp(4)
x	x	Loud Motor Boat at 1 m	x	x	x	x
10 exp(-2)	x	Croakers	150	x	x	1000
x	x	x	x	x	x	x
10 exp(-3)	x	x	140	x	x	100
x	x	Loud Motor Boat at 100 m	x	x	x	x
10 exp(-4)	x	Sea State 6	130	Pipe Organ	x	10
x	x	Heavy Shipping	x	x	x	x
10 exp(-5)	Loud Motor Boat at 1 m	x	120	x	x	1
x	x	x	x	x	x	x
10 exp(-6)	x	Snapping Shrimp	110	Loud Radio	x	0.1
x	Croakers	Sea State 0	x	x	x	x
10 exp(-7)	Quiet Motor Boat at 1 m	x	100	x	x	0.01
x	Loud Motor Boat at 100 m	Delaware Bay tests at 1/2 mi.	x	x	x	x

		+/- 10dB				
10 exp(-8)	Under Ice	x	90	Shouting	x	10 exp(-3)
x	Heavy Shipping	x	x	x	x	x
10 exp(-9)	x	x	80	x	x	10 exp(-4)
x	Sea State 0	x	x	x	x	x
10 exp(-10)	Snapping Shrimp	x	70	x	x	10 exp(-5)
x	x	x	x	Conversation Level	x	x
10 exp(-11)	x	x	60	x	x	10 exp(-6)
x	x	x	x	x	x	x
10 exp(-12)	Min. Manatee Hearing Threshhold at 16 kHz	x	50	x	x	10 exp(-7)
x	Sea State 0	x	x	x	x	x
10 exp(-13)	x	x	40	x	x	10 exp(-8)
x	Arctic Quiet at 100 Hz	x	x	x	x	x
10 exp(-14)	x	x	30	Very Soft Whisper	x	10 exp(-9)

Sound in water is usually given in dB re 1 μPa in a 1-Hz band. That in air usually is denoted as a level integrated over some frequency band. I show Sea State levels as integrated over their -3 dB spectral level frequency ranges. Without more knowledge of the sound such as frequency region, etc., one cannot infer too much from tables such as these. For example, heavy shipping noise is more stressful than Sea State 6 noise because it occurs in the 10 to 100-Hz range while Sea State 6 noise occurs in the 100 to 1000-Hz range. A better measure of damage is acoustic particle displacement that is inversely proportional to frequency for constant sound pressure.

If you have a source you would like to see added to the Table above or an error to report, please send it to me at

joeblue@earthlink.net