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10th Meeting of the Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV)

Characteristics of Sounds Emitted During High Resolution Marine Geophysical Surveys

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Acknowledgments

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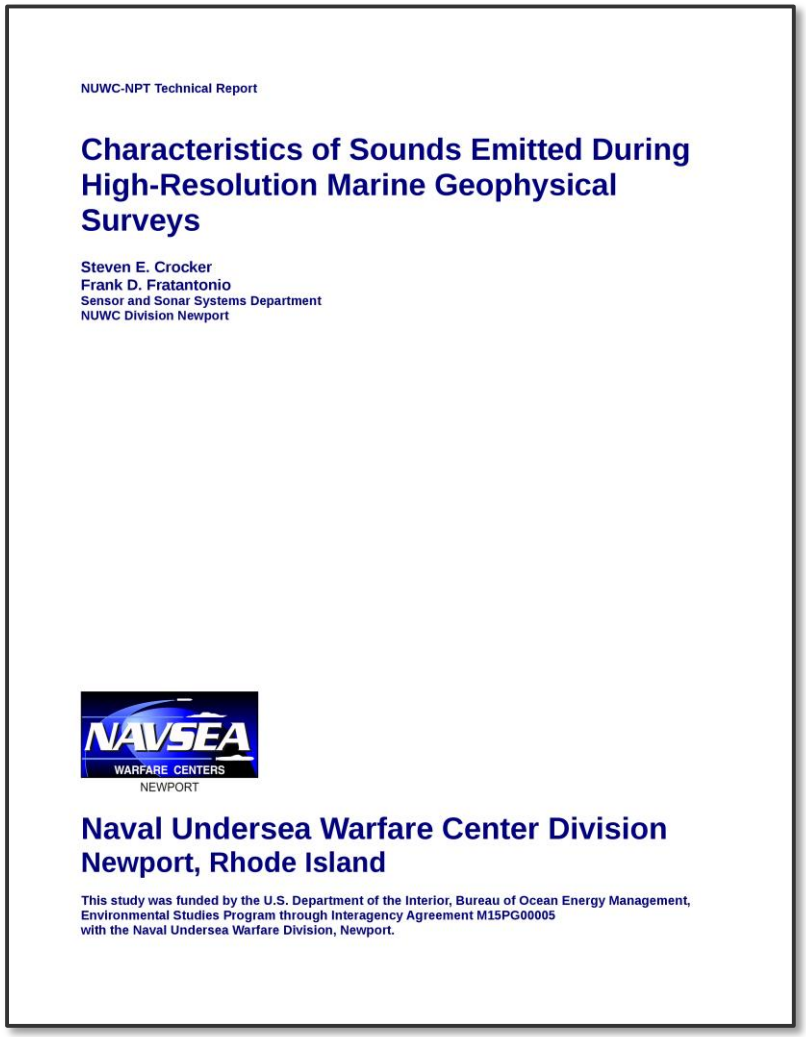
The United States Geological Survey (USGS) was essential in this study with their contribution of equipment, manpower and technical expertise during the testing.



NUWC-NPT Technical Report

Characteristics of Sounds Emitted During High-Resolution Marine Geophysical Surveys

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NAVSEA WARFARE CENTERS
NEWPORT

Naval Undersea Warfare Center Division Newport, Rhode Island

This study was funded by the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program through Interagency Agreement M15PG00005 with the Naval Undersea Warfare Division, Newport.

Background

Marine Mammal Protection Act

The MMPA prohibits, with certain exceptions, the **"take"** of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S.

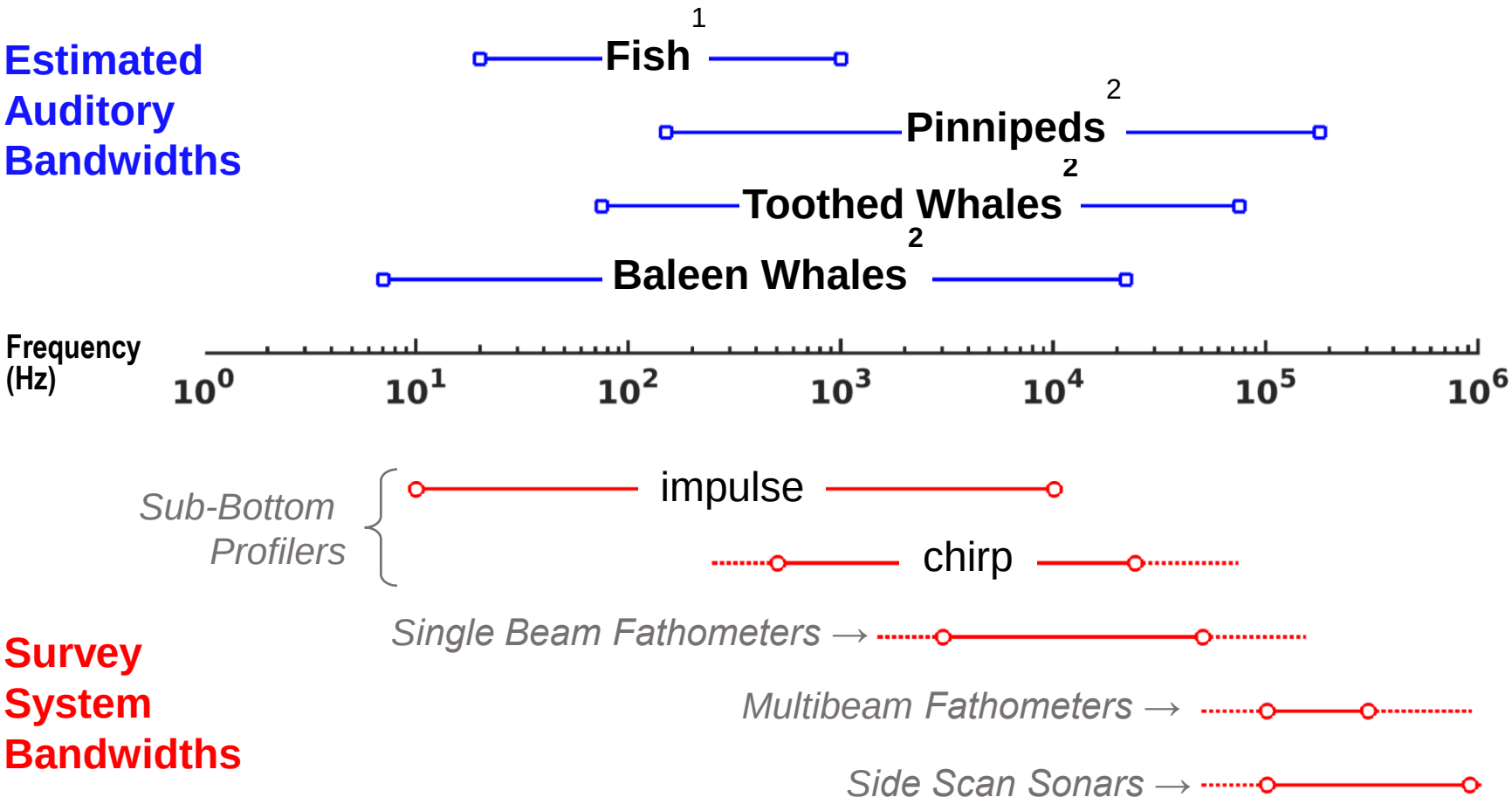
Definitions

Take: To harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.

Harass: Any act of pursuit, torment, or annoyance which - (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B].

Sources: Marine Mammal Protection Act (MMPA) Sec. 3 (18); http://www.nmfs.noaa.gov/pr/laws/mmpa/; http://www.boem.gov/BOEM-Science-Note-March-2015/

Acoustic Spectrum Usage



1) Hastings and Popper, 2005
2) Southhall et. al., 2007

Study Objective

Given the scientific questions and uncertainty about the potential impact of noise in the marine environment, a number of regulatory requirements and precautionary mitigation strategies are being applied to lower energy geophysical surveys.

The U.S. Bureau of Ocean Energy Management is working to ensure that environmental mitigation requirements are scientifically supported, cost effective, operationally feasible and impact reducing. The Bureau is advancing this objective by characterizing the acoustic energy radiated by geophysical survey systems used in shallow bodies of water under U.S. jurisdiction.

The objective of this study is to characterize the acoustic fields radiated by marine geophysical survey systems as a critical first step to understanding the potential impacts to marine ecosystems.

Geophysical Survey Systems

Seafloor Mapping		*Sub-Bottom Profiling*	
System	*Description*	*System*	*Signal*
Echotrac CV100	Single Beam Fathometer	AA* 200	Impulse
Reson 7111	Multibeam Fathometer	AA* 251	Impulse
Reson T20-P	Multibeam Fathometer	AA* S-Boom	Impulse
Sea Swath Plus	Interferometer	FSI** Bubble Pulse	Impulse
Klien 3000	Side Scan Sonar	EdgeTech 424	FM Chirp
Klien 3900	Side Scan Sonar	EdgeTech 512i	FM Chirp
EdgeTech 4200	Side Scan Sonar	Knudsen 3202	FM Chirp

*Applied Acoustics, Ltd.
**Falmouth Scientific, Inc.

Reported Parameters

Source level (rms 90%)	dB re 1μPa@1m
Peak acoustic pressure	dB re 1μPa@1m
Peak-to-peak acoustic pressure	dB re 1μPa@1m
Sound exposure level	dB re 1μPa^{2}s@1m
Spectrum level	dB re 1μPa^2/Hz@1m
Effective (90%) pulse width	seconds
Half-power (3 dB) bandwidth	Hz
Beam patterns	dB
Half-power (3 dB) beam width	degree
10 dB beam width	degree
Principal side lobe level	dB
Principal side lobe location	degree

Sub-Bottom Profiling Systems

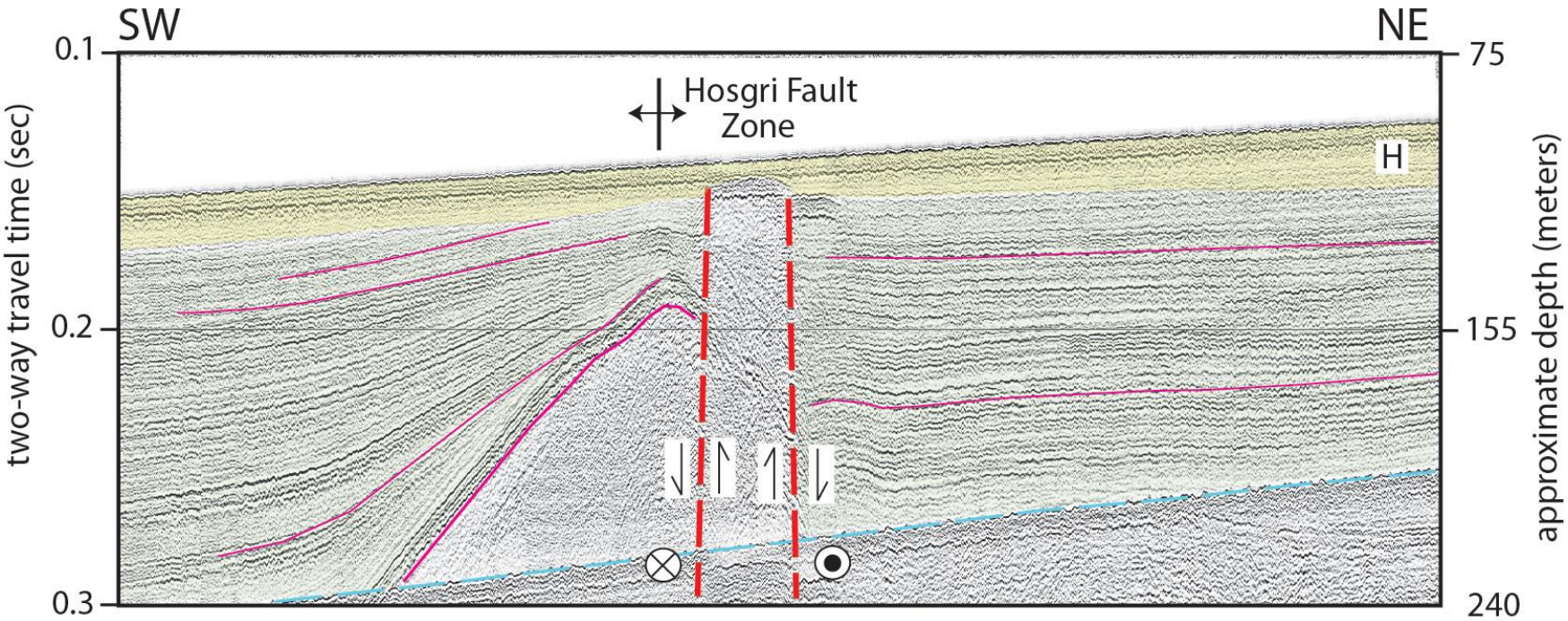
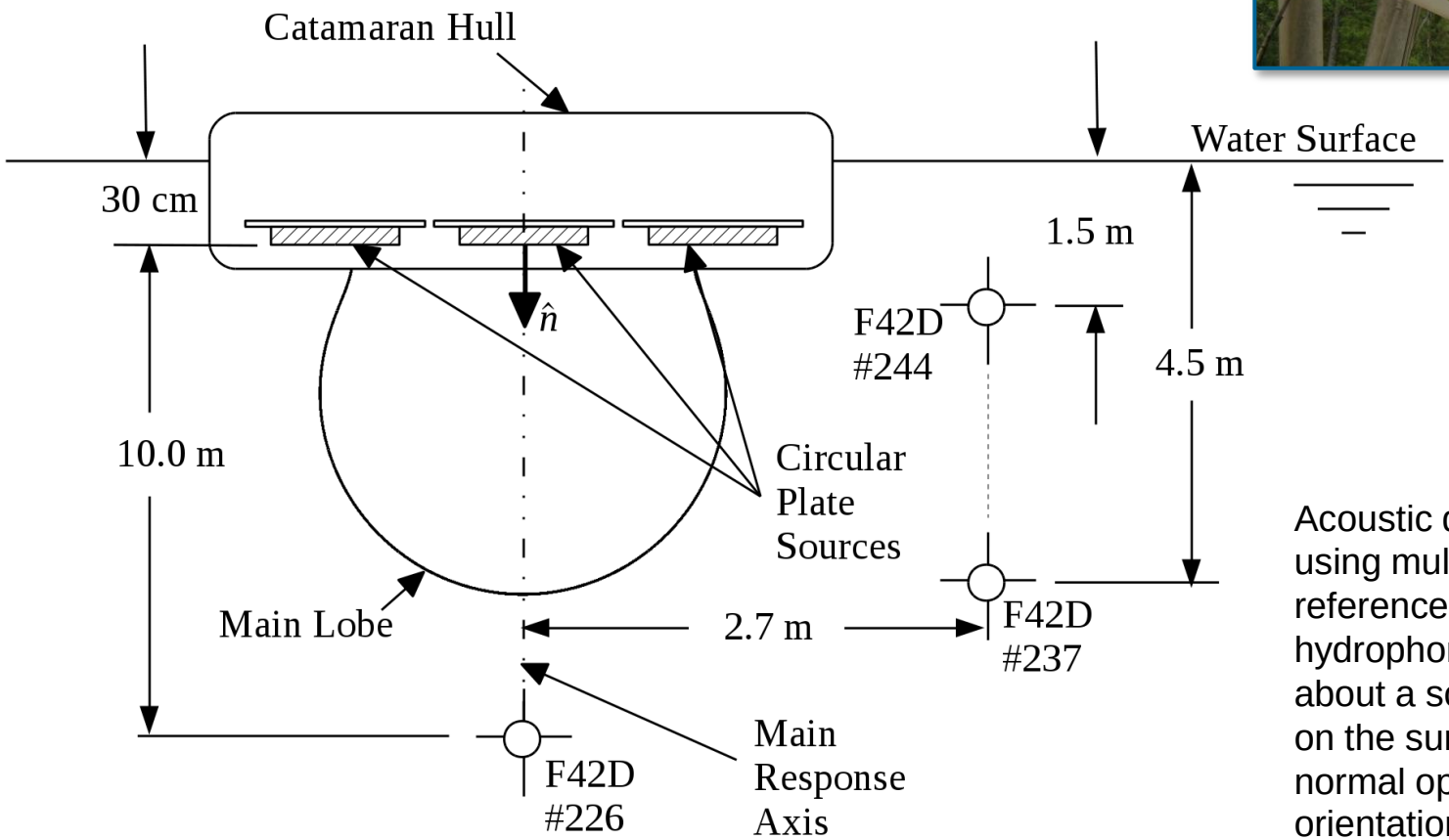


Image: United States Geological Survey

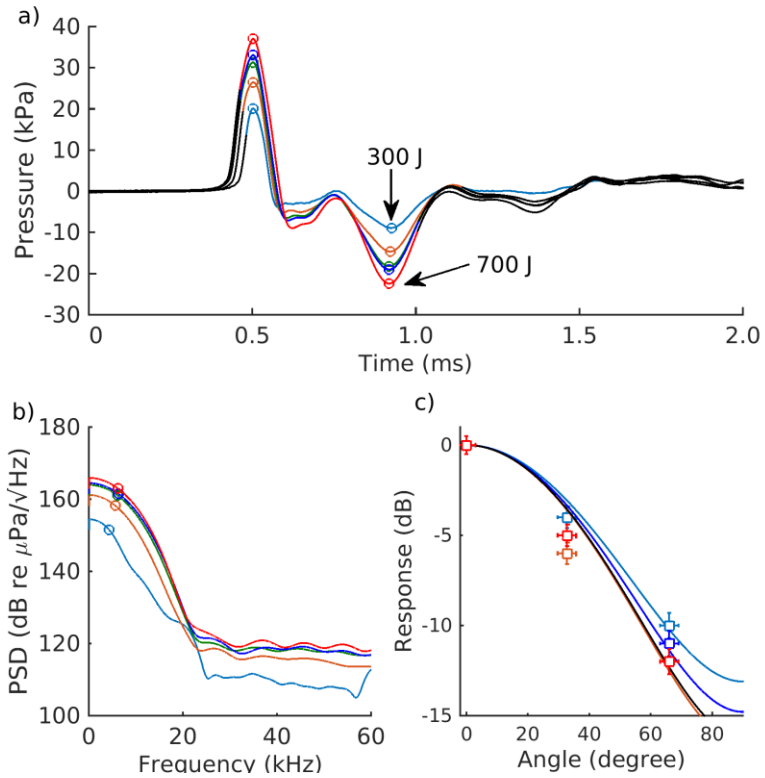
Applied Acoustic S-Boom Sub-Bottom Profiler



Acoustic data collected using multiple calibrated reference standard hydrophones distributed about a source deployed on the surface in its normal operating orientation

Applied Acoustic S-Boom Sub-Bottom Profiler

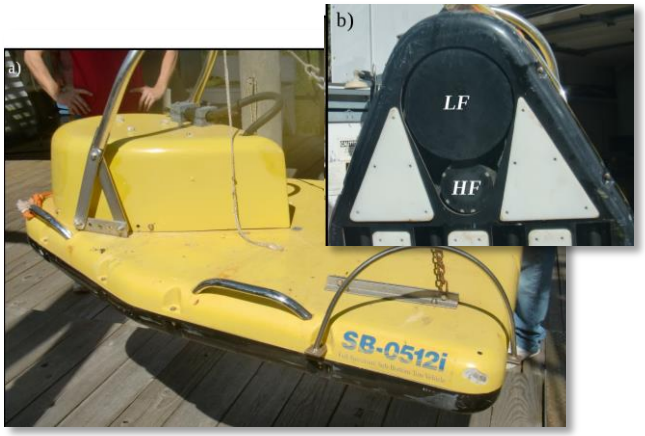
Signal characteristics measured for a wide variety of user selected operating modes

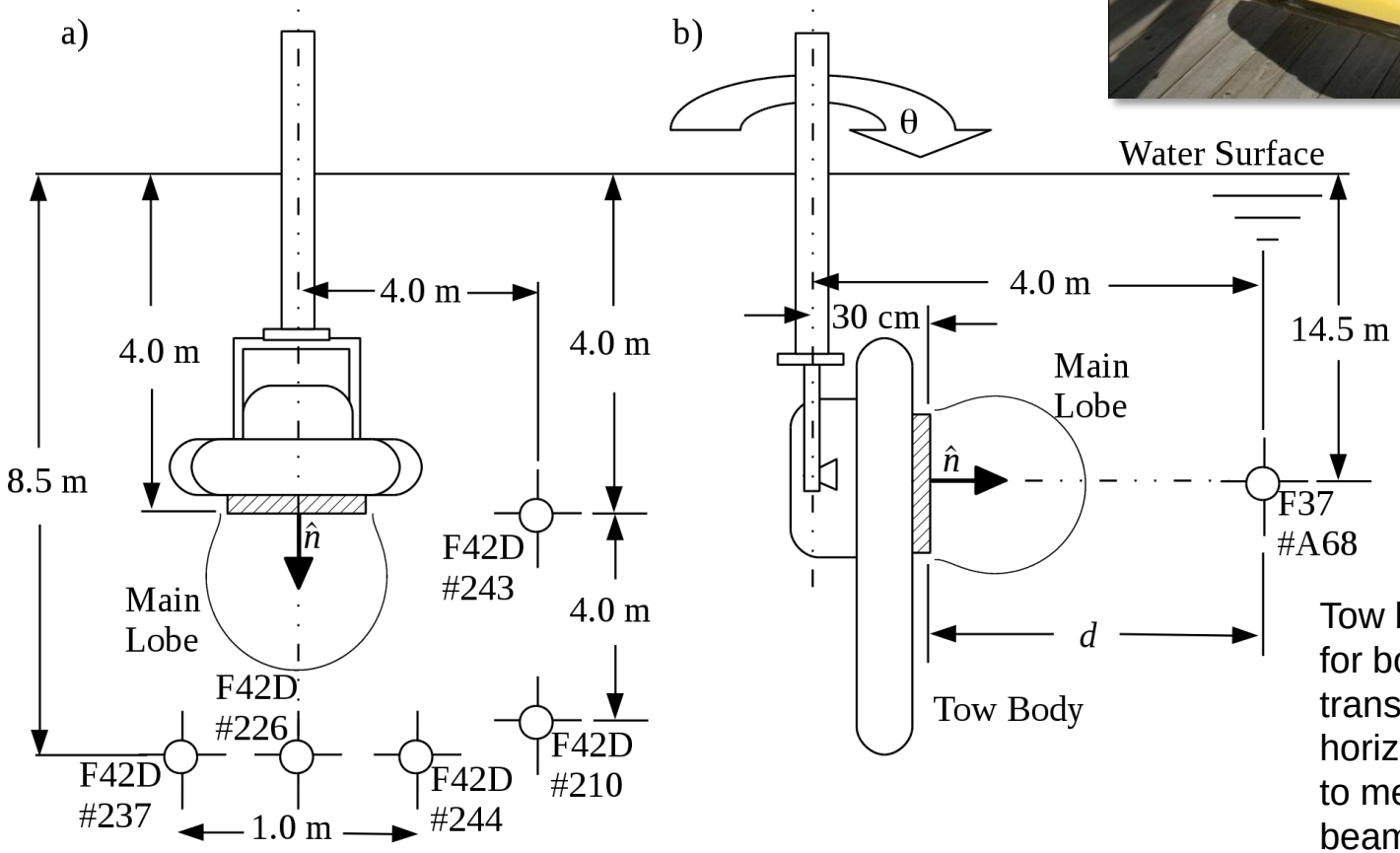


Source Setting (Joules)	Source Level (dB re 1μPa@1m) Pk-Pk	Pk	RMS	SEL	Pulse Width (ms)	Bandwidth 3 dB (kHz)	Beam Pattern ka	MRA Width 3 dB (deg)
100 (1)	202	199	189	157	0.6	7.5	1.2	N/A
100 (2)	202	199	187	157	1.1	4.4	2.1	98
100 (3)	199	196	185	155	1.2	3.3	2.6	78
100 (12)	203	200	190	158	0.6	9.1	3.0	66
100 (13)	203	200	188	157	0.8	5.4	3.1	64
200 (1)	203	201	191	159	0.7	5.7	0.6	N/A
200 (2)	204	201	190	160	1.0	4.4	2.1	98
200 (3)	202	199	187	158	1.2	3.5	2.5	82
200 (12)	205	202	192	160	0.7	6.4	2.9	67
200 (13)	205	202	189	160	1.3	4.1	2.8	70
300 (1)	207	203	195	164	0.8	4.5	0.0	N/A
300 (2)	208	204	195	164	0.9	4.6	2.1	98
300 (3)	206	202	193	163	0.9	4.0	2.1	98
300 (12)	209	205	196	165	0.8	4.8	2.5	80
300 (13)	209	205	194	165	1.1	4.1	2.7	75
300 (123)	209	206	194	165	1.1	4.3	3.1	62
400 (12)	212	208	200	168	0.6	6.1	2.7	75
400 (23)	212	208	199	168	0.8	5.0	2.9	68
400 (13)	212	208	197	168	1.2	4.0	2.6	78
400 (123)	212	208	200	168	0.7	5.6	3.2	60
500 (12)	213	209	202	170	0.7	5.5	2.6	76
500 (23)	214	209	201	170	0.8	4.8	2.8	71
500 (13)	213	209	199	170	1.2	3.8	2.5	80
500 (123)	214	210	202	170	0.6	6.1	3.2	61
600 (12)	214	209	202	170	0.6	5.7	2.5	81
600 (23)	214	210	201	171	0.9	4.6	2.8	71
600 (13)	214	209	200	170	1.2	3.6	2.5	80
600 (123)	214	210	203	171	0.6	6.3	3.2	60
700 (123)	216	211	205	172	0.6	6.2	3.2	61

NOTE: (1) Forward Plate, (2) Middle Plate, (3) Aft Plate

EdgeTech 512i Sub-Bottom Profiler



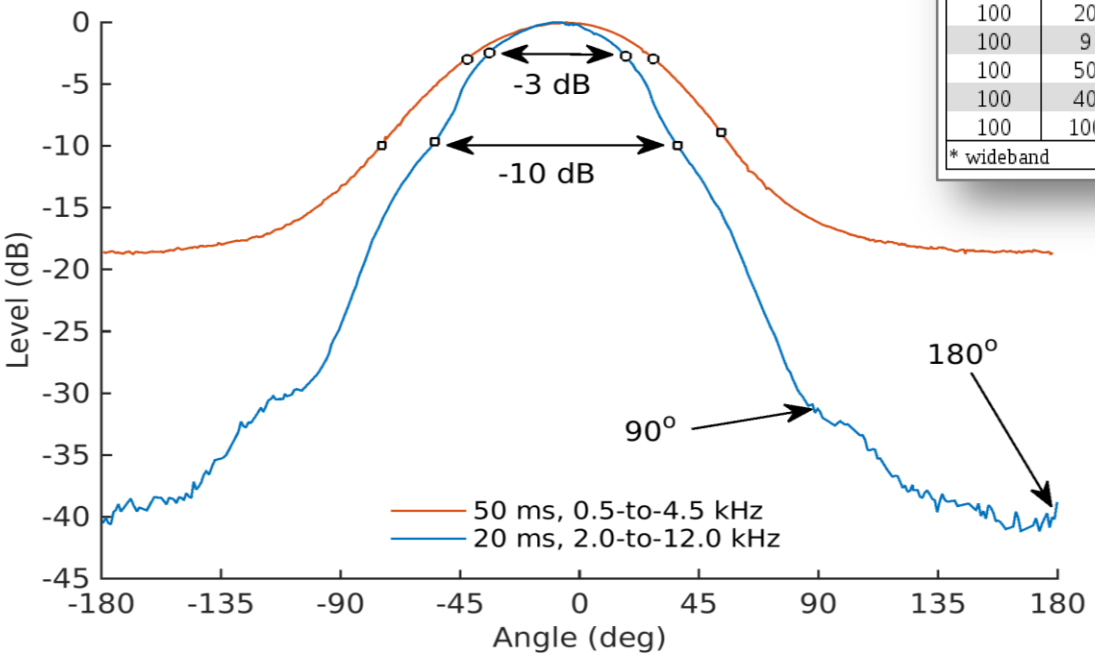


Tow bodies arranged for both normal (vertical) transmission and for horizontal transmission to measure acoustic beam patterns with an angular resolution on the order of one degree.

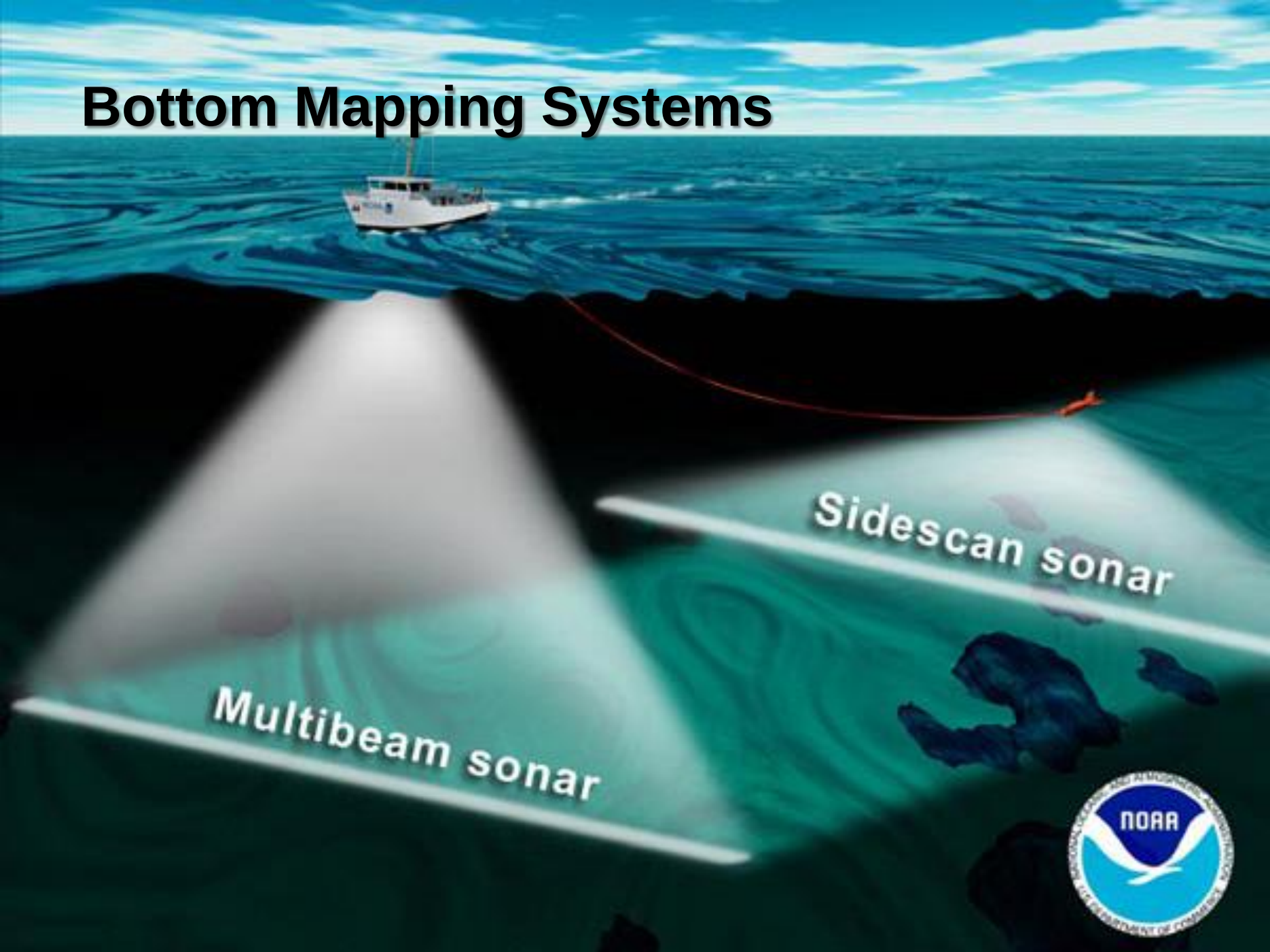
EdgeTech 512i Sub-Bottom Profiler

Beam patterns measured, with summaries tabulated for user selected operating modes

Source Settings			Beam Width (degrees)		Attenuation (dB)	
Power (%)	Pulse Width (ms)	Bandwidth (kHz)	-3 dB	-10 dB	90°	180°
100	20	2.0-to-12.0	51	91	31	40
100	40	1.0-to-6.0	66	112	27	31
100	5	1.0-to-10.0	65	110	29	32
100	20	0.7-to-12.0	60	99	26	29
100	5	0.5-to-8.0	70	108	25	26
100	30	0.5-to-7.2	71	112	24	26
100	20	0.5-to-7.0*	71	127	20	26
100	9	0.5-to-6.0	65	108	23	25
100	50	0.5-to-4.5	70	128	16	19
100	40	0.4-to-4.0*	80	153	15	20
100	100	0.5-to-2.7	74	150	16	22
* wideband						



Bottom Mapping Systems



Multibeam Sonar

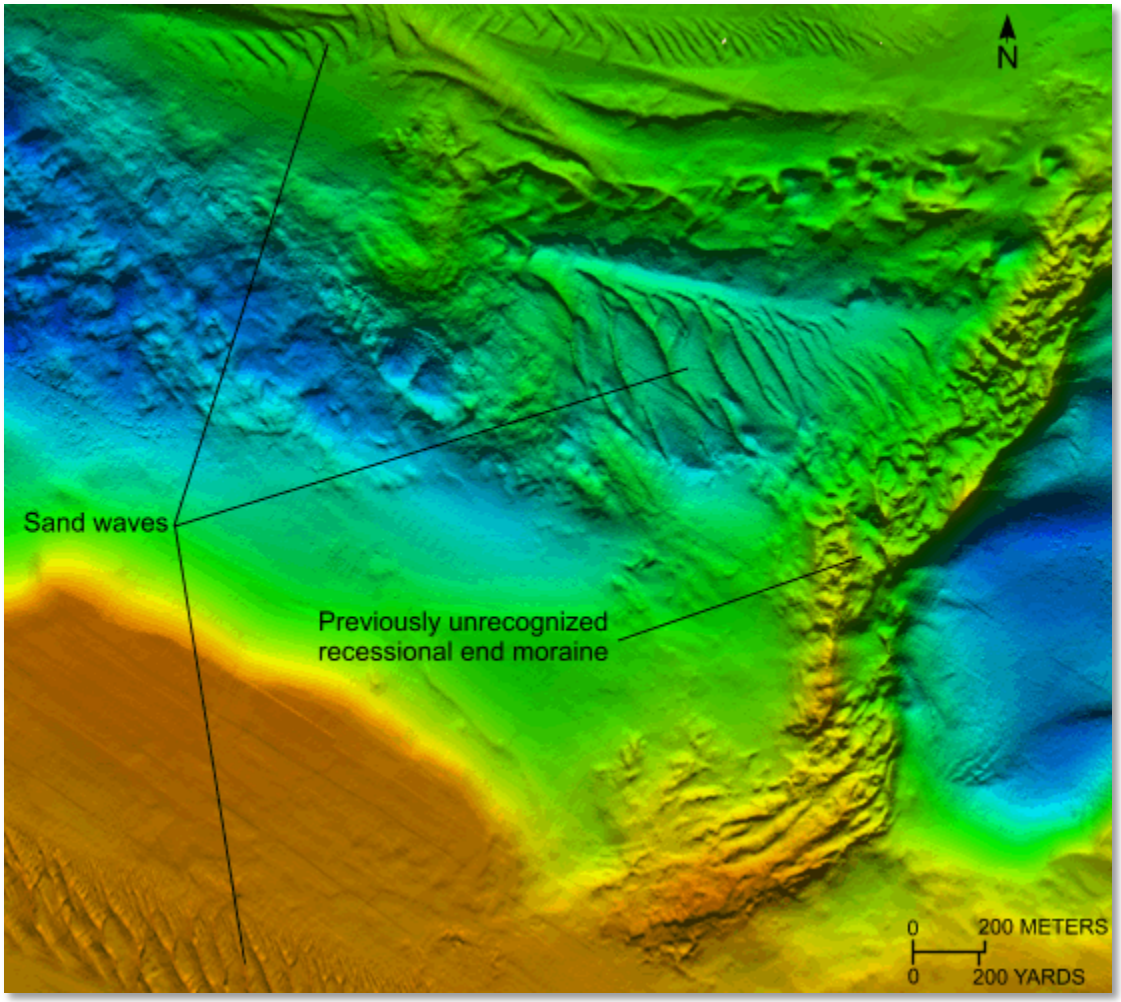
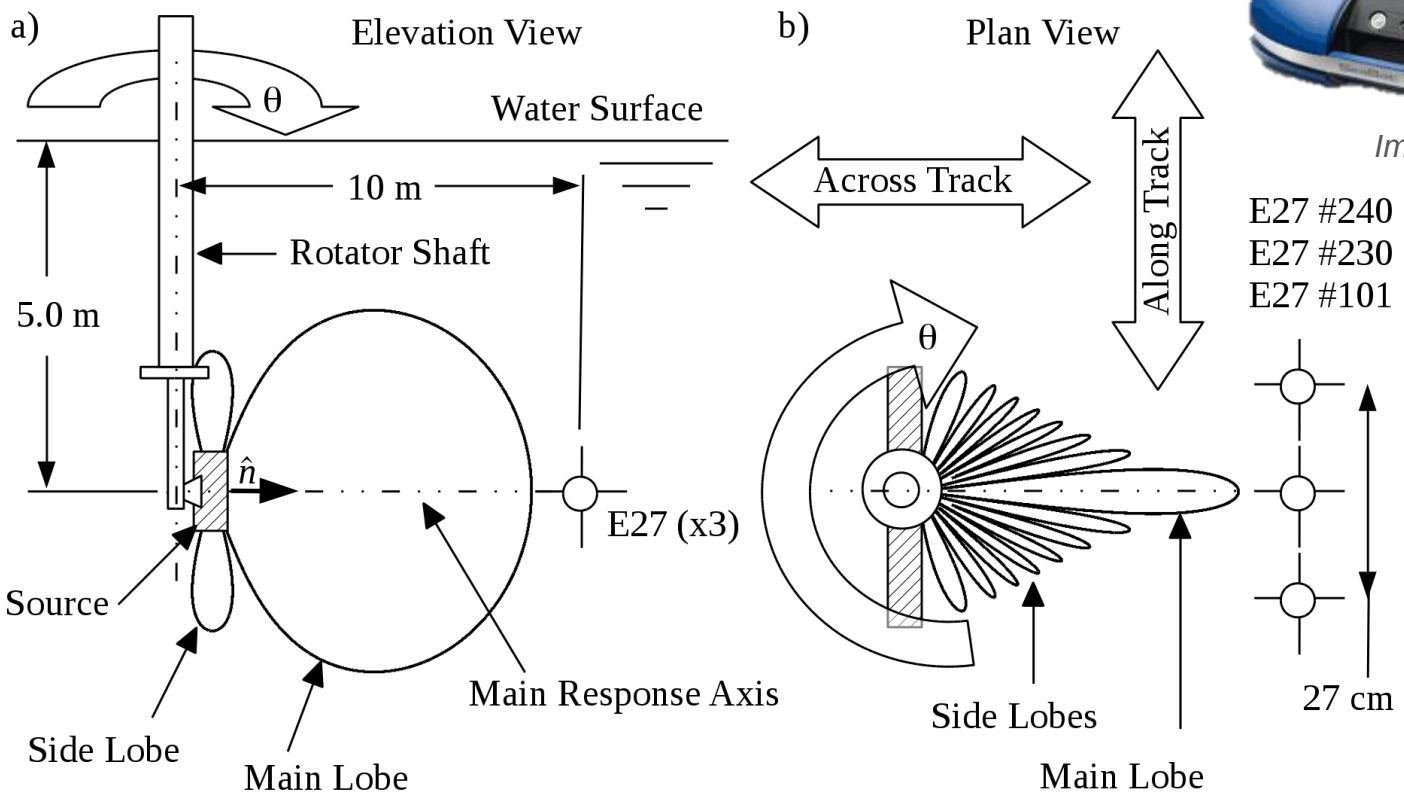


Image: United States Geological Survey

T20P Multibeam Fathometer

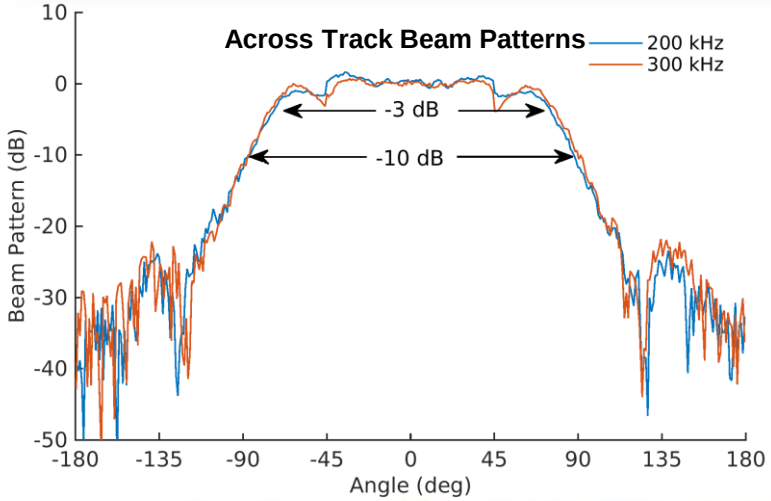
Image: Teledyne Reson

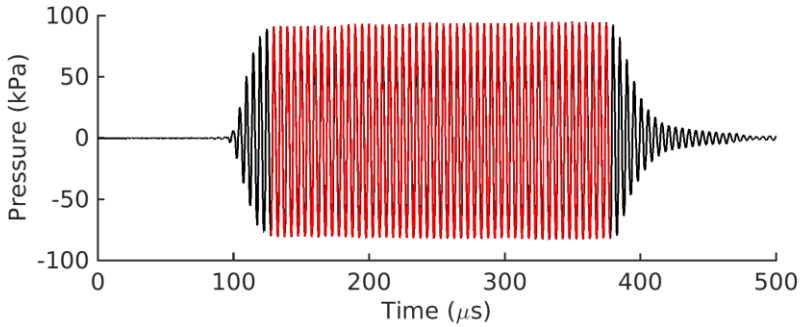


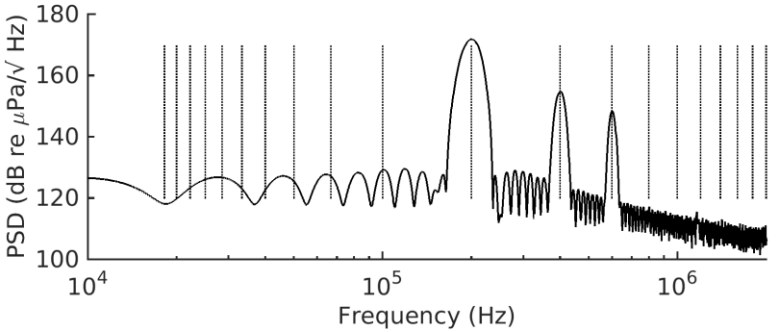
Geometry for measurement of along track beam patterns using closely spaced calibrated reference standards to improve resolution of narrow beam widths.

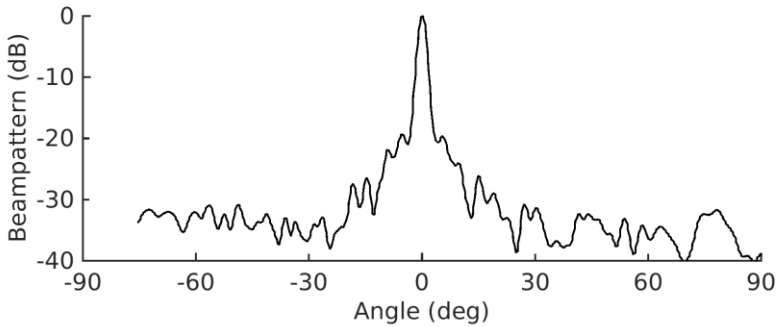
T20P Multibeam Fathometer

Source Settings			Source Level (dB re 1μPa@1m)				Effective Pulse Width (μs)
Freq. (kHz)	Source Level (dB)	Pulse Width (μs)	Pk-Pk	Pk	RMS	SEL	
200	220	300	226	221	218	182	250
200	205	300	213	208	204	168	248
200	190	300	193	187	184	150	254
300	220	300	232	227	221	185	253
300	205	300	215	210	205	169	252
300	190	300	197	191	185	149	254
400	220	300	229	223	220	184	254
400	205	300	214	208	204	168	257
400	190	300	197	191	185	150	269









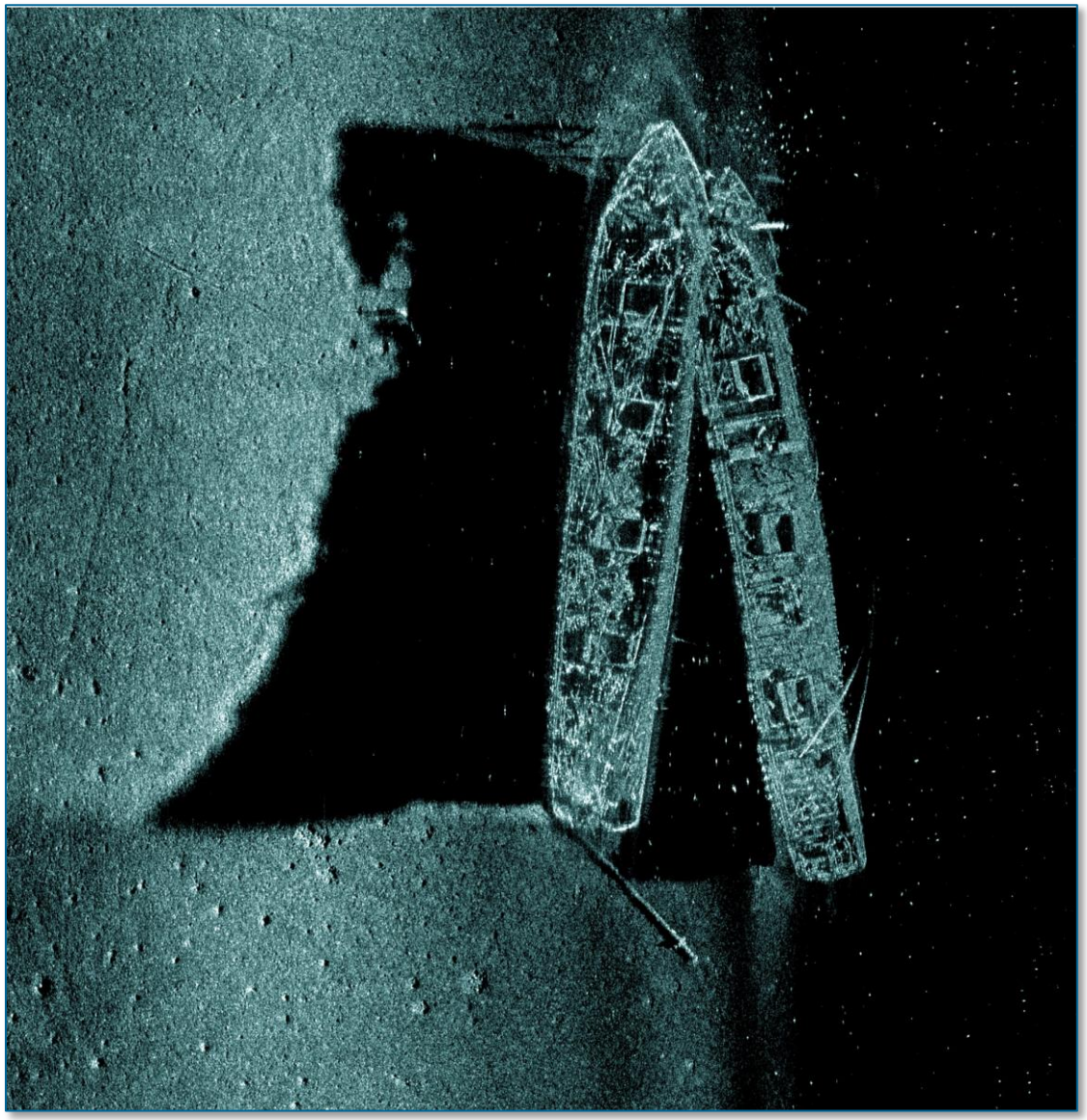
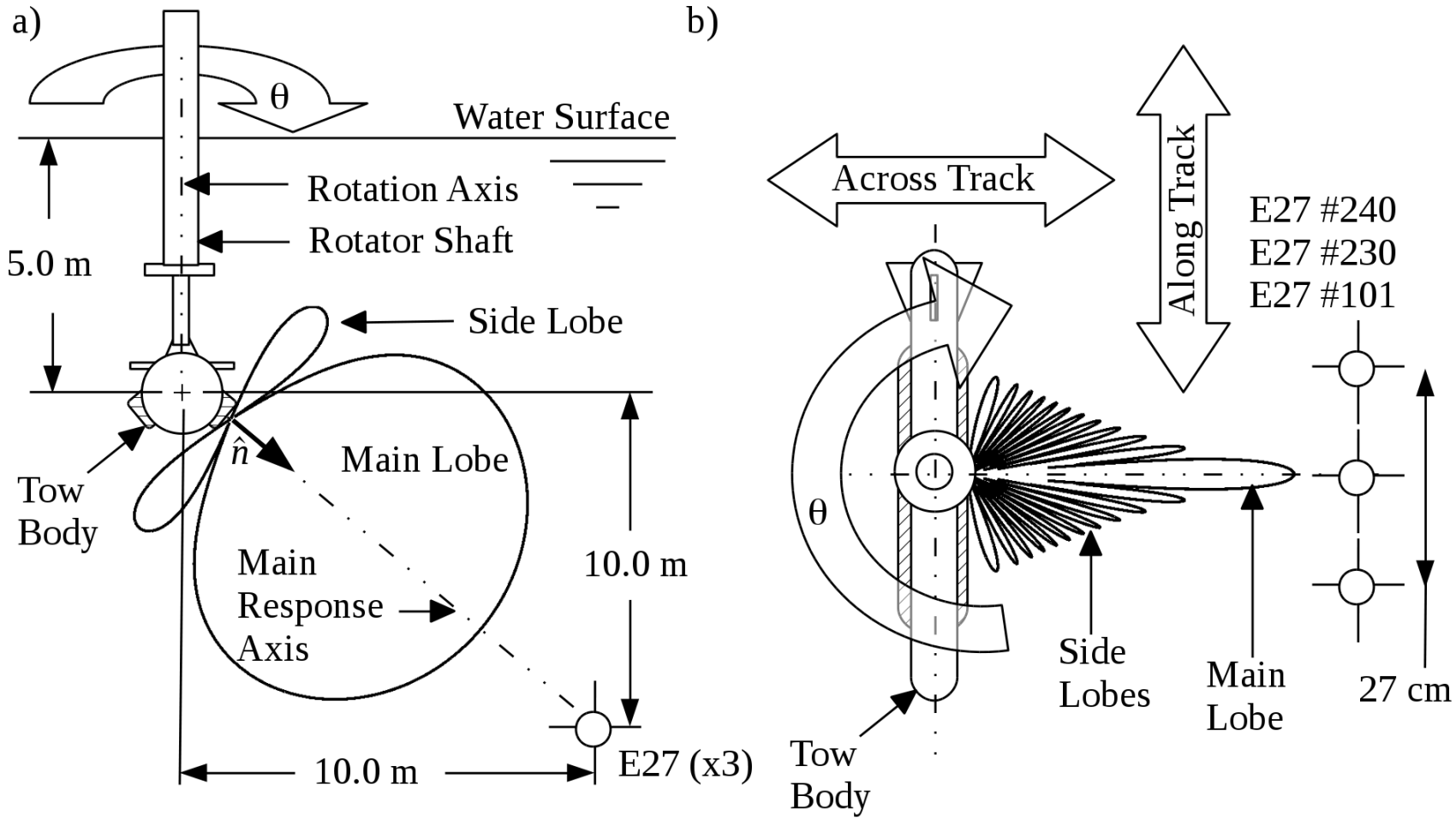


Image: National Oceanic and Atmospheric Administration (USA)

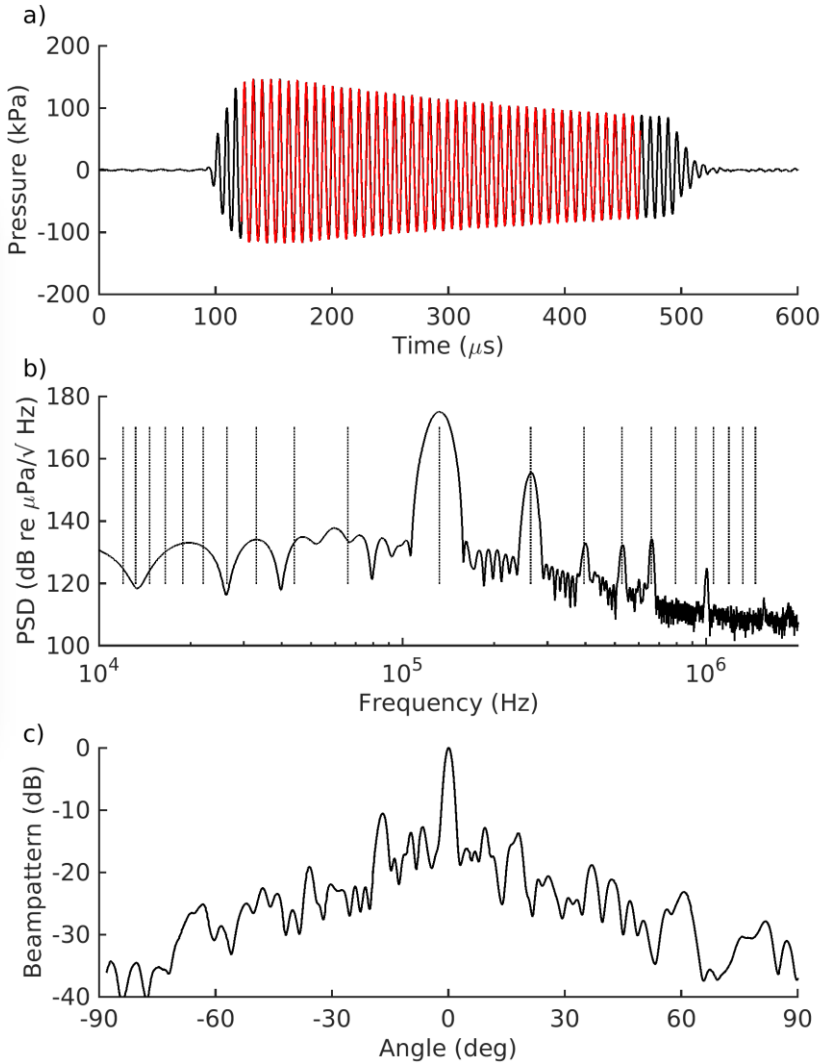
Side Scan Sonar

Klein 3000 Side Scan Sonar

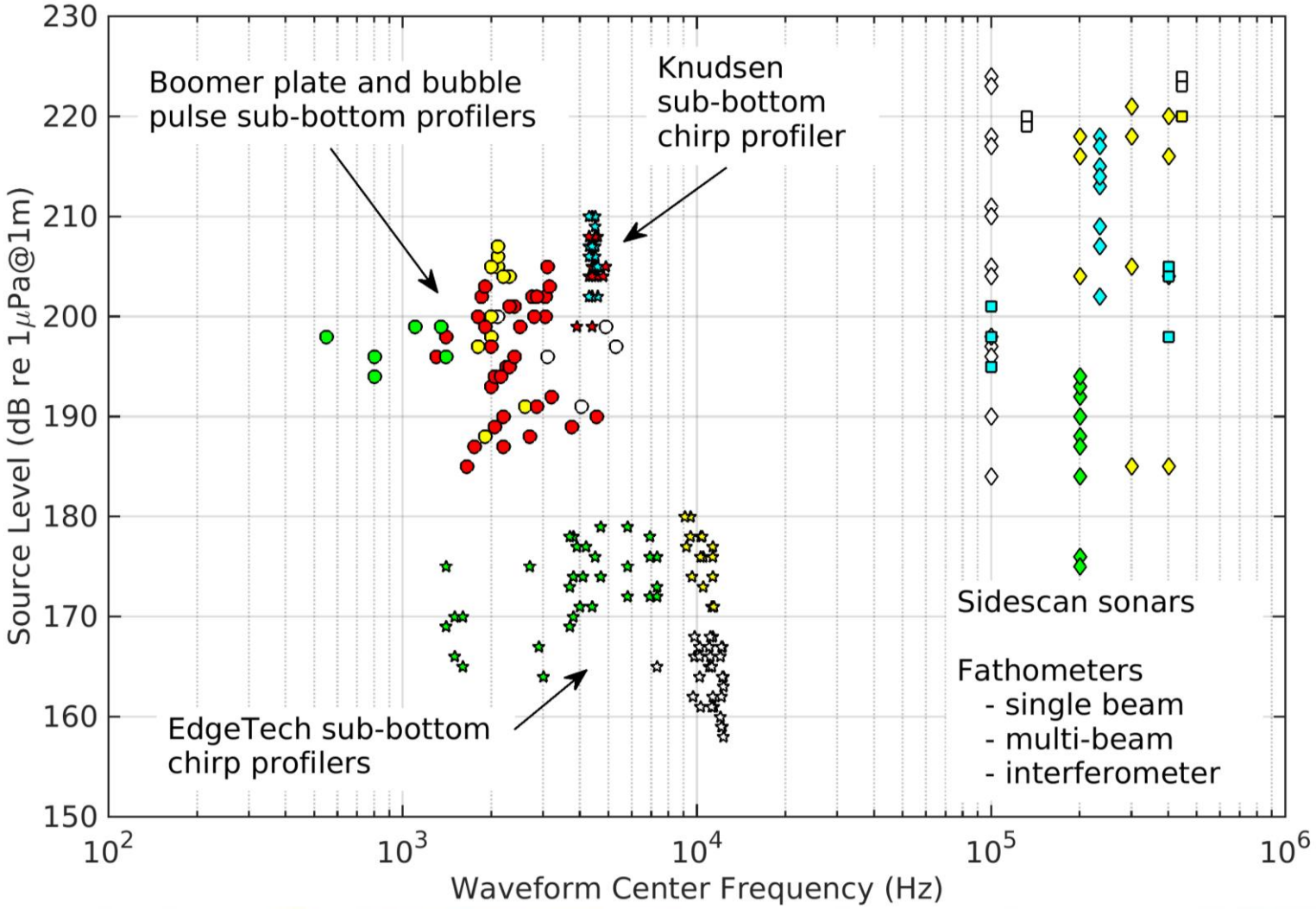


Klein 3000 Side Scan Sonar

Source Settings			Source Level (dB re 1μPa@1m)				Eff. Pulse Width (us)	Main Lobe Width (3 dB) (deg)	Max. Side Lobe	
Freq. (kHz)	Pulse Width (us)	Range (m)	Pk-Pk	Pk	RMS	SEL			Angle (deg)	Level (dB)
132	50	25	229	224	219	176	44	2.4	-16	-10
132	50	50	229	224	220	176	44	2.4	-17	-9
132	50	100	229	224	220	176	42	2.2	-17	-10
132	50	400	230	225	220	176	44	1.9	-17	-10
132	50	600	230	225	220	176	44	2.2	-17	-9
132	100	100	230	224	220	179	81	2.1	-17	-10
132	200	200	230	225	220	182	168	1.8	-17	-10
132	400	400	230	224	219	184	343	1.7	-17	-11
132	400	600	230	224	219	184	343	1.8	-17	-11
445	25	50	233	227	224	177	21	1.2	-5	-16
445	25	600	233	227	223	177	21	0.8	-5	-17
445	100	100	233	227	223	182	88	1.2	-5	-19



Measurement Summary



Conclusion

Information to support estimation of environmental impacts associated with the operation of high-resolution, marine geophysical survey systems is not usually available in the vendor data.

The Bureau of Ocean Energy Management funded a study, performed by the Underwater Sound Reference Division and U.S. Geological Survey to acquire and analyze calibrated acoustic source data for a number of commonly used geophysical survey systems.

The full report will be posted to: http://www.boem.gov/Studies/

Interested persons can also request to receive a copy by contacting the author at steven.crocker@navy.mil