Journal of
Marine Science and Engineering

MDPI

Article

Categorizing Alternative Seismic Sources Based on Their Potential to Affect Marine Mammals

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Both TPS and Gemini are in the same tier (tier 2)
(Harmony is “lower” tier 1—almost made it.)

smaller ranges compared to Tier 1 conventional airgun arrays (Table 2). Thus, considering

https://doi.org/10.3390/jmse14151379

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the expected likelihood of auditory injury and based on the configurations presented, two pneumatic ULF alternative sources (i.e., TPS™ and Gemini Source™) can be placed in Tier 2. For the Harmony™ source, expected auditory injury onset ranges were similar to the 1500 in^3 3000 psi airgun array, which is the lower bound of Tier 1 (Table 2). The small-scale

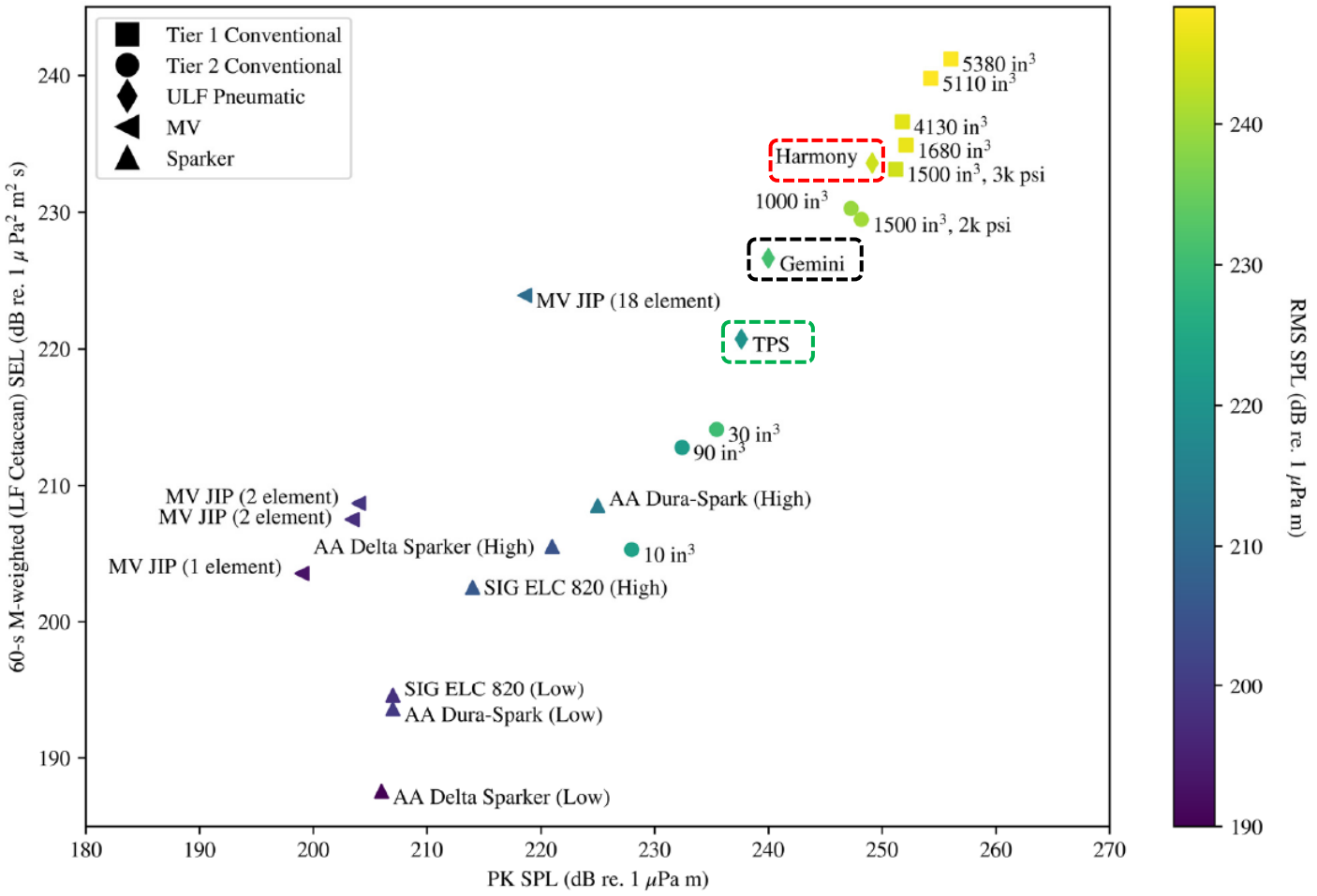


Figure 3. Visual comparison of PK SPL and $SEL_{60s,M}$ source levels for all sources. The low-frequency cetacean hearing group was selected for the representative 60 s M-weighted SEL ($SEL_{60s,M,LF}$) values. Sources are colored based on RMS SPL source levels shown on the secondary y-axis.

Harmony is in Tier 1

Gemini is in Tier 2

TPS is also in Tier 2

Arguably

TPS should be in Tier 3

Or better: do away with tiers and calculate environmental impact from the numbers

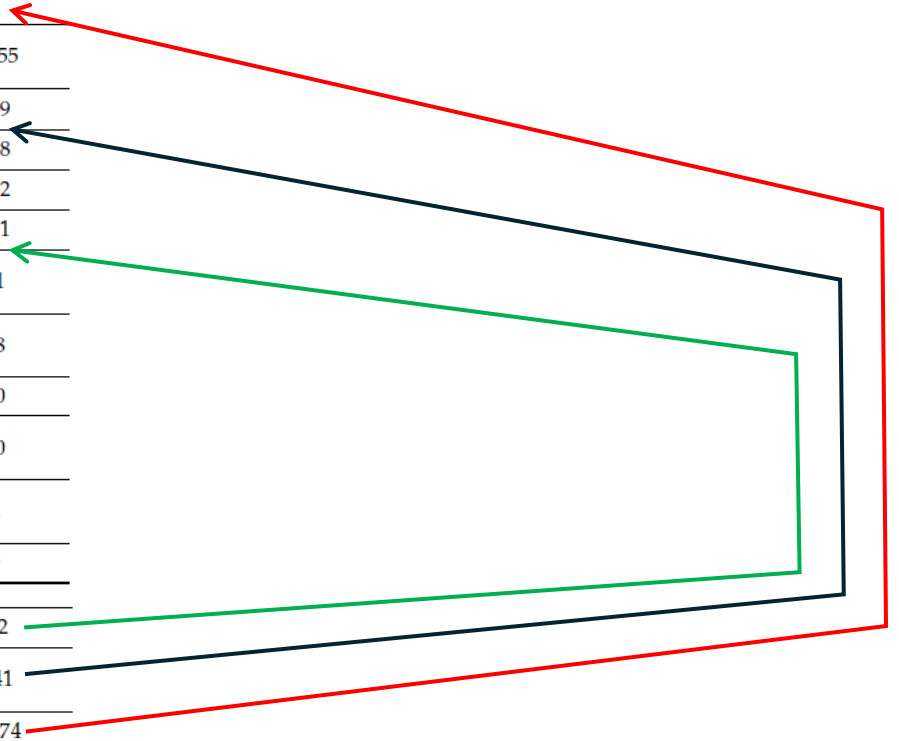
Table 2. NMFS auditory injury (AUD INJ) "safe distances" (m)

Source Category	Source	Configuration	SEL AUD INJ Safe Distance					PK SPL AUD INJ Safe Distance					160 dB Distance
			LF	HF	VHF	PW	OW	LF	HF	VHF	PW	OW	
Tier 1	5380 in^3	42 airguns	2910	4	92	165	13	50	20	502	45	20	25,214
	5110 in^3	32 airguns	1674	2	38	71	5	41	16	411	37	16	26,062
	4130 in^3	31 airguns	1230	1	14	53	3	31	12	308	27	12	19,389
	1680 in^3	20 airguns	1087	1	20	55	3	32	13	320	28	13	20,694
	1500 in^3 (3K psi)	6 airguns	486	2	153	43	7	29	11	287	26	11	16,040
Tier 2	1500 in^3 (2K psi)	6 airguns	224	1	69	21	3	20	8	203	18	8	10,155
	1000 in^3	12 airguns	205	1	118	23	4	18	7	183	16	7	9189
	90 in^3	1 airgun	10	0	0	1	0	3	1	33	3	1	1258
	30 in^3	2 airguns	17	0	1	2	0	5	2	47	4	2	3252
	10 in^3	1 airgun	3	0	0	0	0	2	1	20	2	1	1511
Tier 3	AA Dura-Spark	2400 J, 400 tip sparker	9	0	213	7	3	1	1	14	1	1	501
	AA Delta Sparker	2400 J sparker	5	0	107	4	1	1	0	9	1	0	178
	SIG ELC 820	750 J sparker	2	0	54	2	1	0	0	4	0	0	200
	AA Dura-Spark	100 J, 80 tip sparker	0	0	7	0	0	0	0	2	0	0	100
	AA Delta Sparker	500 J sparker	0	0	2	0	0	0	0	2	0	0	32
	SIG ELC 820	300 J sparker	0	0	8	0	0	0	0	2	0	0	79
Alternatives	TPS™	1–28,000 in^3	11	0	1	0	0	6	2	60	5	2	962
	Gemini Source™	1–8000 in^3	70	0	25	2	0	8	3	79	7	3	3541
	Harmony™	1–6000 in^3	415	0	4	8	1	23	9	227	20	9	15,774
	MV JIP IPN	18 elements	0	0	0	0	0	n/a	n/a	n/a	n/a	n/a	339
	MV JIP IPN	1 element	0	0	0	0	0	n/a	n/a	n/a	n/a	n/a	45
	MV JIP IPN	2 elements	0	0	0	0	0	n/a	n/a	n/a	n/a	n/a	88
	MV JIP IPN	2 elements	0	0	0	0	0	n/a	n/a	n/a	n/a	n/a	79

Harmony almost makes it to Tier 2

Gemini in the middle of Tier 2

TPS almost makes it to Tier 3



Normalized to TPS = 1 (divide by zero is blank)

	SEL					SPL					160 dB distance
	LF	HF	VHF	PW	OW	LF	HF	VHF	PW	OW	
TPS	1		1			1	1	1	1	1	1
Gemini	6.4		25			1.3	1.5	1.3	1.4	1.5	3.7
Harmony	38		4			3.8	4.5	3.8	4	4.5	16
CAG 5110	152		38			6.8	8	6.9	7.4	8	27

Copied from table 2 including 5110 cui Array of Conventional Air Guns (CAG)

	SEL					SPL					160 dB distance
	LF	HF	VHF	PW	OW	LF	HF	VHF	PW	OW	
TPS	11	0	1	0	0	6	2	60	5	2	962
Gemini	70	0	25	2	0	8	3	79	7	3	3541
Harmony	415	0	4	8	1	23	9	227	20	9	15774
CAG 5110	1674	2	38	71	5	41	16	411	37	16	26062

Harmony is in Tier 1

Gemini is in Tier 2

TPS is also in Tier 2

Table 2. *Cont.*

Source Category	Source	Configuration	SEL AUD INJ Safe Distance					PK SPL AUD INJ Safe Distance					160 dB Distance
			LF	HF	VHF	PW	OW	LF	HF	VHF	PW	OW	
Alternatives	TPS™	1–28,000 in^3	11	0	1	0	0	6	2	60	5	2	962
	Gemini Source™	1–8000 in^3	70	0	25	2	0	8	3	79	7	3	3541
	Harmony™	1–6000 in^3	415	0	4	8	1	23	9	227	20	9	15,774
	MV JIP IPN	18 elements	0	0	0	0	0	n/a	n/a	n/a	n/a	n/a	339
	MV JIP IPN	1 element	0	0	0	0	0	n/a	n/a	n/a	n/a	n/a	45
	MV JIP IPN	2 elements	0	0	0	0	0	n/a	n/a	n/a	n/a	n/a	88
	MV JIP IPN	2 elements	0	0	0	0	0	n/a	n/a	n/a	n/a	n/a	79

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TPS should be in Tier 3

Or better: do away with tiers and calculate environmental impact from the numbers