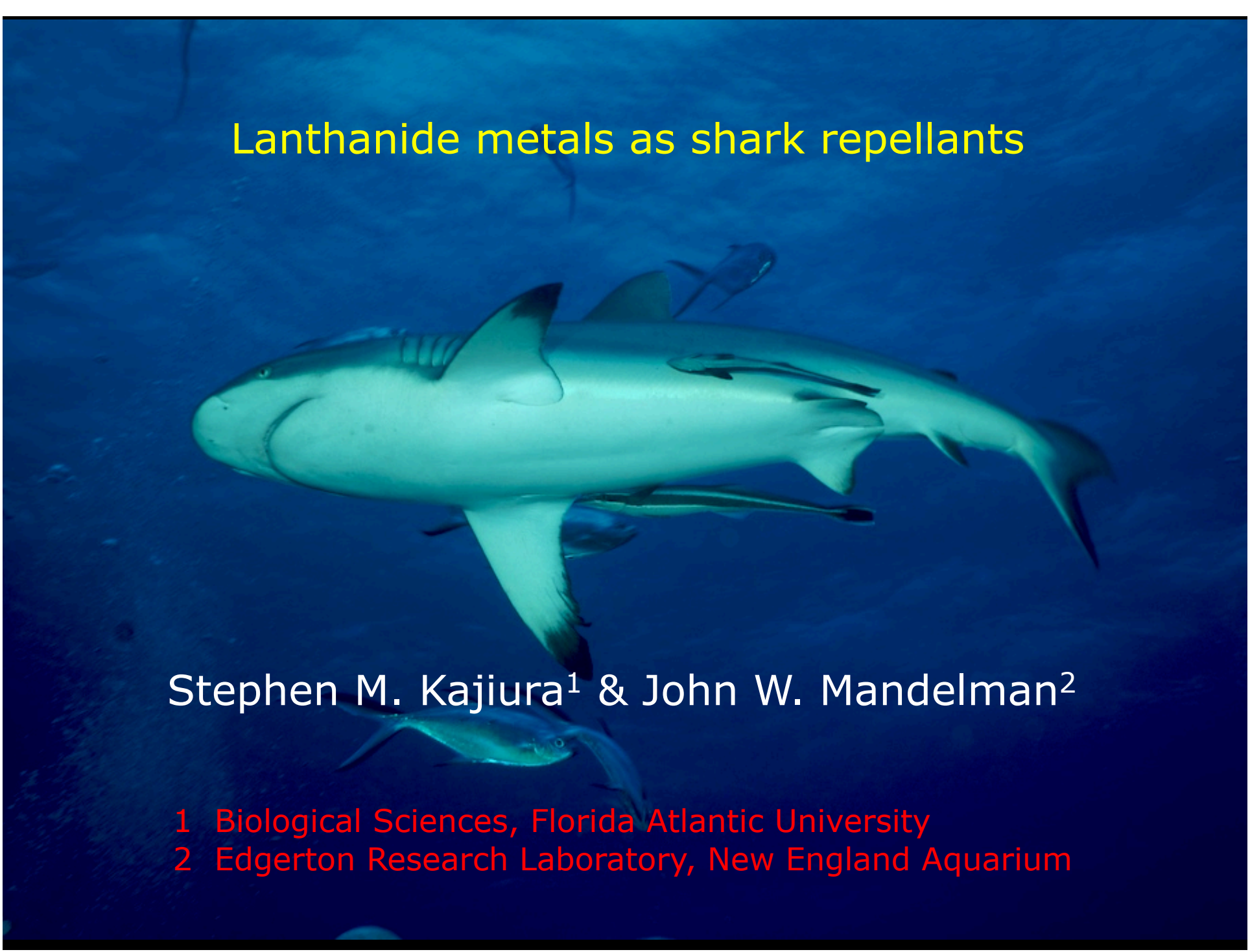
Lanthanide metals as shark repellants



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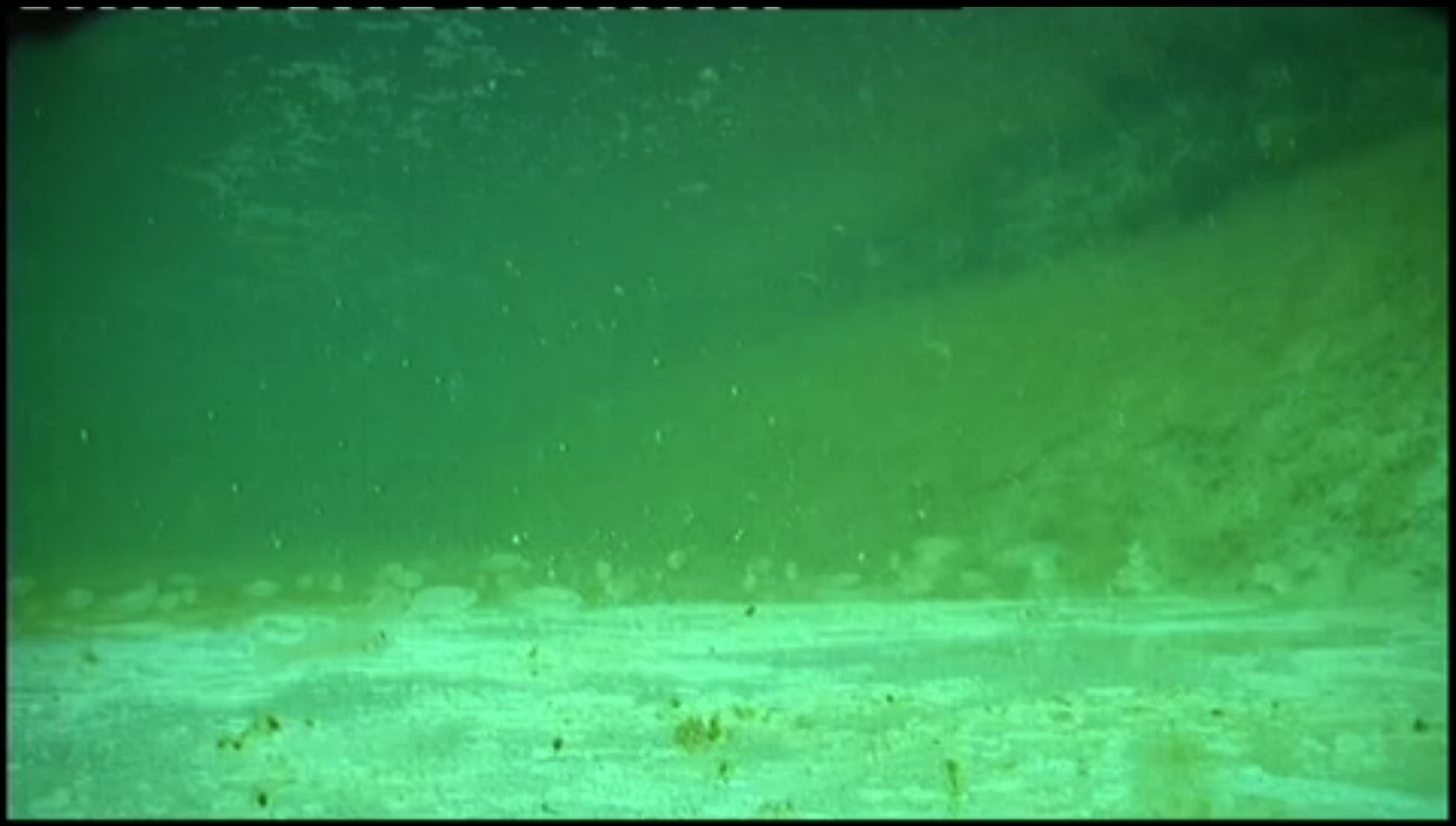
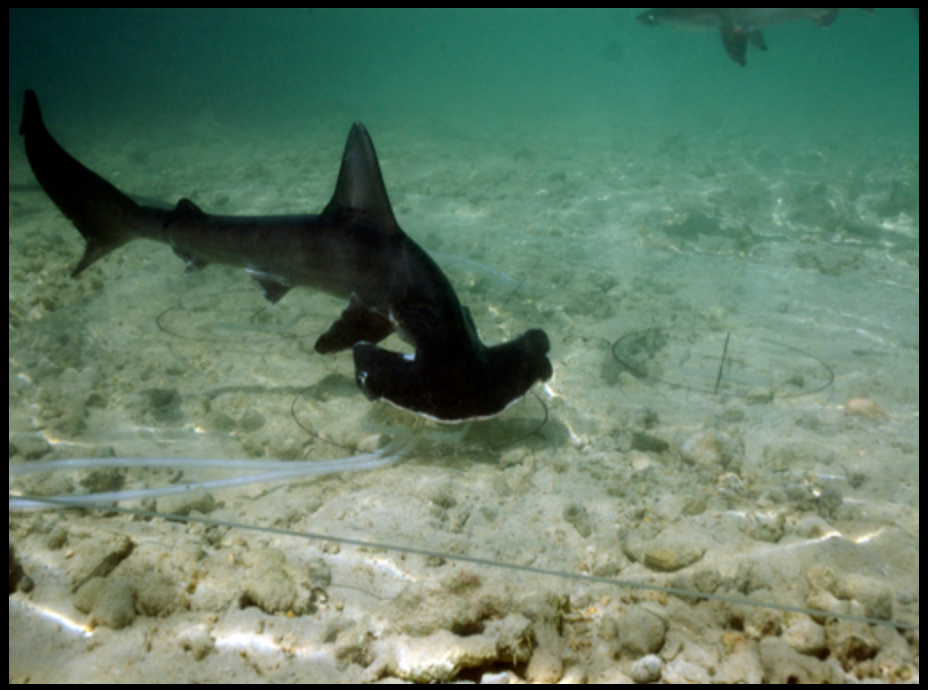
Longline bycatch

Electroreceptors

Electroreception; prey-simulating electric field



Electroreception; prey-simulating electric field

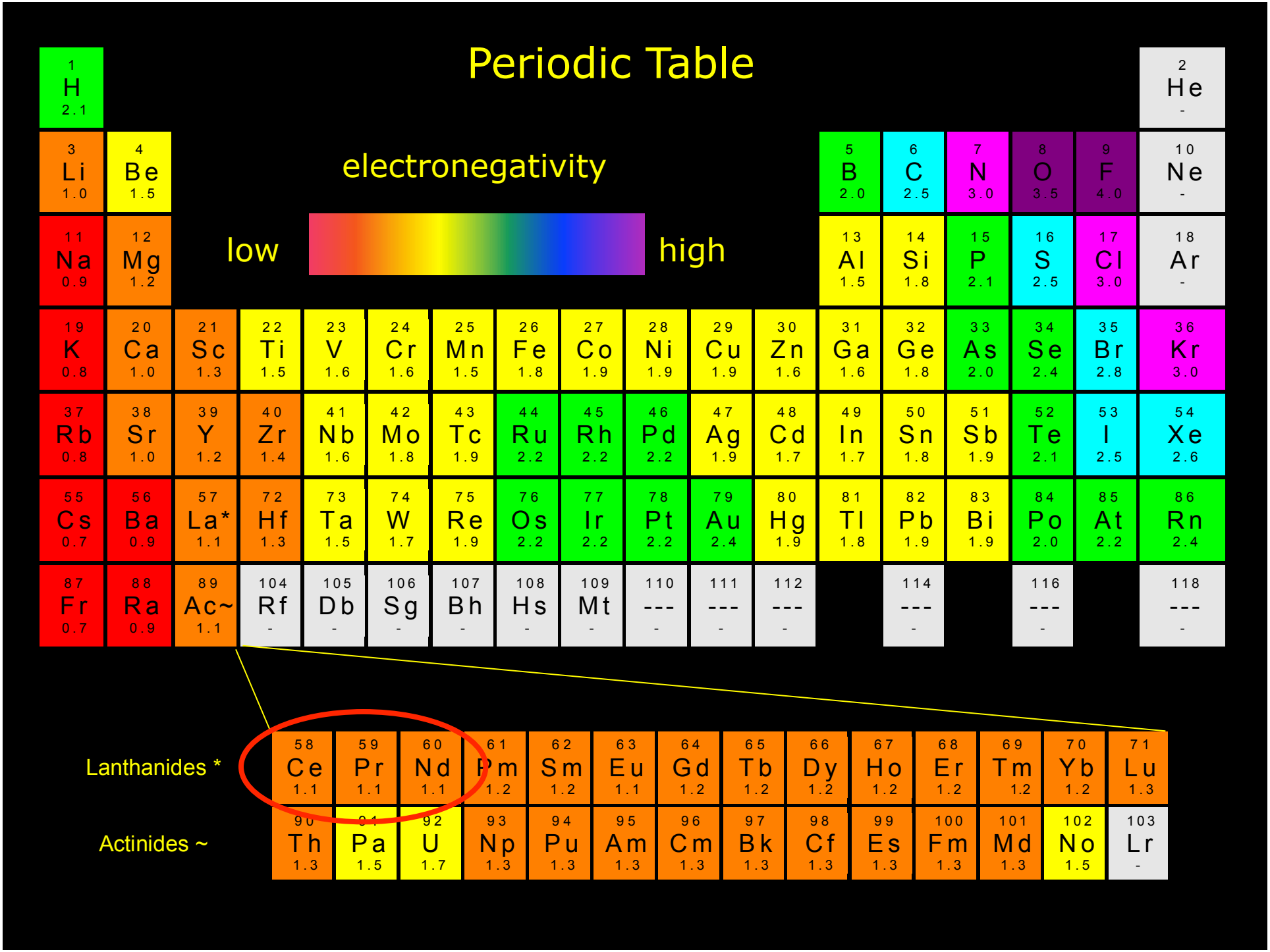


Periodic Table

1 H 2.1																	2 He -
3 Li 1.0	4 Be 1.5											5 B 2.0	6 C 2.5	7 N 3.0	8 O 3.5	9 F 4.0	10 Ne -
11 Na 0.9	12 Mg 1.2											13 Al 1.5	14 Si 1.8	15 P 2.1	16 S 2.5	17 Cl 3.0	18 Ar -
19 K 0.8	20 Ca 1.0	21 Sc 1.3	22 Ti 1.5	23 V 1.6	24 Cr 1.6	25 Mn 1.5	26 Fe 1.8	27 Co 1.9	28 Ni 1.9	29 Cu 1.9	30 Zn 1.6	31 Ga 1.6	32 Ge 1.8	33 As 2.0	34 Se 2.4	35 Br 2.8	36 Kr 3.0
37 Rb 0.8	38 Sr 1.0	39 Y 1.2	40 Zr 1.4	41 Nb 1.6	42 Mo 1.8	43 Tc 1.9	44 Ru 2.2	45 Rh 2.2	46 Pd 2.2	47 Ag 1.9	48 Cd 1.7	49 In 1.7	50 Sn 1.8	51 Sb 1.9	52 Te 2.1	53 I 2.5	54 Xe 2.6
55 Cs 0.7	56 Ba 0.9	57 La* 1.1	72 Hf 1.3	73 Ta 1.5	74 W 1.7	75 Re 1.9	76 Os 2.2	77 Ir 2.2	78 Pt 2.2	79 Au 2.4	80 Hg 1.9	81 Tl 1.8	82 Pb 1.9	83 Bi 1.9	84 Po 2.0	85 At 2.2	86 Rn 2.4
87 Fr 0.7	88 Ra 0.9	89 Ac~ 1.1	104 Rf -	105 Db -	106 Sg -	107 Bh -	108 Hs -	109 Mt -	110 --- -	111 --- -	112 --- -		114 --- -		116 --- -		118 --- -

Lanthanides *	58 Ce 1.1	59 Pr 1.1	60 Nd 1.1	61 Pm 1.2	62 Sm 1.2	63 Eu 1.1	64 Gd 1.2	65 Tb 1.2	66 Dy 1.2	67 Ho 1.2	68 Er 1.2	69 Tm 1.2	70 Yb 1.2	71 Lu 1.3
Actinides ~	90 Th 1.3	91 Pa 1.5	92 U 1.7	93 Np 1.3	94 Pu 1.3	95 Am 1.3	96 Cm 1.3	97 Bk 1.3	98 Cf 1.3	99 Es 1.3	100 Fm 1.3	101 Md 1.3	102 No 1.5	103 Lr -

Periodic Table



Previous studies

Study	Metal	Lab	Field	Species
Stoner & Kaimmer, 2008	CeLa Misch	70% reduction		Spiny dogfish – Pacific
Kaimmer & Stoner, 2008	CeLa Misch		19% reduction on protected longline hooks	Spiny dogfish - Pacific
Tallack & Mandelman, 2008	CeLa Misch	Some avoidance, but only for satiated fish	5-10% fewer on protected hooks (Not Significant)	Spiny dogfish - Atlantic
Brill et al., 2009	NdPr Metal Alloy	Avoid metal when no food present	Significant deterrent for sharks, not rays	Juvenile sandbar sharks

Proposed research

Treatment metals:

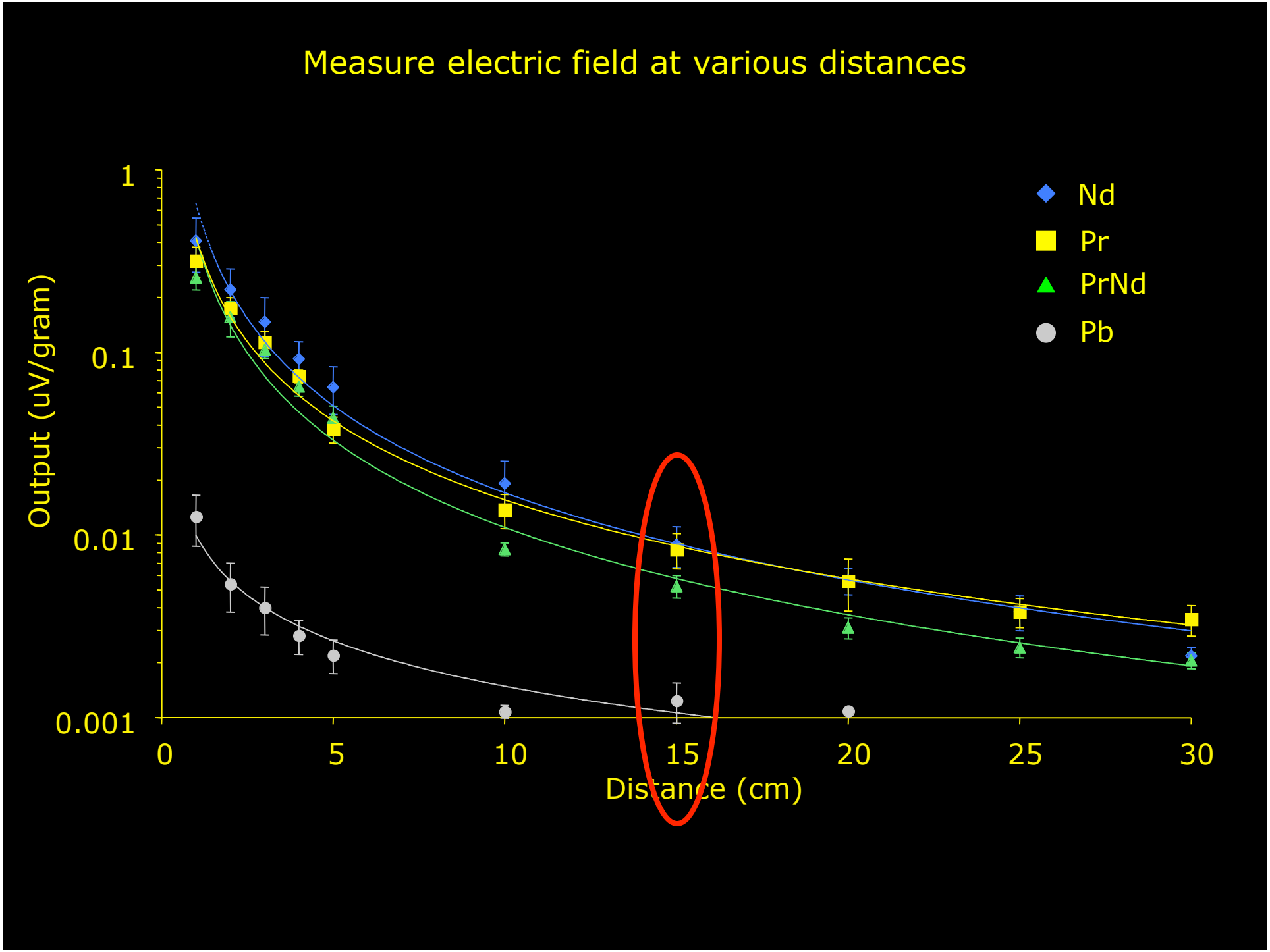
- Cerium (Ce)
- Praseodymium (Pr)
- Neodymium (Nd)
- Ce-La misch metal
- Pr-Nd misch metal
- Pr-Nd metal alloy

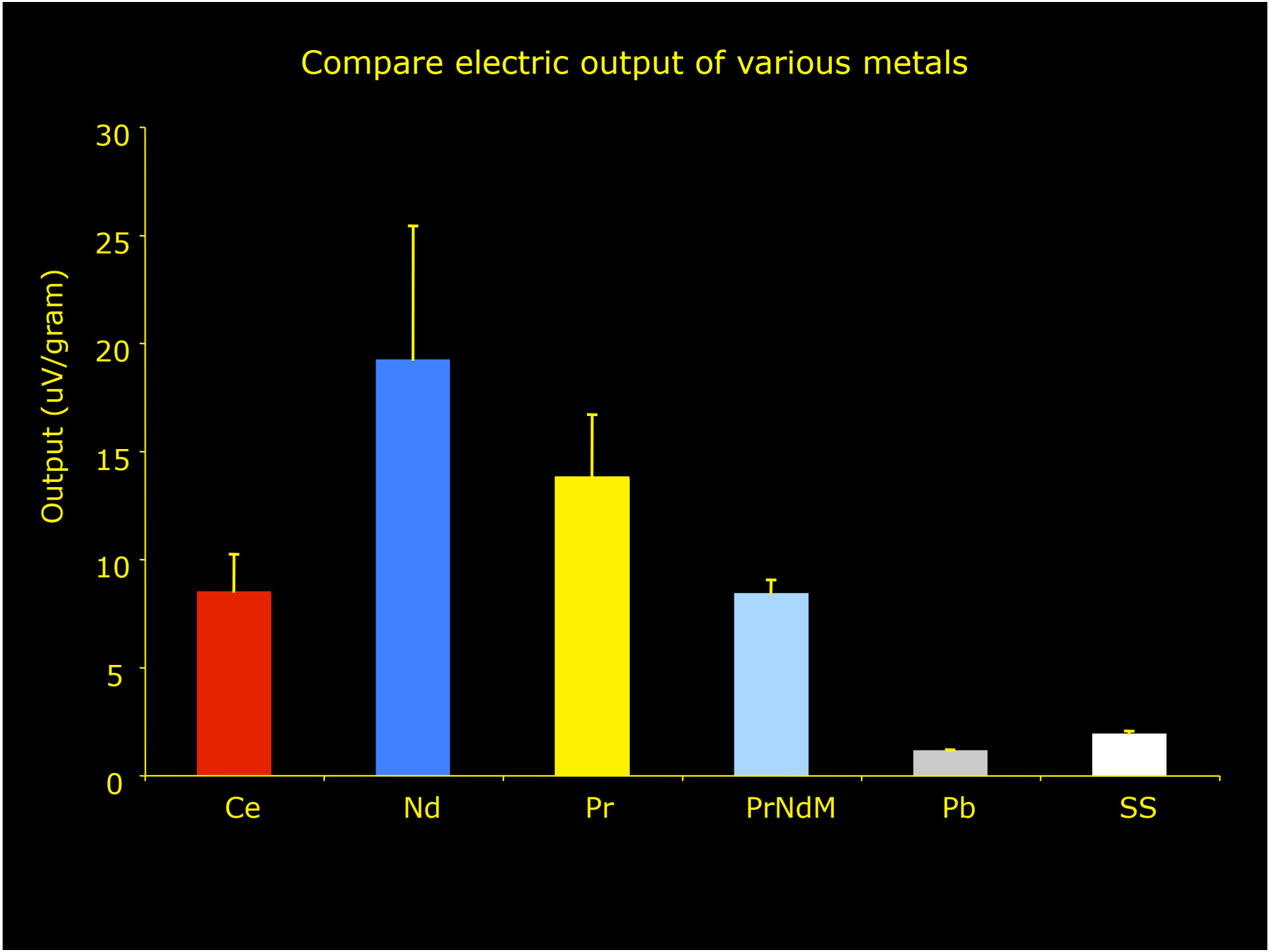
Controls:

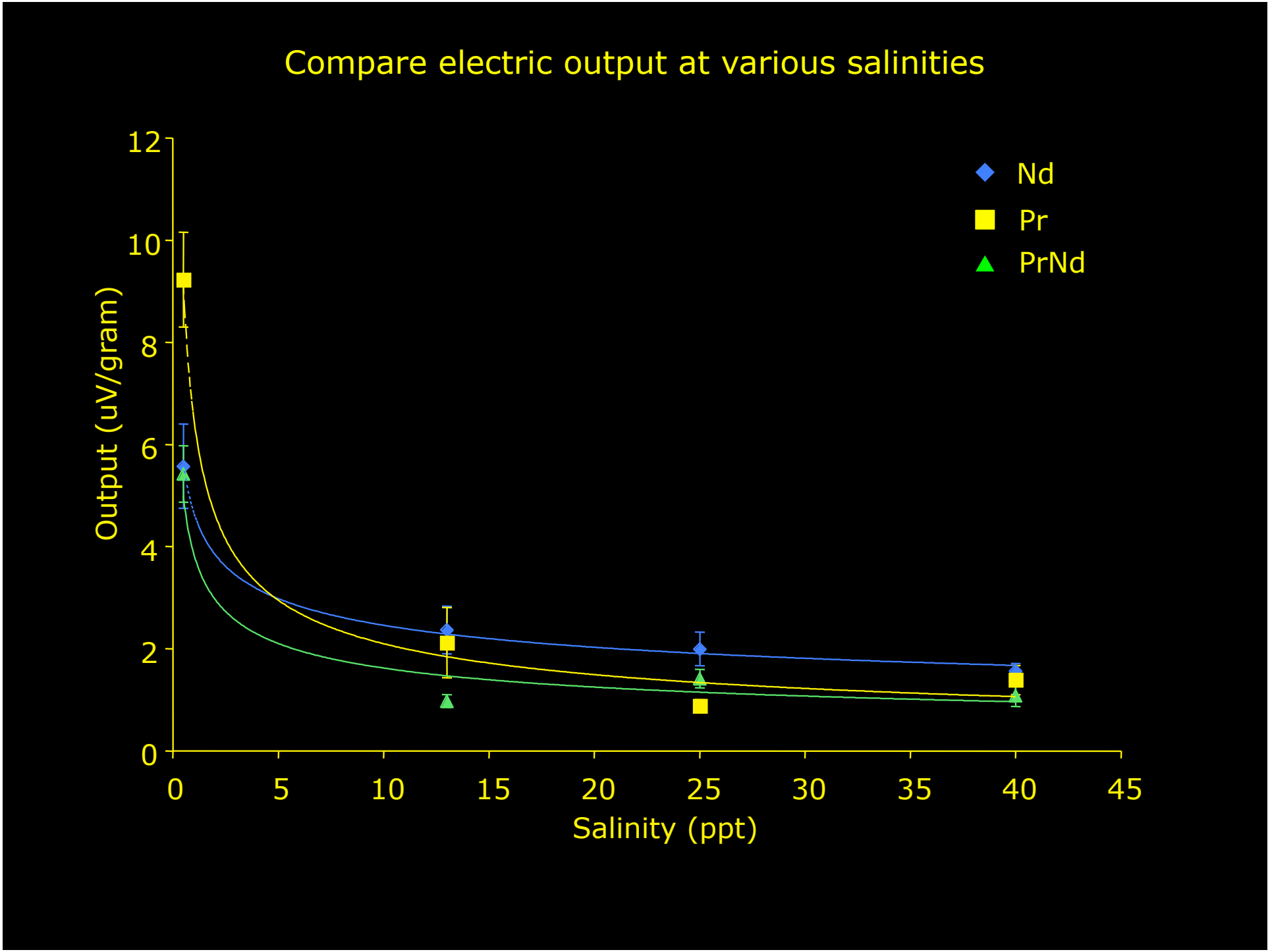
- Lead (Pb)
- Stainless Steel
- Acrylic

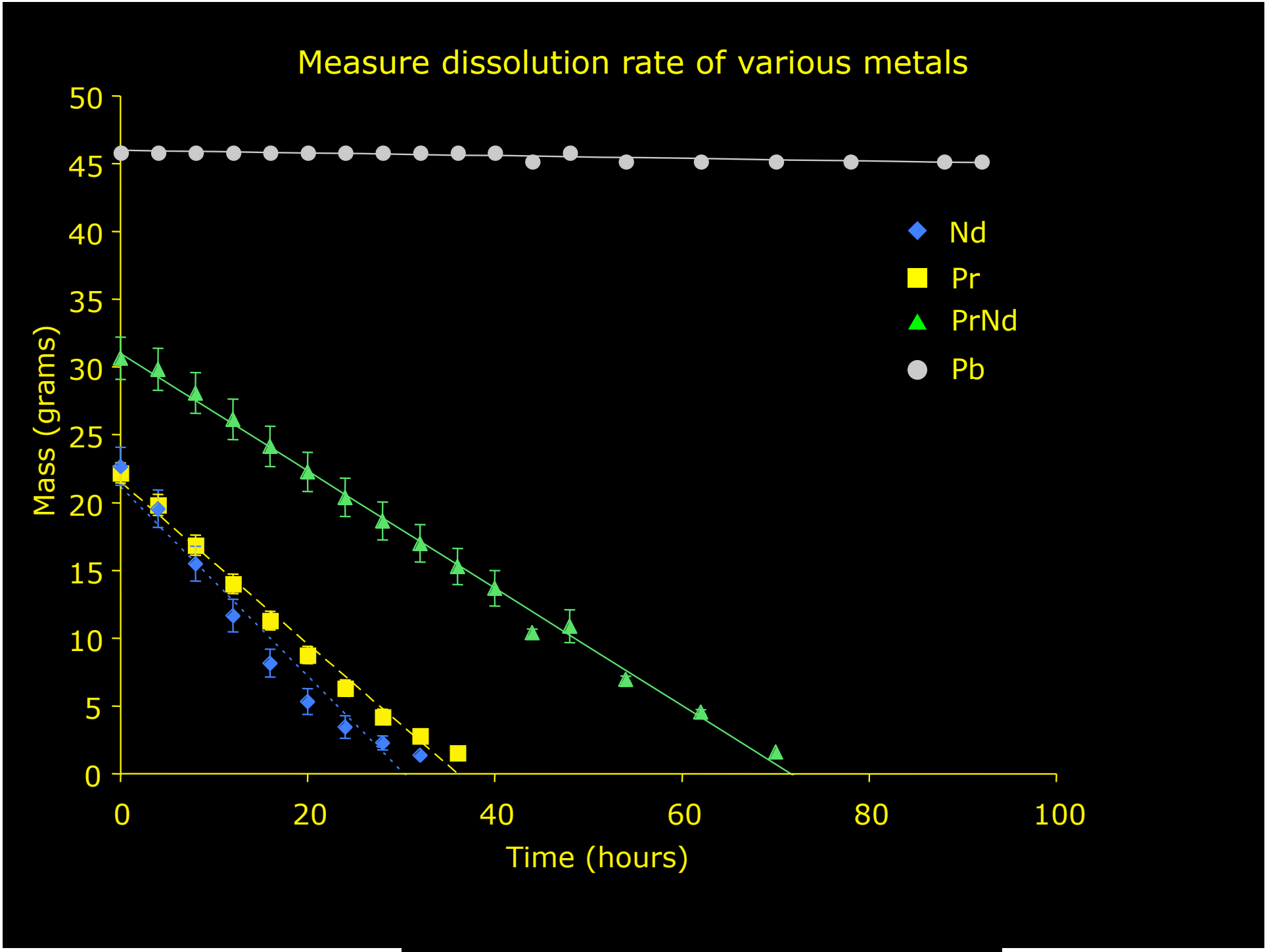
1. Measure e-fields of various metals
2. Neurophysiology of various species
3. Behavioral tank trials
4. Scientific fishing field trials
5. Commercial longline trials

Measuring electric fields


Measure electric field at various distances
Output (uV/gram)
1
0.1
0.01
0.001
0
5
10
15
20
25
30
Distance (cm)
Nd
Pr
PrNd
Pb


Compare electric output of various metals
Output (uV/gram)
30
25
20
15
10
5
0
Ce
Nd
Pr
PrNdM
Pb
SS


Compare electric output at various salinities
Output (uV/gram)
Salinity (ppt)
Nd
Pr
PrNd
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35
40
45


Measure dissolution rate of various metals
Mass (grams)
Time (hours)
0
5
10
15
20
25
30
35
40
45
50
0
20
40
60
80
100
Nd
Pr
PrNd
Pb

Determine which metals provide greatest potential

Treatment metals:

- Cerium (Ce)
- Praseodymium (Pr)
- Neodymium (Nd)
- Ce-La misch metal
- Pr-Nd misch metal
- Pr-Nd metal alloy

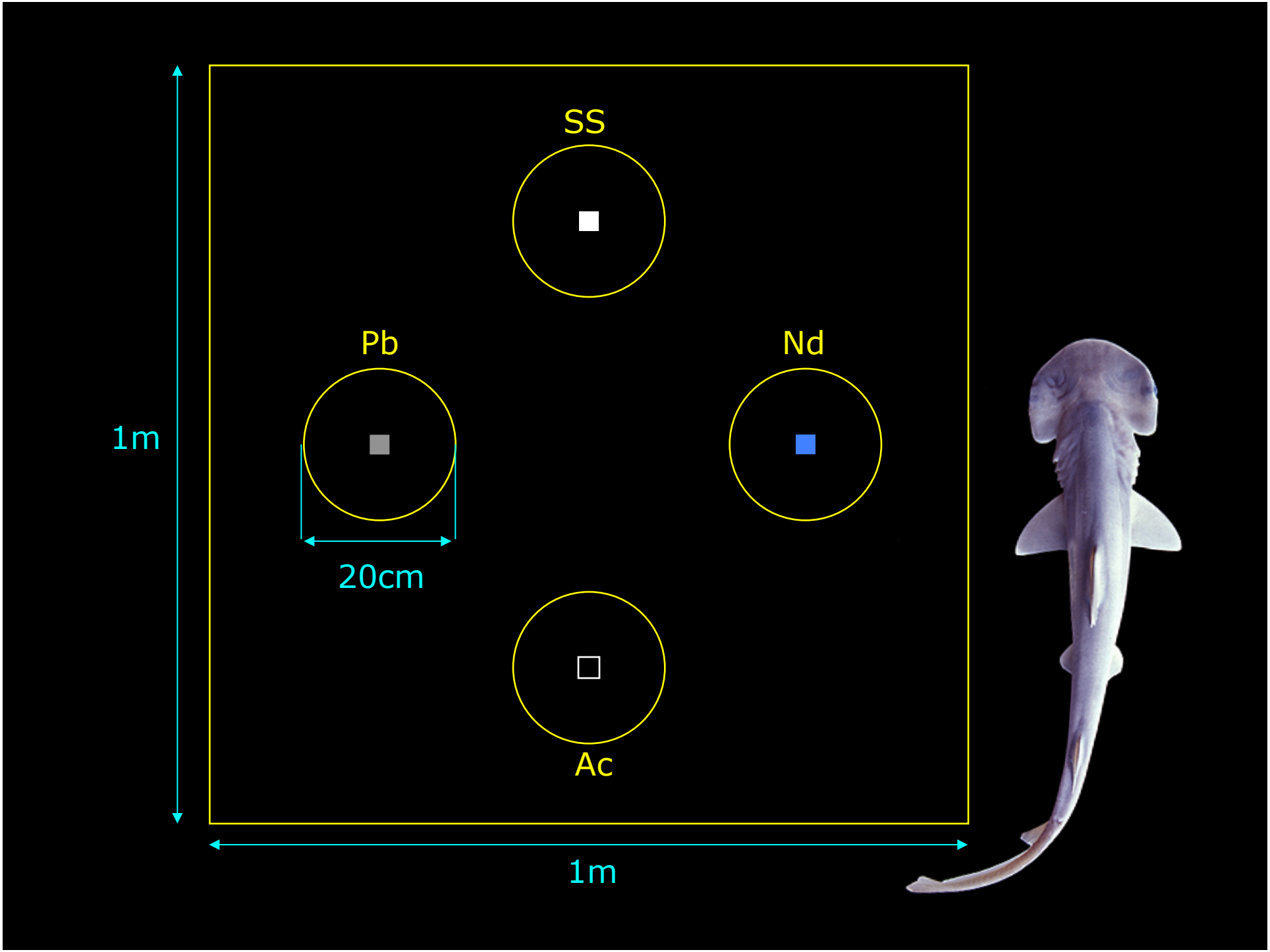
Consider:

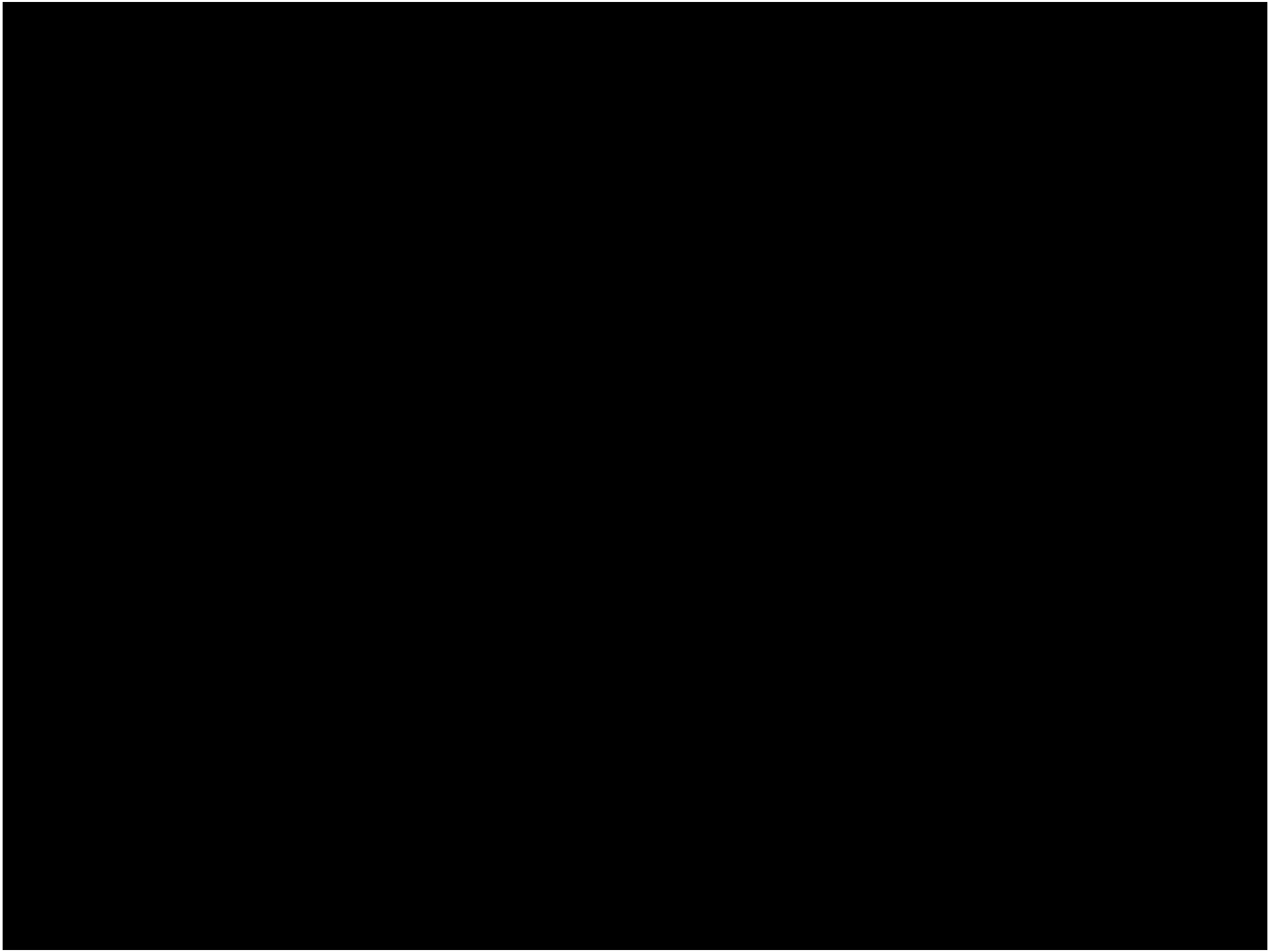
Electrical output (volts/gram)

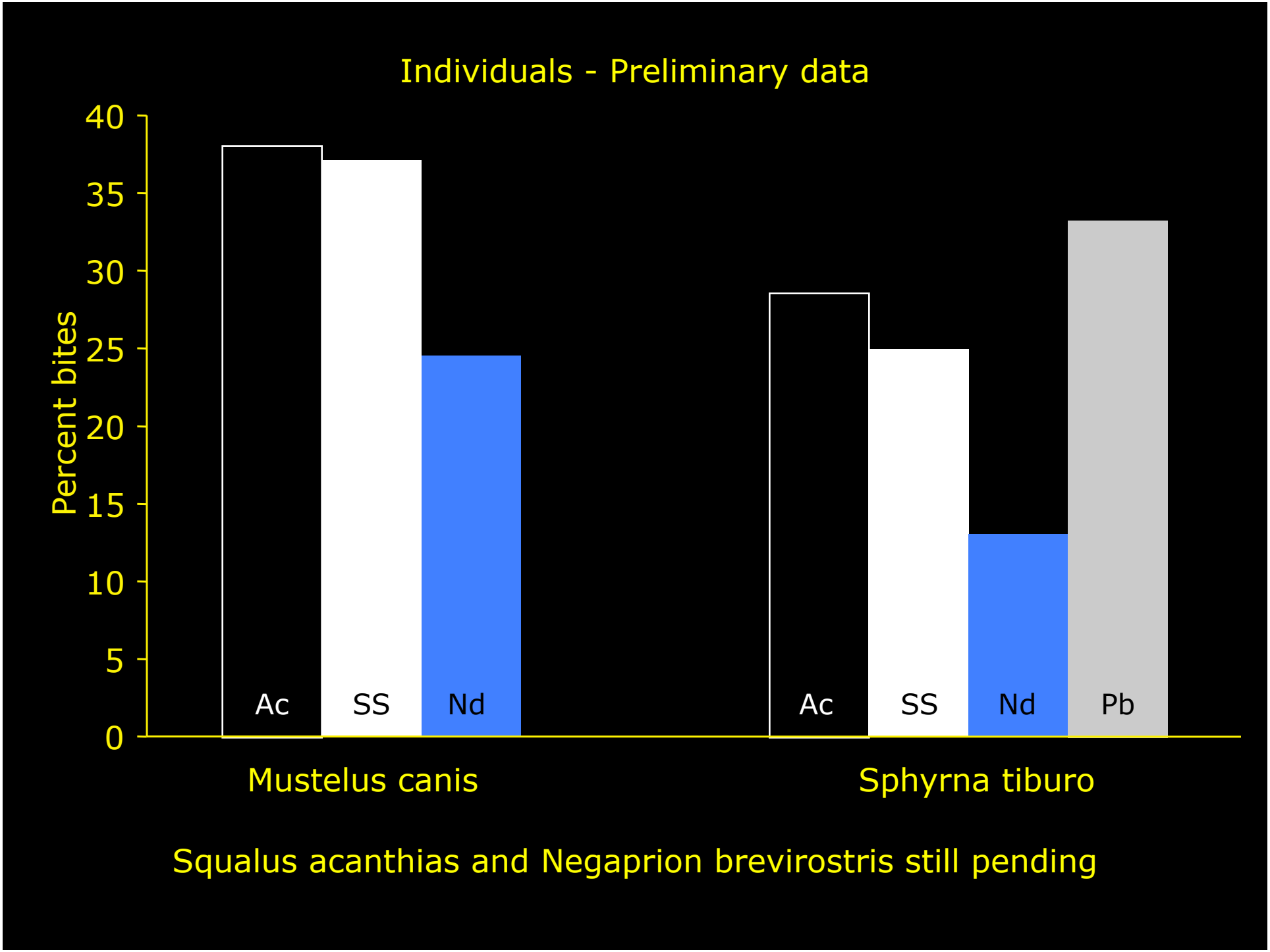
Dissolution rate

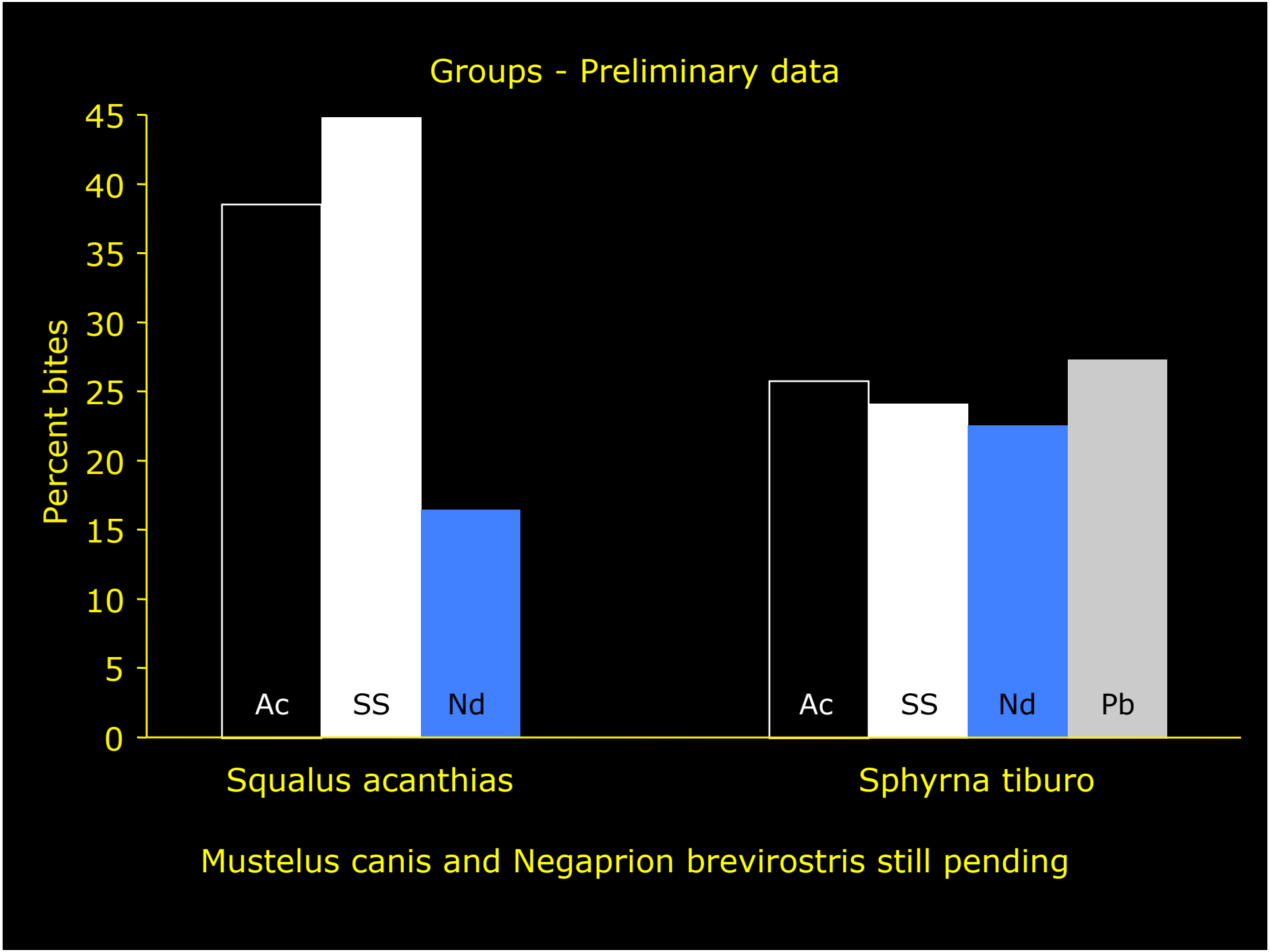
Machinability

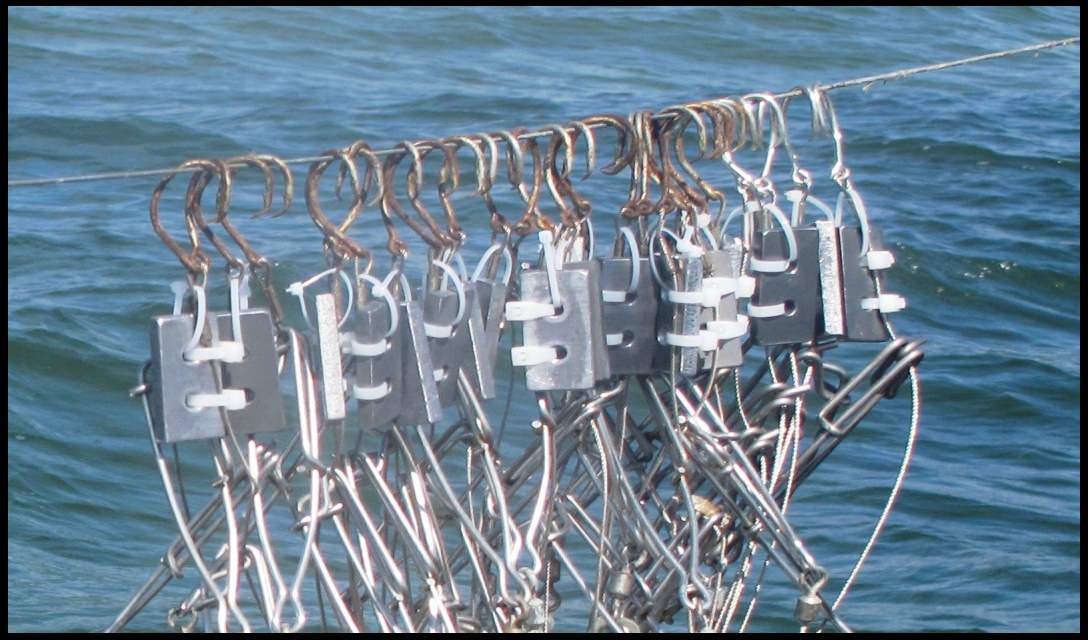
Price

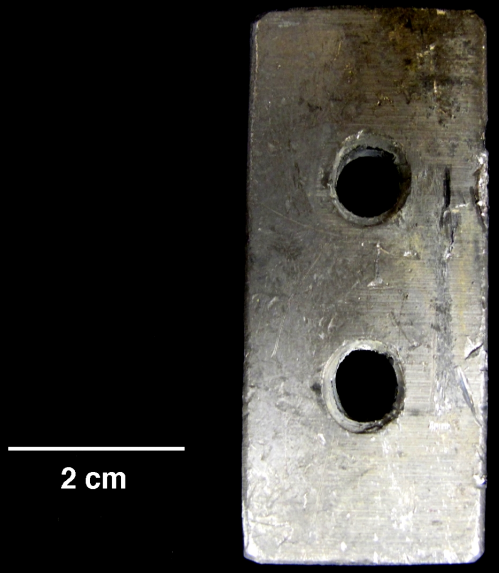

SS
Pb
Nd
Ac
1m
20cm
1m

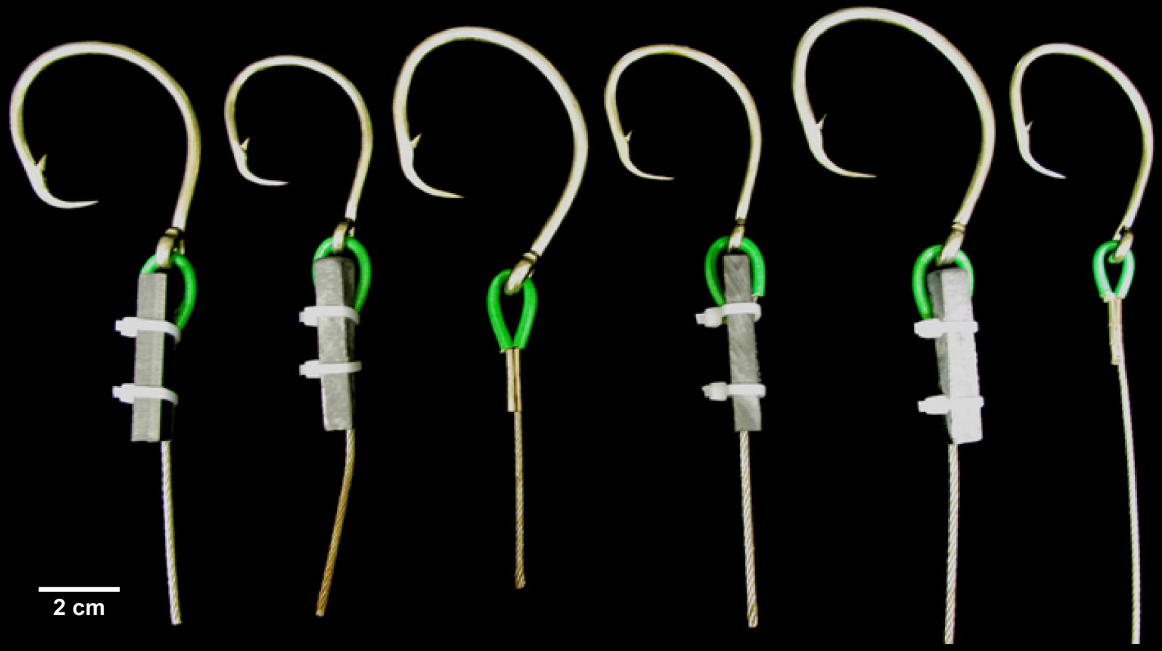


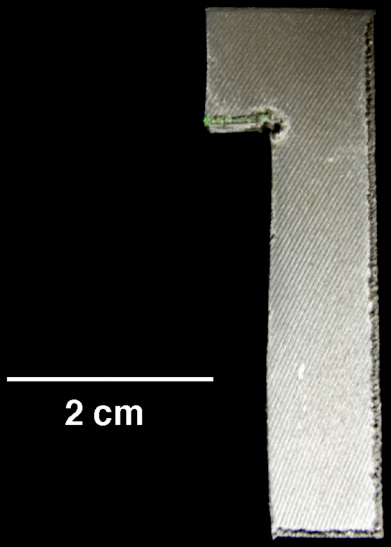

Individuals - Preliminary data
Percent bites
40
35
30
25
20
15
10
5
0
Ac
SS
Nd
Ac
SS
Nd
Pb
Mustelus canis
Sphyrna tiburo
Squalus acanthias and Negaprion brevirostris still pending


Groups - Preliminary data
Percent bites
45
40
35
30
25
20
15
10
5
0
Ac
SS
Nd
Ac
SS
Nd
Pb
Squalus acanthias
Sphyrna tiburo
Mustelus canis and Negaprion brevirostris still pending




2 cm


2 cm


2 cm

Pending research

Scientific longline fishing
- n=20 sets completed
- metal redesigned to minimize interference
- restart fishing in spring 2011

Commercial longline application
- awaiting results of scientific longlining

Neurophysiology
- technical hurdles overcome
- data collection will begin in Nov

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Bycatch Consortium