TO BLOW OR NOT TO BLOW?

Ask EDGAR

Explosives use in Decommissioning –
Guide for Assessment of Risk

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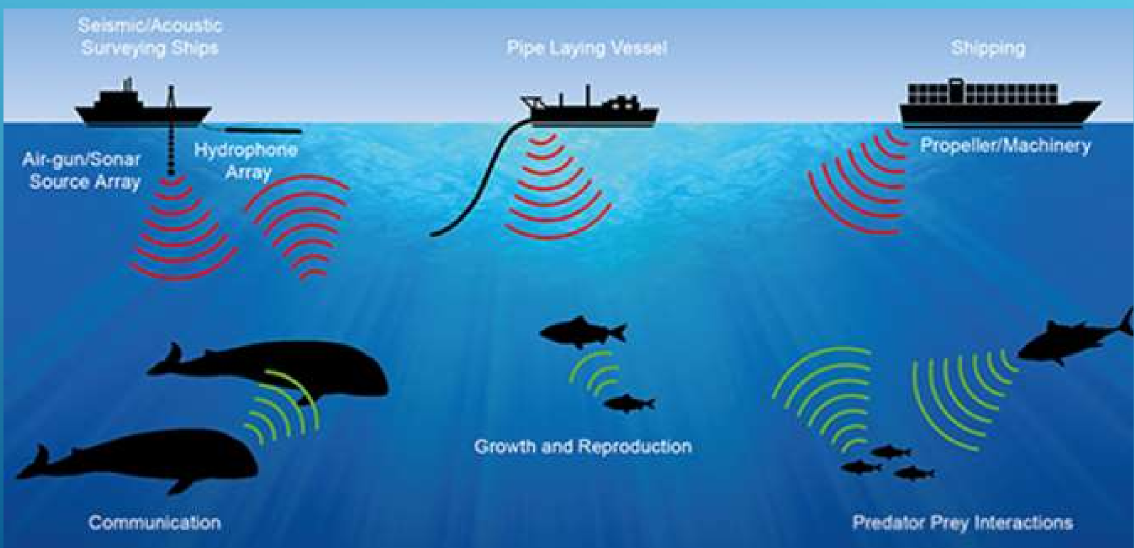
UNDERWATER NOISE Sources & Environmental Impact



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UNDERWATER NOISE Characterisation & Metrics

To characterise potential effects of sound on marine animals, regulators use:

- **Sound Pressure Levels** (SPLs) (acoustic amplitude)
- **Sound Exposure Levels** (SELs) (acoustic energy: SPL + duration)
    - SEL_{ss} (single strike or shot)
    - SEL_{cum} (cumulative)

SEL_{cum} can be used to predict the **risk for hearing loss**

Equal Energy Hypothesis:

- Sounds received at lower levels for longer durations may have similar effects as sounds received at higher levels for shorter durations
- If the interval between pulses is long enough hearing can be recovered

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Fit for Purpose?

https://giphy.com/gifs/johnlewisandpartners-john-lewis-christmas-excitable-edgar-gLic1F2QA32BSVfuR0

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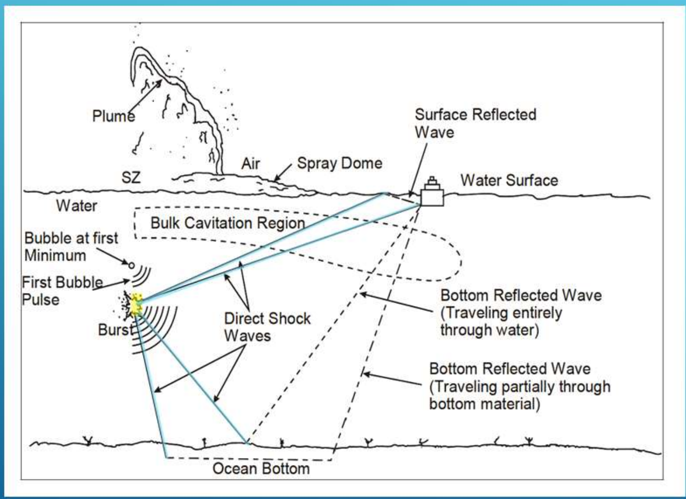
UNDERWATER EXPLOSION Phenomena Summary



(After Costanzo, 2010)

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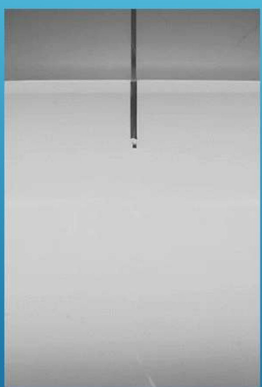
UNDERWATER EXPLOSIONS Pressure Changes



https://www.youtube.com/watch?v=AvM2E540nYg&feature=emb_logo&ab_channel=WarpedPerception

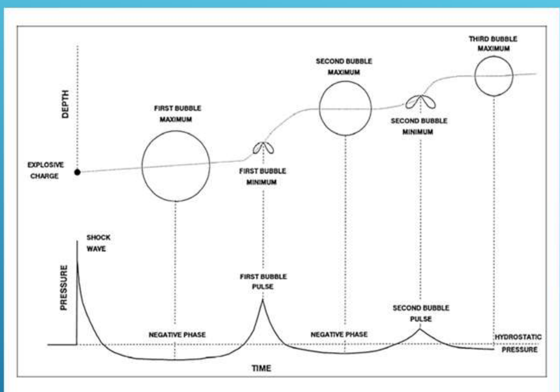


Fig. 14 – Explosion Bubble Phases and Pressure-Time History

(After Costanzo, 2010)

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Project No.	Project Title	Reference
TAP-025	Overpressures Developed by Shaped Explosive Charges Used to Remove Wellheads	(Heathcote, n.d.)
TAP-118	Blast Effects Upon the Environment from the Removal of Platform Legs by Explosives	(Connor, 1990)
TAP-429	Oil Platform Removal Using Engineered Charges: In Situ Comparison of Engineered and Bulk Explosive Charges	(Saint-Arnaud et al., 2004)
TAP-570	Measurement of the Effect of Depth Below Mudline of Charge Placement During EROs	(Poe et al., 2009)
OCS Study MMS 2003-059	Shock Wave/Sound Propagation Modeling Results for Calculating Marine Protected Species Impact Zones During Explosive Removal of Offshore Structures	(Dzwilewski & Fenton, 2003)
OCS Study MMS 2005-013	Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf	(U.S. Dept. of the Interior. Minerals Management Service, 2005)
OCS Study BOEM 2016-019	Pressure Wave and Acoustic Properties Generated by the Explosive Removal of Offshore Structures in the Gulf of Mexico	(Barkaszi et al., 2016)

Note: Technology Assessment Program (TAP) Projects were previously known as Technology Assessment Research (TAR) Projects before the creation of the Bureau of Safety and Environmental Enforcement (BSEE)

Gulf of Mexico Explosive Severance Decommissioning Projects

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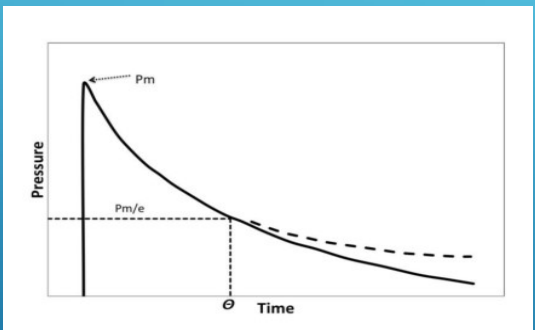
EXPLOSIVES Determination of peak pressure



Similtude Equations (After Cole, 1948)

$$p = K_p \left(\frac{W^{1/3}}{r} \right)^{\alpha_p}$$

$$\theta = K_t W^{1/3} \left(\frac{W^{1/3}}{r} \right)^{\alpha_t}$$

Determination of the peak pressure and the time constant

P_m is the peak pressure and θ is the time constant. (After Barkaszi et al., 2016)

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EDGAR Model Concept Diagram

Location	Activity	Explosive characteristics	Marine mammal population	Acoustic impact criteria	Underwater noise impact analysis
UKCS Quadrat number	Type of activity • Open water blast • Conductor severance • Pile severance Number of events per activity	For each activity • Charge weight • Explosive type	For each quadrant • Determine species potentially present • Establish organism density per species	Determine thresholds for • Behavioural response • Temporary threshold shift (TTS) • Permanent threshold shift (PTS) • Fish with and without swim bladders	• Propagation analysis • Radii of potential impact/ Isopleth • Number of animals impacted per species

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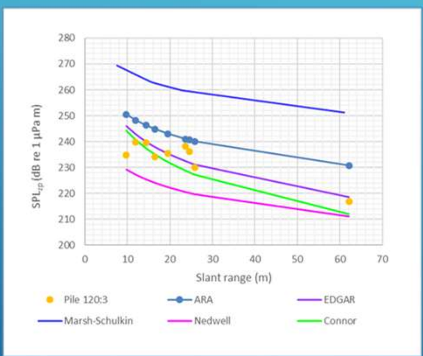
EDGAR Initial Concept



$$SPL_{pk} \approx SL_{pk} r^{-m_x/10^3}$$

$$SPL_{pk} = \begin{cases} \left(\dfrac{SL_{pk} + A_{ED} W^{b_{ED}/3}}{r^{m_x/10^3}}\right) & m_x = 44, \quad \text{for open water} \\ \left(\dfrac{SL_{pk} + A_{ED} W^{b_{ED}}}{r^{m_x/10^3}}\right) & m_x = 64, \quad \text{for conductor or pile} \end{cases}$$

Comparison of simulated and measured (orange) sound pressure levels (peak) against slant range for explosive severance of Huber 120 pile 3 using a 4.6 lb RDX engineered charge (TAP-429: Saint-Arnaud et al., 2004)

Models used include: ARA (Dzwilewski et al., 2003), Connor (Connor, 1990), EDGAR (current study), Marsh-Schulkin (Marsh and Schulkin, 1962) and Nedwell (Nedwell and Edwards, 2004)

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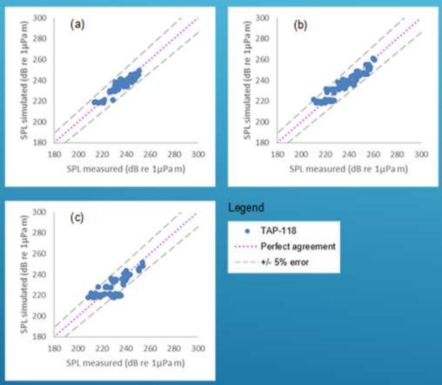
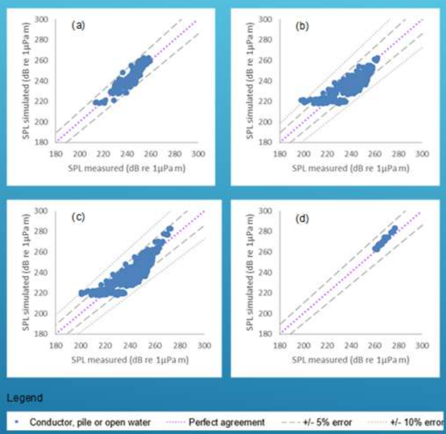
EDGAR Sound Pressure Level (SPL) Evaluation





Comparison of simulated and measured SPL values

LEFT: TAP-118 (Connor, 1990), (a) Conductors; (b) Main/ Leg piles; and (c) Skirt piles

RIGHT: Combined (a) Conductors (BML); (b) Piles; (c) Conductors and piles; TAP-025 (d) Open water

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EDGAR SPL Statistical Evaluation

Severance type	r	Adj R²	Lower bound (dB re 1 μPa m)	RMSE (dB re 1 μPa m)	Upper bound (dB re 1 μPa m)	RMSE (%)	Nash-Sutcliffe Efficiency index, E_f	NRMSE	Bias (dB re 1 μPa m)	Relative bias (%)	n
****Conductor**	0.93	0.86	2.89	3.55	21.64	1.51	0.85	0.38	-0.55	-0.23	56
****Main/ leg pile**	0.95	0.89	3.64	4.45	31.98	1.88	0.89	0.34	-0.31	-0.13	77
Skirt pile	0.78	0.60	5.82	7.25	46.94	3.14	0.56	0.66	-2.15	-0.93	65

Severance type	r	Adj R²	Lower bound (dB re 1 μPa m)	RMSE (dB re 1 μPa m)	Upper bound (dB re 1 μPa m)	RMSE (%)	Nash-Sutcliffe Efficiency index, E_f	NRMSE	Bias (dB re 1 μPa m)	Relative bias (%)	n
****Conductor (BML)**	0.90	0.81	3.48	4.35	47.2	1.79	0.77	0.48	-0.17	-0.07	184
****Conductor & Pile**	0.89	0.79	5.25	6.69	126.4	2.78	0.78	0.47	-1.03	-0.43	597
***Pile**	0.85	0.73	6.60	8.10	122.4	3.44	0.69	0.56	-1.94	-0.82	344
Open water	0.99	0.98	3.57	3.86	29.0	1.44	0.38	0.79	3.57	1.34	66

Statistical evaluation of EDGAR simulated and measured GOM values for conductor and pile severance

TOP: **TAP-118** Conductors; Main and skirt piles (air- and water- terminated, respectively).

BOTTOM: **Combined** conductor, pile and conductor/ pile severance BML and **open water** blasts.

Note: Conductor (BML) refers only to conductors where the explosive charge was placed below the mudline.

TAP-025 (Heathcote, n.d.); TAP-118 (Connor, 1990); TAP-570 (Poe et al., 2009); BOEM 2016-019 (Barkaszi et al., 2016).

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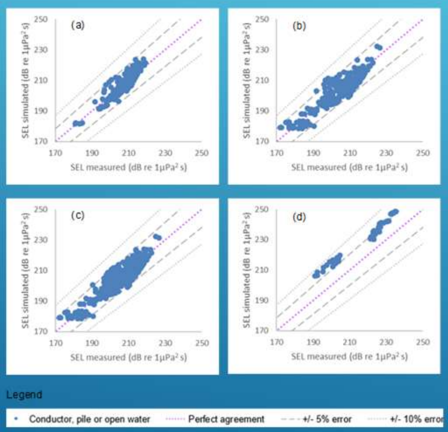
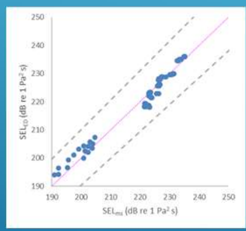
EDGAR Sound Exposure Level (SEL) Evaluation



Comparison of simulated and measured SEL values

LEFT: (a) Conductors; (b) Piles; (c) Conductors & piles; and Open water (before adjustment)
Sources: TAP-025 (Heathcote, n.d.), TAP-118 (Connor, 1990); TAP-570 (Poe et al., 2009) and BOEM 2016-019 (Barkaszi et al., 2016)

RIGHT: Comparison of simulated and measured values of SEL for open water
Sources: TAP-025 (Heathcote, n.d.) and TAP-570 (Poe et al., 2009)



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EDGAR SEL Statistical Evaluation

Severance type	r	Adj R²	Lower bound (dB re 1 µPa² s)	RMSE (dB re 1 µPa² s)	Upper bound (dB re 1 µPa² s)	RMSE (%)	Nash-Sutcliffe Efficiency index, E_f	NRMSE	Bias (dB re 1 µPa² s)	Relative bias (%)	n
Conductor (BML)	0.88	0.76	3.14	3.94	42.92	1.91	0.68	0.56	0.64	0.31	187
Conductor & Pile	0.91	0.83	3.60	4.41	78.69	2.17	0.82	0.42	-0.15	-0.07	478
Pile	0.90	0.81	1.41	5.30	24.52	2.64	0.81	0.43	-0.11	-0.05	303
Open water	0.99	0.97	12.31	12.48	110.76	5.64	-0.10	1.05	12.31	5.56	81
Open Water (adj)	0.99	0.97	1.66	2.10	14.95	0.95	0.97	0.18	0.31	0.14	81

Note: Conductor (BML) refers only to conductors where the explosive charge was placed below the mudline.

Statistical evaluation of EDGAR simulated and measured GOM values for conductor and pile severance BML

Combined conductor, pile and conductor/ pile severance BML and **open water** blasts (before and after model adjustment applied).

Sources:
Conductors: TAP-025 (Heathcote, n.d.) and BOEM 2016-019 (Barkaszi et al., 2016).
Piles: TAP-570 (Poe et al., 2009) and BOEM 2016-019 (Barkaszi et al., 2016).
Open water:TAP-025 (Heathcote, n.d.) and TAP-570 (Poe et al., 2009)

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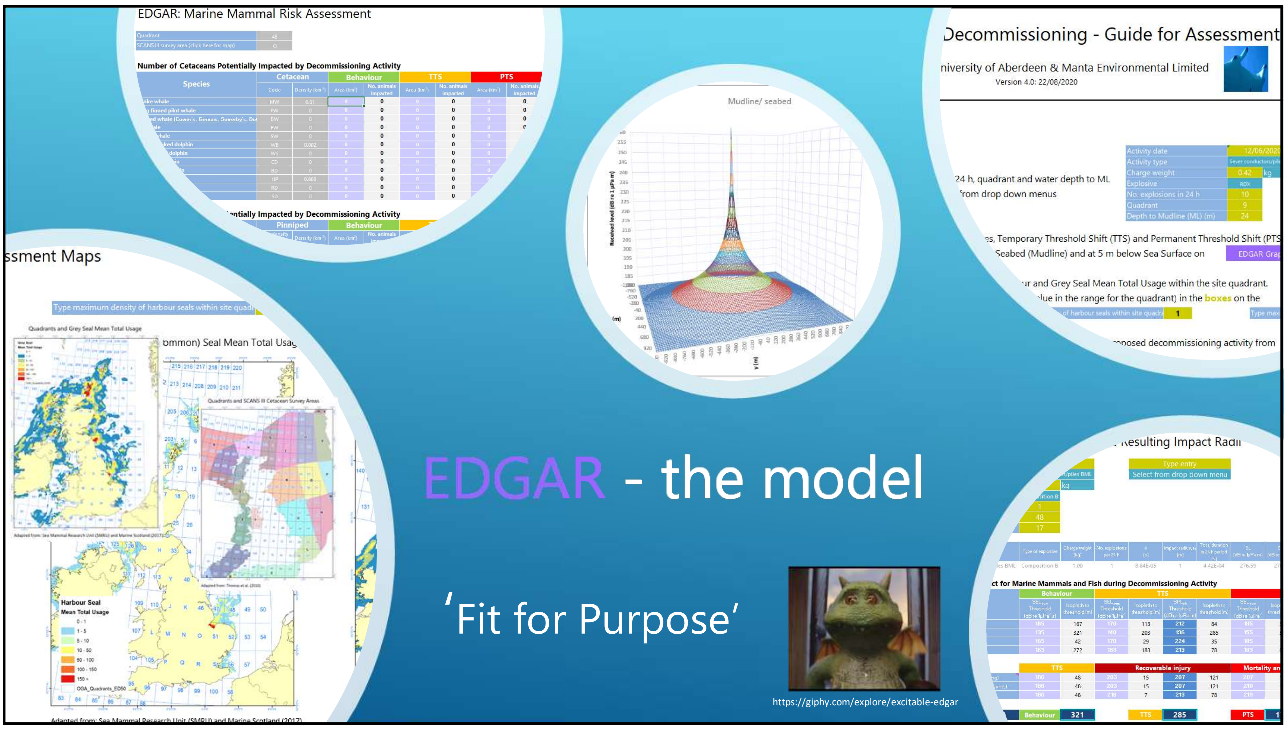

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EDGAR

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Guide for Assessment of Risk

Thank you for listening

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