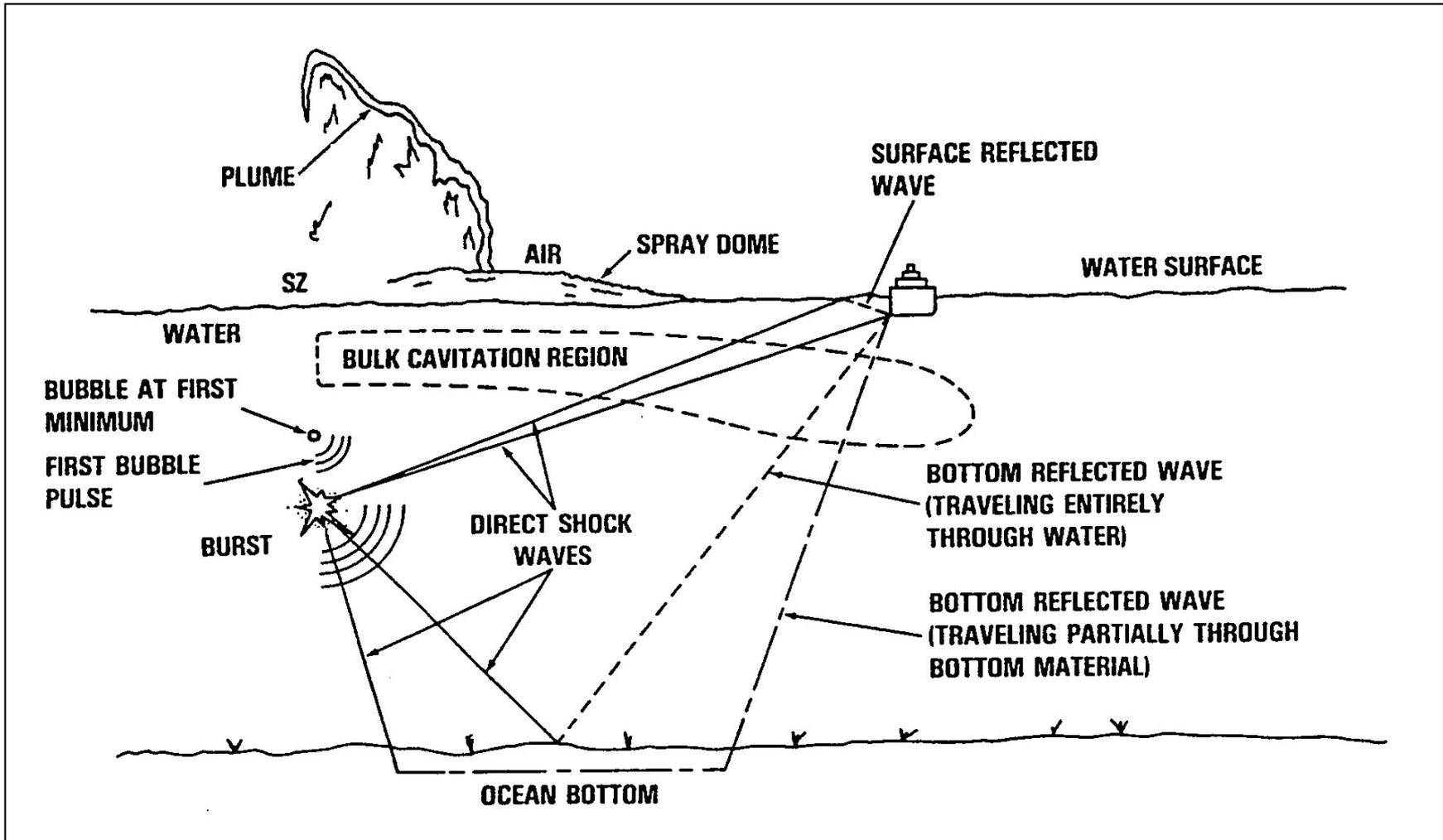


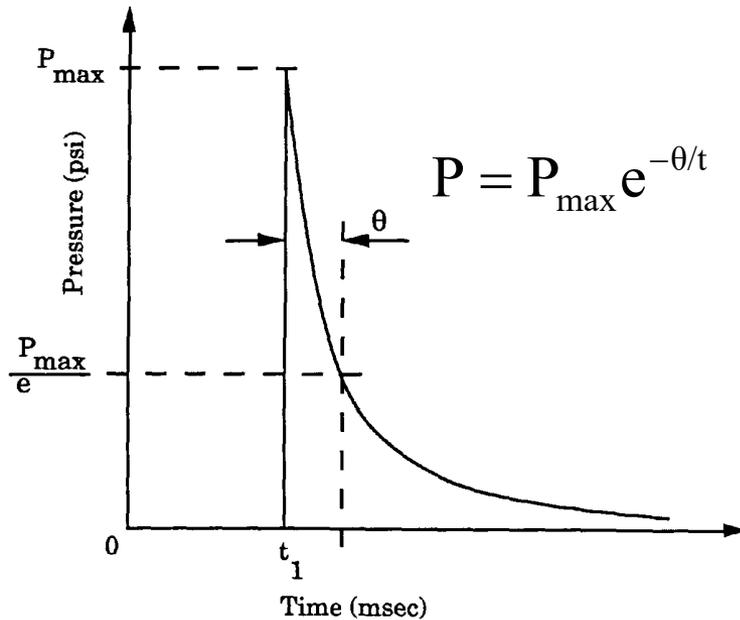


Explosives in the Marine Environment

Explosive effects



Shock wave



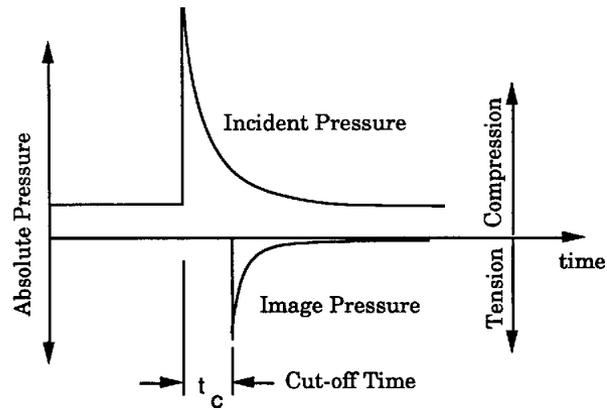
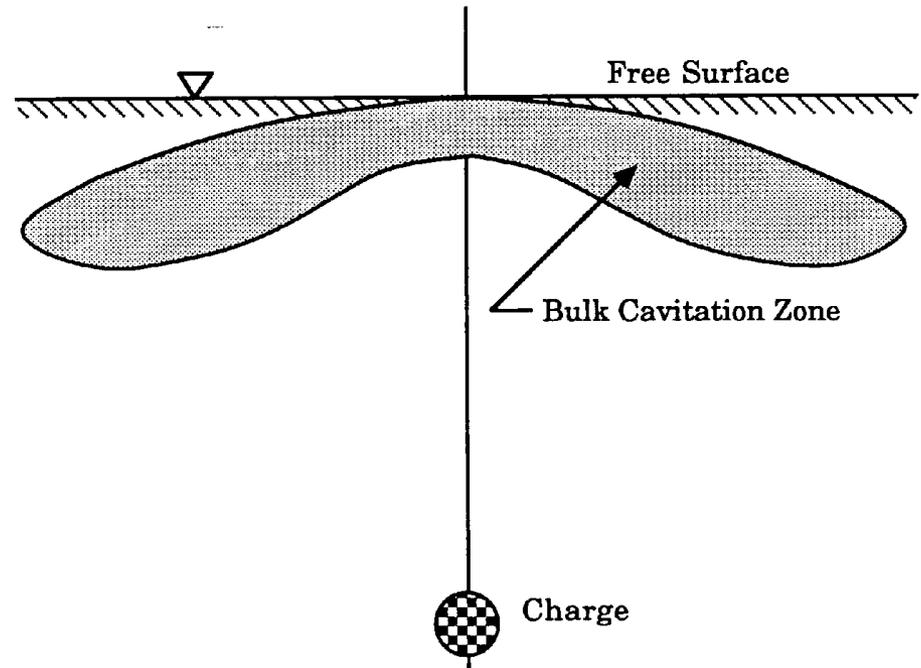
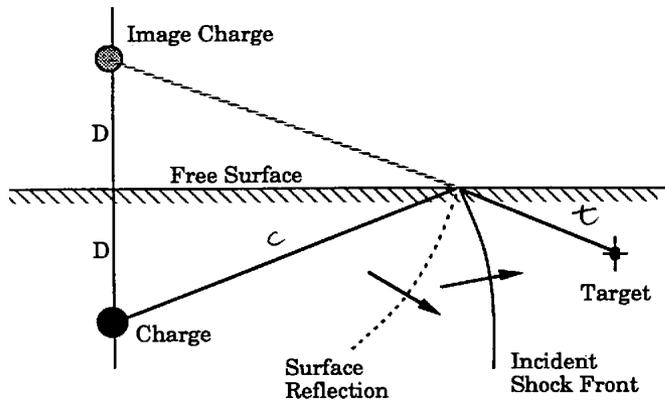
Shock wave parameters for 150kg TNT at a distance of 12m

- Peak Pressure = 20.82 MPa (approx 3000 psi)
- Time Constant = 0.56ms
- Impulse = 14.53 kPa.s
- Energy = 79.2 kJ/m²
- Speed = 1500m/s
- Effective length = 1~2 m

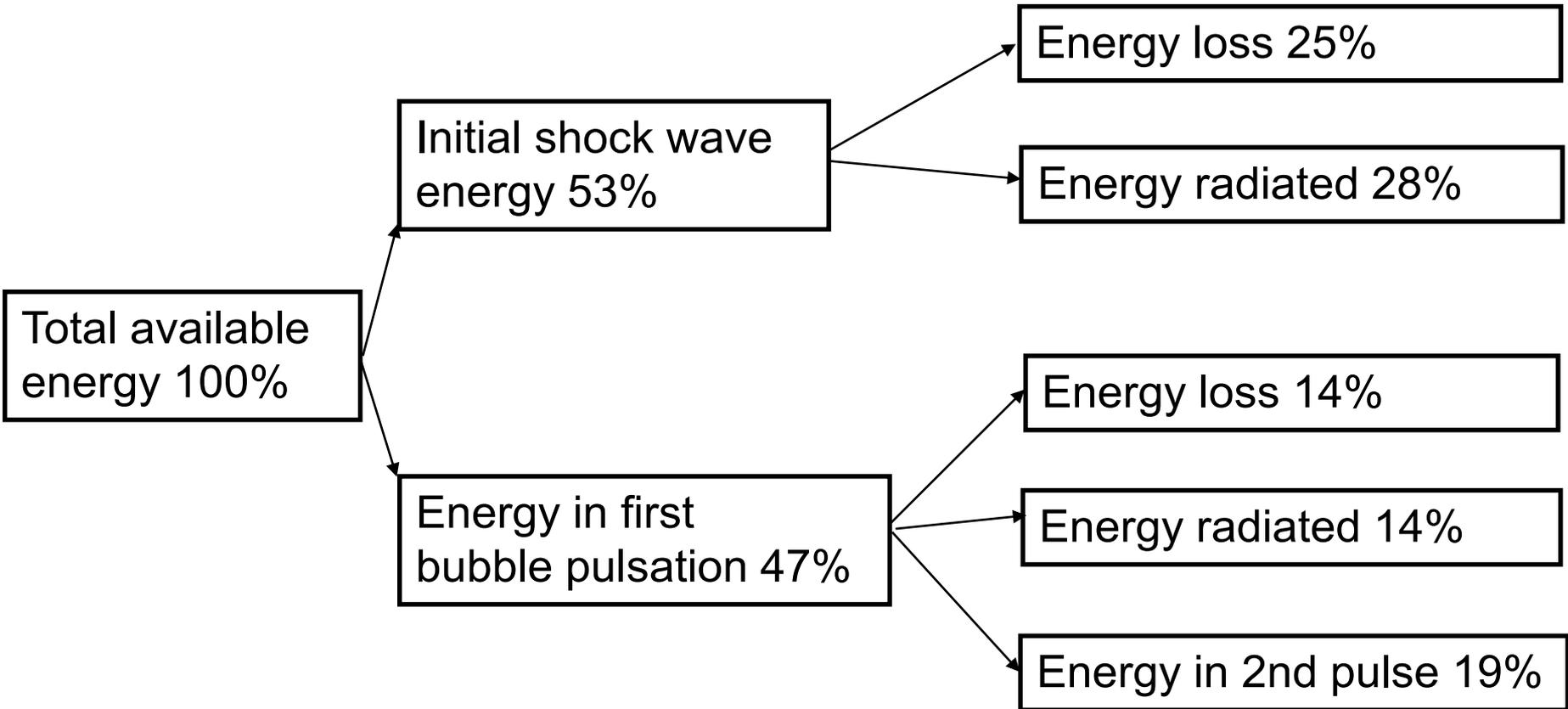
$$P_{\max} = K_1 \left(\frac{W}{R} \right)^{\frac{1}{3} A_1} \quad \text{Peak Pressure}$$

$$\theta = K_2 W^{\frac{1}{3}} \left(\frac{W}{R} \right)^{\frac{1}{3} A_2} \quad \text{Decay Constant}$$

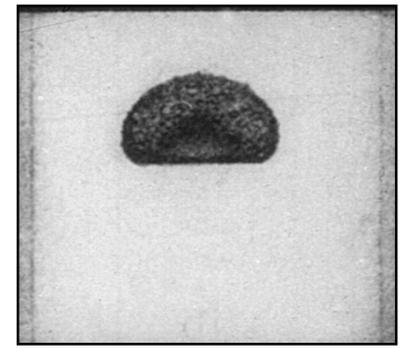
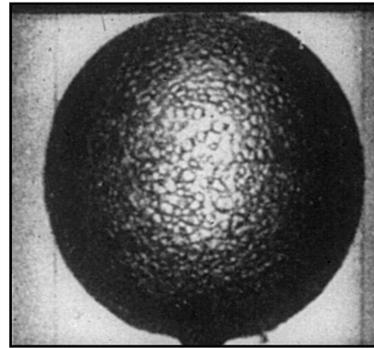
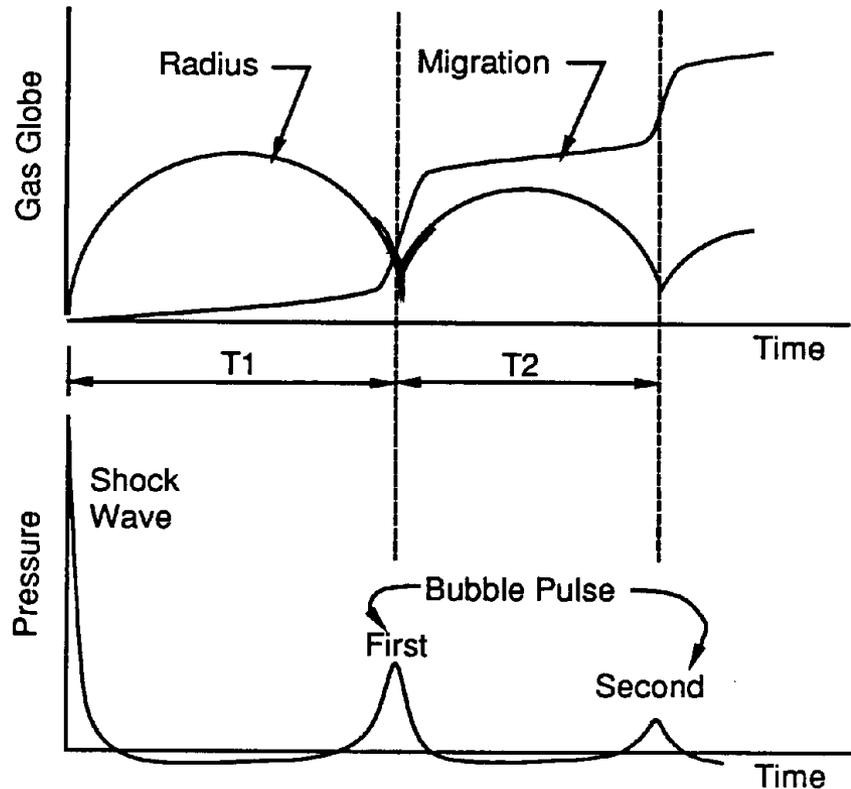
Bulk cavitation



Energy partition for TNT



Bubble behaviour



Bubble parameters for 150kg TNT at a depth of 10m

- Bubble Period = 0.9s
- Bubble Diameter = 13.2m
- Bubble Volume = 1200m³

Bubble parameters for 500kg TNT at a depth of 10m

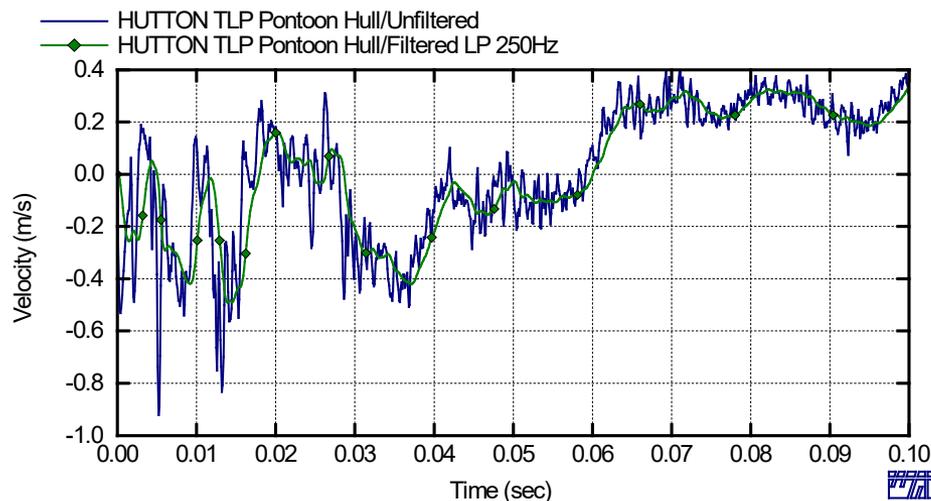
- Bubble Period = 1.35s
- Bubble Diameter = 20m
- Bubble Volume = 4200m³

Explosive testing



Offshore use of explosives

- Downhole perforation techniques and cutting tools
- Well Abandonment – severance of well casings below the mudline
- Pile cutting, manifold removal, protective structure removal
- Anchor chain cutting
- Jacket and structure removal
- Module separation
- Selective cutting applications
- *UXO and collateral effects*

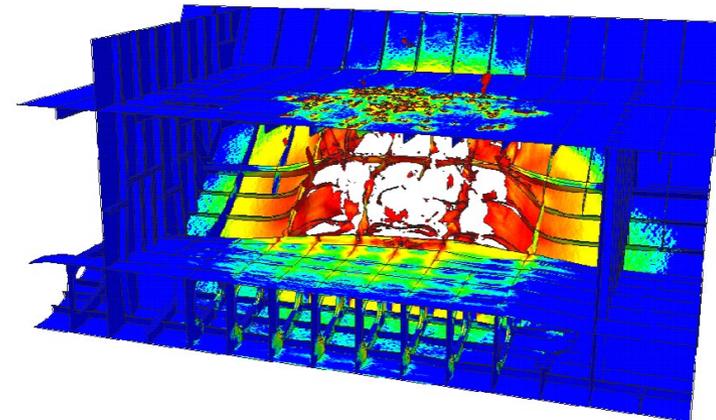
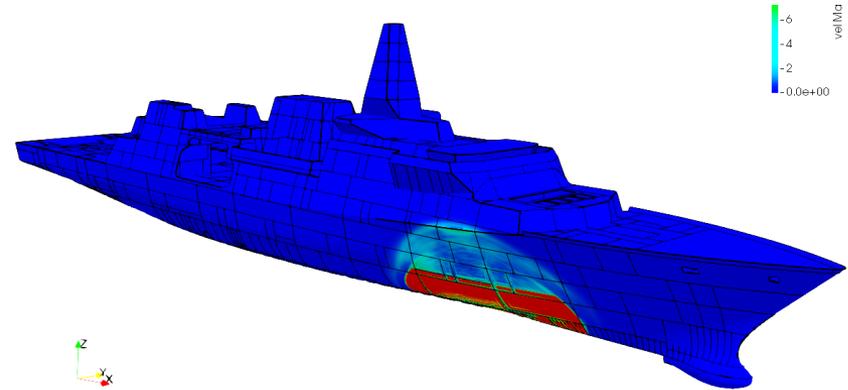


Improvements in the use of explosives

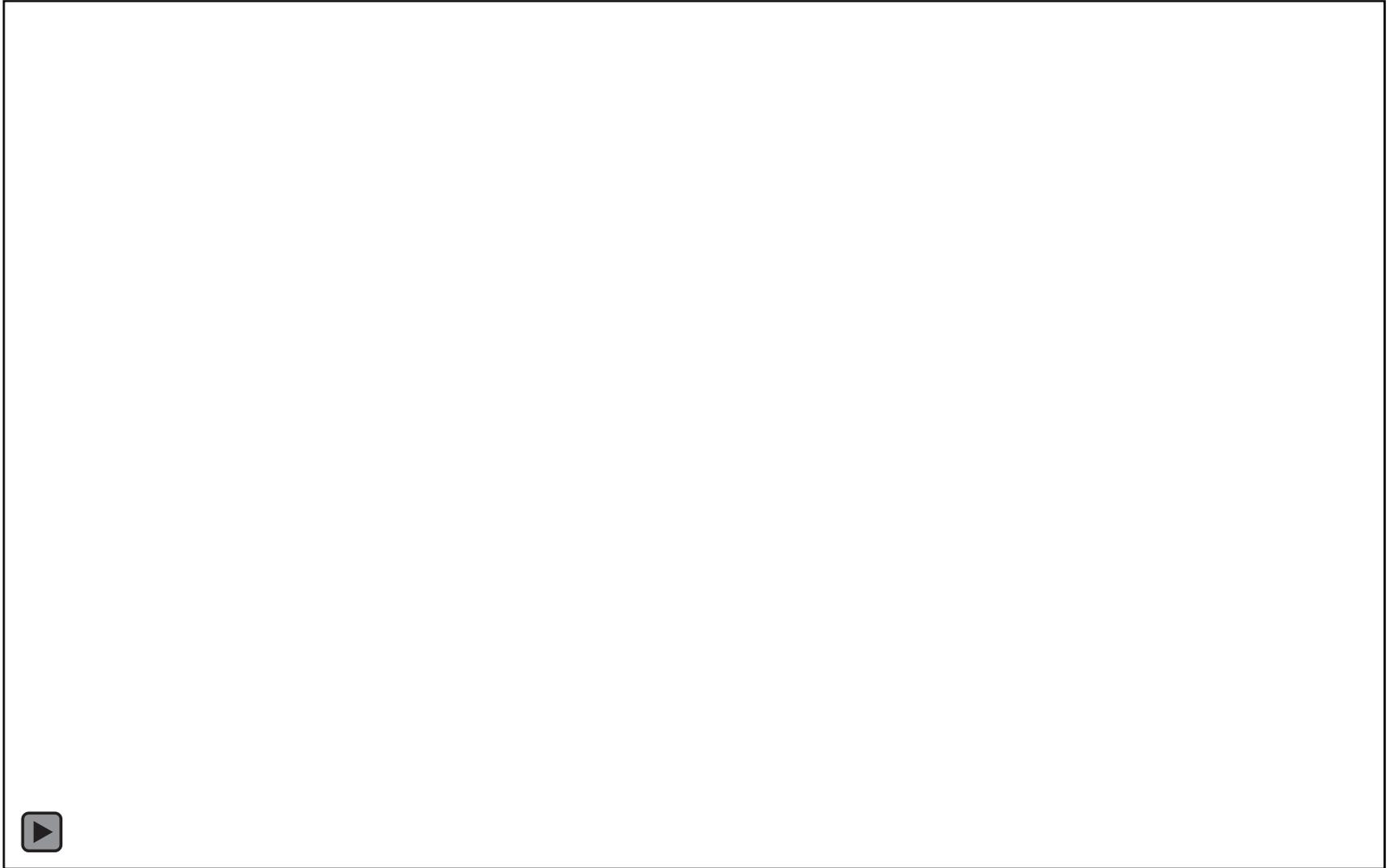
- Use state-of-the-art tools to assess environmental effects including:
 - Establishing safe stand-offs
 - Establishing zones requiring MMOs
 - Critical volumes calculated with due regard for charge location and composition
 - Critical distances/volumes for fishkill, mammal injury, PTS, TTS and behavioural changes
- Initiate multiple charges asynchronously to avoid superposition effects
- Make use of the bubble energy
- Optimise the charge size for a given application:
 - Model scenarios to establish parameters
 - Test limited prototypes in suitable facility
- Mitigation methods

Making full use of modelling and simulation

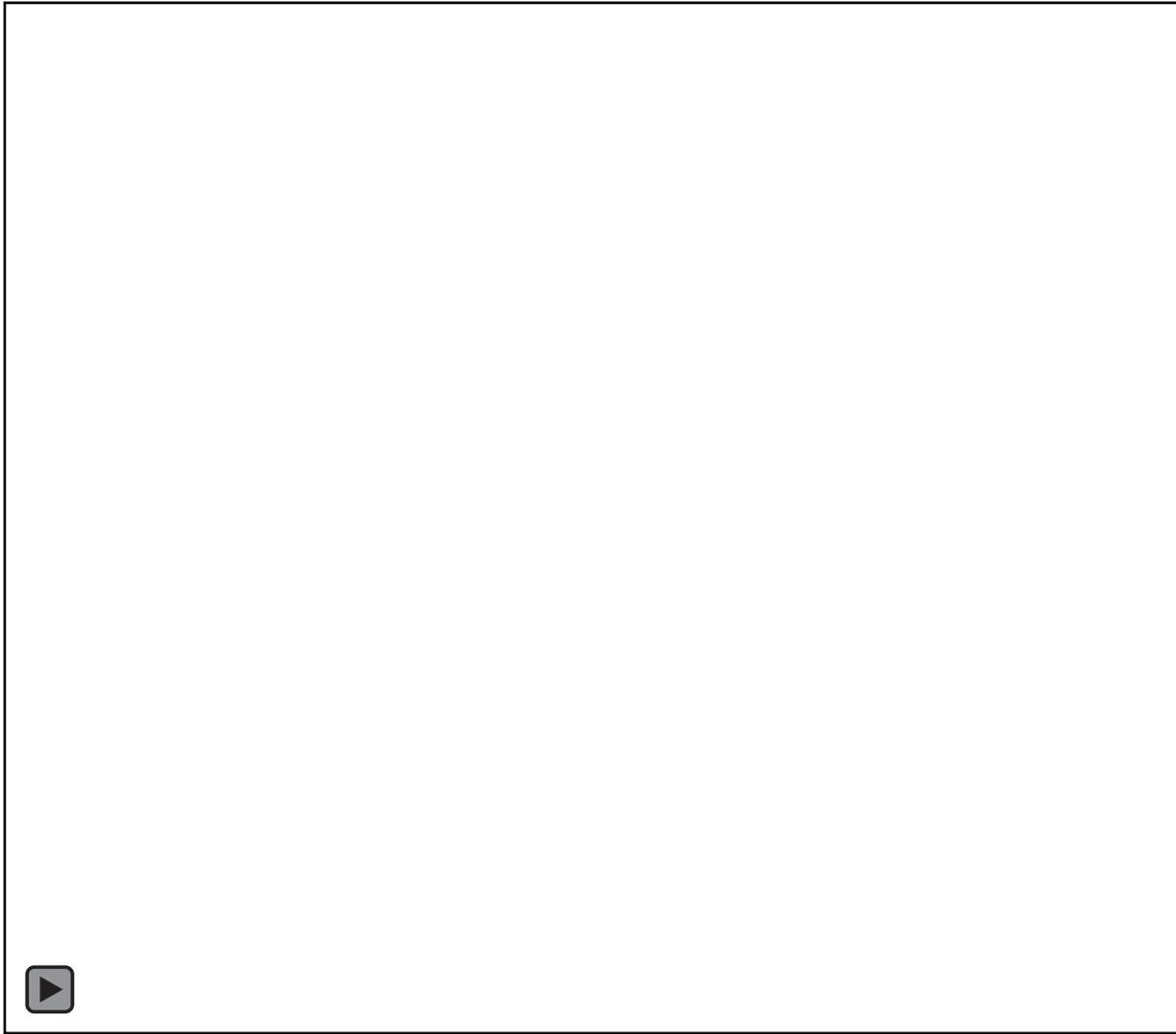
- TT software developed for modelling explosive effects and close-in weapon effects research
- Fluid-structure interaction techniques developed for simulating response of warships to attack and developing protective methods
- Can be used to develop decom strategies using explosives, safety cases and environmental impact studies
- Optimisation of:
 - charge size and design
 - geometry
 - initiation
 - mitigation



Dynamically-induced implosion of pipes and volumes

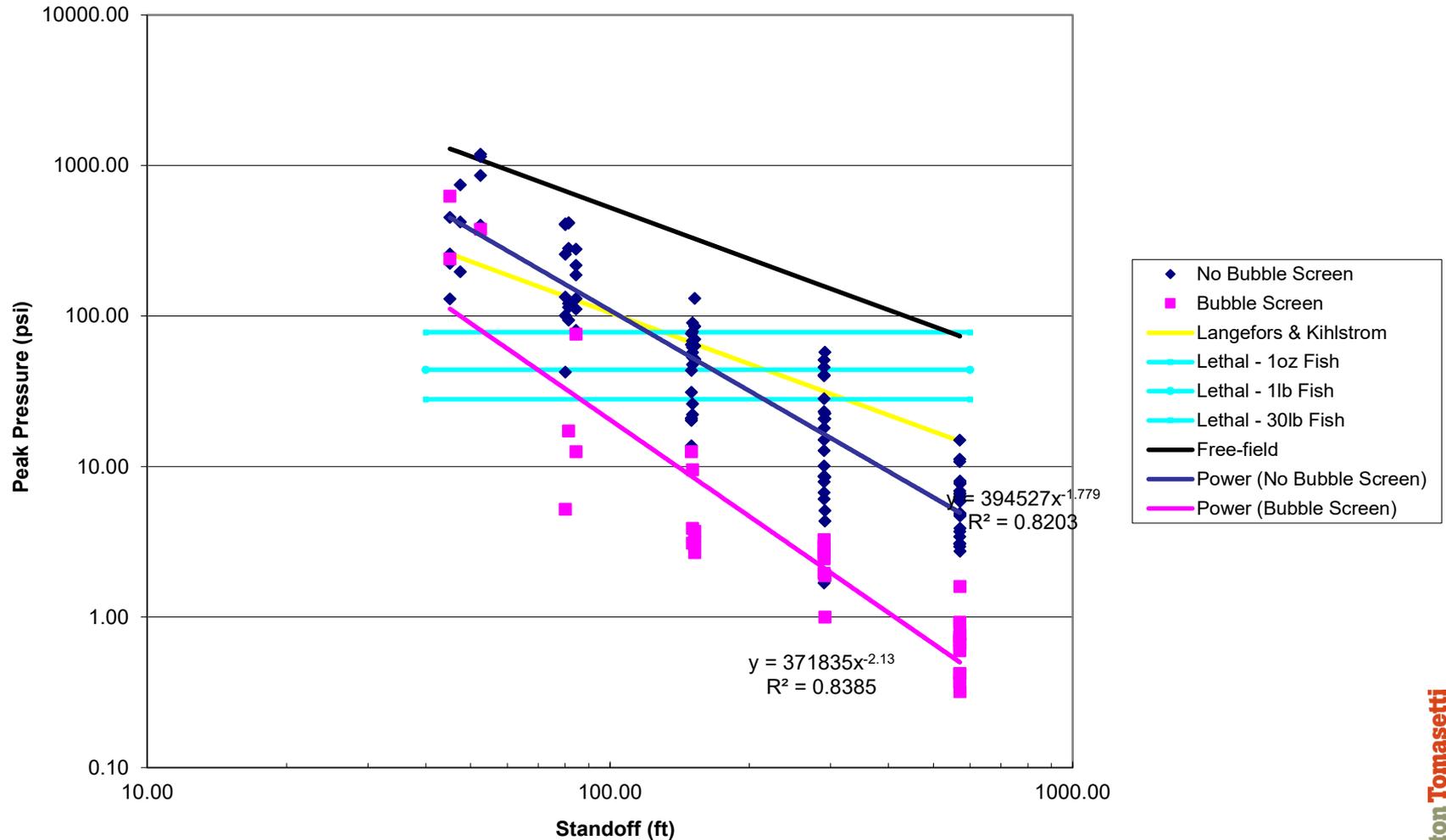


Prediction or pressure fields in complex environments



Fish Mortality Calculation

Peak Pressure due to Borehole Explosion



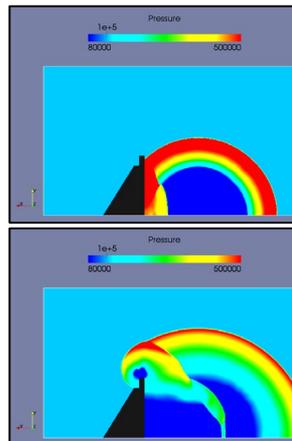
Making full use of experimental testing

- Allows charge configurations to be optimised through M&S and then tested before being deployed in the field
- Test site is a flooded quarry and allows charge sizes up to 50kg to be tested against test articles specifically designed to replicate actual structures
- Test data is used to validate M&S and M&S is used to plan the test.
- Instrumentation is routinely deployed on a test to understand test performance

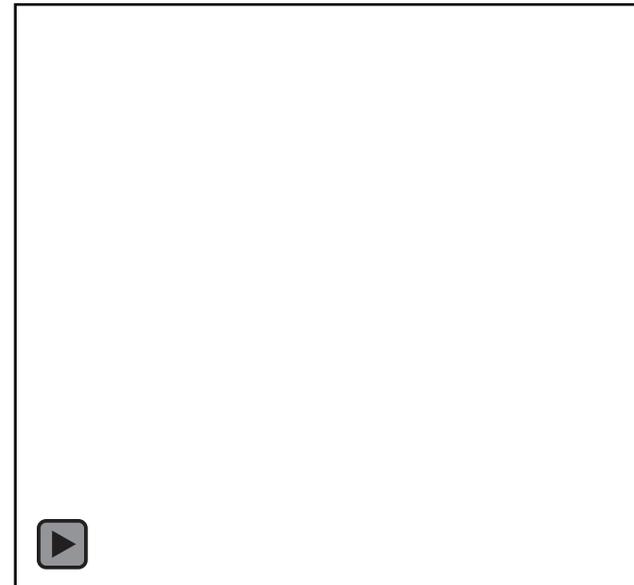
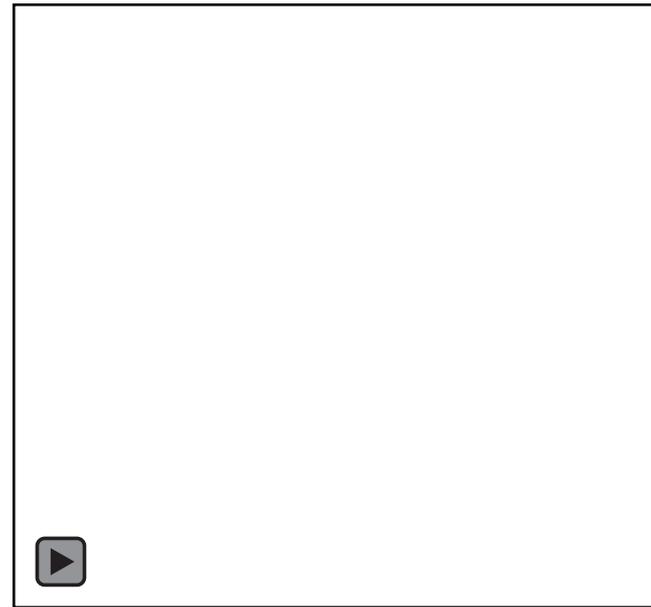


Mitigation Methods

- Bubble screens work by introducing a ρc mismatch zone of bubbly water
- Screen width, bubble density, size etc. critical to efficiency
- Not good where currents are strong
- Wraparound of the shock wave is possible
- Does not mitigate bubble effects



After Gefkin and Greenfield SRI International



Thornton Tomasetti

www.ThorntonTomasetti.com