



AN EVALUATION OF THE HAZARDS FROM PHOSGENE MUNITIONS DUMPED INTO BEAUFORT'S DYKE

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CONTENTS....



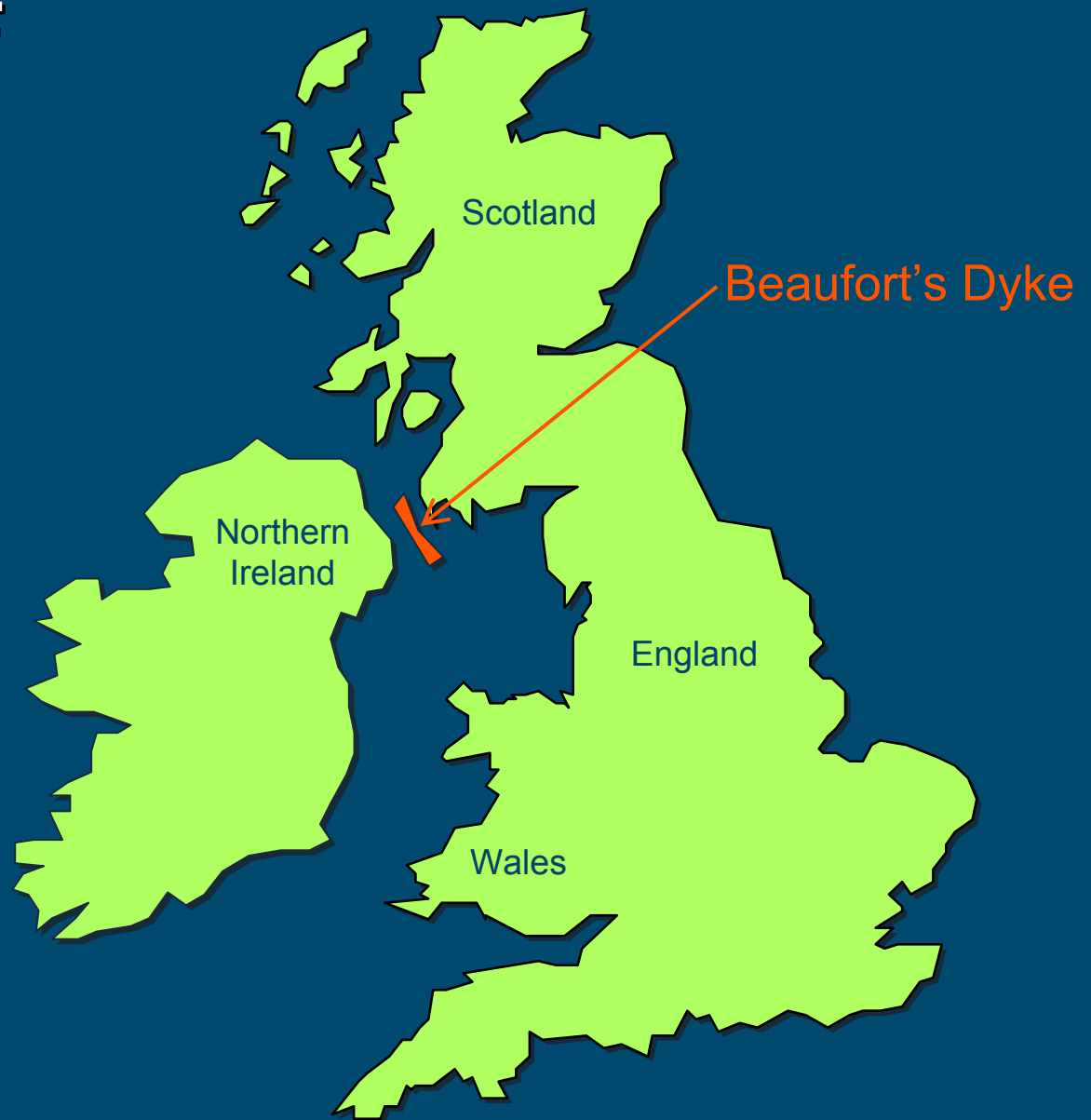
- The issue
- Disposals in Beaufort's Dyke
- Toxicity of phosgene
- Evaluate the hazard
- Discussion
- Conclusions

THE ISSUE

- Phosgene containing munitions were disposed in large quantities in Beaufort's Dyke immediately following WWII
- Concern has been expressed that release of phosgene from munitions on the sea bed could give rise to a health or environmental hazard

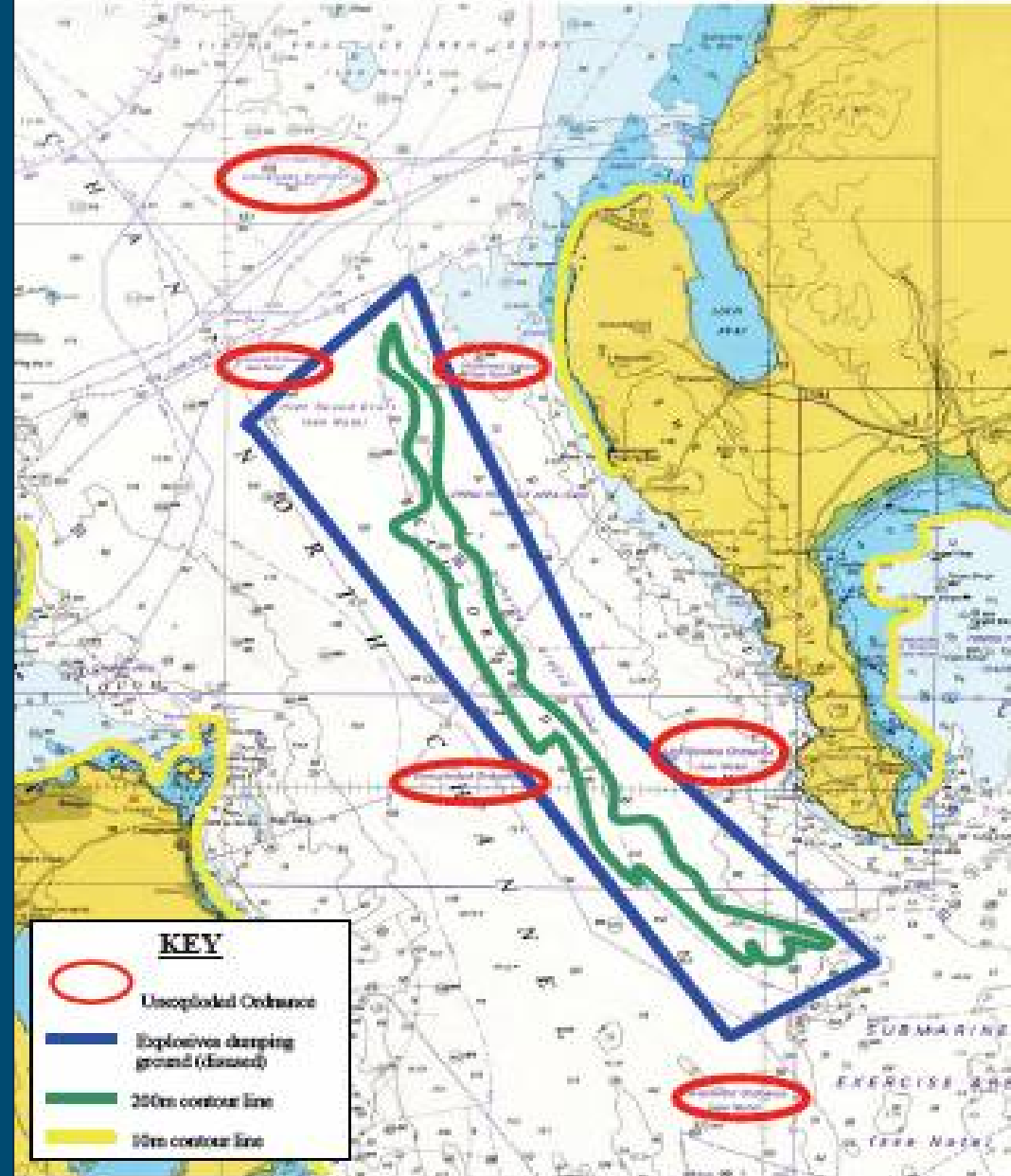


LOCATION OF BEAUFORT'S DYKE



SEABED PROFILE AND DUMPING AREAS

- Boxes weighted to ensure they didn't float
- Boxes palletised
- Dumped from moving vessel leading to a line of pallets
- Some reports that munitions may have been dumped short of the dumping ground



ROCKET 5" (U) MARK 1



- Approximately 14,500 tonnes dumped in Beaufort's Dyke in July 1945
- Agent weight approximately 4.7kg
- Warhead also used on 30Lb LC A/C bomb
- But, were rockets and warheads disposed together?

BEST AND WORST CASE SCENARIOS FOR LEAKING MUNITIONS

- Best Case
 - A single munition leaking over a period of time as the munition walls corrode
- Worst Case
 - An explosive event takes place causing the simultaneous fracturing of a number of munitions

TOXICITY OF PHOSGENE



- Phosgene (carbonyl chloride, COCl_2 , CG) is a colourless gas, which is denser than air at room temperature
 - Phosgene is a corrosive, highly toxic and highly reactive gas
 - Phosgene is primarily inhaled into the body
 - Can result in death, commonly known as dry land drowning or pulmonary oedema
- Phosgene is also a severe irritant of the eyes and skin

LITERATURE REVIEW

- No reports have been found that examine the migration and reactions of phosgene
- A number of sampling programmes have been undertaken [*Marine Laboratory, Aberdeen (1996), 1994 HELCOM, Howard and Meylan (2002)*]
- Phosgene has not been detected in environmental samples from Beaufort's Dyke. This could be because:
 - phosgene has leaked from munitions, but not spread widely enough;
 - phosgene has not leaked;
 - it has broken down so quickly that it causes no contamination; or
 - contaminated flora and fauna die rapidly once contaminated so living organisms contaminated with phosgene are not detected

THE CURRENT STUDY

■ Factors considered:

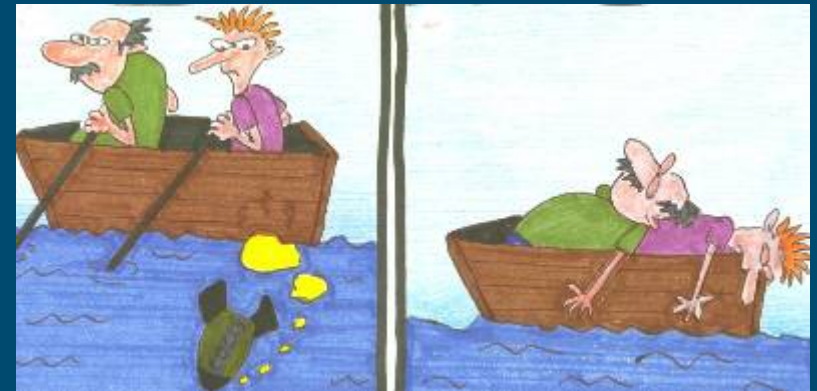
- physical environment
- acute effects on occupants of a vessel
- effects on marine flora and fauna

■ Factors not considered:

- corrosion rates of munitions
- munitions buried in the sea bed
- the consequences of munitions brought to the surface

EVALUATING THE HAZARD

- If phosgene is released from munitions:
 - Can it migrate to the sea surface (as a liquid or gas) to present a hazard?
 - Can it damage the environment?
- Considerations
 - *Is phosgene a gas when released from munitions on the sea bed?*
 - *How rapidly does phosgene dissolve / degrade?*
 - *How toxic are the degradation products of phosgene?*



PHYSICAL AND PHYSIOCHEMICAL FACTORS

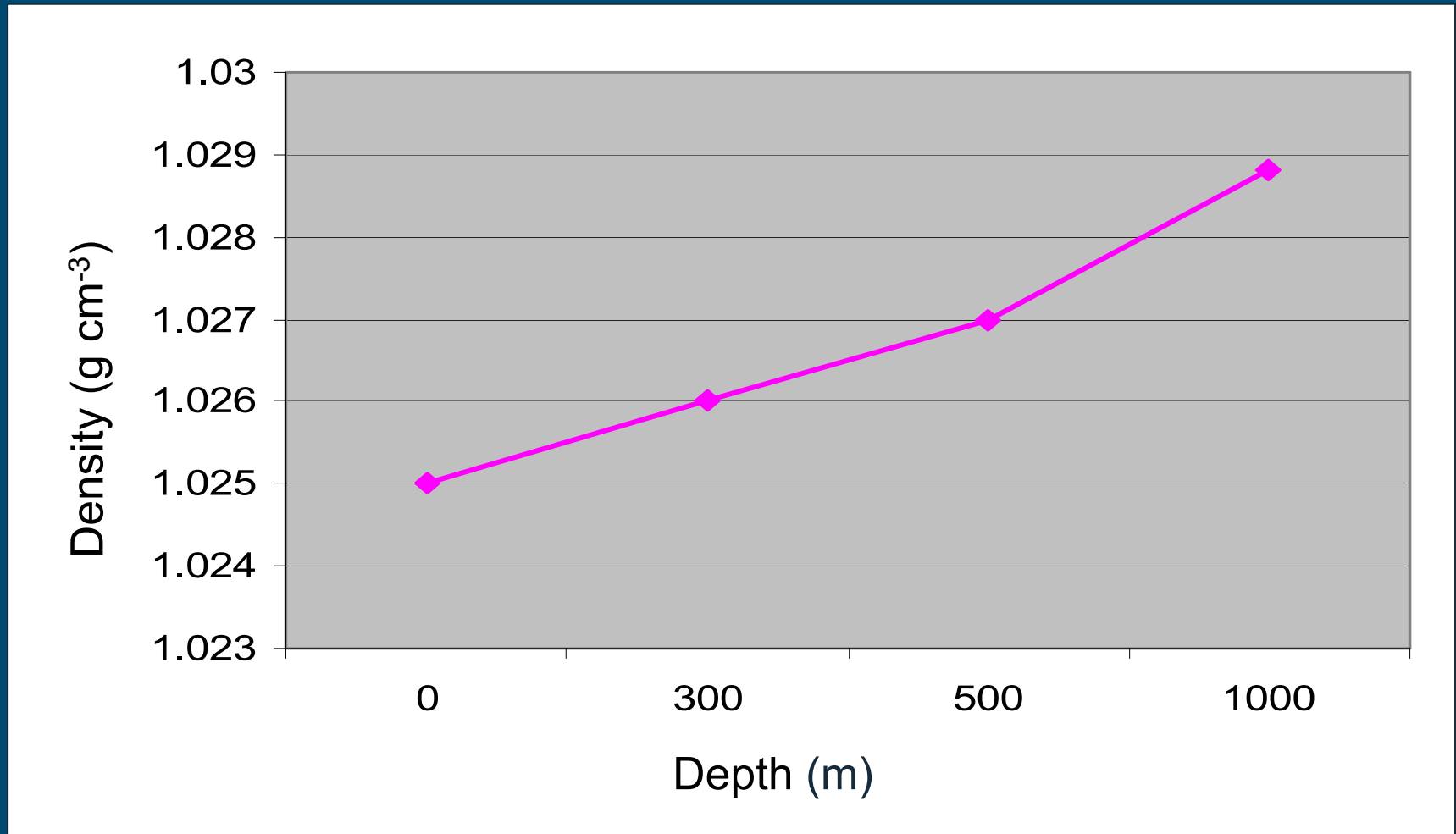


- Physical Conditions in Beaufort's Dyke
 - Currents near the sea floor
 - Sea water density
 - Temperature and Pressure
- Physiochemistry of phosgene
 - Density of liquid phosgene
 - Vapour pressure of phosgene
 - Boiling point of phosgene
 - Solubility of phosgene
 - Hydrolysis of phosgene in water

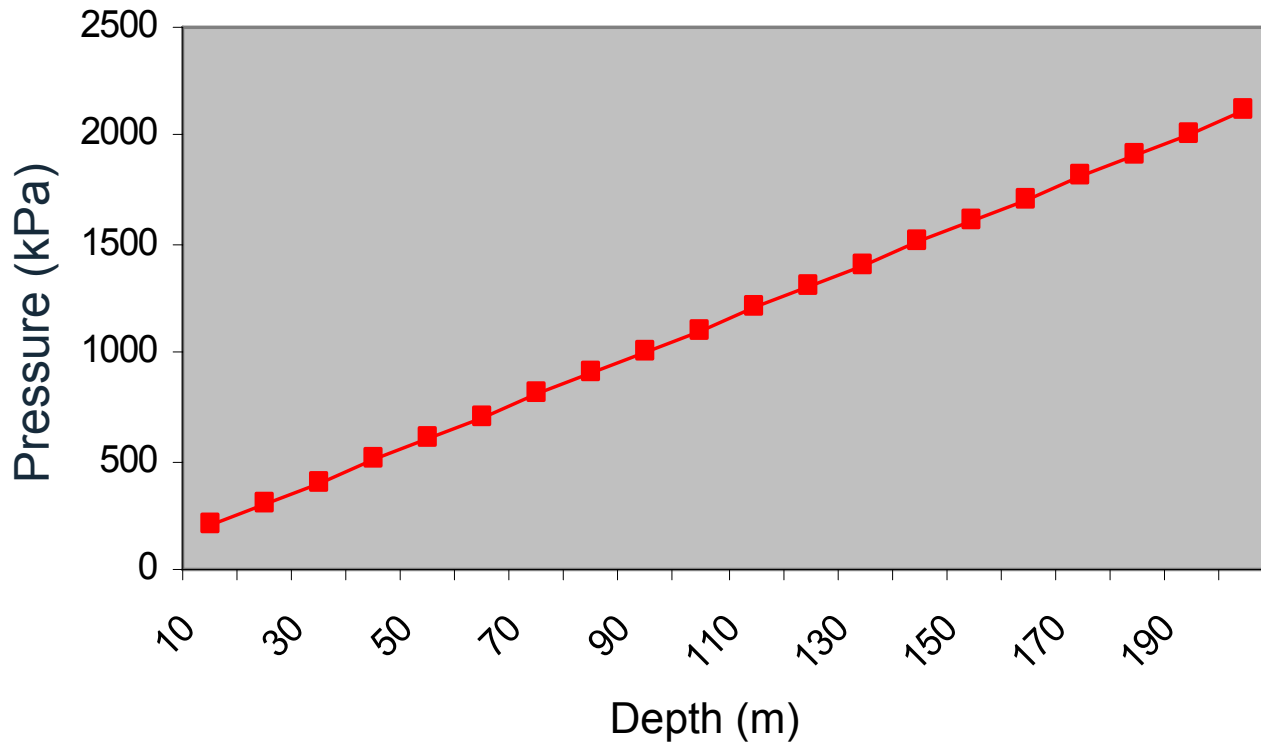
CURRENTS AT THE BOTTOM OF BEAUFORT'S DYKE

Month	Average Bottom Current (cm s ⁻¹)
January	10-20
April	0-5
May	0-15
June	0-10
July	0-10
August	0-5

DENSITY OF SEA WATER



WATER PRESSURE AND TEMPERATURE



- Surface Waters

- Summer
14 -15°C
- Winter
9.5 -11°C

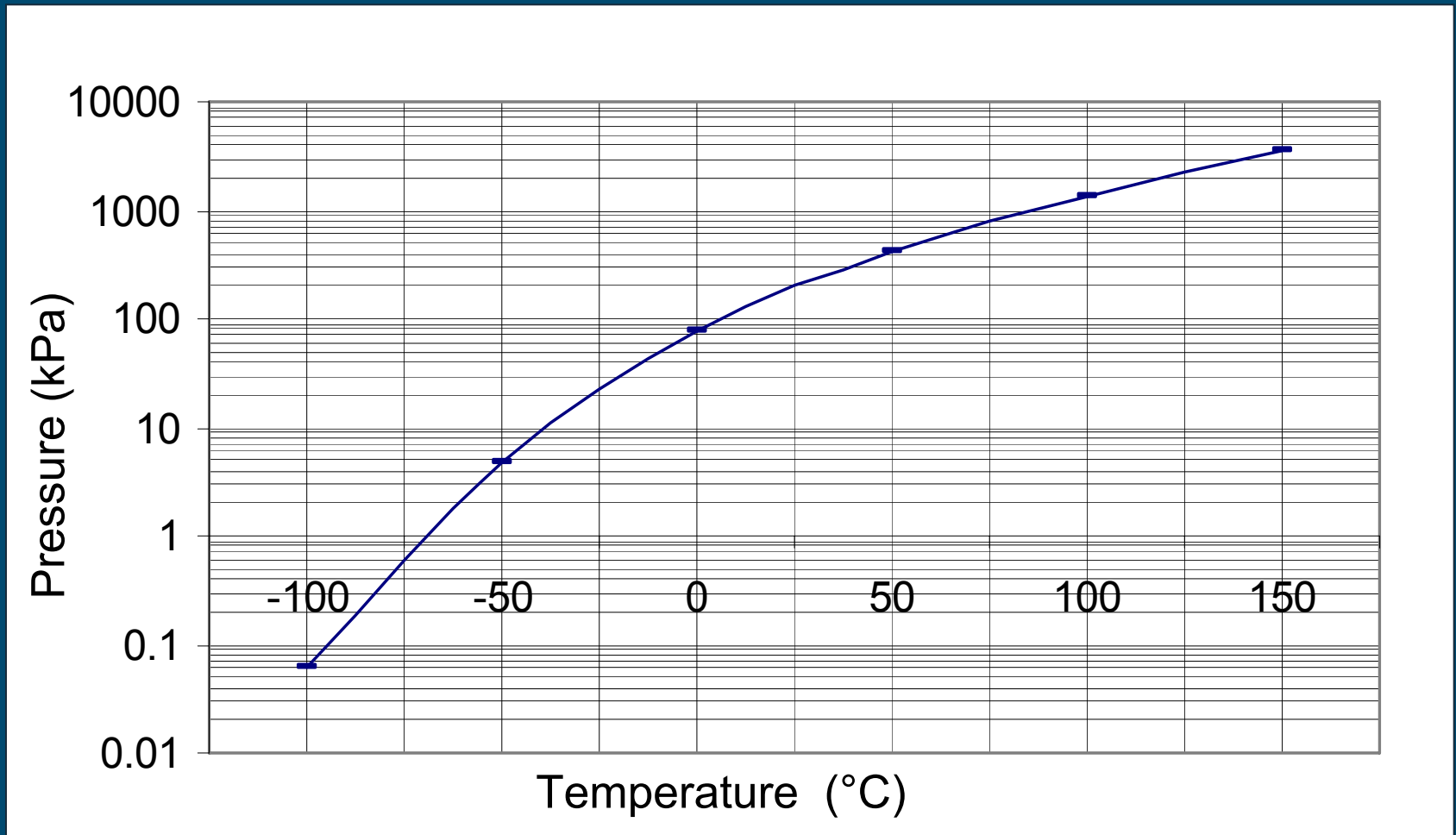
- Sea Bed

- Summer
10 -12°C
- Winter
7 - 9°C

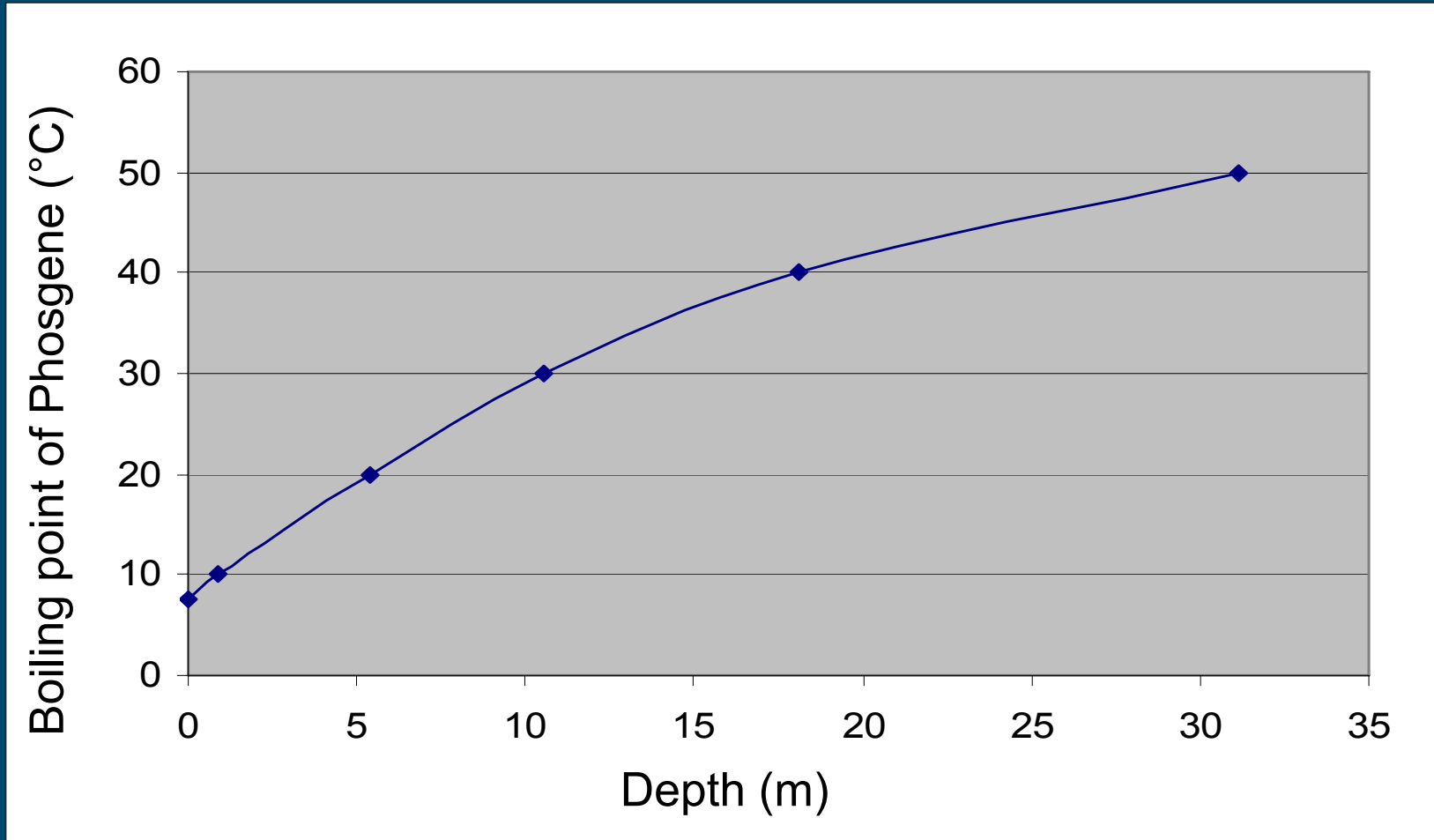
Density of phosgene

- At surface at 25°C
 - Gas
 - 3.4 times heavier than air
- At surface at 0°C
 - Liquid
 - Density 1.4 g cm³

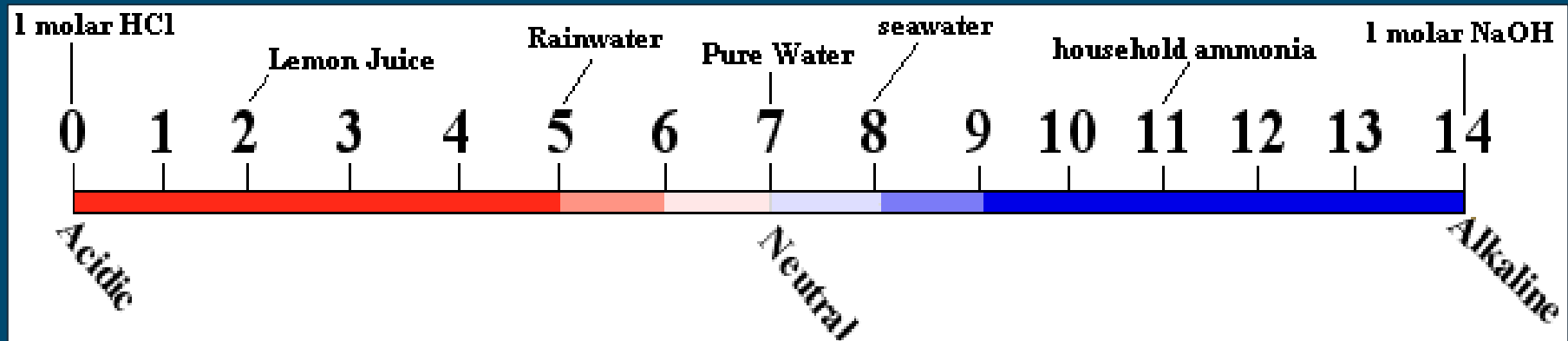
VAPOUR PRESSURE CURVE FOR PHOSGENE



BOILING TEMPERATURE OF PHOSGENE AT SHALLOW DEPTHS

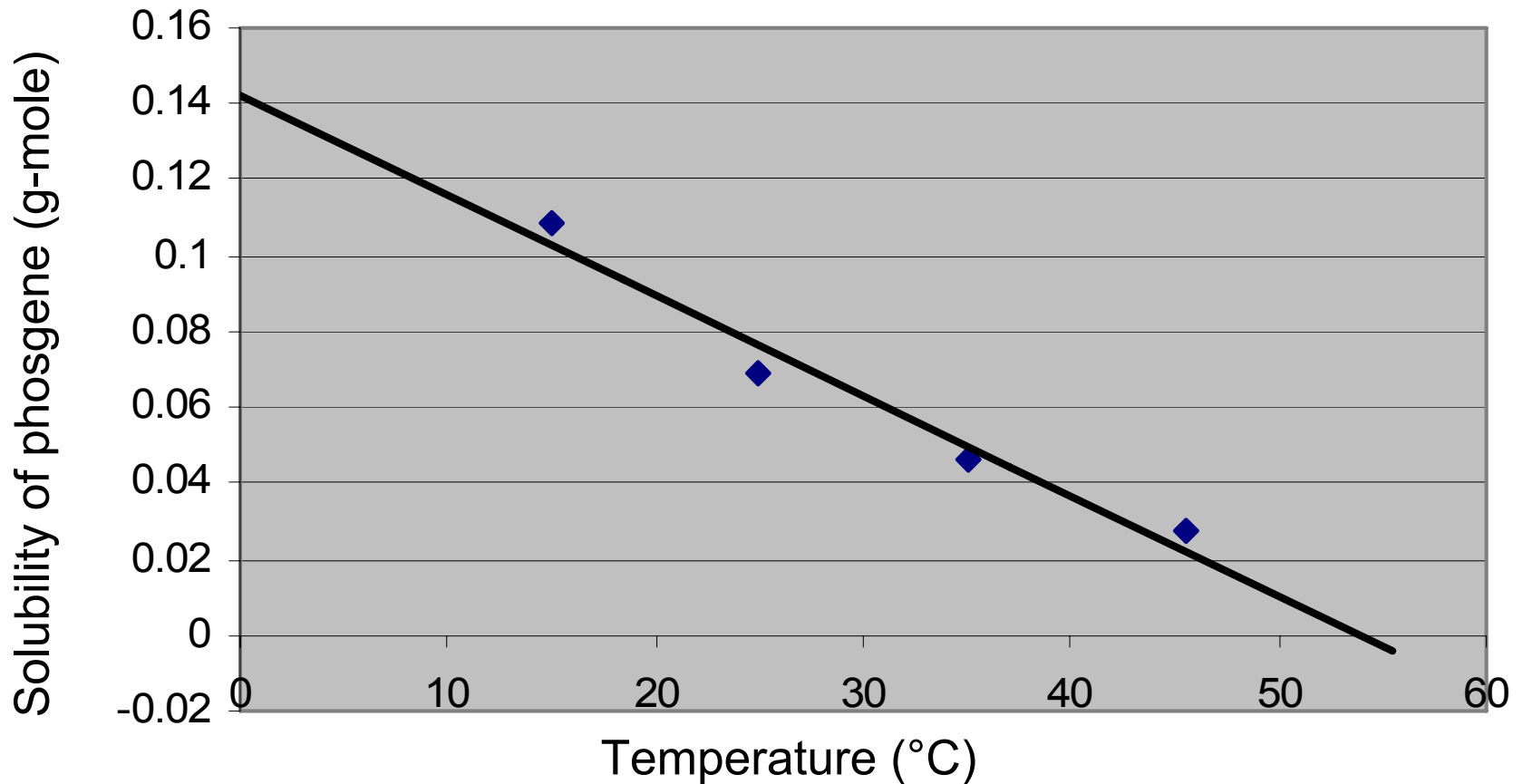


HYDROLYSIS OF PHOSGENE IN SEAWATER



- $\text{COCl}_2 + \text{H}_2\text{O} \rightarrow \text{CO}_2 + 2\text{HCl}$
- Most reports simply state that hydrolysis is rapid
- HCl will be neutralised by the large excess of slightly alkaline water
- Studies give a half life of approximately 0.25s at 15°C

SOLUBILITY OF PHOSGENE IN WATER



DISCUSSION

- Density of phosgene is 1.4 g cm^3 compared 1.025 g cm^3 for sea water therefore it will settle to the lowest point on the seabed if released as long as it doesn't boil
- Increased pressures will prevent phosgene below an approximate depth of 10 m from boiling therefore a gas will not be formed which could migrate to the surface
- The rate of dissolution of liquid phosgene will depend very much on local factors such as seabed currents, topography of the seabed, presence of 'containers' and the type of sediment

CONCLUSIONS

- Phosgene dumped at depth will not cause harm to vessels or people on the surface
- Phosgene leaking from munitions will slowly dissolve into the water and hydrolyse to harmless products. Long term contamination of water will not occur
- Rate of dissolution of liquid phosgene not known so corrosive liquid may exist for a significant period on the sea bed
- Contamination of flora and fauna likely to be short lived and local so unlikely to detect with infrequent sampling

