

World War 2 Operational Research revisited

Exploring the work of RAF Coastal Command
OR Section in the Battle of the Atlantic

John Magill

ISMOR 2023

Session: Leveraging Historical Analysis

World War 2 Operational Research revisited

(and updating)

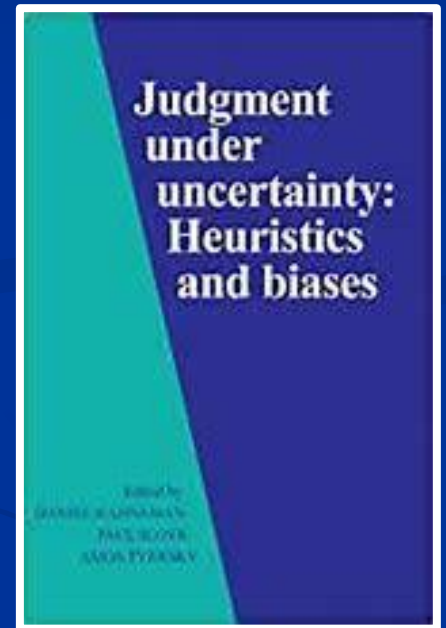
Exploring the work of RAF Coastal Command
OR Section in the Battle of the Atlantic

John Magill

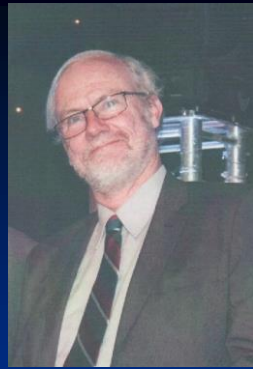
Part 2: Attacking the U-boats

Leveraging Historical Analysis

- “It is better to be wise after the event than not wise at all, and wisdom after one event may lead to wisdom before another.” -- John C. Slessor (*Air Power and Armies*, xiii)
- Real scenarios – “it’ll never happen” (again)
- Constants: Decisions, judgements under uncertainty: where statistics meets psychology



john.magill@cantab.net



Who am I

- long ... career in Aerospace and Defence
- worked in Systems Engineering and OR/OA for 40 years
- hold half a degree in OR
- started out as a real engineer, can drop things on your toes



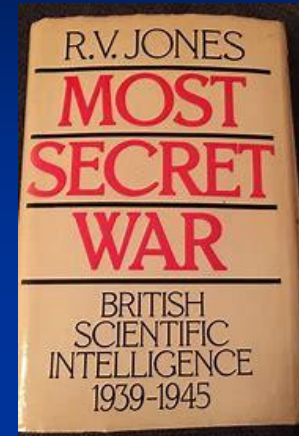
University of Cambridge

MPhil, Control Engineering & Operational Research



Why am I so interested

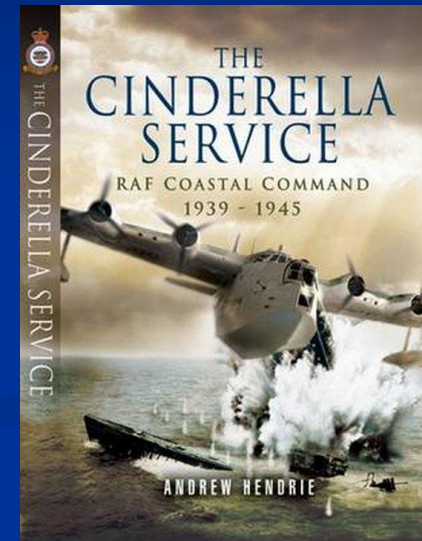
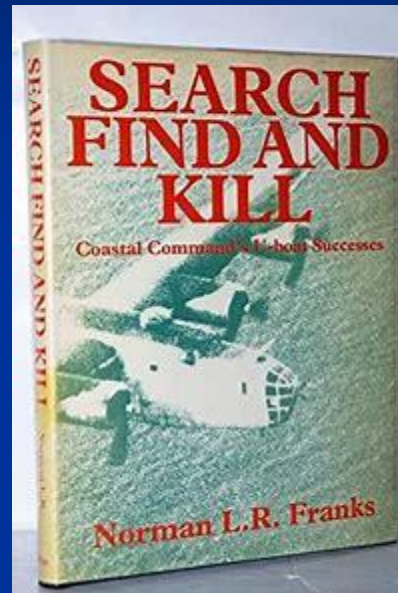
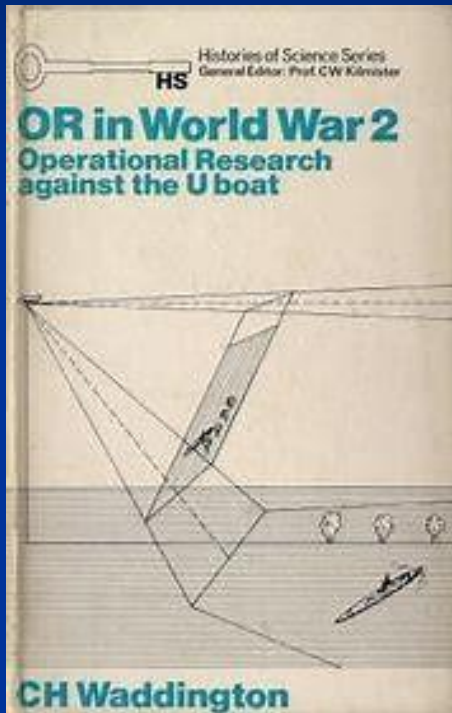
- 70's revelations on TV and print
 - met Prof RV Jones at College



- Started my career on defence systems at Marconi Stanmore
- Distinguished relative was in RAF Coastal Command
 - flew Harry Hopkins to meet Stalin July 1941
 - via North Cape to Archangel
 - Round-the-world and Arctic flights
 - AOC Malta
 - Air Vice Marshal David McKinley



Source material



Torpex and the Atlantic Victory

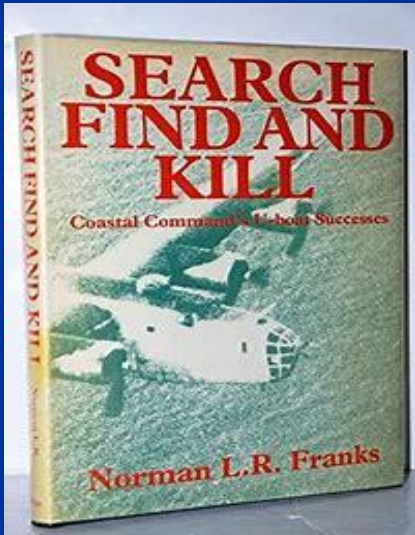
Posted on [May 12, 2021](#) by [Admin](#)

Colin F. Baxter

East Tennessee State University

Contents

- Introduction
- Scenario
- The U-boat Sighting Problem
- Attacking U-boats:
 - depth charge problems
 - bombs
- Conclusions



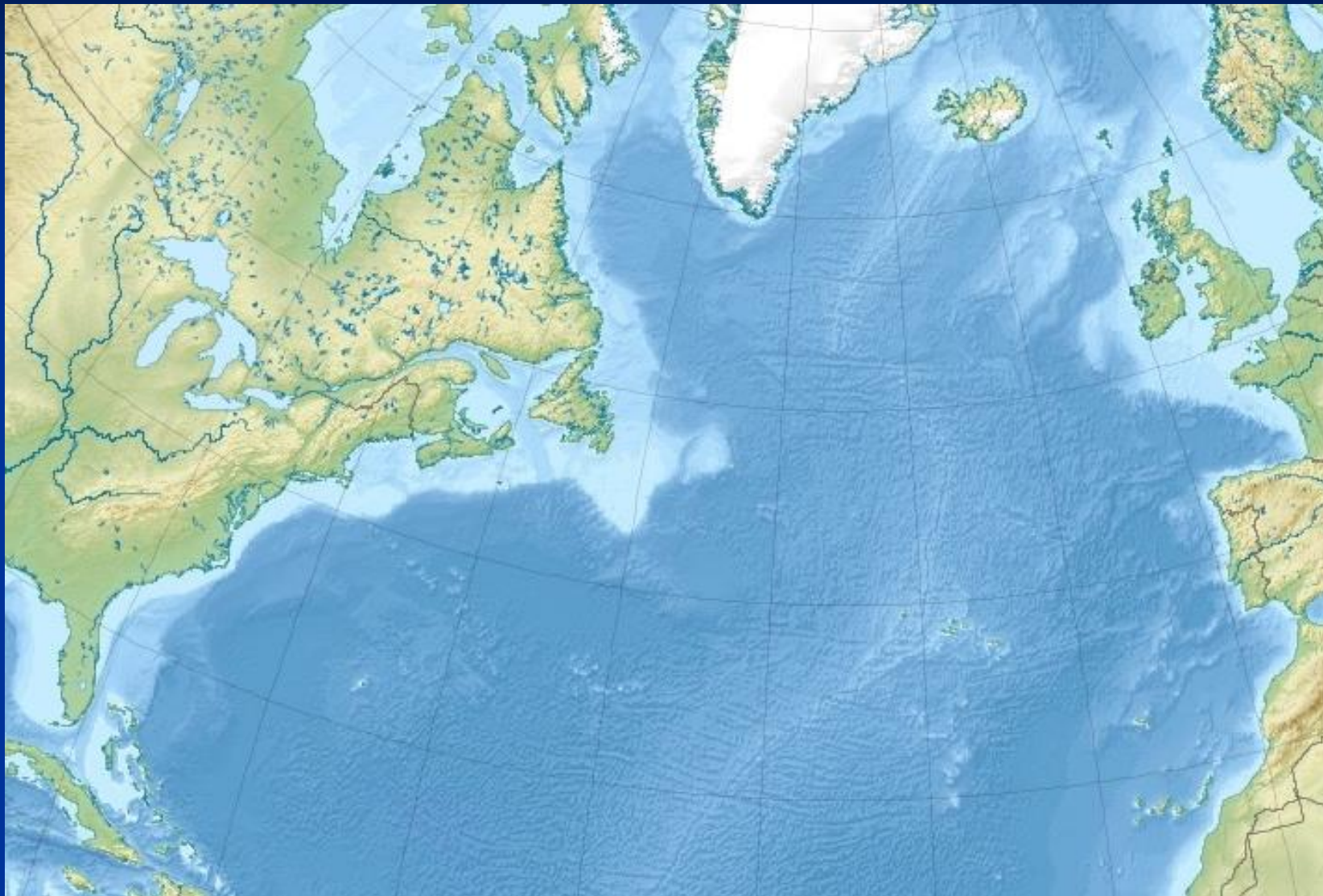
Famous person quote

“...the submarine has been mastered”

Winston S Churchill

March 1939

Scenario: Battle of the Atlantic



Battle of the Atlantic: 80 years on

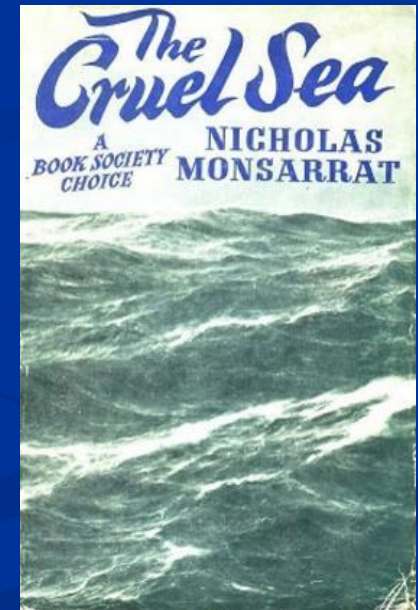


U-Boat Wargamers | Sky HISTORY TV Channel

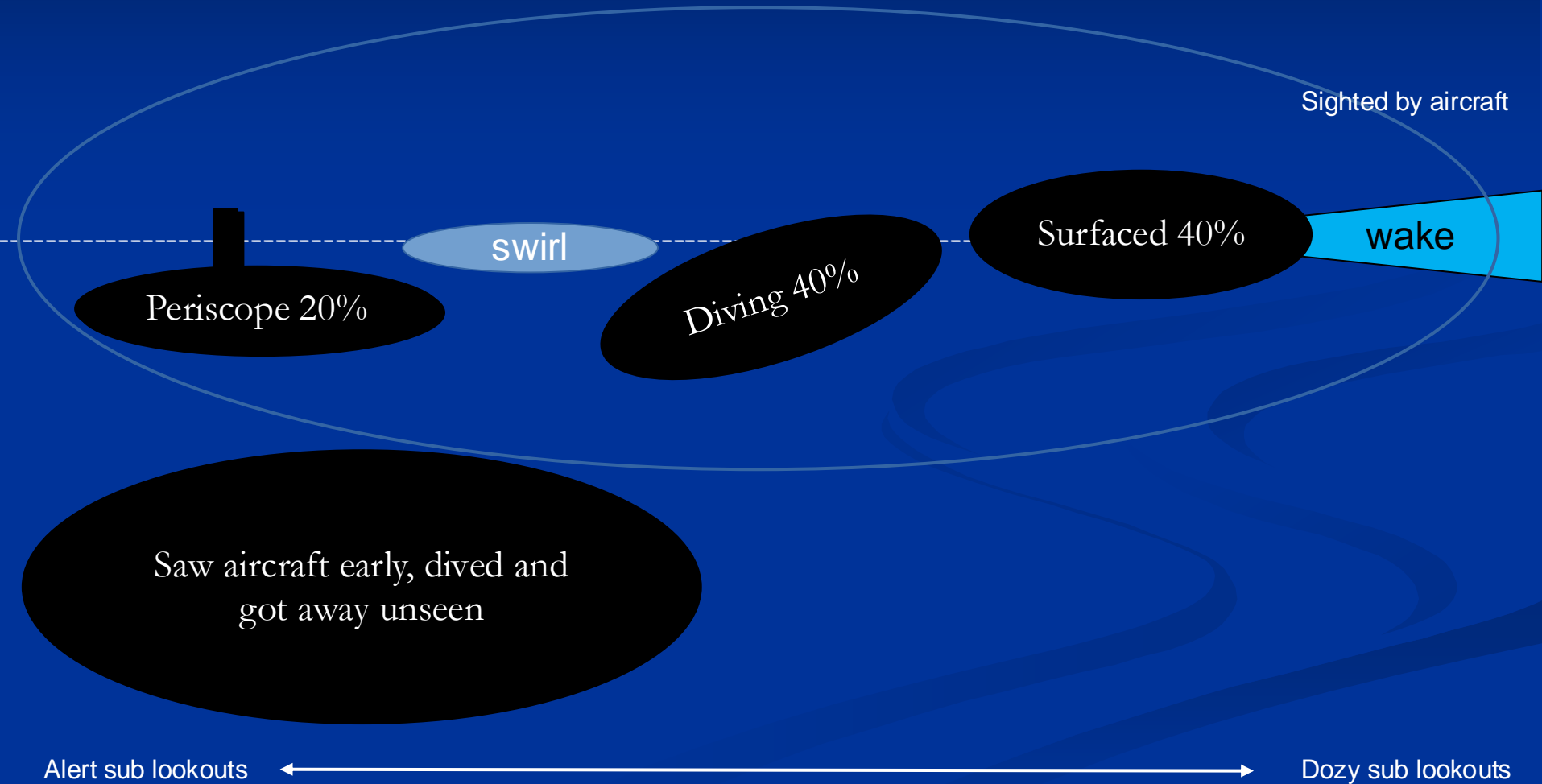


Scenario: Battle of the Atlantic

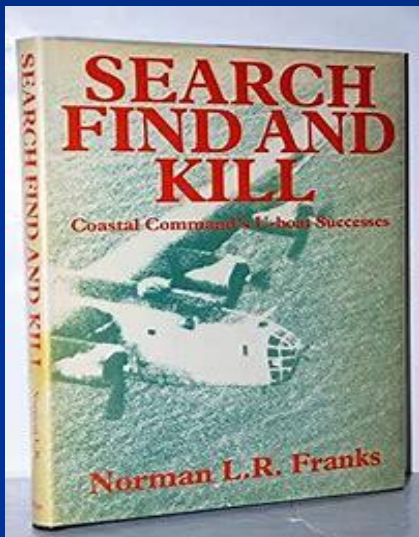
- Need to secure routes across Atlantic
- Convoys of merchantmen and escorts, vs
- U boats:
 - Submarines/submersibles – limited speed and endurance under water
- Epoch May 1941:
 - before Barbarossa, Pearl Harbor, Schnorkel
 - U boats would dive as soon as they see aircraft
- RAF aircraft flying around not seeing very much
- Tasks:
 - Find U boats: Visual sighting; ASV Radar; HF DF; Intel
 - Destroy/ Deter U-boats: Force to dive; attack



U-boat diving status when spotted



The U-boat sighting problem: “Search and Find”



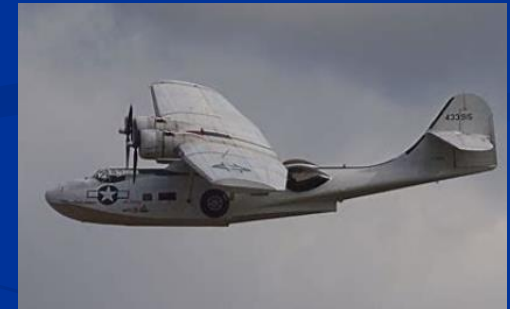
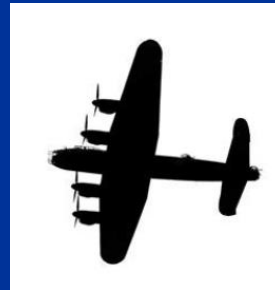
- Why are we not seeing as many U boats as we expect?
- We know roughly how many there are out there:
 - Intel, Enigma, HF DF (shore and ship-based)
- are they running submerged?
- or diving when they detect aircraft approaching
 - Visually or other means?
 - (Germany did experiment with Radar and Radar Warning Receivers later)
- In many cases, the U-boat was already diving when seen... so maybe they saw the aircraft first...

So...what to do?



■ Blackett recounts...

- A Wing Commander asked, what colour are our aircraft?
- mostly (night) bomber types, painted black to reduce visibility to searchlights...
- ...but stand out against a daylight sky



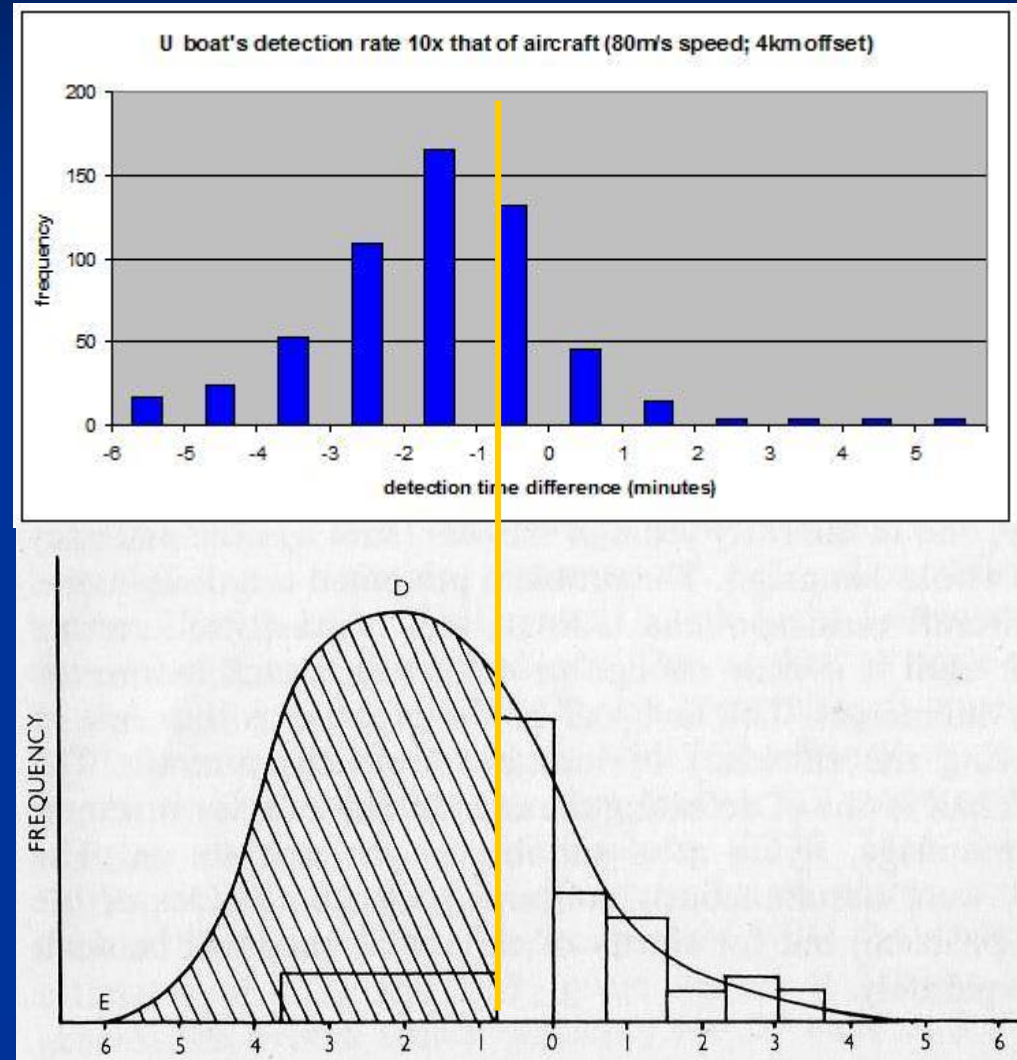
■ So, painting the undersides white:

- Reduced detection range (of the aircraft by the U-boat) by ~20%, and
- Increased attack rate by ~30%

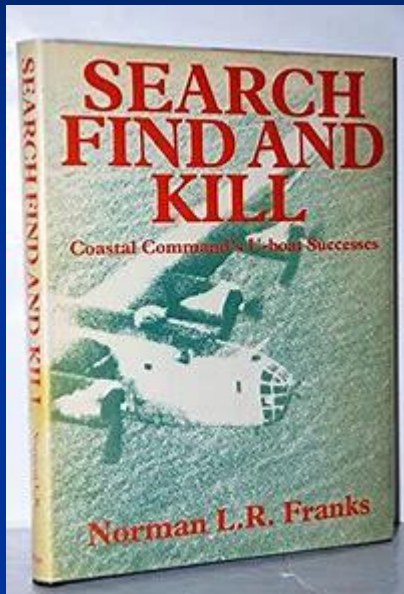
Matching the outputs

- U-boat takes <1 minute to dive
- U-boat “missed” if it sees first by >45s (yellow line)

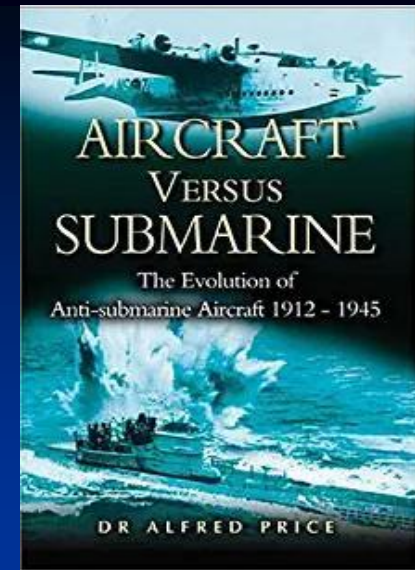
Need to increase U-boat's detection rate significantly before comparable results are obtained



“Kill”



Attack U boat from the air



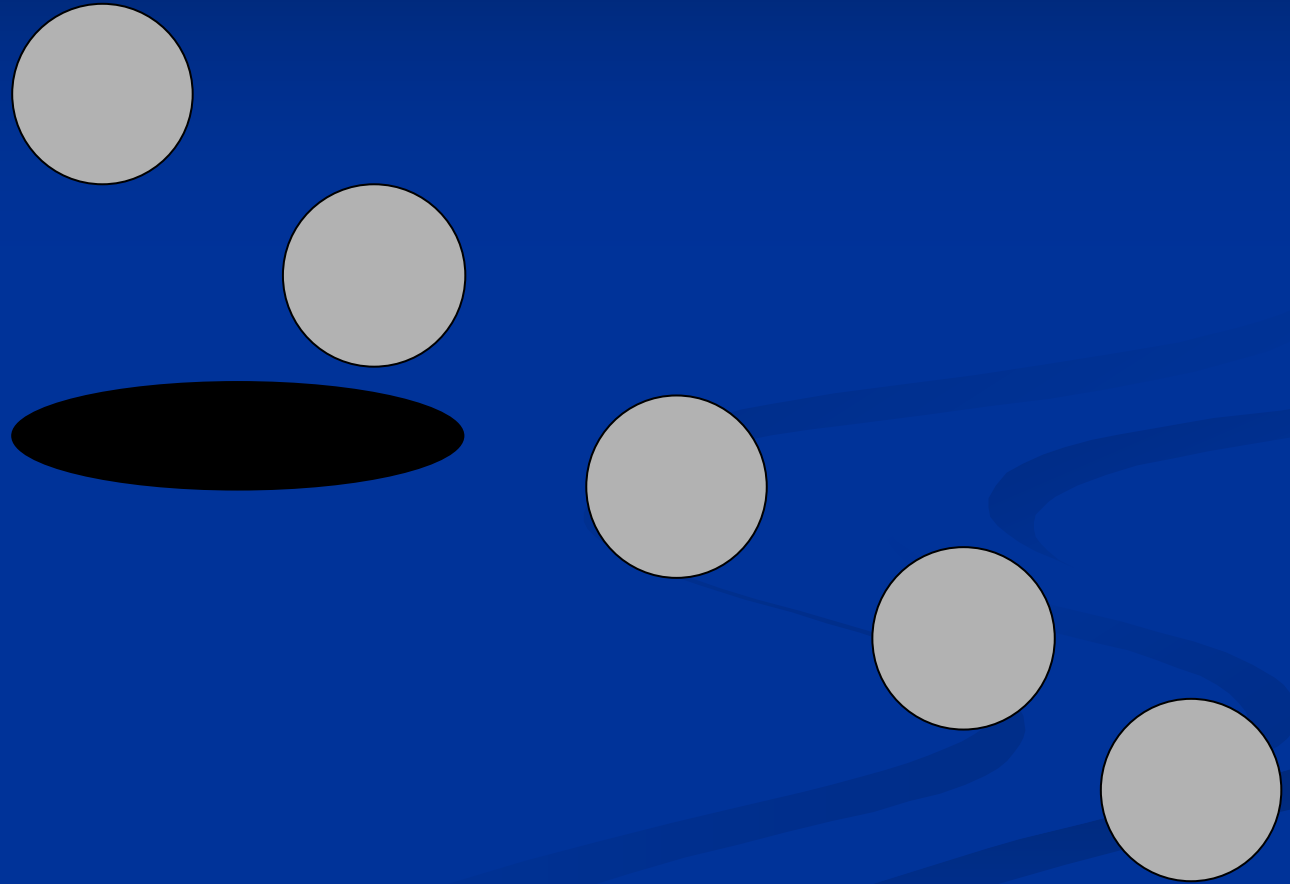
■ Bombs

- Initially more dangerous to the aircraft than U boat

■ Depth charges

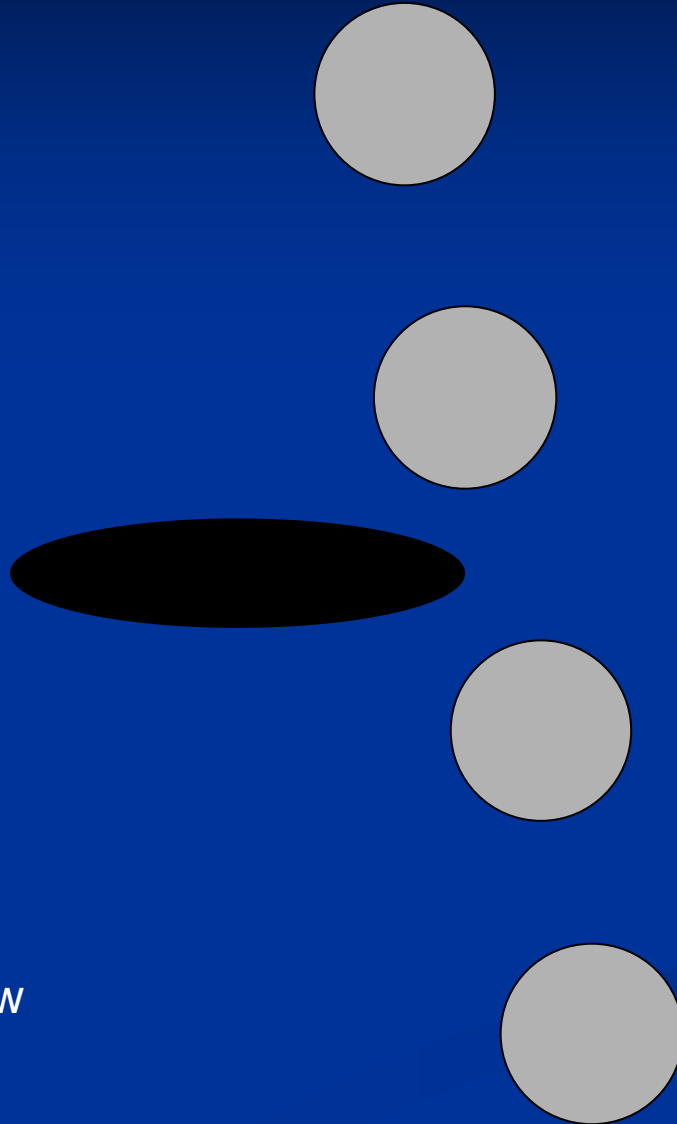
- only ones immediately available were ship-launched types, set for 100ft
- Escorts would attack a *surfaced* U boat with gunfire or ramming
- 450lb, size of (old) dustbin, few Coastal Command aircraft could carry them, need low altitude and low speed release
- 250lb variant cleared for air drop May 41
- Lethal radius thought to be about 20ft

“Stick” of DCs



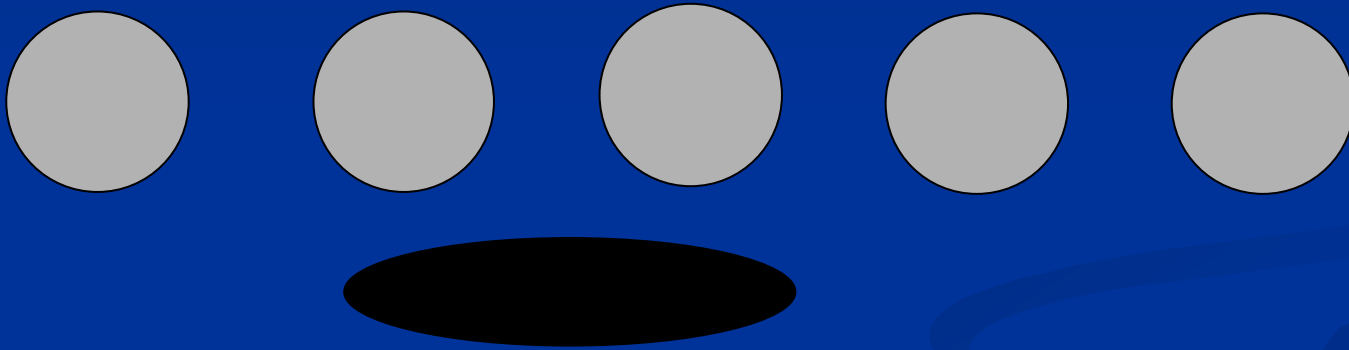
Plan view

Beam attack



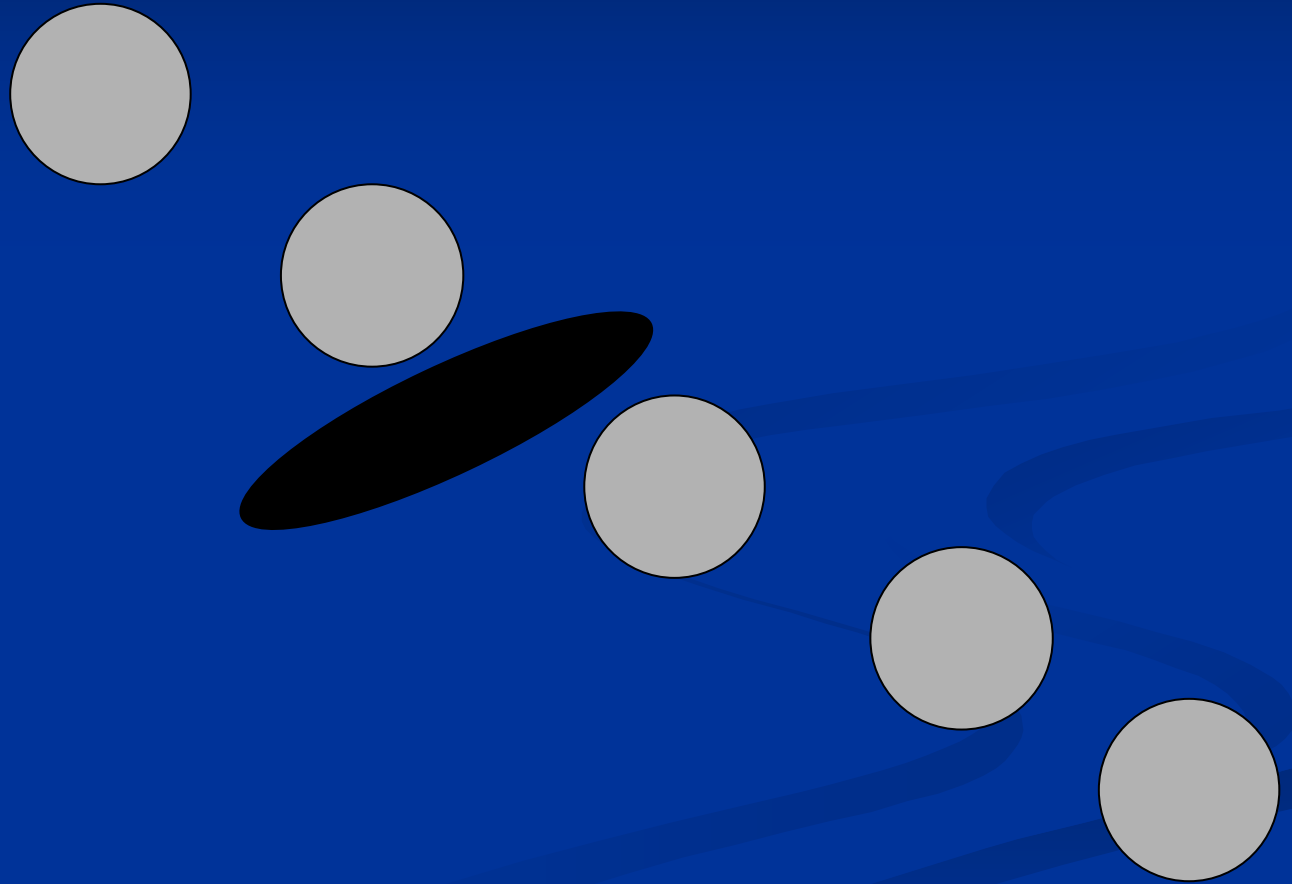
Plan view

Track attack



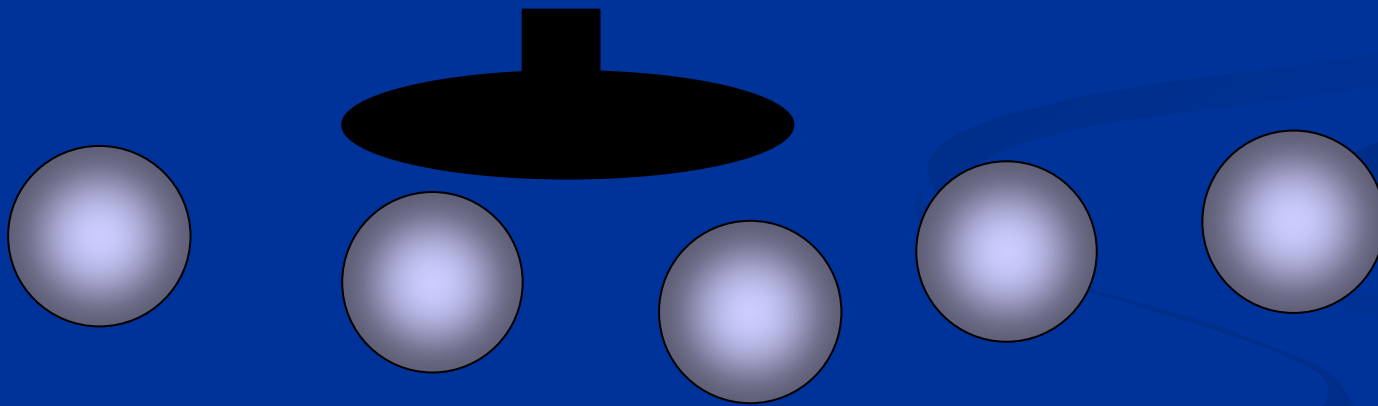
Plan view

“Straddle”



Plan view

Ship-launched pattern



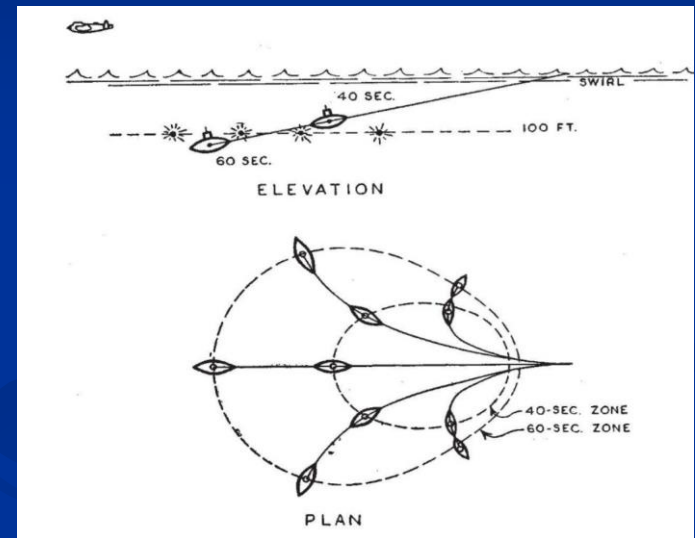
OR Section looked at

- Depth settings of charges
- Number and size of charges dropped
 - Subject to overall weight constraints
- Length of stick; stick spacing
- Accuracies
- Attack bearing: beam/track
- “Depth Bombs” vs “Depth Charges”
 - Differences in release height, safety of aircraft
 - Aerodynamics, hydrodynamics, fuzing
 - Direct hits – DCs liable to break up

The Depth Charge depth-setting problem

- Coastal Command initially assumed that (on average) a U boat would see aircraft a few km away, ~2 mins before the attack came in

- would immediately dive (<1 min)
- dive (at 2 ft/sec) to ~100 ft
- So 100ft was an appropriate setting



- Good “tamping”: depth charges more effective at depth, and underneath the target, other things being equal..., like, that’s where the U-boat was...

The depth-setting problem (2)

- Ineffective tactic:
 - If U boat had dived to 100ft, aircraft has little idea of plan position, so drops charges to explode at right depth but in **wrong place**
 - If near surface, drops in right place but explode at **wrong depth**
 - Pk about 1/1000 for a lethal radius of 20ft
 - Even 15s out of sight after diving often enough to protect sub
- ORS suggested more effective to concentrate on the “better” targets caught near the surface and attack with **shallow-set charges**
 - Expected to improve lethality by factor of 10
 - Also good idea to use the most energetic explosive
- Recommendations accepted, mid 1941
- Took a while to be implemented

Lethality of attacks

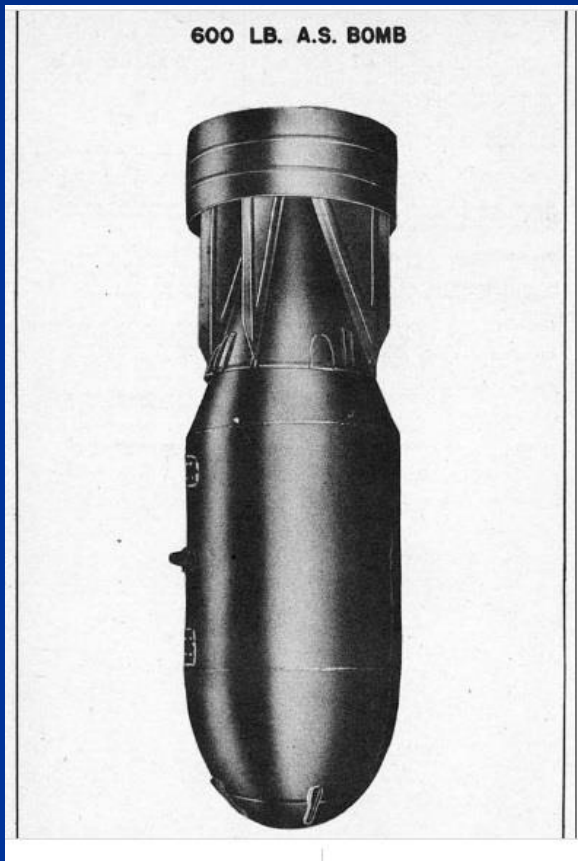
- BDA/Lethality hard to assess
- Still disappointing (~15%) by mid 1942 even with 25ft depth setting and Torpex filling

Pilots/ Air Staff:
We're scoring "straddles".
Maybe 250lb charge not big enough.
How about 600lb depth bombs?

ORS:
Accuracy is paramount:
keep practising.
Or maybe drop more, but
smaller bombs, to fill in the
"gaps" in the stick?

Contenders

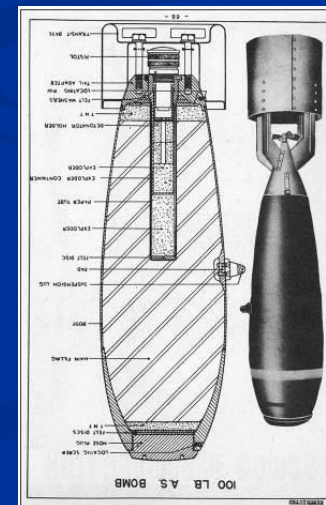
600lb



250lb



100lb



35lb



So, what do we know...

UNDERWATER EXPLOSIONS



By ROBERT H. COLE

includes reports from WHOI, Underwater
Explosives Research Laboratory

Woods Hole Oceanographic Institution
ARCHIVE COLLECTION

PRINCETON, NEW JERSEY · 1948

PRINCETON UNIVERSITY PRESS

Parameter	Functional dependence	Acoustic law
Peak pressure P_m	$f(W^{1/3}/R)$	constant $\cdot (W^{1/3}/R)$
Characteristic time t' (e.g., time constant θ)	$W^{1/3} f(W^{1/3}/R)$	constant $\cdot (W^{1/3})$
Impulse $I(t'/W^{1/3})$	$W^{1/3} f(W^{1/3}/R)$	constant $\cdot (W^{2/3}/R)$
Energy density $E(t'/W^{1/3})$	$W^{1/3} f(W^{1/3}/R)$	constant $\cdot (W/R^2)$

The following parameters are functions only of the ratio $W^{1/3}/R$:

Peak pressure P_m , reduced time constant $\theta/W^{1/3}$, reduced impulse $I/W^{1/3}$, reduced energy density $E/W^{1/3}$.

(see section 4.2). Accordingly, it is convenient to write the peak pressure, impulse, and energy flux in English units as

$$(7.6) \quad P_m = k \left(\frac{W^{1/3}}{R} \right)^\alpha$$

$$I(t/W^{1/3}) = l W^{1/3} \left(\frac{W^{1/3}}{R} \right)^\beta$$

$$E_f(t/W^{1/3}) = m W^{1/3} \left(\frac{W^{1/3}}{R} \right)^\gamma$$

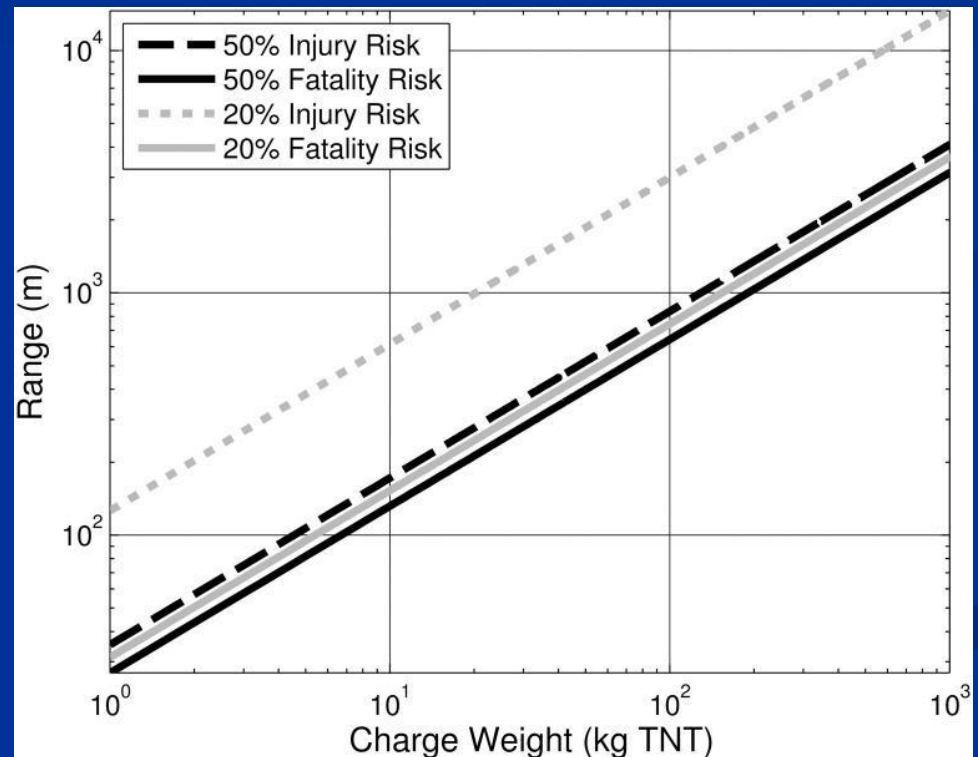
curve to exponential form. The reduced impulse, integrated to a time $t = 6.7\theta$, is plotted in Fig. 7.6. The points are fitted quite well, except close to the charge, by the formula:

$$I(6.7\theta) = 2.18 W^{1/3} \left(\frac{W^{1/3}}{R} \right)^{1.05}$$

Charge size vs effective range

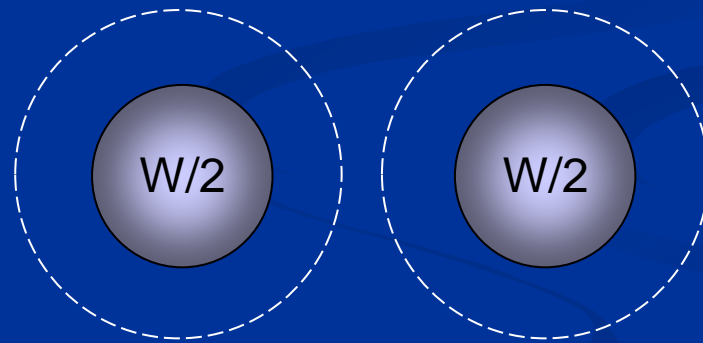
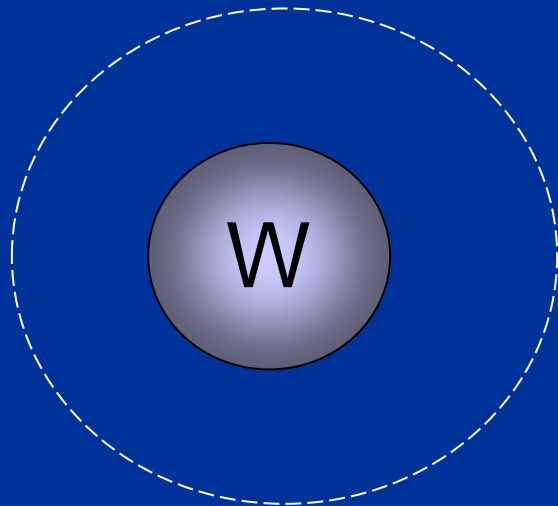
- Choose Integrated Impulse as damage mechanism
- “constant damage distance” goes as charge size $W^{0.7}$

- Human vulnerability...



So, a few big or many small?

Radius of constant effect



0.62 R

0.62 R

R

Reconciling the views

- US naval board study 1936: “600lb charge better than 2x 300lb charges”
- March 42: Admiralty Standing Committee on ASW claimed “stick of 250lb DCs more effective than equivalent weight of 500lb”
- May be naval/aerial charge differences:
 - Dimensionality of the respective problems
 - Accumulated damage vs lucky hits
- Decision was made to keep the 250lb depth charge while developing other, both heavier and lighter, options
- Rockets and acoustic torpedoes - another day

Conclusions

- Choice of weapons took a number of turns
- Bombs
 - Initially tended to be more dangerous to aircraft than U boat
 - 600lb Depth Bomb showed some utility towards end, but only credited with sinking 1 U-boat (U-462)
- Depth charges
 - 250lb turned out to be a good, robust solution: just needed to be dropped accurately
 - Rivals to the standard 250lb DC were developed, but entered service too late to be decisive; some lack of robustness to attack direction
- => Make best use of existing equipment before rushing to replace!

End