Squat

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The **squat effect** is the hydrodynamic phenomenon by which a **vessel** moving quickly through **shallow water** creates an area of lowered pressure that causes the ship to be closer to the **seabed** than would otherwise be expected. This phenomenon is caused when water that should normally flow under the hull encounters resistance due to the close proximity of the hull to the seabed. This causes the water to move faster, creating a low-pressure area with lowered water level surface (See **Bernoulli's principle**). This squat effect results from a combination of (vertical) sinkage and a change of trim that may cause the **vessel** to dip towards the stern or towards the bow.\(^1\) Squat effect is approximately proportional to the square of the speed of the ship. Thus, by reducing speed by half, the squat effect is reduced by a factor of four.\(^2\) Squat effect is usually felt more when the depth/draft ratio is less than four\(^2\) or when sailing close to a **bank**. It can lead to unexpected groundings and handling difficulties.

Amazingly accurate
SHALLOW WATER EFFECTS

SQUAT

- PROPORTIONAL TO:
  - SPEED
  - DISPLACEMENT
  - DEPTH & BREADTH OF CHANNEL

- CAN CAUSE SHIP TO STRIKE BOTTOM

- CAUSES WET WELLS TO INCREASE DEPTH UNEXPECTEDLY AND OUT OF CONTROL

- REDUCED RUDDER EFFECTIVENESS

- LESS SPEED

- SHIP’S WAKE CAN BE AN INDICATOR
Bernoulli’s Principle

\[ p + \rho gh + \frac{1}{2} \rho v^2 = \text{constant} \]

- \( p \) is pressure
- \( \rho \) is mass density
- \( g \) is acceleration due to gravity
- \( v \) is ships speed (ft/s or m/s)

Vessels push water in front of her bow. Water flows back at sides and under the vessel to fill the void of water displaced by the ship, barge or tug. Water forced to move faster.

**IF ONE PRESSURE GOES UP OTHERS GO DOWN**
IF ONE PRESSURE GOES UP
OTHERS GO DOWN
ALL Vessels Squat!
In open water Squat Negligible

Open channel
Minimum Squat

SQUAT = $C_B \times \frac{V^2}{100}$ (meters)
V in knots

Dr. C. B. Barras
ALL Vessels Squat!

In restricted water!

Maximum Squat

\[ SQUAT = 2C_B \times \frac{V^2}{100} \] (meters)

V in knots

Dr. Barras (both rough estimates)
ALL Vessels Squat!

A more involved and more accurate formula

Still an estimate!

Maximum Squat

\[
SQUAT = \left( C_B \times s^{2/3} \times V^{2.08} \right) / 30
\]

(meters)

V in knots
Vessel Parameters

B = Beam; T= Draft
$C_B = \text{Block Coefficient}; \quad C_w = \text{Waterline Coefficient}$

Typical for barges

$0.90 - 0.95 \quad 0.98 - 1.0$

Channel Parameters

$h = \text{water depth}; \quad W = \text{Channel Width}$

$h_i = (4.96 + 52.68(1-C_w)^2 \times T$

$W_i = (7.7=45(1-C_w)^2 \times B$

$h_i \quad \text{– critical depth}$

$W_i \quad \text{– critical width}$

UKC – Under Keel Clearance
Channel Parameters Confined

\[ A_s = \text{Ship Area} \]
\[ A_c = \text{Channel Area} \]
\[ S = \text{Blockage } A_s/A_c \]
\[ s = S/(1+S) \]

\[ \text{SQUAT} = (C_B \times s^{2/3} \times V^{2.08})/30 \text{ (meters)} \]
Vessel Parameters for example

\[ B = 30 \text{ m}; \; T = 10\text{ m} \]
\[ C_B = 0.95; \; C_w = 0.99 \]

\[ h = 11 - 14\text{ m} \]
\[ W = 200\text{ m and } 100\text{ m} \]
\[ h_i = 49.7\text{ m} \]
\[ W_i = 231.1\text{ m} \]
\[ UKC = 1 - 4\text{ m} \]
Reference;

Ship Stability for Masters and Mates

Chapter 31

Barras and Derrett BH