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DEPARTMENT OF THE NAVY

COMPARATIVE POWERING CHARACTERISTICS FOR A 154-FOOT HIGH-SPEED PGM MOTOR GUNBOAT IN WAVES WITH AND WITHOUT TRANSOM WEDGES FROM TESTS OF MODEL 4950 (U)

HYDROMECHANICS



AERODYNAMICS



STRUCTURAL MECHANICS



APPLIED MATHEMATICS



ACOUSTICS AND VIBRATION

by

DTIC ELECTE JUN 17 1983

David R. Hoekzema

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HYDROMECHANICS LABORATORY RESEARCH AND DEVELOPMENT REPORT

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September 1965

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NOTATION

<u>Symbol</u>	<u>Definition</u>	<u>Dimensions</u>
B	Beam	feet
D	Propeller diameter	feet
g	Acceleration due to gravity	feet/second ²
L	Length between perpendiculars	feet
N _r	Increase of revolution per second due to wave action	revolutions/second
P _r	Increase of power due to wave action	foot pounds/second
Q _r	Increase of torque due to wave action	pound feet
r	Wave amplitude	feet
T _r	Increase of thrust due to wave action	pounds
v	Speed	feet/second
λ	Wave length	feet
γ _r	$\frac{N_r D^3 v}{g r^2 B^2 / L}$ - dimensionless transfer function for increase of rps	
π _r	$\frac{P_r}{\rho g r^2 v B^2 / L}$ - dimensionless transfer function for increase of power	
ρ	Density	pounds second ² /foot ⁴
τ _r	$\frac{T_r}{\rho g r^2 B^2 / L}$ - dimensionless transfer function for increase of thrust	
χ _r	$\frac{Q_r}{\rho g r^2 D B^2 / L}$ - dimensionless transfer function for increase of torque	



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ABSTRACT

A model (4950) of a high-speed PGM motor gunboat was self-propelled in smooth water and regular waves with and without transom wedges. The results indicate that the required power and thrust increase due to ahead seas is greater with the wedges than without. The total thrust is, however, less in a seaway with the wedges than without.

ADMINISTRATIVE INFORMATION

The test program for this phase of the PGM project was authorized by Bureau of Ships letter F013-02-04, Serial 442-1C5, of 15 October 1962. This work was charged to Appropriation 17X1319.2435, RDT & N 1963, Project S-F013 02 04, Task 1712, Allotment 20169.

INTRODUCTION

The Bureau of Ships requested that the David Taylor Model Basin conduct tests of three new designs for a high-speed PGM motor gunboat. Two of these designs were self-propelled in waves.¹ After these tests, hull form "C," Model 4950, was refitted with Model Basin designed appendages and transom wedges.² This report compares the results of further powering tests of Model 4950 in waves with the TMB appendages with and without a 3-inch transom wedge.

TEST PROGRAM

The TMB-designed appendages consisted of single combination strut-rudder horns with contraflow sections. These were fitted to Model 4950 and propulsion tests were conducted in ahead and following seas. These seas consisted of regular waves with wave length to ship length ratios (λ/L) of 1.0, 1.5, and 2.0. Consistent with the more extensive tests run prior to the appendage modification, the wave height to wave length ratio (r/λ) was 1/40 for λ/L equal to 1.0 and 1/50 for λ/L equal to 1.5 and 2.0.¹

Tests were conducted both with and without wedges at ship speeds up to 32 knots in ahead seas and up to 40 knots in following seas. Since the increase in resistance in waves is largely caused by inertial and gravitational forces and it is difficult to apply a towing force to a model free to surge, the model was propelled at the model propulsion point. Propeller forces were measured with electronic transmission dynamometers and recorded on paper strip charts. Values of these forces were read from the recorded data as average values over one or more complete periods of motion.

¹References are listed on page 14.

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TEST RESULTS

Measurements were made of thrust, torque, and rpm. These data were reduced to dimensionless form according to the methods of References 3 and 4. The Gerritsma method is to determine the difference in thrust, torque, rpm, or power between the model operating in waves and operating at the same speed in still water. This difference is then multiplied by the appropriate scaling factors and physical constants to reduce it to dimensionless form. It is assumed that these dimensionless transfer functions are the same for both the model and the ship. Comparisons of these dimensionless functions for both the hull forms with and without wedges are presented as Figures 1 through 8.

The dimensionless transfer functions for the increase in thrust, torque, rpm, and power may be expanded to full scale; however, it is done here only for power and thrust. The comparisons of the expanded power and thrust increases are presented as Figures 9 and 10. Figure 11 shows the total thrust with and without wedges in still water and ahead seas.

DISCUSSION AND RECOMMENDATIONS

With the exception of high speeds in following seas, the increase in thrust and power required for operation in a State 5 Neumann spectrum sea is less for the hull without the wedge. However, the hull with the wedge is sufficiently superior in smooth water that it still maintains some superiority in waves. Figure 11, for example, shows that the hull with the wedge generally requires less thrust to maintain speed in a State 5 Neumann spectrum sea than does the hull without wedge in smooth water.

These tests in regular waves (whose direction of motion is parallel to that of the model) where the model is restricted in yaw, roll, and sway do not fully indicate ship performance in waves. Transom wedges decrease the running trim of the ship and thus increase the hazard of broaching or difficult handling, particularly in following seas. This problem could be minimized through the use of an adjustable flap aft of the transom rather than the fixed wedge.

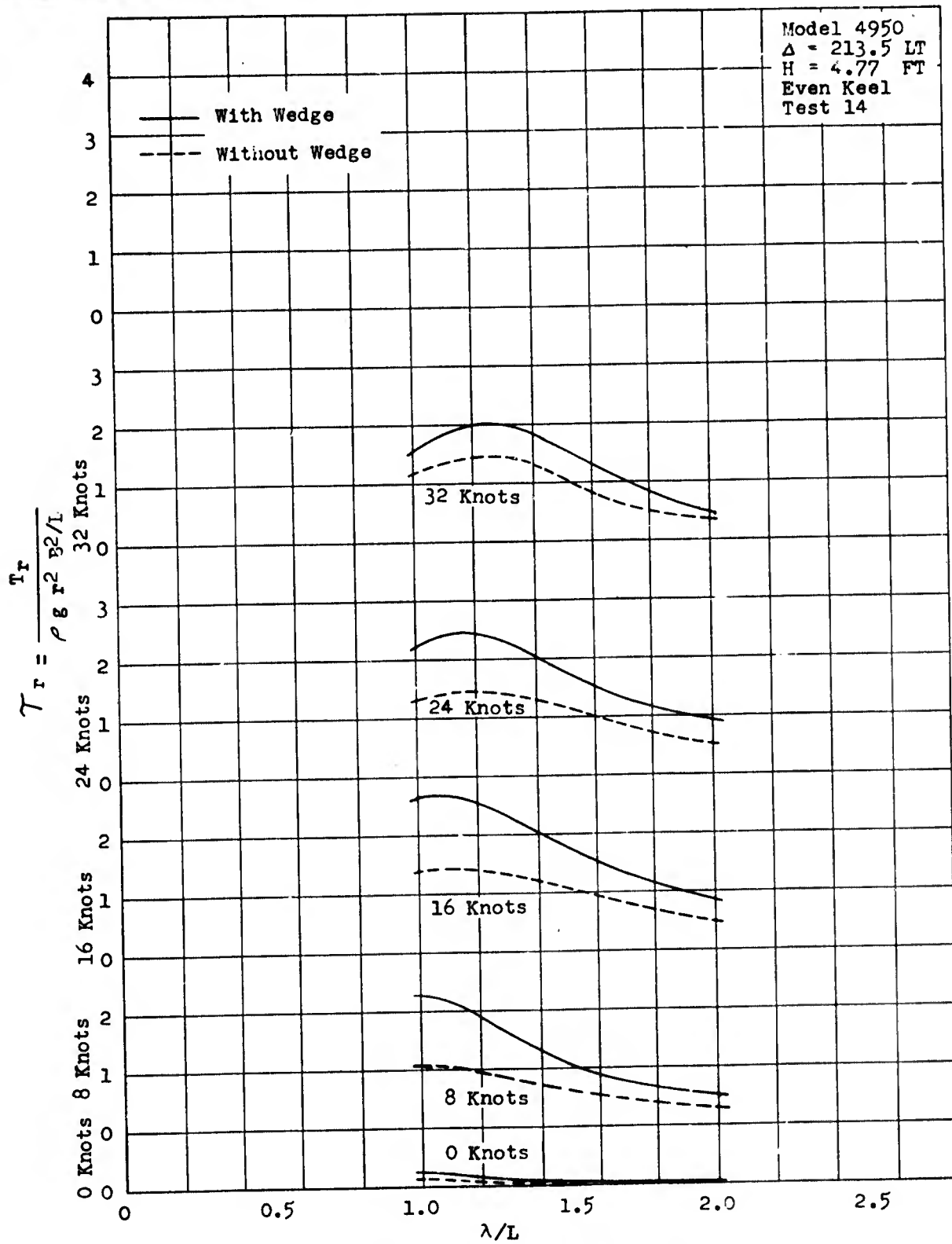


Figure 1 - Dimensionless Thrust Increase due to Regular Head Seas with and without Transom Wedges

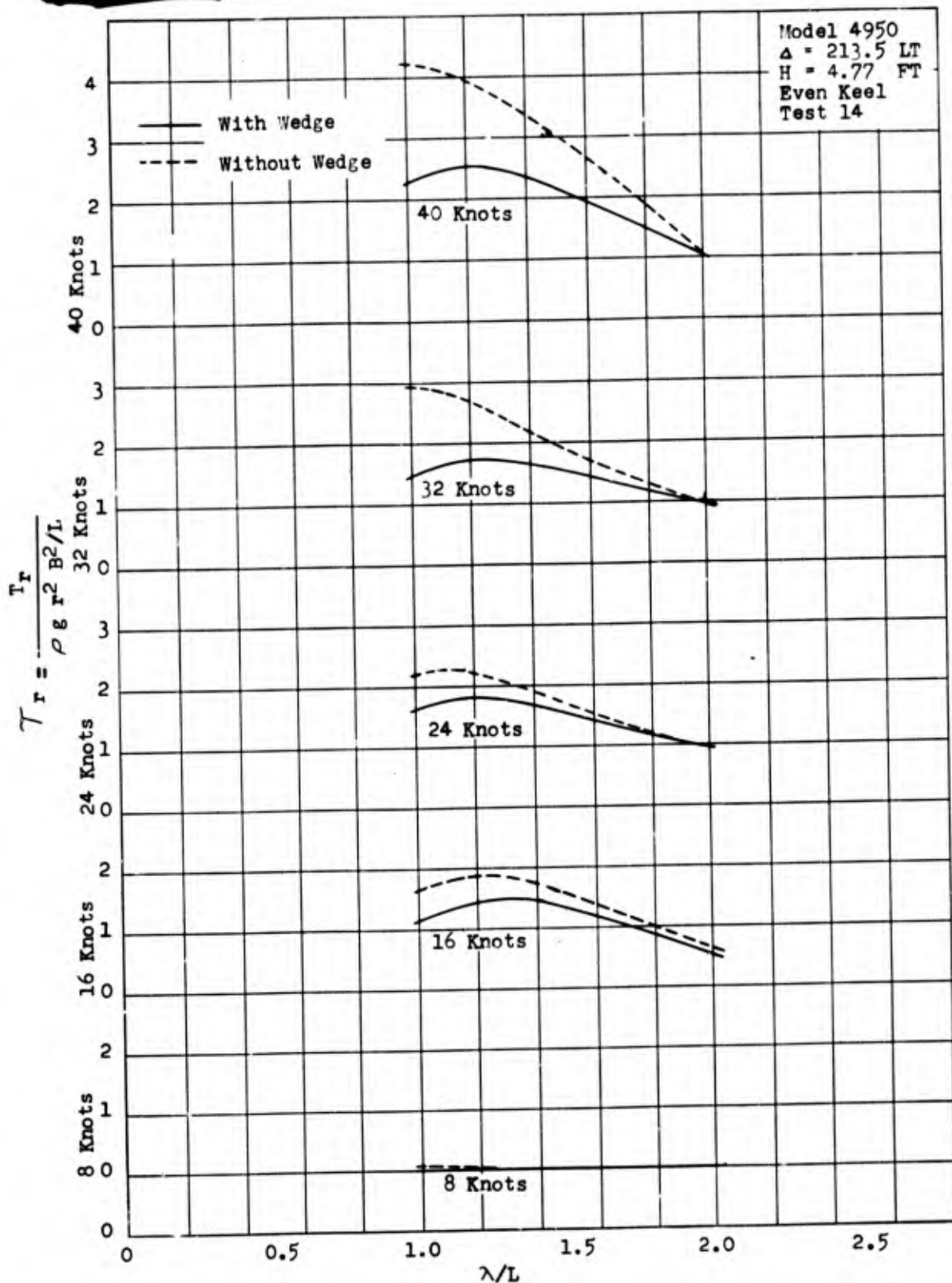


Figure 2 - Dimensionless Thrust Increase due to Regular Following Seas with and without Transom Wedges

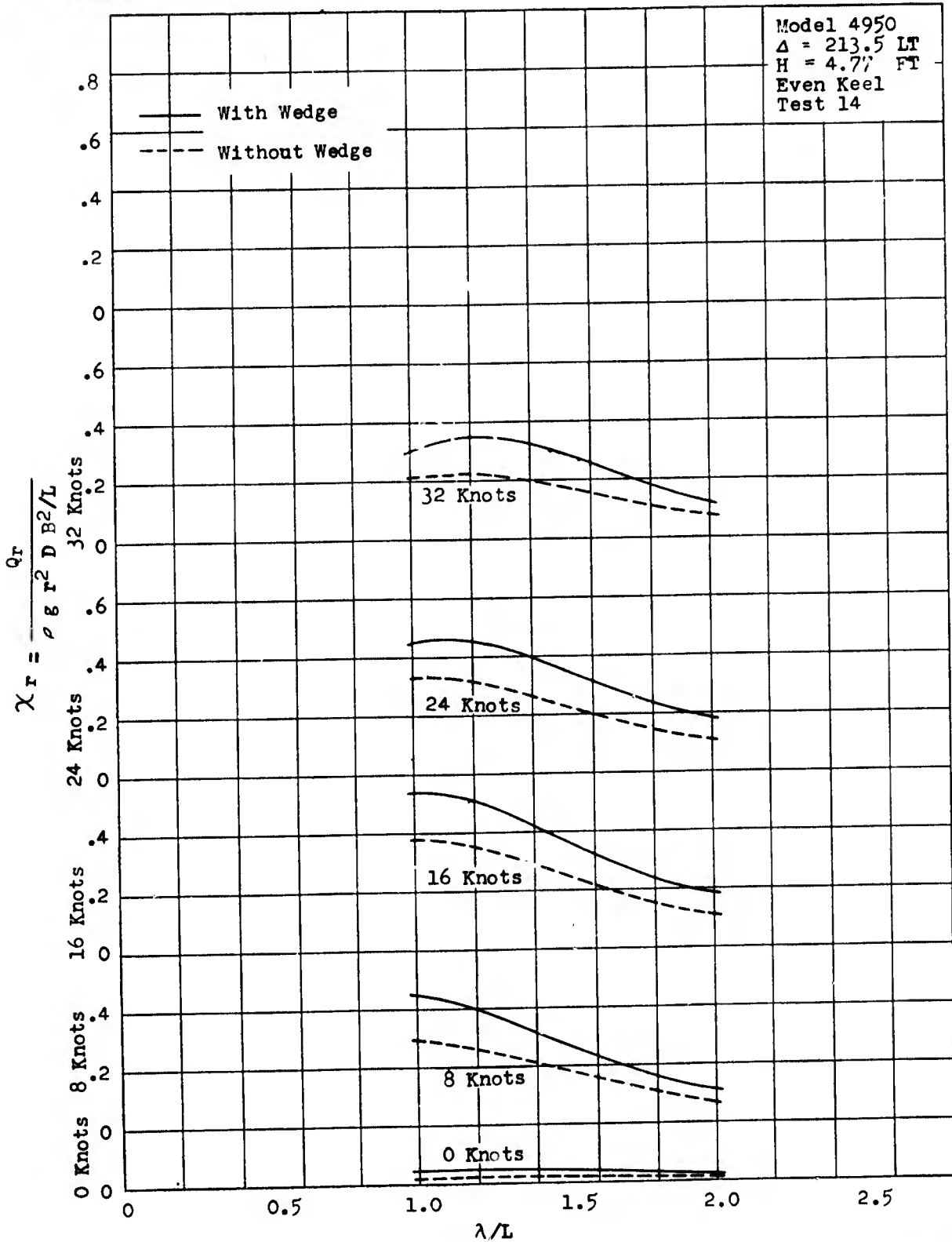


Figure 3 - Dimensionless Torque Increase due to Regular Head Seas with and without Transom Wedges

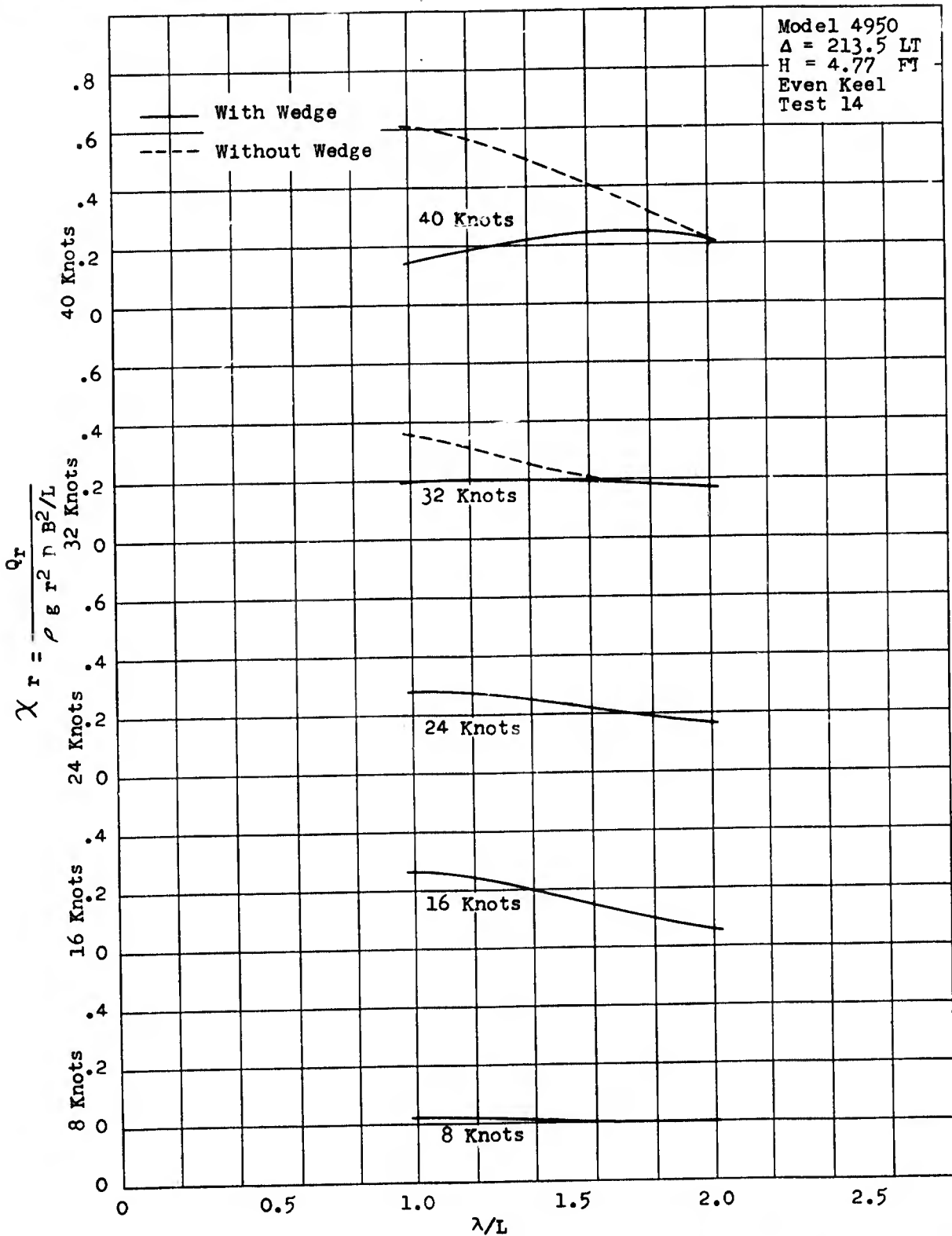


Figure 4 - Dimensionless Torque Increase due to Regular Following Seas with and without Transom Wedges

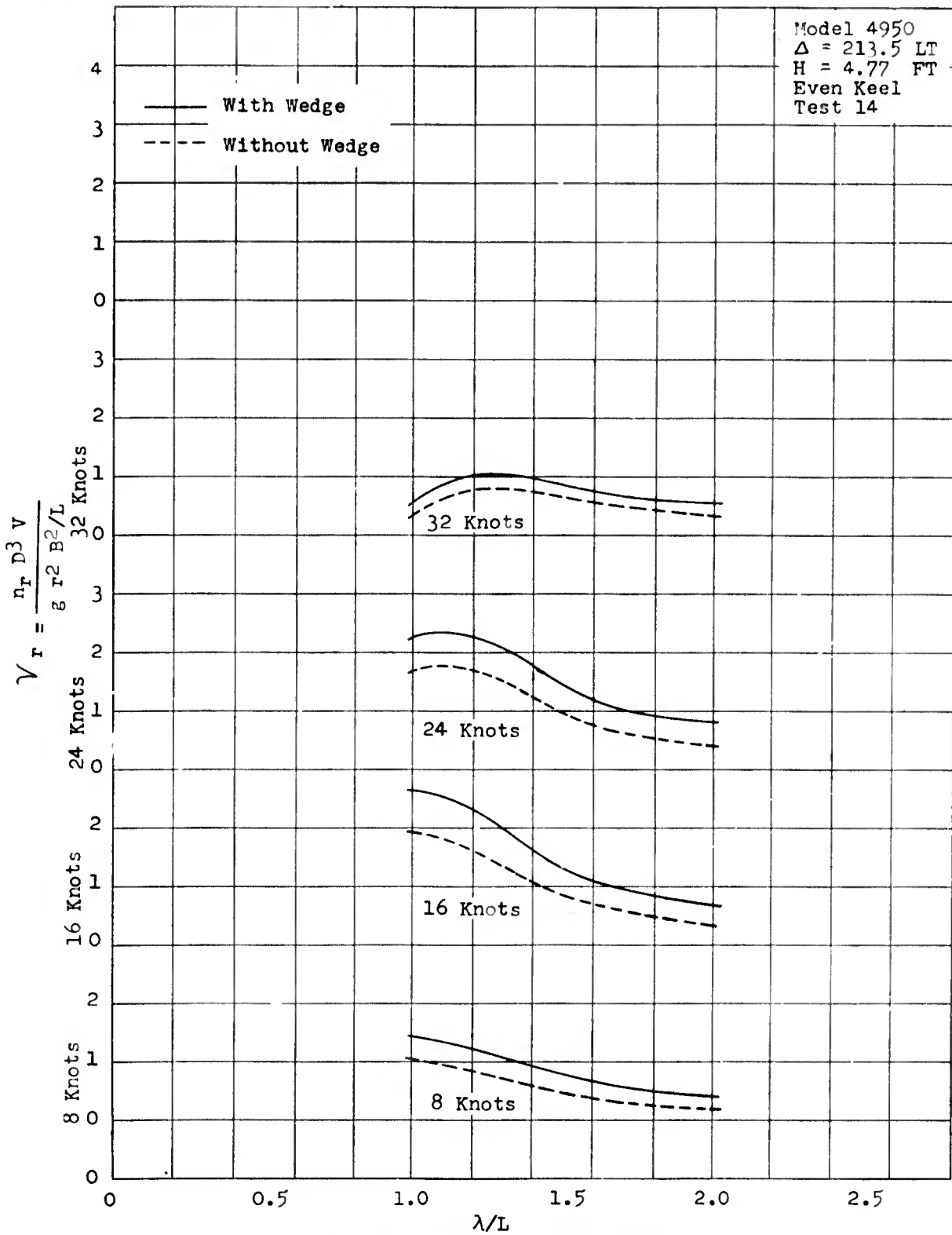


Figure 5 - Dimensionless RPM Increase due to Regular Head Seas with and without Transom Wedges

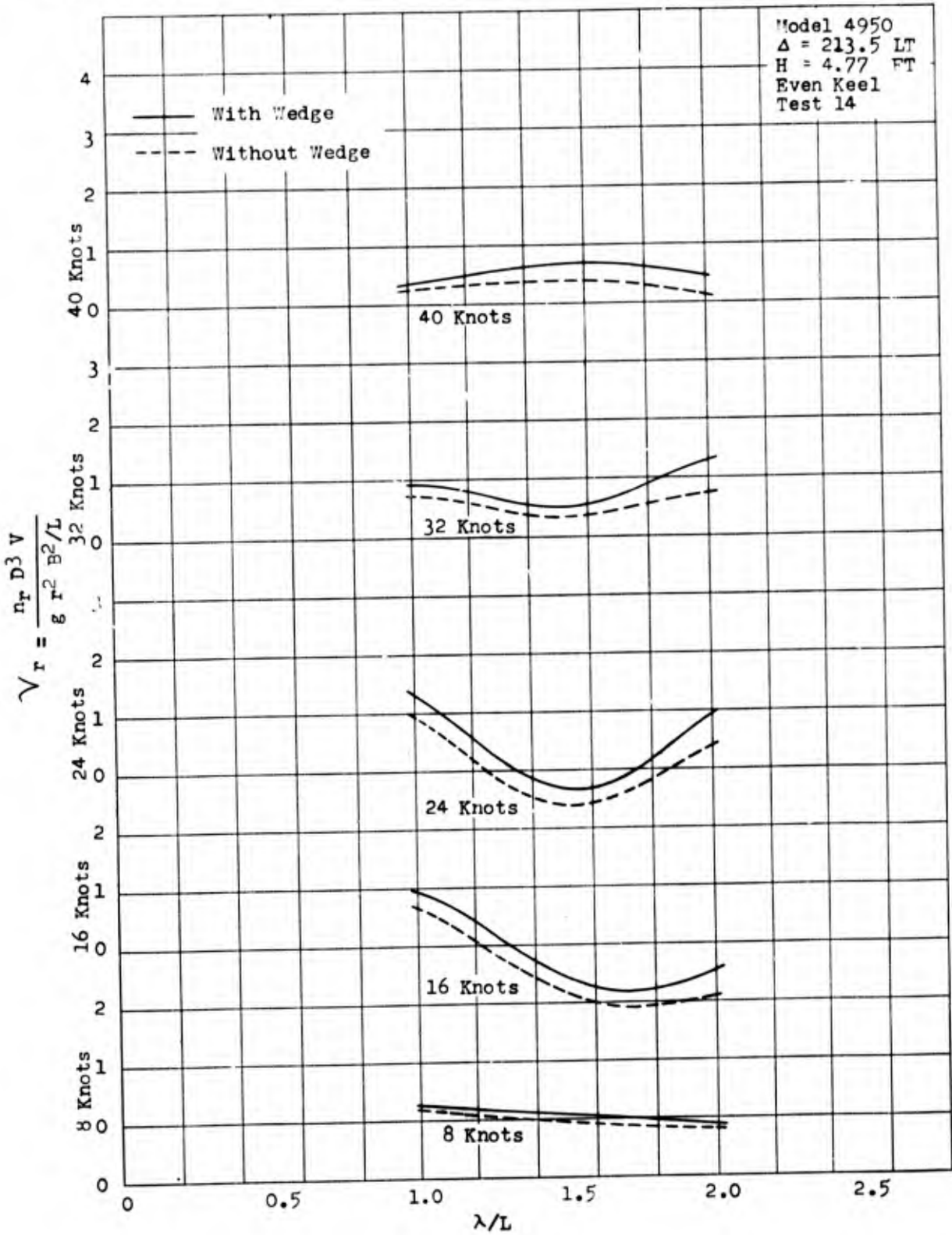


Figure 6 - Dimensionless RPM Increase due to Regular Following Seas with and without Transom Wedges

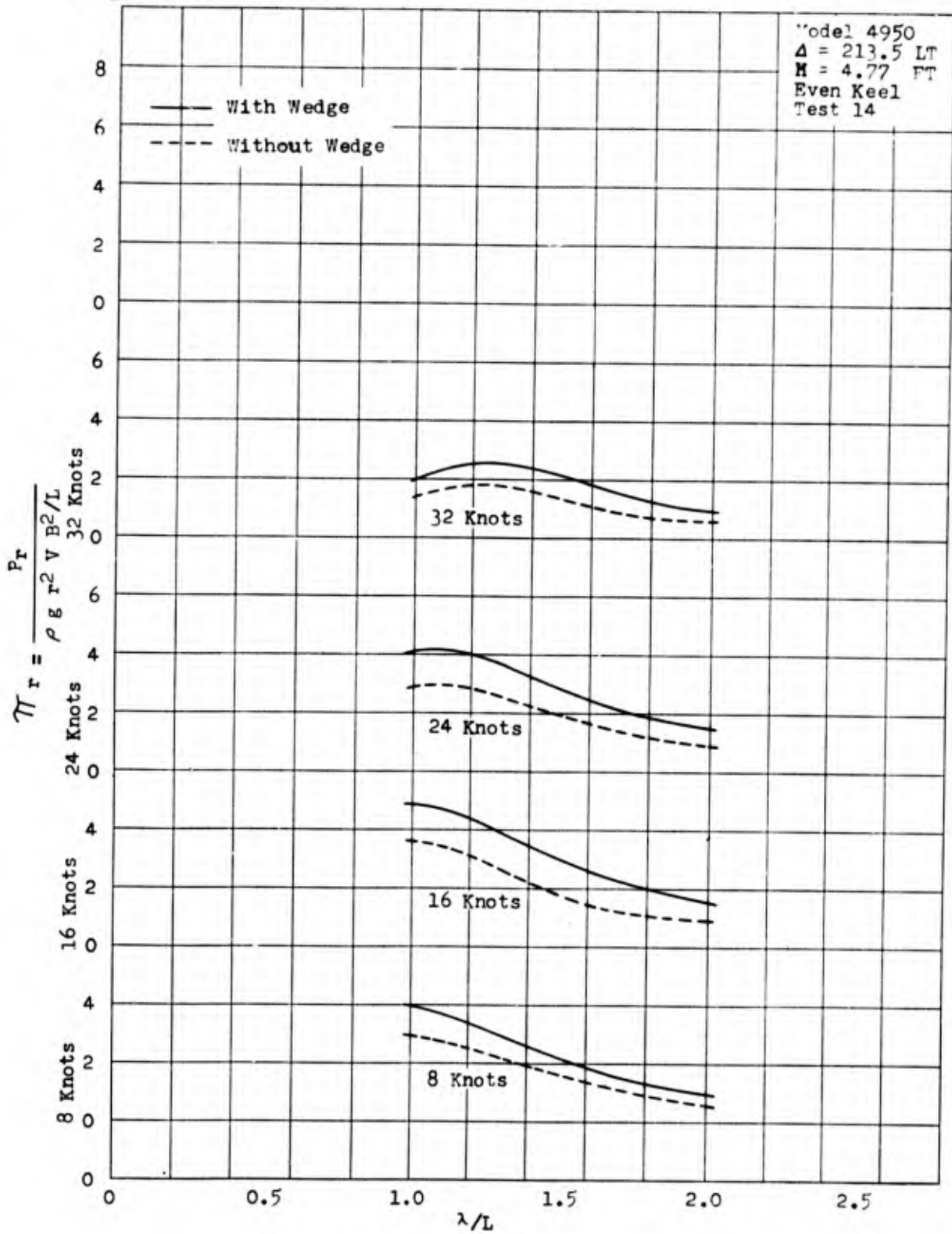


Figure 7 - Dimensionless Power Increase due to Regular Head Seas with and without Transom Wedges

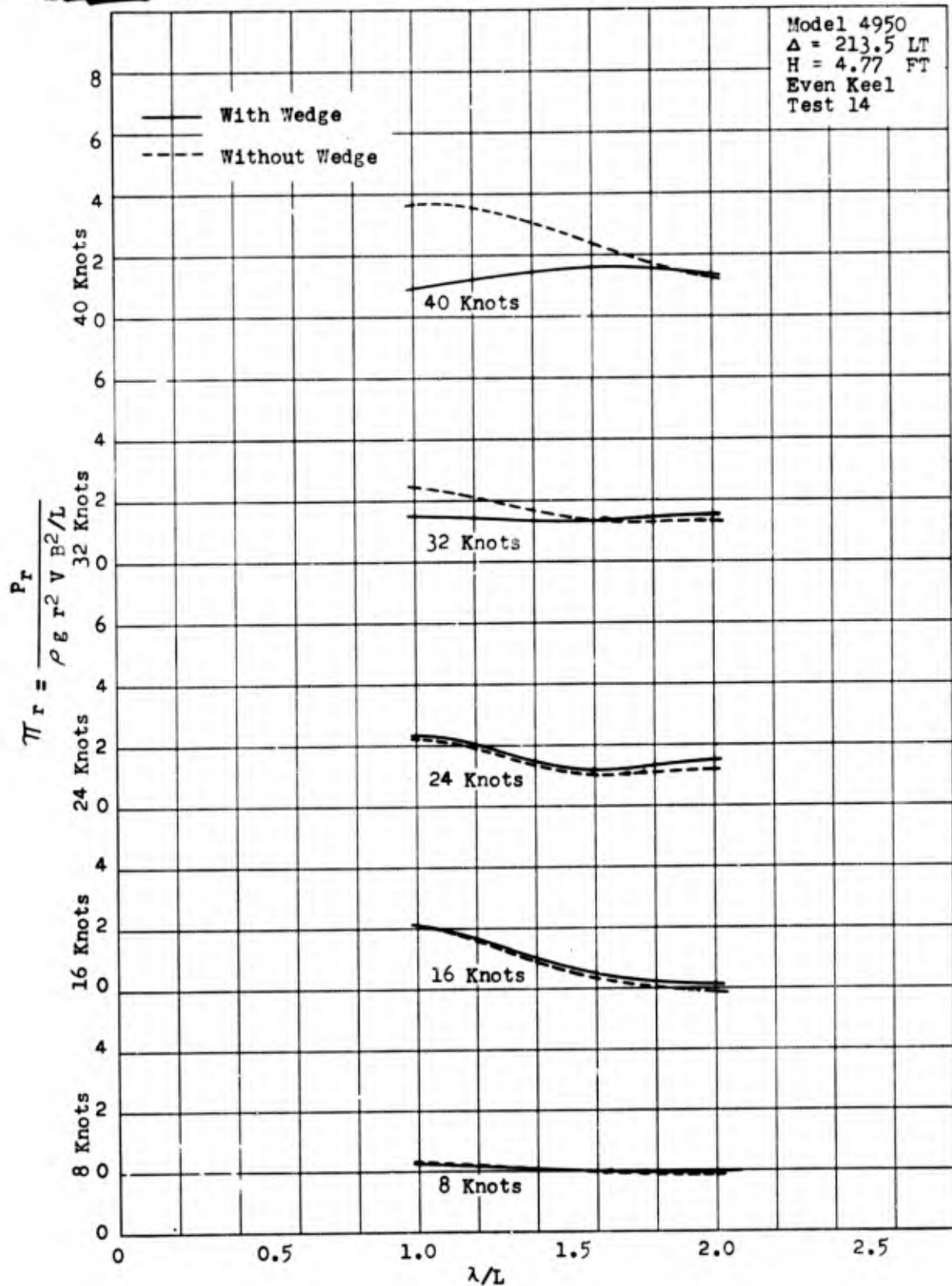


Figure 8 - Dimensionless Power Increase due to Regular Following Seas with and without Transom Wedges

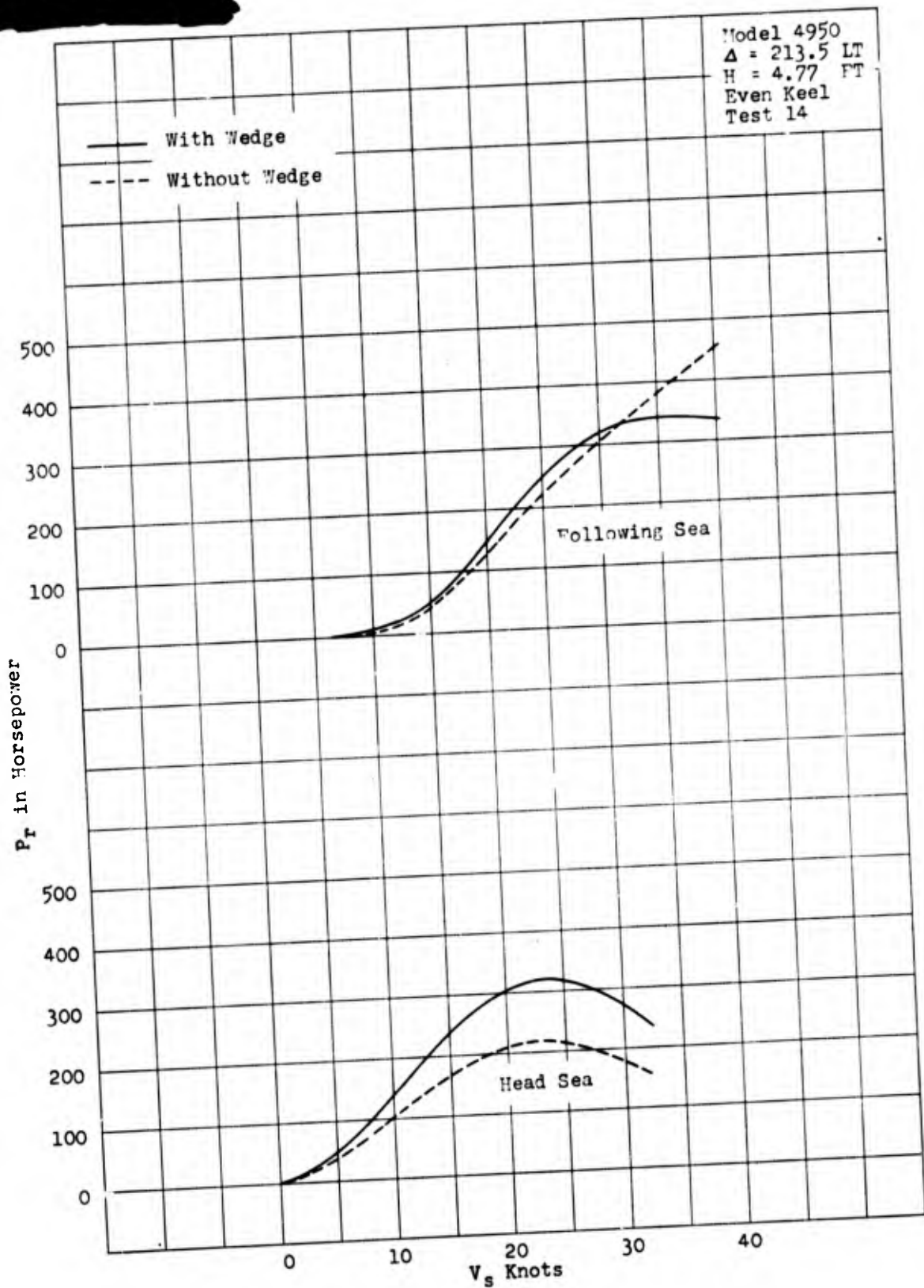


Figure 9 - Increase in SHP due to A State 5 Neumann Spectrum Sea

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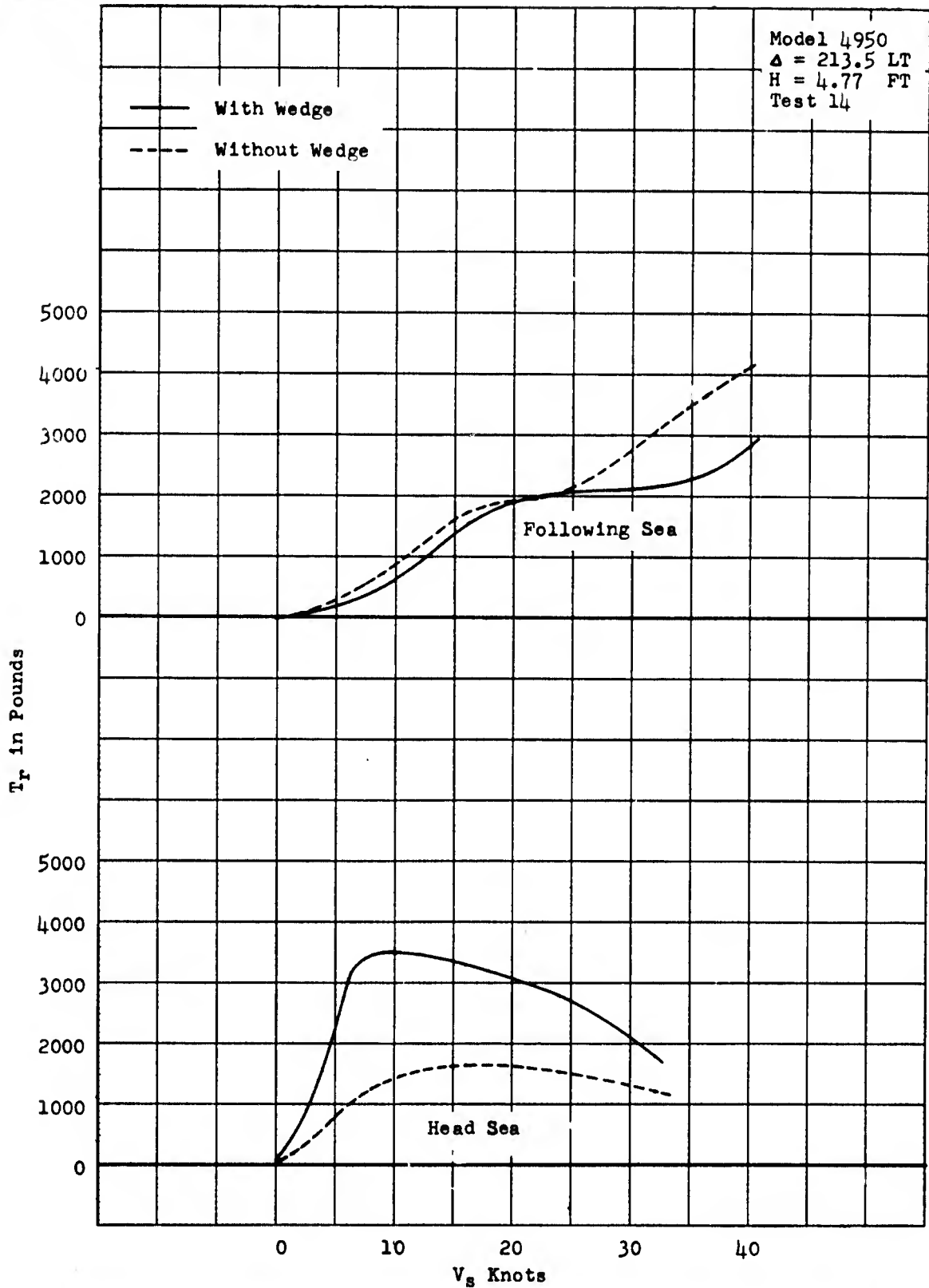


Figure 10 - Increase in Thrust due to A State 5 Neumann Spectrum Sea

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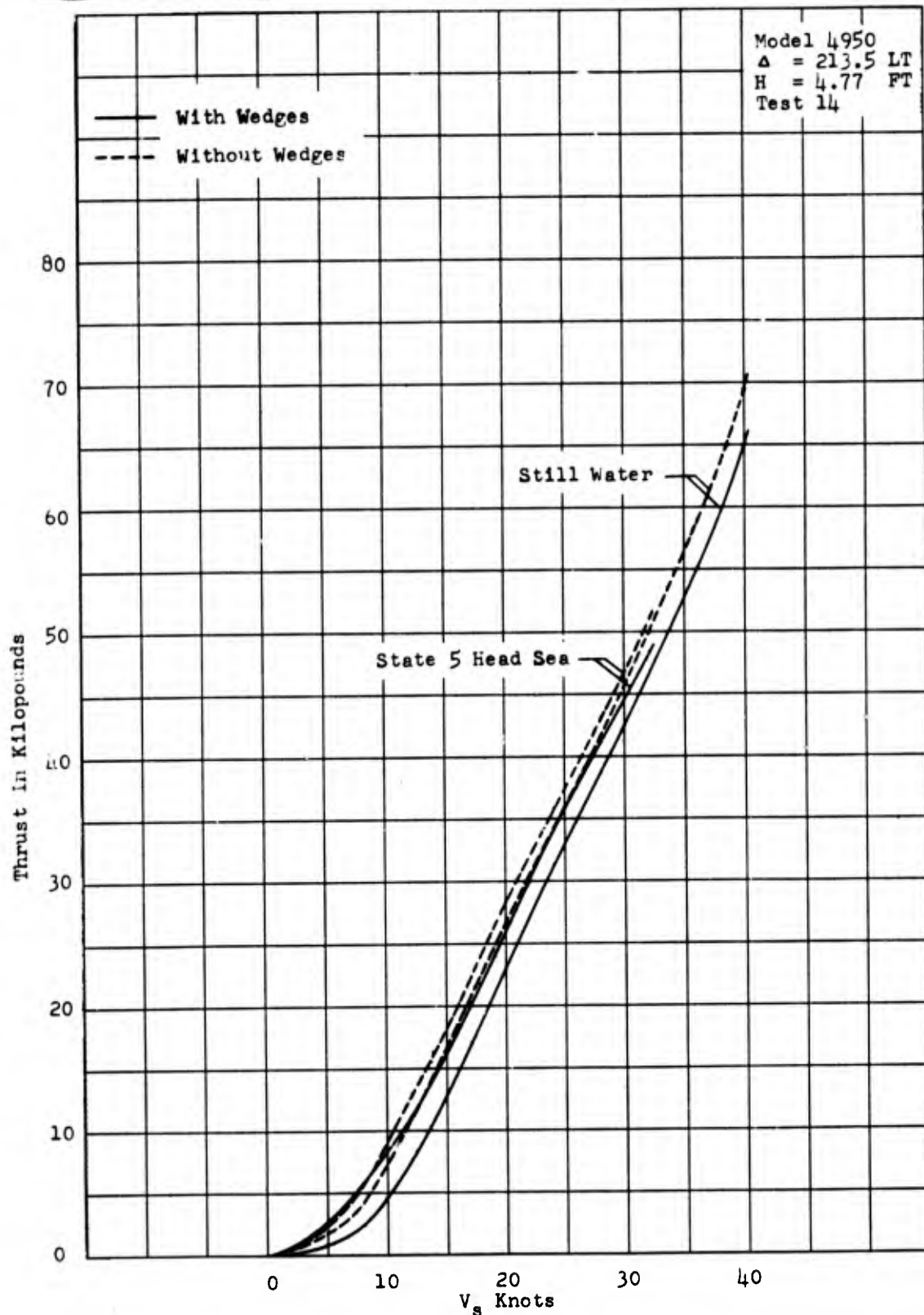


Figure 11 - Thrust in Still Water and in A Head Sea for A State 5 Neumann Spectrum Sea

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2. David Taylor Model Basin Drawing No. 552-4950-04, Model 4950 Proposed Stern Appendages for PGM "C."
3. Gerritsma, J. et al, "Propulsion in Regular and Irregular Waves," Internationaional Shipbuilding Progress, Vol. 8, No. 82, pp. 235-247 (June 1961).
4. Vossers, Prof. Dr. Ir. G., "Resistance, Propulsion and Steering of Ships," Ships and Marine Engines Part IIC, "Behaviour of Ships in Waves" (1962).

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 2. Gunboats--Resistance--Model tests
 3. Transom wedges--Effectiveness
 4. Ship hulls--Effective horsepower
 5. PGM (U.S. motor gunboat)
 6. Ship models--Model TMB 4950
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