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THE EFFECT OF TOWED-BODY MASS ON SLACK TOWLINE EFFECTS.(U)
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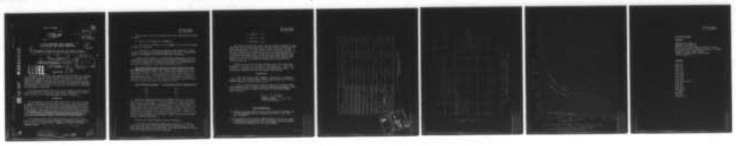

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U.S.NAVY UNDERWATER SOUND LABORATORY
FORT TRUMBULL, NEW LONDON, CONNECTICUT

THE EFFECT OF TOWED-BODY MASS ON SLACK TOWLINE EFFECTS.

By

Frank B. Rakoff

USL Technical Memorandum No. 933-168-63

21 June 1963

7 p.

INTRODUCTION

USL Report No. 558 (ref. (a)) examines the possibility of a towline going slack, which can result from the inability of a VDS towed body to accelerate downward at as high a rate as the fantail of a ship. The report also examines the high cable tensions which can result from the sudden restoration of towline tension at some time after the slackening. The likelihood of occurrence of a slack line is a function of the ratio of fish weight to fish mass.

This memorandum demonstrates the need for combining the "G factor" characteristic and the mass of a towed body in determining the likelihood of the loss of a towed body under specific conditions.

DISCUSSION

It is possible, if the so-called "G factor" of the fish is known, to determine the exact time in a ship motion cycle when a towline will go slack. The "G factor" is defined as the maximum downward acceleration, in G's, that a particular towed body can experience as a result of its weight in water and its drag. The "G factor" itself is useful in determining the likelihood of and the time of a zero towline tension event, but the mass of the body is the more important parameter in determining the ultimate effects of the loss of towline tension.

The relative roles of "G factor" and mass in the loss of cable tension and in the high tension attendant to subsequent recapture can be put in proper perspective by a comparison of bodies of various characteristics.

Three distinct bodies are examined which have characteristics shown in Table I:

1. Fish "A" approximates the AN/SQA-11.

2. Fish "B" is a variation of the AN/SQA-11 in that the transducer enclosure is shortened.

3. Fish "C" is an arbitrarily selected light body with the same "G factor" (based on an approximate equation that gives a conservative value) as the AN/SQA-11 but with significantly lower mass.

Given the data in Table I and using methods detailed in ref. (a), computations can be made for any ship pitch angle to determine whether or not the towline will go slack and to evaluate the consequences, at the time of recapture, of the towline having gone slack.

The input conditions from ship motion must be established before the computations can be made. The effects of all possible sea states up to and including at least state 8 (whole gale conditions) must be considered. A state 7 sea can be assumed to cause ship pitches up to 5°, as shown in Fig. 1, which applies for most practical purposes to destroyer-type vessels. If ship pitch is assumed about a transverse axis that is about 65% aft of the stem, the resulting excursion at the stern for a given pitch will be as tabulated below:

Ship Pitch Angle (degrees)	Half-amplitude Taffrail Excursion (ft)
4	10.5
4.2	11
4.6	12
5	13
5.4	14

The above values are based on the somewhat optimistic view that heave does not contribute to the half-amplitude. It requires considerable resolution when aboard a ship to disregard the heave effects of state 8 seas, with a 1000-ft. wavelength and a 60-ft. wave height. The reader should keep in mind that the acceleration that results from the combination of pitch and heave is the important number. Simple pitch motion and its attendant stern excursions are used in the examples to simplify the calculations for purposes of demonstration. A motion equivalent to that produced by a sea state 7 could be produced by a lesser sea when combined with swells.

The three fish being compared can now be examined.

On the basis of an assumed maximum ship pitch of 5°, it can be shown (ref. (a)) that each of the fish being considered will, at some time, cause the towline to become slack. The ship pitch angles at which this slack would first occur are as follows:

1. Fish "A" 3.7°

2. Fish "B" 4.5°

3. Fish "C" 3.7°

The towline tension that would occur as a result of angles of these magnitudes are not catastrophic since the zero towline tension does not exist long enough for the towed body to build up velocity. Indeed Fish "B" experiences no slack at all at 4.5° if equations from ref. (a) are used, which are more rigorous than the first approximations used to determine the angles above. As the ship pitch angle (and the time available to the fish to increase velocity free of the towline) gets larger, so also do the consequences become more serious when the towline fetches up.

Figure 2 is a plot of the peak tensions, which will result from recapture of the fish, as a function of cable payed out. Fish "B" is shown for a 5.4° ship pitch in order to show significant values. The conclusions reached on the basis of Figure 2 are obvious.

CONCLUSIONS

1. Two fish ("A" and "C") of equal "G factor" but of different weight (mass) will cause different towline peak tensions when loss and violent recovery of towline tension occur.

2. Two fish ("A" and "B") of equal weight but of different mass will experience loss of towline tension at different magnitudes of ship pitch and will exhibit significantly different effects on maximum towline tension.

Frank B. Rakoff per S. G.
FRANK B. RAKOFF
Mechanical Engineer

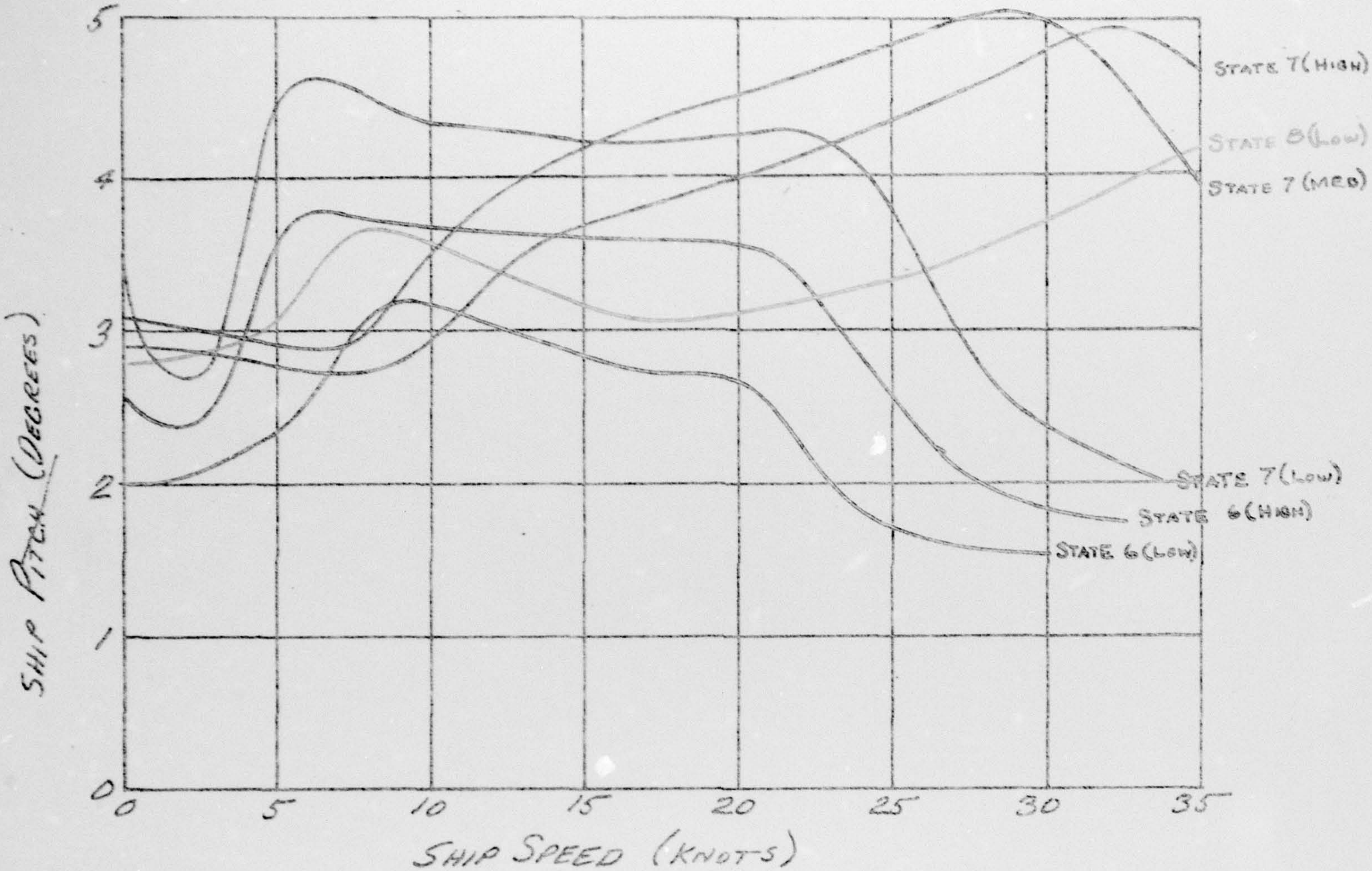
List of References

(a) "Effects of Certain Ship Motions on Cable Tensions in Systems for Handling Submerged Bodies," USL Report #558 dated 7 Aug. 1962, by F. B. Rakoff.

(b) "Investigations of Pitching," DTMB Translation No. 232 of a paper presented at the Convention of the Association Technique Maritime et Aeronautique Session June 1945, by R. Brard.

ITEM	FISH "A"	FISH "B"	FISH "C"
FISH WT. IN WATER (lbs)	17,000	17,500	11,290
X'DUCER HOUSING LENGTH (ft)	16.96	13.00	15.00
X'DUCER HOUSING WIDTH (ft)	5.79	5.79	5.00
X'DUCER HOUSING DEPTH (ft)	5.92	5.92	5.00
ENCLOSED VOLUME (ft^3)	304	233	196.4
PLAN AREA (FISH) (ft^2)	77	59.1	58.1
AREA OF STEEL IN CABLE (in^2)	1.16	1.16	1.16
MASS (FISH) (slug)	1572	1332	1014.9
"G" FACTOR (g)	.35	.42	.35
RATIO OF Weight/BULK (lb/ft^3)	57.5	75	57.5
MAX FANTAIL EXCURSION PERMISSIBLE W/O LOSS OF TENSION (CORRESP. PITCH ANGLE)	10.5(ft) 4°	125(ft) 4.75°	10.5(ft) 4°

TABLE 1 USL Tech. Memo. No. 933-168-63 of 21 June 1963



PROBABLE SHIP PITCH VS SHIP SPEED AT SELECTED SEA STATES (DATA FROM REF b)

USL Tech. Memo. No. 933-168-63 of 21 June 1963 - Figure 1

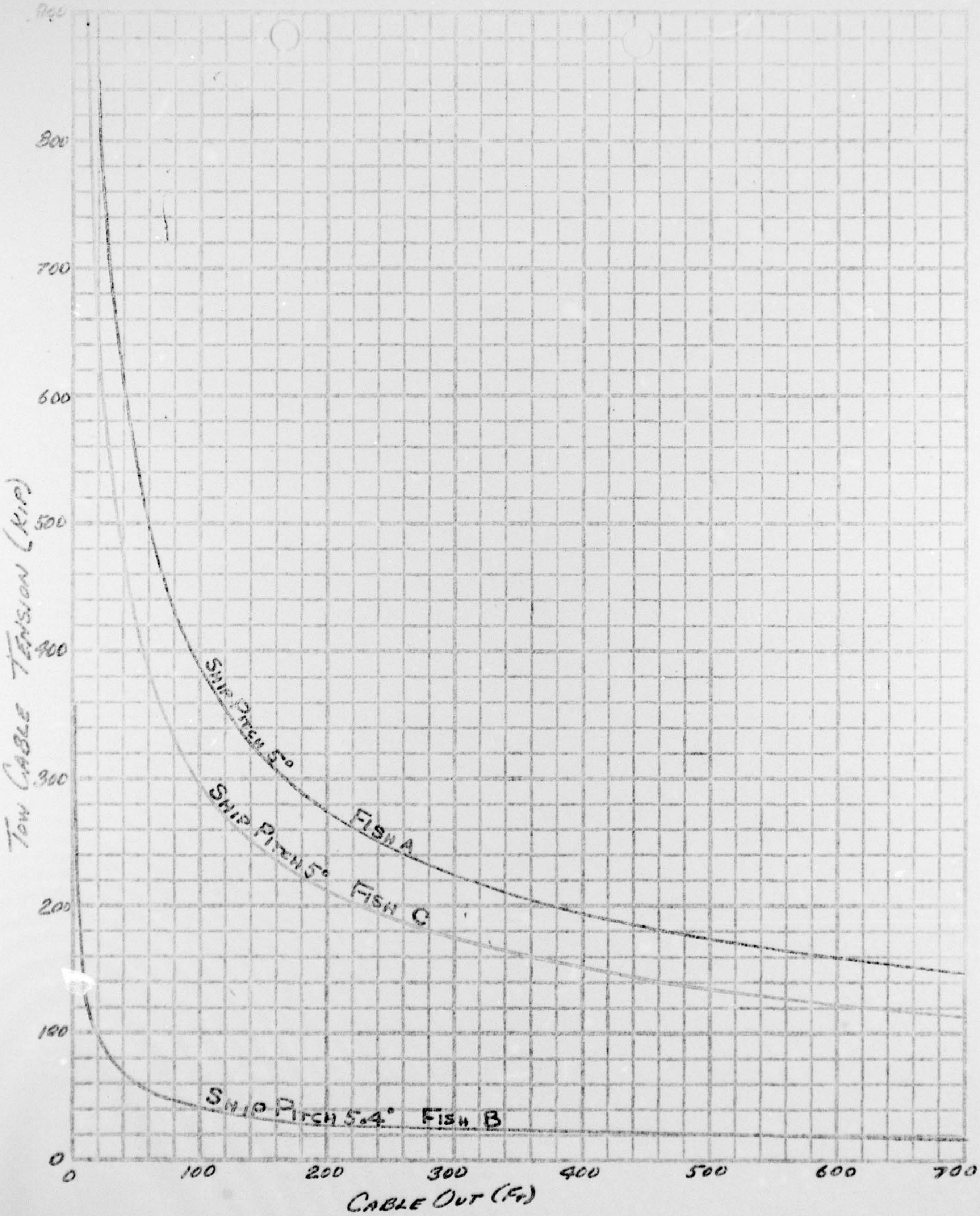


FIG 2 VARIATION OF PEAK TOWLINE TENSION WITH LENGTH OF TOWLINE PAYED OUT

USL Tech. Memo. 933-168-63 of 21 June 1963

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