3.2 Frequency of Damaged Bottom Trawl Gear in NEFSC Surveys

Summary

1) Analysis of tow records for NEFSC spring, fall and winter bottom trawl surveys by the R/V *Albatross IV* using the Yankee No. 36 bottom trawl during 1982-2002 shows that the frequency of tows with damage to survey bottom trawls varied randomly during 1983-2002, with relatively little variation during recent years.
2) Of eight surveys during 2002-2002 with mis-marked warps, two surveys had more than average levels of any gear damage while six surveys had average or less than average levels of any gear damage.
3) Simple graphical analyses and GAM model results suggest that mis-marked warps had little or no effect on the probability of gear damage.
4) Frequency of gear damage increases with depth. However, the frequency of major damage (i.e. severe enough to preclude use of the tow in stock assessment calculations) is not appreciable at depths routinely surveyed and for tows used in most stock assessments.

Introduction

Gear damage may have increased or decreased during recent surveys if mis-marked warps affected operating characteristics of the NEFSC survey bottom trawls. Gear damage data provide evidence about possible changes in net operating characteristics. However, gear damage data probably provide no information about changes in the fishing efficiency of NEFSC bottom trawls. Gear damage and fishing power are not directly linked because their relationship is unknown (a net prone to damage may catch more or less fish than a net not prone to damage), and because survey tows with major damage are routinely excluded from NEFSC stock assessment calculations.

We examined trends in survey tow records to determine if mis-marked warps changed the frequency of survey tows with gear damage. The information used was qualitative gear condition data recorded by the watch chief or chief scientist routinely following all bottom trawl survey tows. Although the data are qualitative, they were collected and recorded based on consistently applied and specific criteria that are available to all watch chiefs and chief scientists.

Tows included in the analysis were from all randomly allocated survey tows (STATYPE=1) by the NOAA Research Vessel *Albatross IV* using the Yankee No. 36 trawl during spring, fall and winter survey cruises beginning in 1983 (Table 3.2.1). Spring and fall surveys cover the same grounds and the all tows since 1983 used the same type of net. Winter surveys have consistently used a different net (with roller gear in place of a ground cable) and cover a smaller area that excludes rocky grounds (mainly on the northern half of Georges Bank) where gear damage may be more likely to occur.

Data used in this analysis were for tows at depths ≤ 620 m. The maximum depth of survey strata for tows used in stock assessments varies but is near 200 fathoms (366 m). Tows with STATYPE=1 at depths greater than 366 m were included (n=23, 0.2% of the total) because they provide useful information about gear damage at relatively extreme depths. However, tows deeper than 366 m are generally not used in stock assessment work because they are not "random" in the same way as tows randomly allocated to survey strata.

Gear damage was evaluated in in three main categories: i) "any" damage, including slight damage that does not prevent use of data from a survey tow in stock assessment work, ii) "major" damage that is severe enough to prevent use of stock assessment data from a tow, and iii) "minor" damage. The frequency of minor damage is of interest because most tows classified as minor for this analysis would also be used in stock assessments (the definitions of useful tows for stock assessment work and tows with minor damage for this assessment correspond approximately). Tows with minor damage were computed by subtraction (i.e. minor = any-major).

Survey bottom trawl tows with gear damage were identified in the NEFSC survey database using the GEARCOND variable, which is part of the data collected by the survey watch chief at the end of each tow. GEARCOND records the physical condition of the trawl on deck at the end of the tow, as judged by the watch chief or chief scientist based on specific criteria. For this analysis, tows with any gear damage were defined as tows with GEARCOND = 2 or larger. Tows with a major damage were defined as tows with GEARCOND=7 or larger.

GEARCOND=6 is used for tows that are obstructed by debris encountered during the tow. The probability of picking up debris is related to tow location and unlikely to be affected by mis-marked warps. Therefore, tows with GEARCOND=6 were excluded. Thus, the analysis dealt with the probability of gear damage in tows that were not significantly obstructed by debris.

A total of 11,402 tows were used in the analysis. In total, 1,102 tows (9.7%) had any gear damage (as defined above), 173 tows (1.5%) had major gear damage and 1102-173=929 tows (8.1%) had minor damage (Table 1 and Figures 3.2.1 to 3.2.3). Proportions for fall, spring and winter surveys were similar (see below).

	N Tows	Proportion tows with "any" gear problems (GEARCOND ≥2)	Proportion tows with "major" gear problems (GEARCOND ≥7)	Proportion tows with "minor" gear problems (GEARCOND ≥7)
FALL	4696	0.0945	0.0132	0.0813
SPRING	5402	0.0950	0.0139	0.0811
WINTER	1304	0.1112	0.0276	0.0836
All	11402	0.0966	0.0152	0.0815

There is no evidence that mis-marked warps increased the probability of gear damage based on trends in frequencies of damaged gear (Table 3.2.1 and Figure 3.2.3). Frequencies of damaged bottom trawls in surveys during 2002-2003 with mis-marked warps were generally lower than average. In particular, six out of eight surveys (75%) during 2000-2002 had lower than average levels of any gear damage. Four out of eight surveys (50%) during 2000-2002 had below average levels of major gear damage. Gear damage was more variable for the fall survey prior to 1988 and for the winter survey prior to 1996. Trends in gear damage for recent surveys with mis-marked warps were similar to trends in prior years.

Modeling

Generalized additive models (GAMs) were used to refine estimates of probability for gear damage during each cruise. Separate GAM models for major and minor gear damage were fit to tow-by-tow survey data by maximum likelihood assuming that the occurrence of gear damage followed a binomial distribution (i.e. as in logistic regression). Cruise id number, season (fall, spring or winter) and mis-marked warps were treated as categorical variables. Treating cruise id numbers as a categorical variable is, in effect, the same as including statistical interactions between all categorical variables that change from survey to survey (i.e. year, season, vessel and type of trawl) and makes season almost redundant. Average tow depth and swell height were included in models as covariates. The relationship between frequency of gear damage and covariates was modeled using loess scatter plot smoothers. The loess term for depth, for example, was a smooth line that allowed estimates of depth effects on gear damage to change continuously with depth.

Swell height was missing in 762 out of 11,402 tows (6.7% of the total) but was not significant in preliminary model runs using the subset of tow records that included swell height data. Therefore, swell height was omitted from further GAM modeling.

Final GAM models were identified using F-tests to measure goodness of fit. A stepwise procedure identified the best final model by eliminating variables with insignificant effect on model fit. However, mis-marked warp effects were always included in final models because they are of special interest. The best model for any damage included warps, cruise, and depth effects. The best model for major damage included only warp and depth effects.

Based on GAM model results, there was no evidence of increased probability of any or major gear damage in cruises with mis-marked warps. Warp effect estimates were very small and statistically insignificant in final models (Figure 3.2.4). Depth had a much stronger effect on the probability of gear damage than any other variable. The probability of any or major damage increases steadily with depth and loess terms for depth were highly significant ($p < 0.0000001$) in both models.

To describe the effects of depth in simple terms, predicted percent tows with any damage and with major damage were calculated from GAM models fit to data for years with and without potential warp effects. The probability of gear damage during cruises with mis-marked warps fell within the range for cruises without the potential problem (Figure 3.2.5). The probability of major gear damage during cruises with and without mis-marked warps was similar at depths < 360 m (Figure 3.2.5). Results for major damage at depths greater than 360 m were erratic for mis-marked warps due to scarcity of tows in deep water during 2000-2002.

The probability of any gear damage averages about 10% at depths less than 220 m and increases to about 25% at 360 m. The probability of major gear damage increases with depth and is less than 6% at all depths less than 360 m. For data collected at depths < 360 m and routinely used in stock assessments, almost all gear damage was minor.

Table 3.2.1. Gear damage and summary information for bottom trawl survey cruises by the *R/V Albatross IV* during 1983-2002. The proportion tows with "any" gear damage is the proportion tows with GEARCOND ≥2. The proportion tows with "major" gear damage is the proportion tows with GEARCOND≥7. Proportion tows with "minor" gear problems was computed by subtraction (any-major). Obstructed tows (GEARCOND=6) were excluded Eight surveys during 2000-2002 had mis-marked warps.

Cruise	Year	Season	N Tows	Proportion tows with "any" gear problems (GEARCOND ≥2)	Proportion tows with "major" gear problems (GEARCOND ≥7)	Proportion tows with "minor" gear problems (GEARCOND ≥7)
198306	1983	Fall	410	0.059	0.010	0.049
198405	1984	Fall	347	0.115	0.009	0.107
198508	1985	Fall	148	0.122	0.027	0.095
198606	1986	Fall	251	0.187	0.012	0.175
198705	1987	Fall	319	0.053	0.016	0.038
198803	1988	Fall	305	0.079	0.013	0.066
199206	1992	Fall	332	0.123	0.018	0.105
199406	1994	Fall	332	0.120	0.018	0.102
199507	1995	Fall	329	0.067	0.006	0.061
199604	1996	Fall	315	0.137	0.022	0.114
199706	1997	Fall	318	0.072	0.006	0.066
199804	1998	Fall	322	0.084	0.012	0.071
199908	1999	Fall	326	0.077	0.015	0.061
200005	2000	Fall	317	0.060	0.003	0.057
200109	2001	Fall	325	0.105	0.018	0.086
198303	1983	Spring	410	0.132	0.015	0.117
198402	1984	Spring	400	0.098	0.013	0.085
198502	1985	Spring	371	0.078	0.016	0.062
198603	1986	Spring	362	0.088	0.006	0.083
198702	1987	Spring	281	0.121	0.007	0.114
198801	1988	Spring	315	0.067	0.010	0.057
199202	1992	Spring	316	0.095	0.013	0.082
199302	1993	Spring	319	0.103	0.013	0.091
199503	1995	Spring	325	0.055	0.012	0.043
199602	1996	Spring	344	0.142	0.026	0.116
199702	1997	Spring	326	0.077	0.012	0.064
199802	1998	Spring	360	0.097	0.017	0.081
199902	1999	Spring	317	0.066	0.016	0.050
200002	2000	Spring	325	0.095	0.015	0.080
200102	2001	Spring	315	0.095	0.016	0.079
200202	2002	Spring	316	0.101	0.016	0.085
199201	1992	Winter	62	0.048	0.032	0.016
199301	1993	Winter	116	0.043	0.000	0.043
199502	1995	Winter	151	0.179	0.040	0.139
199601	1996	Winter	134	0.112	0.037	0.075
199701	1997	Winter	124	0.121	0.032	0.089
199801	1998	Winter	133	0.128	0.023	0.105
199901	1999	Winter	139	0.122	0.036	0.086
200001	2000	Winter	124	0.105	0.032	0.073
200101	2001	Winter	167	0.114	0.018	0.096
200201	2002	Winter	154	0.091	0.026	0.065

Figure 3.2.1. Location of tows by the *R/V Albatross IV* with “any” damage in NEFSC fall, spring and winter surveys during 1983-2002.

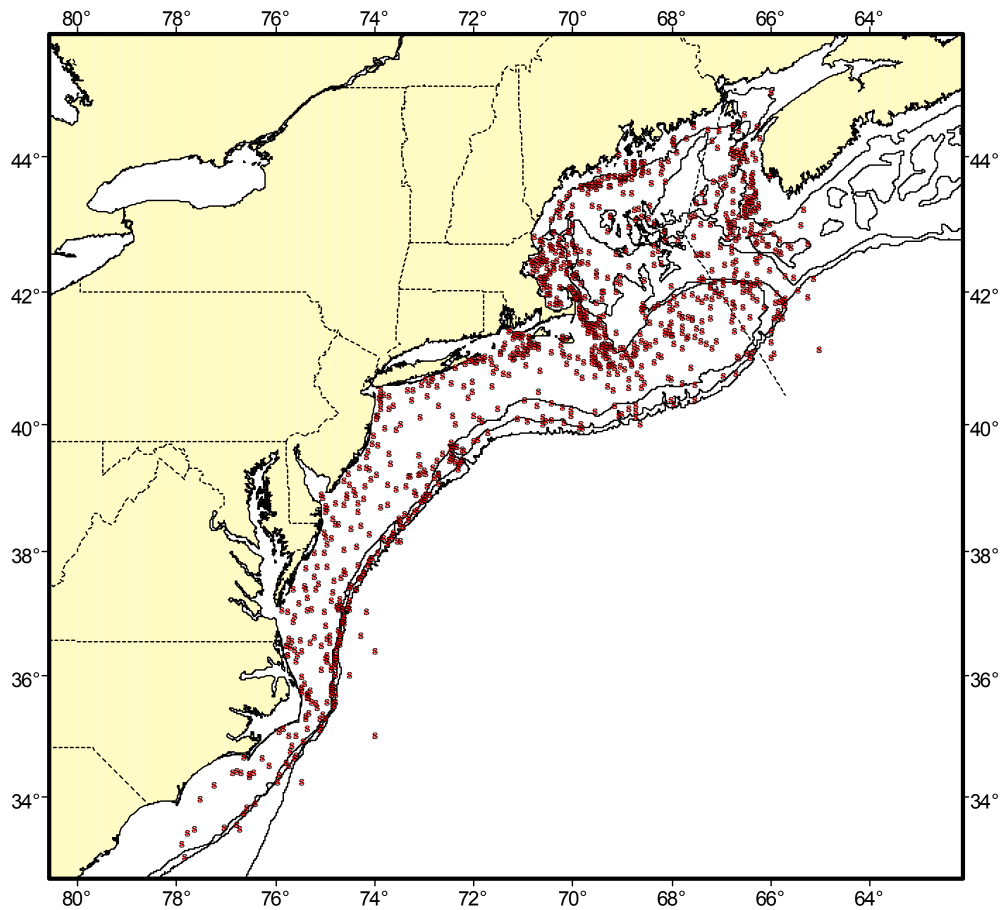


Figure 3.2.2. Location of tows by the *R/V Albatross IV* with "major" damage in NEFSC fall, spring and winter surveys during 1983-2002.

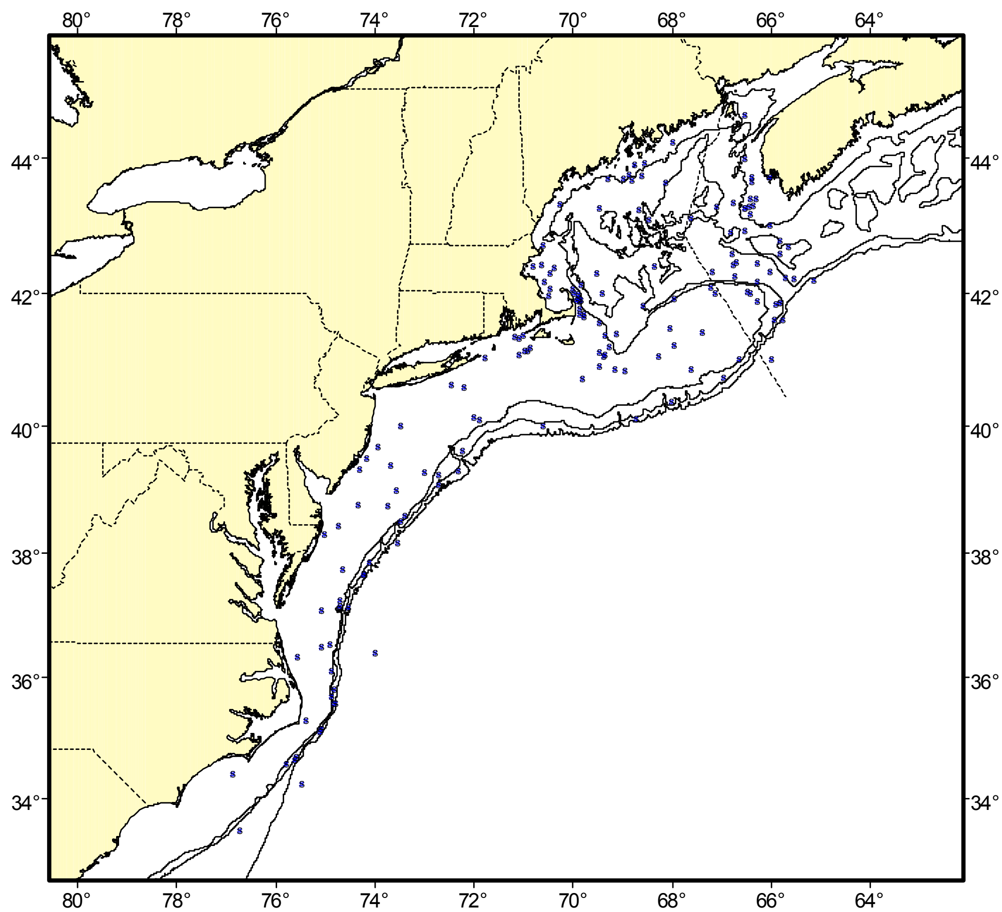
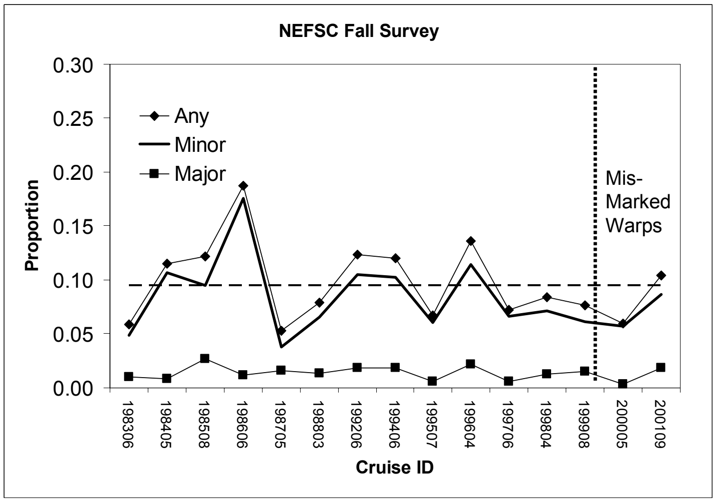
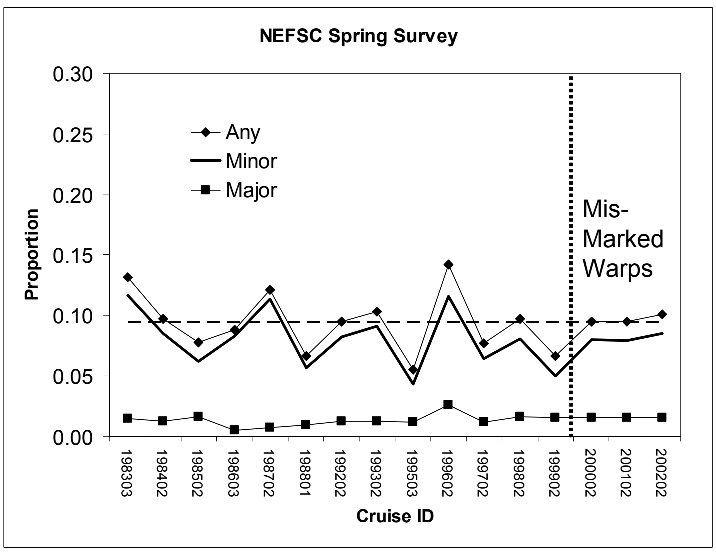


Figure 3.2.3. Proportion of tows with any, minor and major damage in NEFSC fall, spring and winter surveys during 1983-2002. The vertical line in each plot separates tows with and without mis-marked warps. The horizontal line in each plot shows the average proportion of tows in each survey with any gear damage.





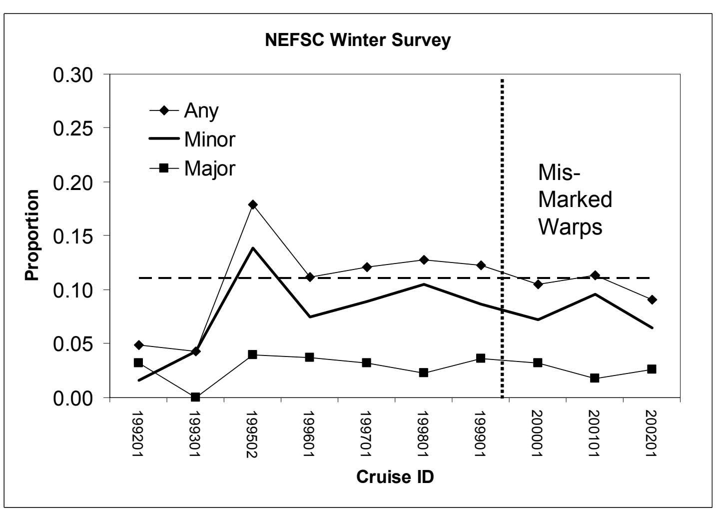


Figure 3.2.4. Estimated warp effects in the final GAM model for the frequency of any damage during NEFSC survey tows. The dotted lines are 95% confidence intervals for the parameter estimates. Results from models for major damage were similar.

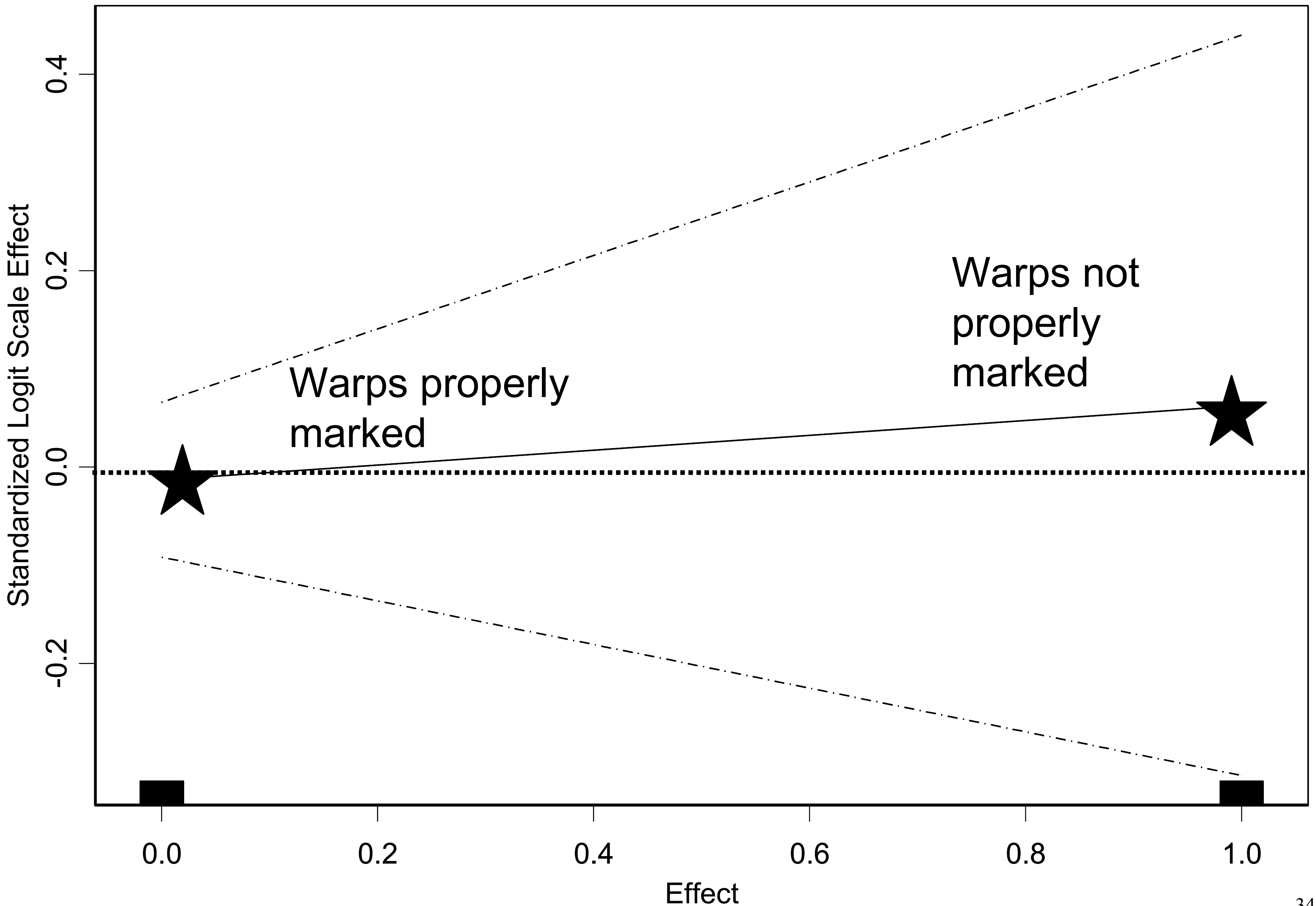


Figure 3.2.5. Predicted frequency of tows with any (top) and major (bottom) gear damage as a function of tow depth, based on separate GAM models for surveys during 2000-2002 with mis-marked warps and surveys during 1983-2001 without mis-marked warps. The GAM model for any damage with warp effects includes depth only. The best GAM model for any damage included cruise effects and predictions for each cruise are plotted ".". In addition, "average" results for any damage from a simplified model with cruise effects omitted are also shown.