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Relative fishing efficiency for witch flounder of vessels and gears used in the August and September bottom-trawl surveys in the Gulf of St. Lawrence

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Abstract

The vessel used to conduct the September survey of the southern Gulf of St. Lawrence changed from the *Lady Hammond* to the *Alfred Needler* in 1992. A comparative fishing experiment between the two vessels was conducted in the southern Gulf in August 1992. We analyzed the results of the this experiment using generalized linear models assuming a Poisson error distribution with overdispersion. We estimated that fishing efficiency of the *Alfred Needler* for witch flounder was 1.5 times that of the *Lady Hammond*. The vessel and gear used to conduct the August survey of the northern Gulf changed from the *Lady Hammond* using a Western IIA trawl to the *Alfred Needler* using a URI trawl in 1990. We estimated relative fishing efficiency of the two vessels and gears for witch flounder from comparative fishing conducted during the 1990 survey. The size distribution of witch catches differed markedly between the two vessels. We calculated relative fishing efficiency for witch flounder 24 cm or greater. Relative efficiency of the two gears and vessels did not appear to vary with length over this length range. The probability of catching witch of these sizes by the *Lady Hammond*/Western IIA trawl was 1.75 times the probability by the *Alfred Needler*/URI trawl. For witch of lengths 24 cm and greater, catch rates by the *Lady Hammond*/Western IIA trawl were 2.0 times those of the *Alfred Needler*/URI trawl. We compare unadjusted time series with those adjusted for changes in survey vessel and gear.

Résumé

En 1992, le navire utilisé pour réaliser le relevé de septembre de la partie sud du golfe du Saint-Laurent a été le *Alfred Needler* au lieu du *Lady Hammond*. Un essai de pêche comparative a été effectué dans le sud du golfe en août 1992 pour ces deux navires. Nous avons analysé les résultats de l'essai par modèles linéaires généralisés en supposant une erreur de distribution de Poisson avec surdispersion. Nous avons estimé que l'efficacité de capture de la plie grise du *Alfred Needler* était 1,5 fois supérieure à celle du *Lady Hammond*. En 1990, le relevé d'août dans le nord du golfe a été réalisé a l'aide de *l'Alfred Needler* et un chalut URI plutôt que le *Lady Hammond* et un chalut Western IIA. Nous avons estimé l'efficacité de capture relative des deux navires et engins pour la plie grise en comparant les pêches effectuées pendant le relevé de 1990. La distribution des tailles des captures de plie grise différait de façon marquée entre les deux navires. Nous avons calculé l'efficacité de capture relative pour les plies de 24 cm ou plus de longueur. Dans cette gamme, l'efficacité relative des deux engins et navires ne variait pas en fonction de la longueur. La probabilité de capture de plies de ces tailles par le *Lady Hammond* et le chalut Western IIA était 1,75 fois supérieure à celle obtenue avec le *Alfred Needler* et le chalut URI. Pour les plies grises de 24 cm et plus, les taux de capture par le *Lady Hammond* et le chalut Western IIA étaient 2,0 fois supérieurs à ceux du *Alfred Needler* et du chalut URI. Nous avons comparé les séries chronologiques non corrigées avec celles corrigées pour les changements apportés au type de navire et d'engin.

Introduction

The relative abundance of groundfish in the Gulf of St. Lawrence has been monitored by bottom-trawl surveys conducted in the southern Gulf in September since 1971 and in the northern Gulf in August since 1984. The gear and/or vessel used in the southern Gulf survey has changed twice since 1971. Fishing was by the *E.E. Prince* using a Yankee 36 trawl from 1971 to 1985, by the *Lady Hammond* using a Western IIA trawl from 1985 to 1991, and by the *Alfred Needler* using a Western IIA trawl since 1992. (See Carrothers [1988] and Nielsen [1994] for gear and vessel specifications.) A single change in gear and vessel has occurred in the northern Gulf survey. Fishing in this survey was by the *Lady Hammond* using a Western IIA trawl from 1984 to 1989 and by the *Alfred Needler* using a URI trawl since 1990.

Comparative fishing during the 1985 September survey failed to reveal a significant difference in fishing efficiency for witch flounder between the the *E.E. Prince*/Yankee 36 trawl and the *Lady Hammond*/Western IIA trawl (Nielsen 1994). Fishing during the 1985 comparison was restricted to daylight hours (0700≤time<1900), the period of the day when fishing occurred during the 1971-1984 surveys. Fishing in the August survey and in the September survey since 1985 has been conducted throughout the 24-h day. Fishing efficiency for witch flounder differs markedly between day and night, with night efficiency varying between 1.6 and 3.2 times day efficiency depending on vessel and gear (Swain and Poirier 1998). The purpose of this report is to test for differences between vessels and gears in fishing efficiency for witch flounder after adjusting for diurnal variation in the catchability of witch. Two comparative fishing experiments are analysed: a 1992 experiment conducted in the southern Gulf between the *Lady Hammond* and the *Alfred Needler,* both using a Western IIA trawl, and a 1990 experiment conducted in the northern Gulf between the *Lady Hammond* using a Western IIA trawl and the *Alfred Needler* using a URI trawl.

Methods

1992 Experiment

There were 66 successful paired fishing tows in the 1992 experiment between the *Lady Hammond* and the *Alfred Needler,* conducted August 1-8 in the southern Gulf. The target fishing procedure for both vessels was a 30-min tow at 3.5 knots. All catches were standardized to a distance of 1.75 nautical miles. Day catches were adjusted to be equivalent to night catches by multiplying the number of witch caught by 2.1 (*Lady Hammond*) or 3.2 (*Alfred Needler*) (Swain and Poirier 1998).

We estimated fishing efficiency of the *Alfred Needler* relative to the *Lady Hammond* using generalized linear models (McCullagh and Nelder 1989). We assumed a Poisson error distribution, because this distribution is often appropriate for counts data, including counts of organisms in sampling units (Pielou 1977). For the Poisson distribution, the natural link between the response variable and its predictors is the log. A log link has the advantage of ensuring positive predicted values and although this link does not permit predicted values of zero, predicted values may be infinitesimal and thus effectively zero. Our model was of the form:

$$E[Y_{ij}] = \mu_{ij} = \exp(\mu_0 + \alpha_i + \beta_j) \qquad (1)$$

$$Var[Y_{ij}] = \phi \mu_{ij} \qquad (2)$$

where Y_{ij} is the number of witch flounder caught in tow pair *i* by vessel *j* (the subscipt H is used for the *Lady Hammond* and N for the *Alfred Needler*), and ϕ is a parameter for extra-Poisson variation. Extra-Poisson variation ($\phi>1$) was expected because organisms typically show a contagious rather than a random spatial pattern (e.g., Pielou 1977). The scale parameter ϕ was estimated using Pearson's χ^2-statistic (see McCullagh and Nelder 1989 for details). Significance of the day/night effect was assessed using analysis of deviance and the *F* test described by Venables and Ripley (1994, p. 187). β_H was set to 0 ($\exp(\beta_H)=1$) in the parameter estimation, so $\exp(\beta_N)$ gives an estimate of *Alfred Needler* fishing power relative to *Lady Hammond* fishing power. We conducted two analyses, one using tow pairs where either vessel caught witch and a second using only those tow pairs where both vessels caught witch. We also conducted an analysis of catches of witch greater than or equal to 24 cm in length. The latter analysis was conducted because abundance indices combining the August and September surveys are restricted to this size class (see below).

1990 Experiment

Paired fishing between the *Lady Hammond* using a Western IIA trawl and the *Alfred Needler* using a URI trawl was conducted in the northern Gulf in August 1990. There were 94 successful tow pairs, conducted at 88 locations (i.e., there were 6 tow pairs conducted at sites previously fished in the experiment). Starting with the ninth tow, the 650 kg Morgère trawl doors initially used with the URI trawl were replaced by 950 kg Portuguese doors. The Portuguese doors have been used with the URI trawl on subsequent surveys (Diane Archambault, pers. comm.). Thus, this analysis was restricted to the 86 tow pairs using the Portuguese doors on the *Alfred Needler*. The target fishing procedure by the *Lady Hammond* was a 30-min tow at 3.5 knots. That by the *Alfred Needler* was a 20-min tow at 2.5 knots. Catches by both vessel were adjusted to a standard tow distance of 1.75 nautical miles.

A preliminary examination of the length distribution of witch catches by the two vessels and gears indicated that the URI trawl caught large numbers of very small witch, at lengths where the Western IIA caught very few witch (see Results below). Relative efficiency of the two gears appeared to change rapidly as length increased above these small values. We concluded that it would not be practical to calculate length-dependent correction factors including these small lengths, and restricted our analysis to lengths of 24 cm and greater. We adjusted day catches to be equivalent to night catches by multiplying by 2.1 (*Lady Hammond*/Western IIA) or 1.6 (*Alfred Needler*/URI) (Swain and Poirier 1998).

We tested for a difference in fishing efficiency between the two vessels and gears using the generalized linear models described above (equations 1 and 2). In this case, the subscipt Nu denotes the *Alfred Needler*/URI and Hw the *Lady Hammond*/Western IIA. β_{Nu} was set to 0 ($\exp(\beta_{Nu})=1$) in the parameter estimation, so $\exp(\beta_{Hw})$ gives an estimate of fishing efficiency of the *Lady Hammond* using a Western IIA trawl relative to the *Alfred Needler* using the URI trawl.

Results

1992 Experiment

Witch flounder were caught by both vessels in only 12 of the 66 pairs of tows. Witch were caught by the *Lady Hammond* alone in an additional 4 tows and by the *Alfred Needler* alone in an additional 6 tows. Thus, unlike results in the 1990 experiment (see below) and in the 1988 day/night experiment (Swain and Poirier 1998), the probability of catching witch did not appear to differ markedly between treatments in this experiment.

There was no indication of a trend with fish length in the differences in fishing efficiency between the two vessels (Fig. 1). A tendency for the *Alfred Needler* to catch more witch than the *Lady Hammond* did appear to be stronger at lengths greater than 45 cm than at lengths less than 42 cm. On the other hand, this tendency was strongly reversed at 44 cm, suggesting that the large differences seen at the greater lengths may simply reflect random fluctuations due to the small number of tows and the small number of large witch caught. Thus, we did not attempt to estimate length-dependent differences in fishing efficiency.

There was also no indication that relative fishing efficiency depended on depth (Fig. 2). There were a number of tows at depths under 150 m when the *Lady Hammond* caught more witch than the *Alfred Needler*, and no such incidences at greater depths. However, these were all tows when no witch were caught by the *Alfred Needler* and 1 or 2 witch were caught by the *Lady Hammond.*

Catches by the *Alfred Needler* tended to be greater than those by the *Lady Hammond* (Fig. 3). This difference was highly significant (Table 1), both in the test using all pairs of tows when witch were caught by either vessel (22 pairs) and in the test using only those pairs where witch were caught by both vessels (12 pairs). Residuals from these models are shown in Figure 4 and do not indicate any severe problems with the models. The scale parameter was estimated to be less than 1 for the model using only the 12 pairs of tows where witch was caught by both vessels. This is contrary to the expectation of overdispersion. We also tried a model assuming that $\phi=1$. The value taken for the scale parameter has no effect on the parameter estimates but does affect their SE. Statistical significance was somewhat lower assuming that $\phi=1$ but remained high ($P<0.01$). All models led to the same estimate of relative fishing efficiency for witch, indicating efficiency of the *Alfred Needler* was about 1.5 times that of the *Lady Hammond.*

Results were similar restricting the analysis to lengths of 24 cm and over. In this case, the estimated coefficient for *Alfred Needler* efficiency relative to *Lady Hammond* efficiency was 1.55 ($\beta_N=0.4403$, SE=0.1399).

1990 Experiment

The length distribution of the total witch catch differed markedly between the *Lady Hammond*/Western IIA and the *Alfred Needler*/URI (Fig. 5). The highest catches by the URI trawl were at small lengths near 10 cm. The Western IIA caught very few witch at these small sizes. Many tows contributed to this difference. For example, witch in the 8-9 cm length interval were caught in 17 URI tows but only 2 Western IIA tows. Fishing efficiency of the URI trawl at these small sizes appeared to be greater than that of the Western IIA by an order of magnitude or more. On the other hand, at larger lengths the difference in fishing efficiency between the two trawls appeared to be reversed, with the Western IIA catching more witch than the URI. We concluded that it would not be practical to estimate relative fishing efficiency of the two trawls over the entire length range and decided to restrict our analysis to lengths of 24 cm and greater. Both of the trawls caught significant numbers of witch at these larger sizes and relative fishing efficiency did not appear to vary substantially with length at these larger sizes.

The *Lady Hammond*/Western IIA tended to catch more witch at lengths of 24 cm and greater than did the *Alfred Needler*/URI. (Fig. 6). At these larger lengths, witch flounder were caught by both vessels in 36 of the 86 pairs of tows. The *Lady Hammond*/Western IIA caught witch in an additional 36 tows when the *Alfred Needler*/URI did not, whereas the *Needler* caught witch in only 5 tows when the *Lady Hammond* did not. This suggests that the probability of catching witch is much higher for the *Lady Hammond*/Western IIA, about 1.75 times the probability for the *Alfred Needler*/URI.

The difference in witch catch rate between the two vessels and gears was highly significant (Table 2), though the estimate of relative efficiency depended on whether pairs of tows where only one vessel caught witch were included in the analysis. The *Lady Hammond*/Western IIA were estimated to be 2.0 times as efficient as the *Alfred Needler*/URI including all tows where either vessel caught witch but only 1.4 times as efficient including only those tows where both vessels caught witch. Residuals from the models are shown in Figure 7. While not ideal, the distribution of residuals did not suggest any obvious improvements to the models. Two pairs of tows with very large catches stand out in Figure 6. We repeated the analysis omitting these two pairs. The omission of these tows did not improve residual distributions. Tests remained significant, both including all tows where either vessel caught witch ($b=2.3$, $P<0.001$) and including only those tows where both vessels caught witch ($b=1.3$, $P=0.033$). These large catches were not overly influential in the estimates of relative fishing efficiency.

The estimate of relative fishing efficiency using all pairs of tows where either vessel caught witch ($b=2.0$) is clearly the more appropriate estimate to use to adjust *Alfred Needler*/URI catches to be equivalent to *Lady Hammond*/Western IIA catches. The length frequency of the total *Alfred Needler*/URI catch corresponds closely to that of the total *Hammond*/Western IIA catch when adjusted by a factor of 2.0 but remains well below the latter catch at most lengths when adjusted by 1.4 (Fig. 8). There is no trend with length to differences between the *Lady Hammond* and adjusted (by 2.0) *Alfred Needler* catch, confirming that differences in fishing efficiency between the *Hammond*/Western IIA and the *Alfred Needler*/URI do not depend on length at lengths of 24 cm and greater.

Discussion

The approach taken in these analyses differs from that normally used in analyses of comparative fishing experiments (e.g., Gavaris and Brodie 1984, Nielsen 1994). Normally, a lognormal model is assumed and the log-transformed catch rates are analysed, using only pairs of tows where both vessels caught the target species. This method is reasonable when the probability of capturing the target species does not differ between vessels or gears. However, in this case, the probability of catching witch (at lengths of 24 cm or greater) was clearly much greater using the Western IIA trawl than using the URI trawl. This difference in capture probability needs to be incorporated in the estimates of relative fishing efficiency. This can be done by including in the analysis pairs of tows where witch were caught by one vessel but not by the other. The inclusion of zero catches is a problem for the lognormal model. The use of Poisson models, which can accomodate zero catches, seems to be a useful alternative approach.

A similar difficulty was encountered when testing for differences in fishing efficiency for witch between day and night (Swain and Poirier 1998). The probability of catching witch was much higher at night than in day. Swain and Poirier (1998) compared results between lognormal and Poisson models. Poisson models appeared to produce appropriate estimates of relative fishing efficiency that were not adversely affected by the number of zero catches included in the analysis. In all cases, the estimate from the Poisson model was equal to the average night catch divided by the average day catch. In all cases, estimates from the lognormal model were smaller than this ratio. Estimates from the lognormal model were severely biased when a large number of zero catches were included in the model (and a constant had to be added to each catch to permit log transformation). However, estimates from the lognormal model appeared to be biased even when no zero catches were included in the analysis. This presumably reflects departures from the assumption of lognormality.

Adjustments for differences in fishing efficiency are no longer straightforward when vessels or gears differ not just in the number of fish captured when they do capture fish but also in the probability of capturing any fish at all. This difference in capture probability needs to be taken into account in order to adjust mean catch rates by one vessel or gear to be equivalent to those by the other vessel or gear. In a sense, individual catches are "over-adjusted" to compensate for the difference in the probability of catching any fish at all in a particular tow. Thus, adjusted mean catch rates are equivalent between vessels or gears, but adjusted catch rates of individual tows are not.

The estimated differences in fishing efficiency between gears and/or vessels in these analyses partly reflect the different corrections for diurnal variation in fishing efficiency that were applied to catches before analysis. For example, in the 1992 experiment, the factor applied to day catches by the *Alfred Needler* was 1.5 times the factor applied to those by the *Lady Hammond*, and fishing efficiency by the *Alfred Needler* was estimated to be 1.5 times that of the *Lady Hammond.* Only one-half of the tows in which the *Alfred Needler* caught witch were conducted in daytime, so the difference in fishing power between the two vessels cannot be entirely attributed to the larger multiplier applied to day tows by this vessel. An alternative to our approach would be to use unadjusted day catches and estimate the day/night effect and its interaction with vessel as part of this analysis of the 1992 and 1990 fishing experiments. However, in our view, these effects would not be well estimated in the 1992 and 1990 experiments because of their relatively small sample sizes and confounding between diurnal and spatial effects. Experiments that control for spatial variation in catch rates using paired day and night tows at the same locations should give the best estimates of diurnal variation in catchability. When such experiments were not available, rather than basing estimates of diurnal variation in catchability and its interaction with vessel on small experiments with as few as 22 paired tows without control for spatial variation in catch rates, we based these estimates on analyses of the entire survey time series, controlling for spatial variation in catch rates by including a term for stratum in the statistical model (Swain and Poirier 1998). Where both were available, the two approaches (i.e., controlling for spatial variation in catch rates by paired day and night tows versus statistical control using a stratum term) gave very similar estimates (Swain and Poirier 1998).

Our ultimate goal was to calculate an abundance index for witch incorporating results from both the September survey in the southern Gulf and the August survey in the northern Gulf (Swain et al. 1998). The

Lady Hammond fishing with a Western IIA trawl has been used in both these surveys. Thus, we decided to adjust catches to be equivalent to this vessel/gear combination. Figure 9 compares adjusted and unadjusted indices. For the southern Gulf survey, indices are shown including witch of all lengths. Results will be similar including only lengths of 24 cm or greater since few smaller witch are caught in this survey. For the northern Gulf survey, indices only include witch 24 cm or greater in length because an adjustment factor could be calculated only for these greater lengths. The index for the northern Gulf survey is not shown for 1984-1986 because length distributions of the catches were not available for these years.

For the southern Gulf survey, the increase in witch catch rates since 1991/1992 is not as great after adjustment for the change in vessel in 1992 as it is in the unadjusted series. Adjustment has the opposite effect in the northern Gulf survey. In this case, the decline in catch rates since 1987 is not as severe after adjustment for the change in vessel and gear in 1990. There is no obvious discontinuity in the year of gear and/or vessel change in either of the unadjusted time series. However, in the northern Gulf series, there is a sharp discontinuity in the *adjusted* time series in the year of gear and vessel change. This might suggest that the adjustment factor overcompensates for the change in vessel and gear. However, the comparative fishing experiment occurred during the 1990 survey, and it appears that a sharp increase in the mean catch rate in the survey would have occurred in 1990 had the survey been conducted using the *Lady Hammond* and the Western IIA trawl. Figure 10 compares mean catch rates in August 1990 between the two vessels and gears for all strata sampled by both vessels. These means include all tows in the strata, not just the paired tows. *Alfred Needler* catches are not adjusted to be comparable to *Lady Hammond* catches in this figure. Mean catches by the *Lady Hammond* tend to be greater than those by the *Alfred Needler*. The sum of the mean catches by the *Lady Hammond* is 2.06 times the sum of mean catches by the *Alfred Needler*, close to the factor (2.0) used to adjust *Alfred Needler* catches for the adjusted northern Gulf time series in Figure 9.

Acknowledgements

We thank Diane Archambault for providing data from the August survey. Diane Archambault patiently answered our many questions about the August and January data and survey procedures. We thank Alan Sinclair and Ghislain Chouinard for advice on these analyses, and Alan Sinclair and Paul Fanning for helpful comments on the manuscript.

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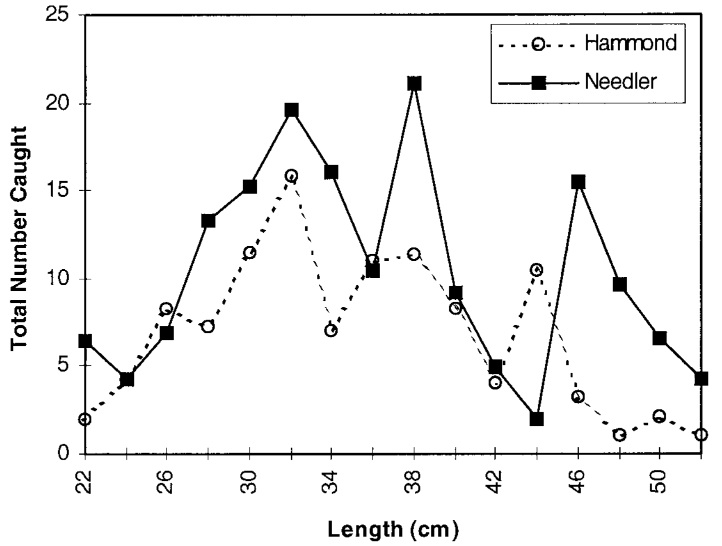
Table 1. Tests for a difference in fishing efficiency for witch flounder between the *Lady Hammond* and the *Alfred Needler* using a Western IIA trawl in paired tows in the southern Gulf of St. Lawrence in August 1992. Results are from Poisson models (Poisson error, log link, ϕ estimated from Pearson's χ^2 or set to 1) with terms for set and vessel. β_N is the estimate of the model parameter for the *Alfred Needler* (β_H=0), SE is its standard error, and *P* is the probability that β_N=0. *F* is the *F*-value for this test, and *df* its degrees of freedom. *b* is the corresponding estimate of *Alfred Needler* fishing efficiency relative to *Lady Hammond* efficiency (b=exp(β_N). *N* is sample size (twice the number of tow pairs).

Data	*N*	ϕ	β_N	SE	F	df	P	b
Witch caught by either vessel	44	1.222	0.4205	0.1367	9.6635	1,21	0.0053	1.523
Witch caught by both vessels	24	0.862	0.4109	0.1184	12.2823	1,11	0.0049	1.508
Witch caught by both vessels	24	1	0.4109	0.1275	10.5934	1,11	0.0077	1.508

Table 2. Tests for a difference in fishing efficiency for witch flounder between the *Lady Hammond* using a Western IIA trawl and the *Alfred Needler* using a URI trawl in paired tows in the northern Gulf of St. Lawrence in August 1990. Analysis is for witch flounder 24 cm or greater in length. Results are from Poisson models (Poisson error, log link, ϕ estimated from Pearson's χ^2) with terms for set and vessel. β_{Hw} is the estimate of the model parameter for the *Lady Hammond*/Western IIA (β_{Nu}=0), SE is its standard error, and *P* is the probability that β_{Hw}=0. *F* is the *F*-value for this test, and *df* its degrees of freedom. *b* is the corresponding estimate of *Lady Hammond*/Western IIA fishing efficiency relative to *Alfred Needler*/URI efficiency (b=exp(β_{Hw}). *N* is sample size (twice the number of tow pairs).

Data	*N*	ϕ	β_N	SE	F	df	P	b
Witch caught by either vessel	154	3.5449	0.6978	0.1174	37.4349	1,76	<0.0001	2.009
Witch caught by both vessels	72	2.1941	0.3341	0.1010	11.1069	1,35	0.0020	1.397



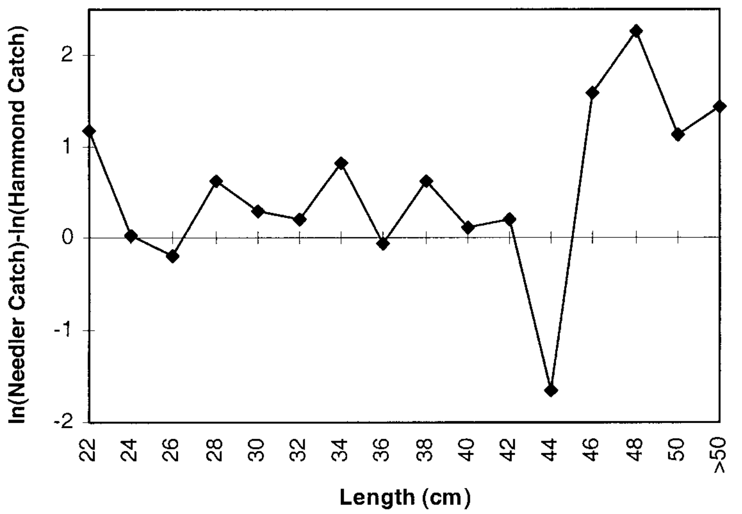


Figure 1. Catches by the *Alfred Needler* and the *Lady Hammond* by length in paired fishing tows in 1992.

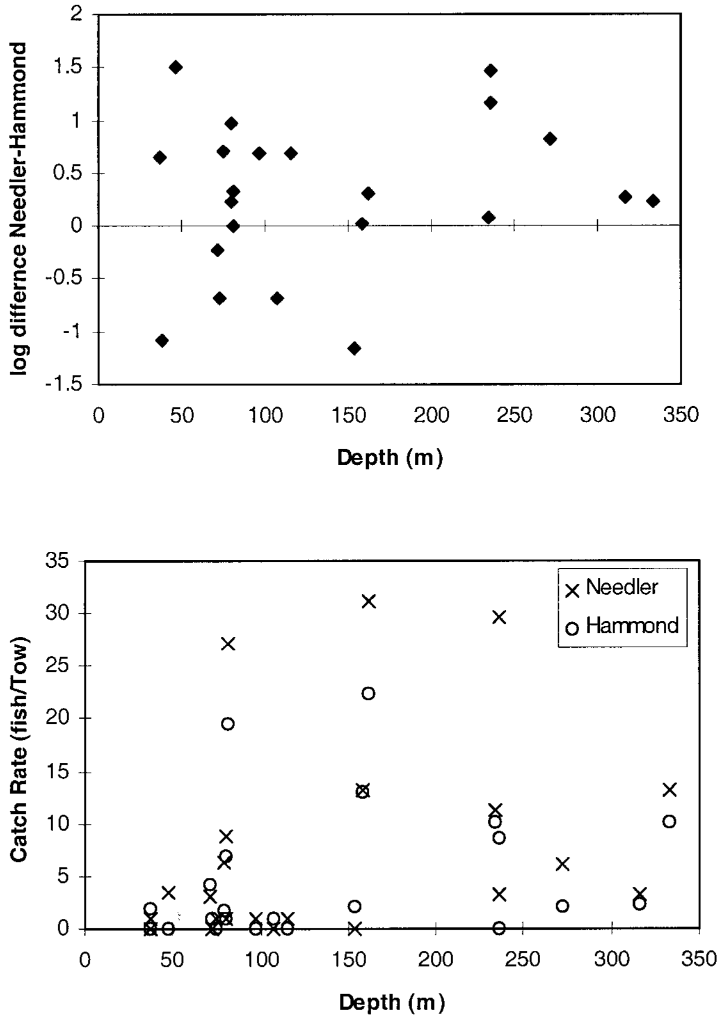
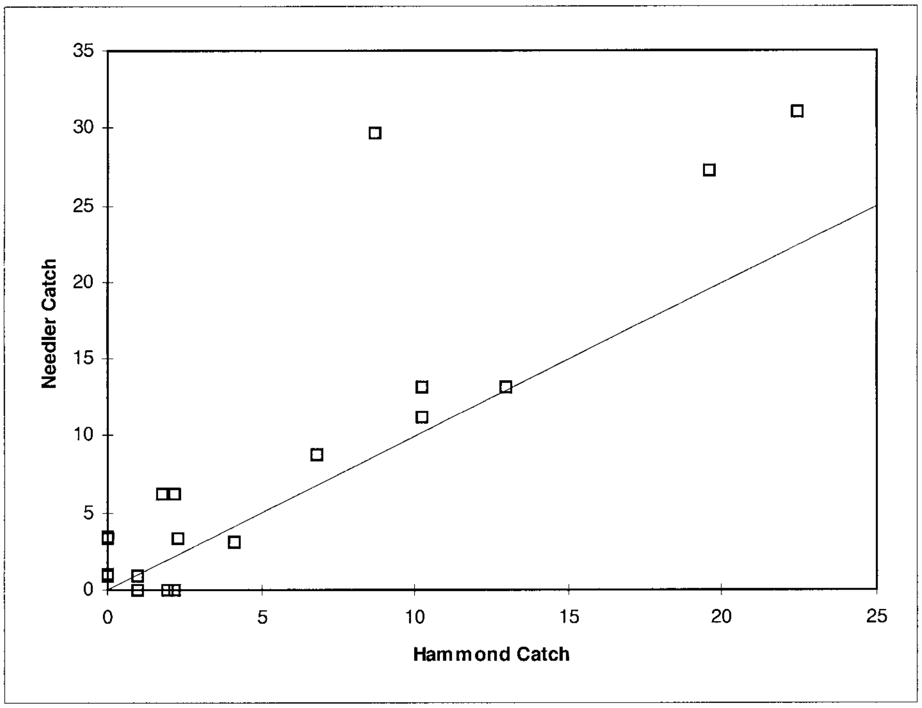


Figure 2. Catches by the *Alfred Needler* and the *Lady Hammond* by depth in paired fishing tows in 1992.



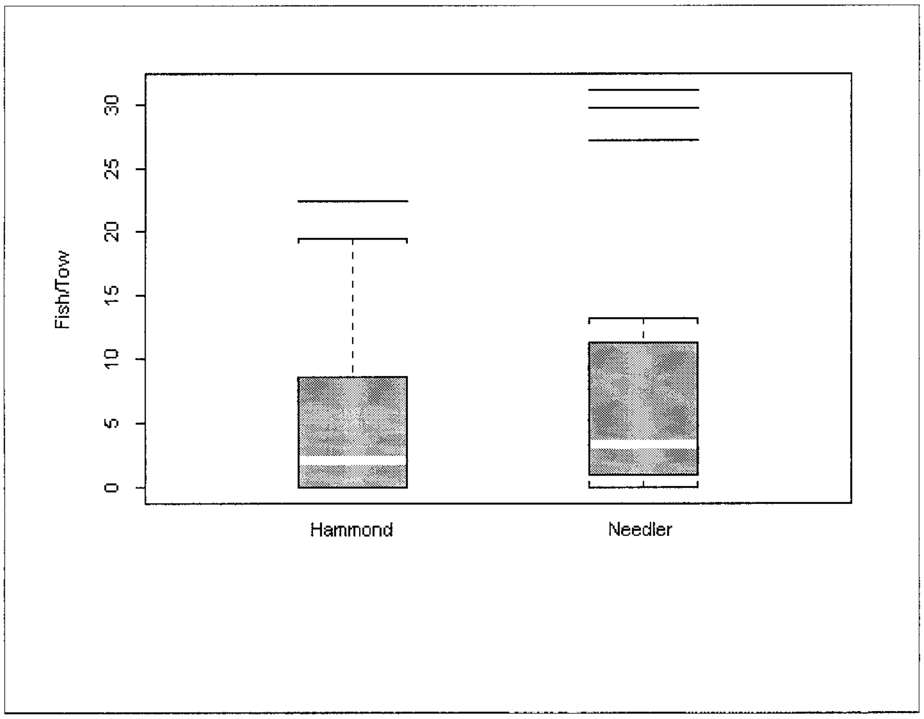


Figure 3. Catches of witch flounder in paired tows by the *Lady Hammond* and the *Alfred Needler* in the southern Gulf of St. Lawrence in August 1992. Boxes show interquartile distance (IQD) and white lines the median. Whiskers cover the range or 1.5 x IQD, whichever is less; horizontal lines show data points beyond 1.5 x IQD.

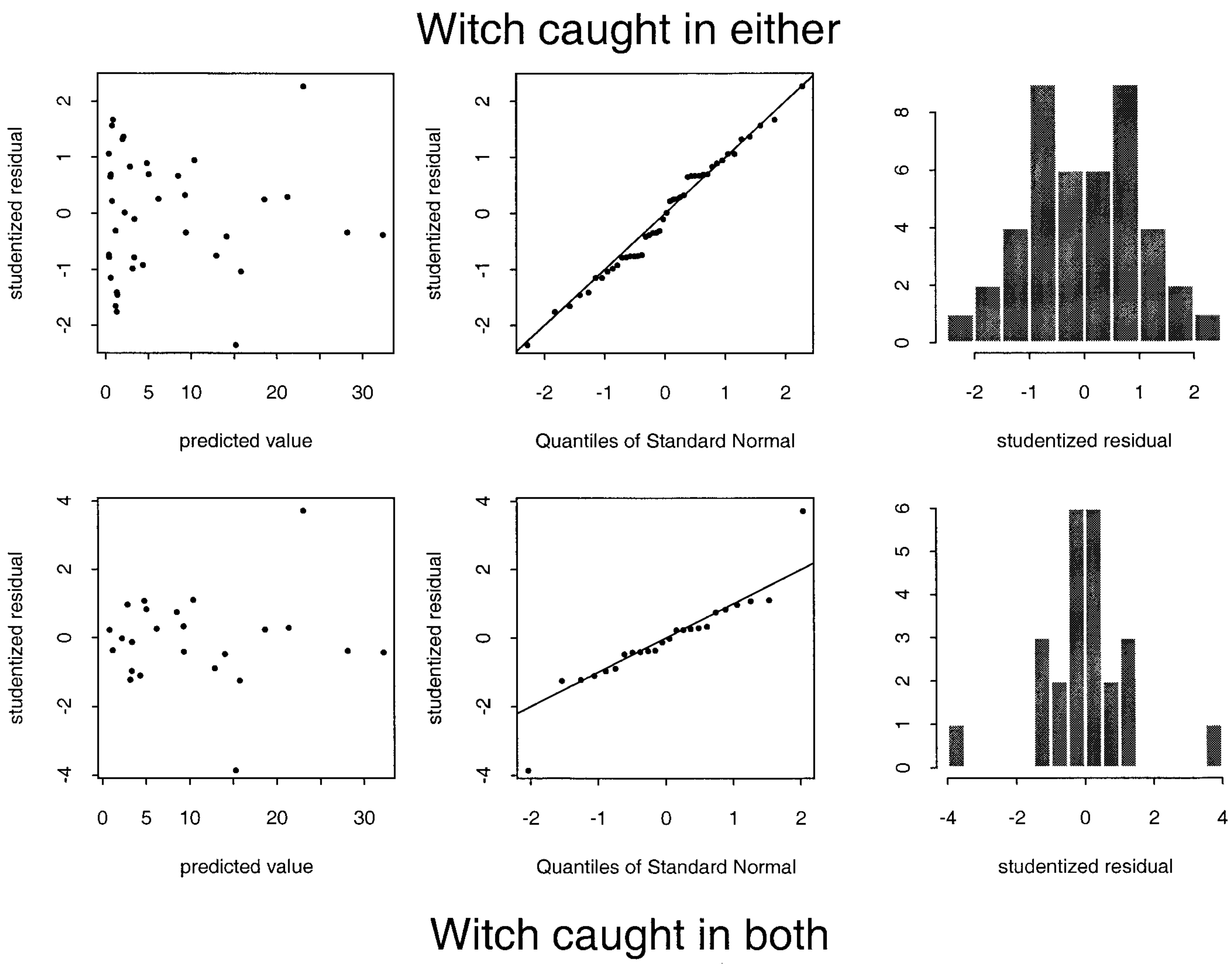


Figure 4. Residuals from models relating witch catch rate in the 1992 paired fishing experiment to set number and vessel

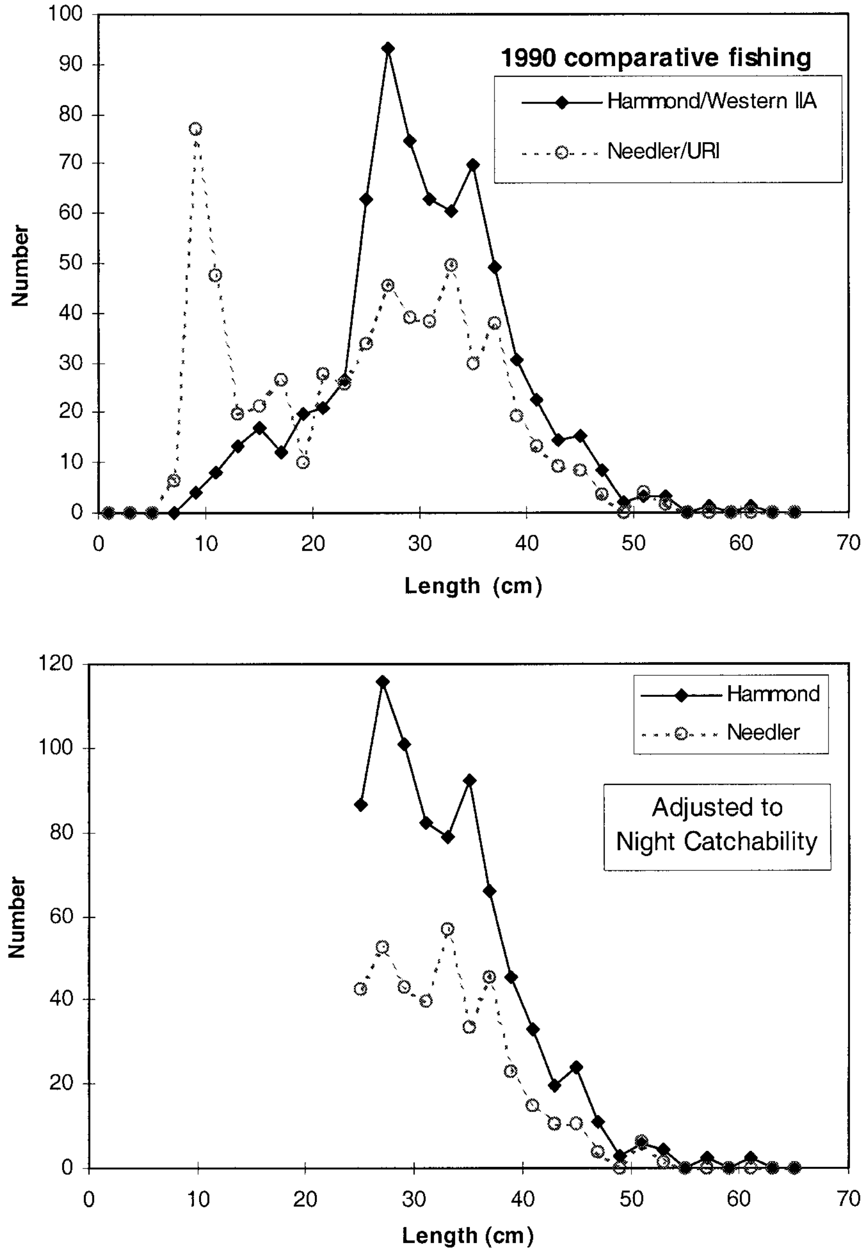
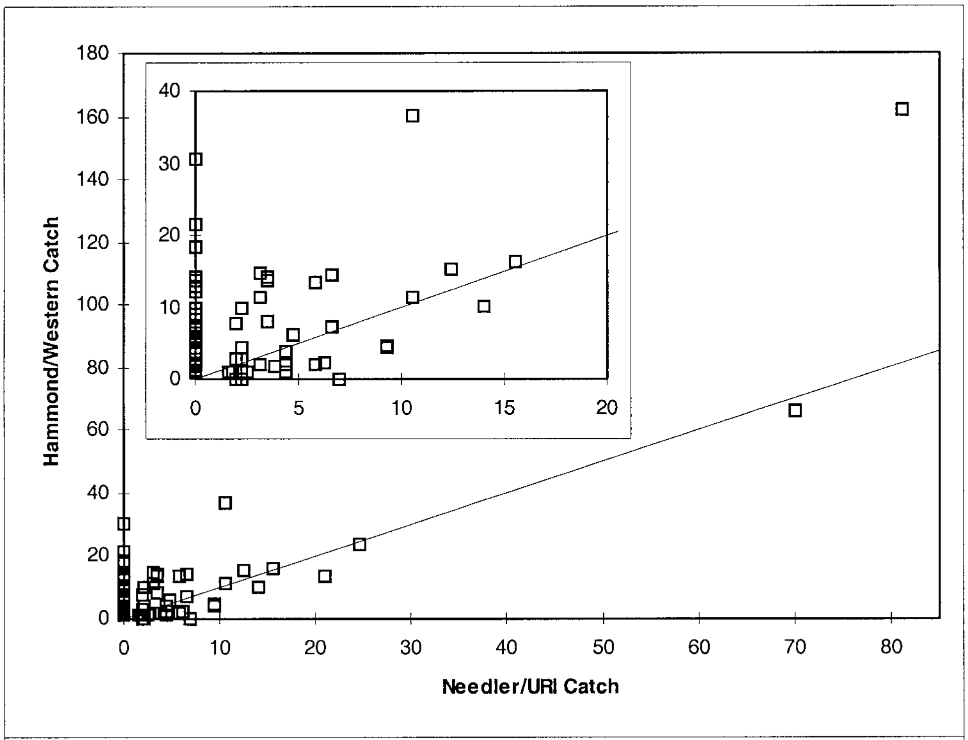


Figure 5. Number of witch flounder caught by length in paired tows in the northern Gulf of St. Lawrence in August 1990.



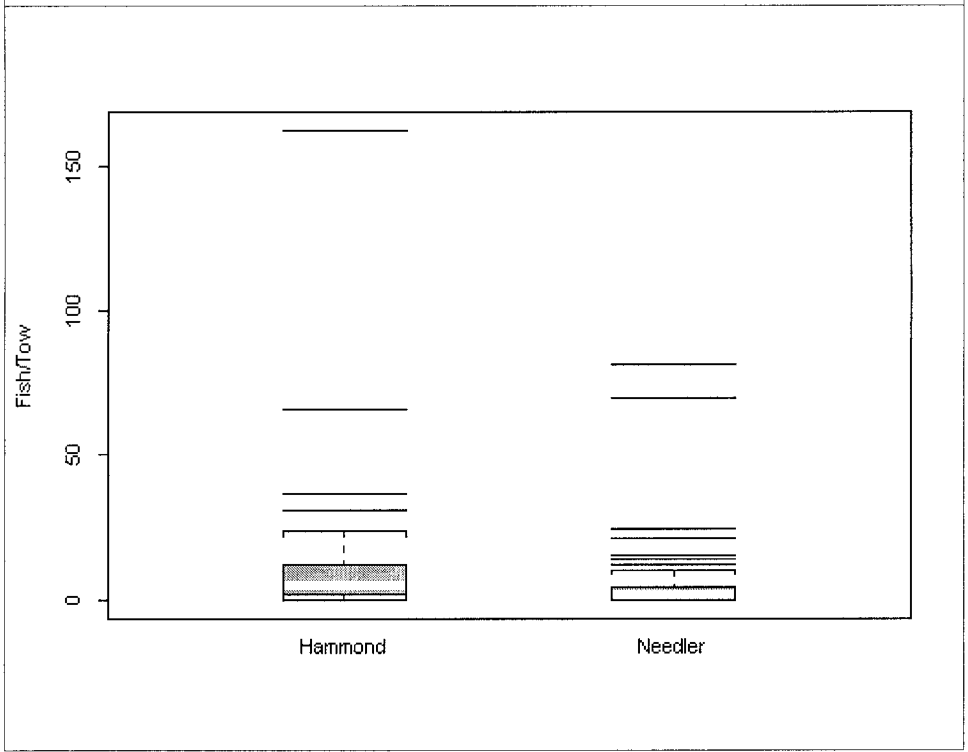


Figure 6. Catches of witch flounder in paired tows by the *Lady Hammond* using a Western IIA trawl and the *Alfred Needler* using a URI trawl in the northern Gulf of St. Lawrence in August 1990. Only witch flounder 24 cm or greater in length are included in catches. Box and whiskers are defined in Fig. 3.

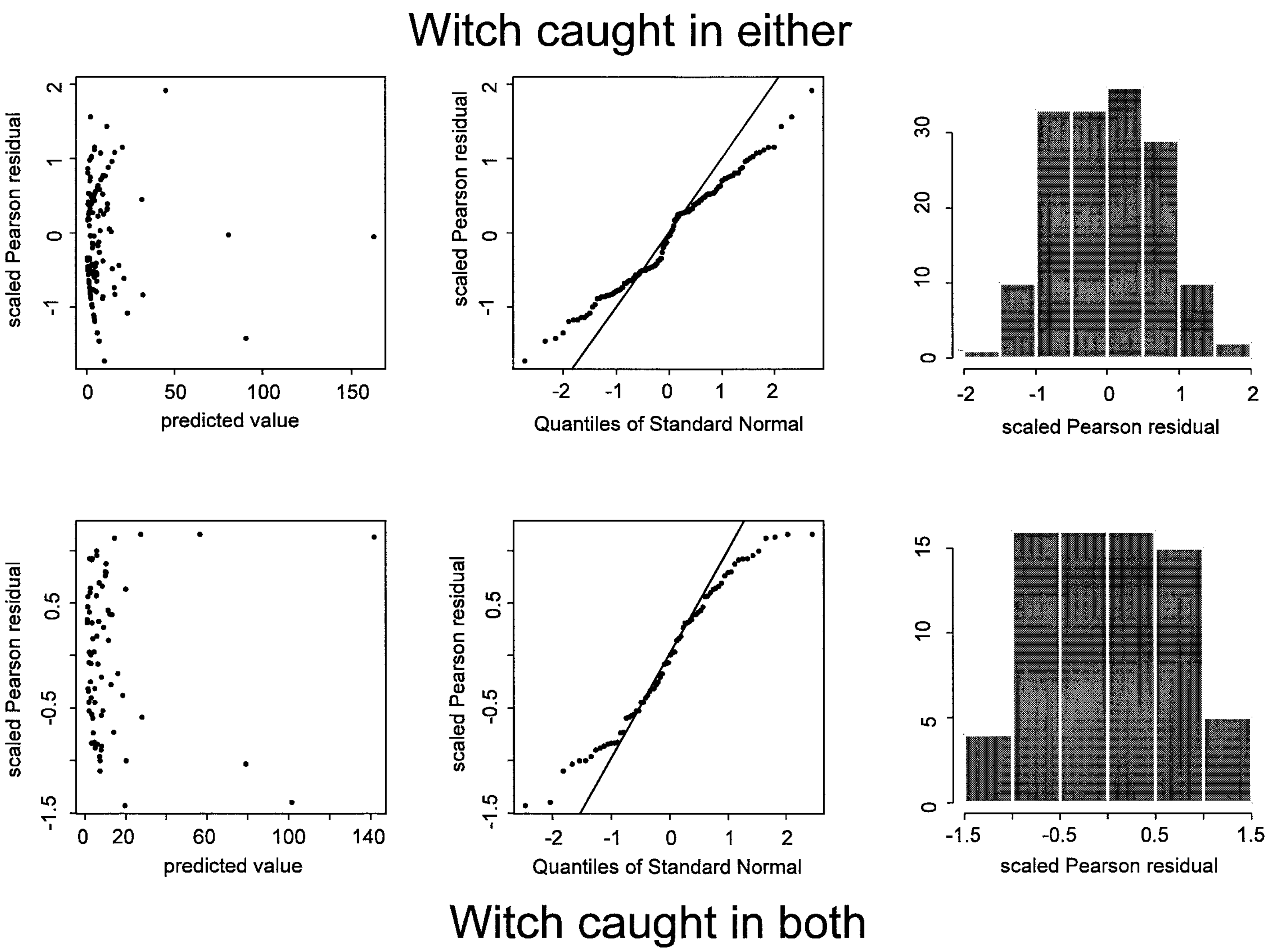


Figure 7. Residuals from models relating witch catch rate in the 1990 paired fishing experiment to set number and vessel

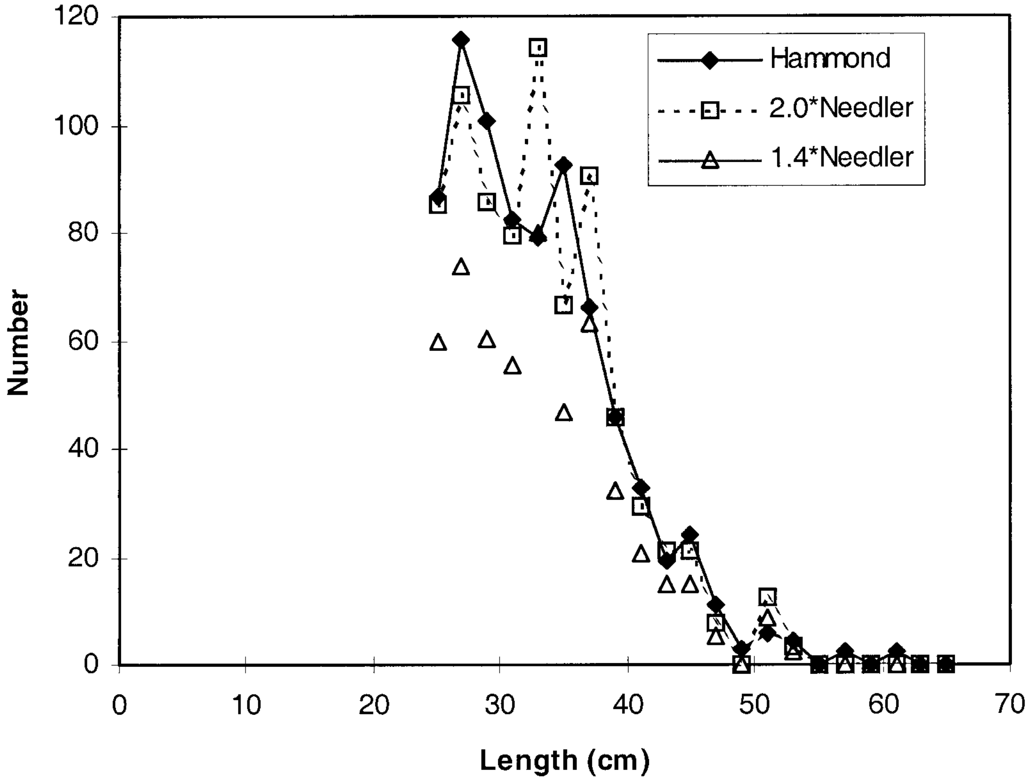
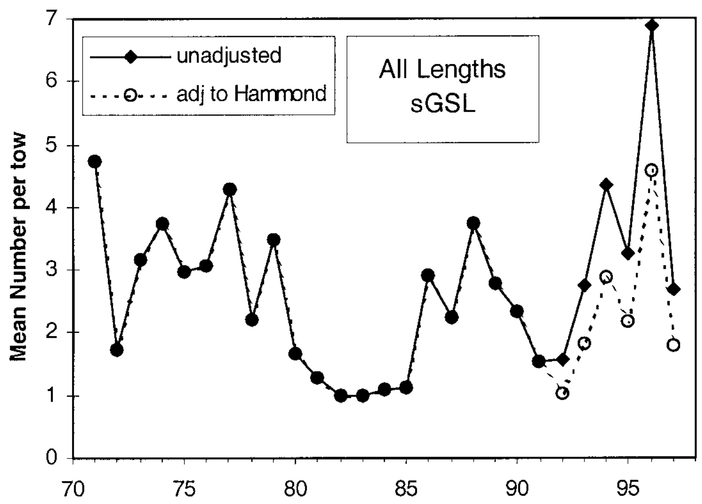


Figure 8. Number of witch flounder caught by length in paired tows in the northern Gulf of St. Lawrence in August 1990, with *Alfred Needler* catches adjusted to be equivalent to *Lady Hammond* catches using the coefficient estimated from an analysis of all paired tows with witch caught by either vessel (2.0) or only those tows with witch caught by both vessels (1.4).



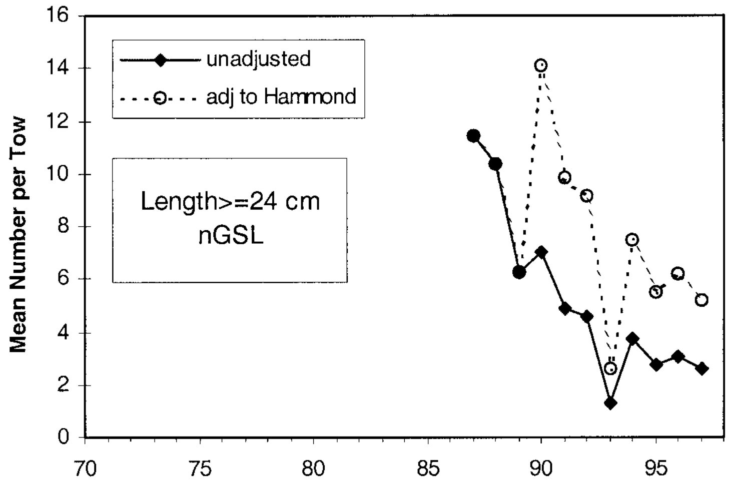


Figure 9. Comparison between abundance indices adjusted for changes in gear or vessel and the unadjusted indices. In both cases, indices are adjusted to night catchability.

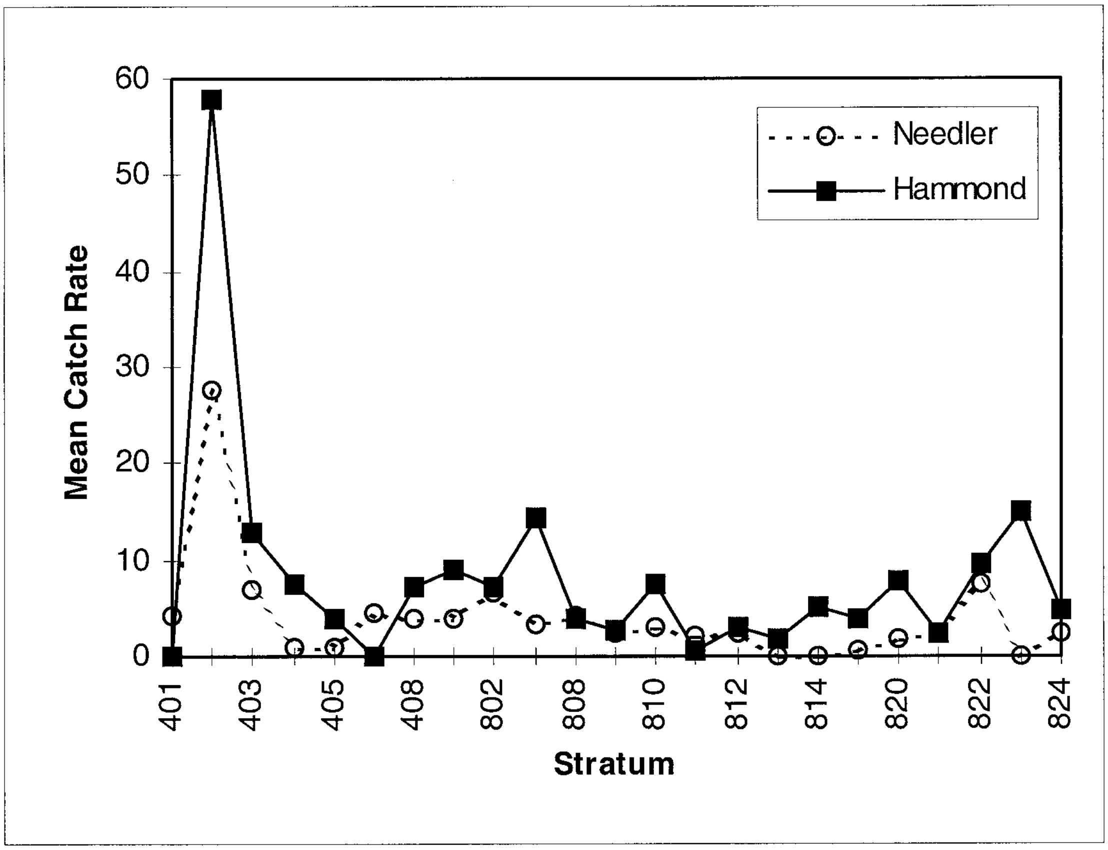


Figure 10. Mean catch rates in the 1990 August survey by vessel. Results are shown for all strata sampled by both vessels and include tows in addition to the paired tows. Catches are adjusted to night catchability and to a standard tow of 1.75 nautical miles for both vessels.