Northwest Atlantic Fisheries Organization

Serial No. N871

NAFO SCR Doc. 84/VI/82

Preliminary Analysis of *Alfred Needler - Lady Hammond* Comparative Fishing Experiments (Silver Hake, 1983)

by

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Introduction

Since 1970 the Marine Fish Division has conducted a time series of summer (July) stratified random groundfish surveys. While the time series is continuous to the present the fishing unit conducting the survey has changed several times. From 1970 to 1977 the survey was done by the A.T. Cameron alone, using a Yankee 36 trawl. In anticipation of the eventual retirement of the A.T. Cameron a series of comparative fishing experiments was begun in 1978. In that year the Lady Hammond, using a high-lift Engel 145 trawl fished comparative sets with the A.T. Cameron. For the 1979 survey the Engel trawl was deemed unsuitable for surveys and replaced with the Western IIA trawl. The data from the 1978 experiment were not considered further since the Engel trawl would not be used subsequently. A preliminary discussion and analysis of the 1979 to 1981 comparative experiments was given by Koeller and Smith (1983). After the 1981 survey the A.T. Cameron was retired and the 1982 survey was conducted by the Lady Hammond alone.

The Present Study

In October 1982 a comparative fishing experiment between the Alfred Needler and the Lady Hammond was performed. Unfortunately, the existence of these data was overlooked in preparing the present analysis. The 1983 comparative fishing of the Alfred Needler and Lady Hammond were carried out in the regular July groundfish survey with both vessels using the Western IIA trawl. An additional 13 sets were conducted in an area with a previously detected concentration of fish. These additional sets were not part of the regular survey.

The two trawl units are described in Table 1. Both vessels are in the same tonnage class and both have adequate power for dragging the gear. Catches were processed on each ship according to standard groundfish survey procedures except that no ageing material was collected on the Lady Hammond.

Exploratory Analysis

Paired t-tests were used to test for differences in speed (based on distance covered in 30 minutes) by assuming that the differences were normally distributed. There were 6 of 85 sets which did not have durations of 30 minutes and all 6 were deleted from subsequent analysis. Although 2 sets could have been adjusted to 30 minutes duration by pro rating the catches this was not done. There was no significant difference ($p > 0.2$) in distances travelled in 30 minutes, which implies there was no significant difference in speeds averaged over a tow between the two vessels.

Differences in depth between the two vessels were also tested with a paired t-test assuming that the difference in depth between the two vessels at each set was normally distributed. There was no significant difference ($p > 0.1$) between the depths of the comparative sets.

A plot of the catch of the Alfred Needler against the catch of the Lady Hammond is given for silver hake (Figure 1). It shows the pattern of most catches being small, clustered near the origin with a few very large catches by one or both vessels scattered about which is typical of comparative catches..

The impact of one or two exceptionally large catches on simple sample means or stratified means is well known. To avoid the problem of having the comparative fishing statistics unduly influenced by such catches a relative catch index (r.c.i.) was used. The r.c.i. of a set is defined as

$$I = \frac{STD}{STD + TEST}$$

where STD = catch of one species by the standard vessel and
TEST = catch of the same species by the test vessel.

In this study the standard vessel was Lady Hammond (hereafter LH) and the test vessel is Alfred Needler (AN). A few points to note with respect to I for a given species (Figure 2):

(i) I is undefined if both vessels have zero catches.
(ii) I = 1 if test vessel had zero catch and standard vessel had non-zero catch.
(iii) I = 0 if test vessel had non-zero catch and standard vessel had zero catch.
(iv) I = 0.5 if test and standard vessels had equal catches.
(v) I is defined on the interval [0,1].

The variability of I is much less than that of the original catches, the difference in catches or the ratio of the catches. As well the sampling distribution of I is approximately beta distributed.

The Beta Distribution

The beta distribution is a flexible distribution with 2 parameters, α and β and is defined on the interval [0,1]. The probability density function (p.d.f.) of the beta distribution is

$$f(x;\alpha,\beta) = \frac{1}{B(\alpha,\beta)} x^{\alpha-1} (1-X)^{\beta-1} I_{0,1}(X); \quad \alpha, \beta > 0$$

where $B(\alpha,\beta) = \int_0^1 x^{\alpha-1} (1-X)^{\beta-1}\, dx; \ \alpha, \beta > 0$ is the complete beta integral (Mood et. al. 1974). The expectation of a beta distribution random variable is

$$E(X) = \mu = \frac{\alpha}{\alpha + \beta} \tag{1}$$

and its variance is

$$V(X) = \sigma^2 = \frac{\alpha\beta}{(\alpha + \beta + 1)(\alpha + \beta)^2} \tag{2}$$

(Mood et. al. 1974).

Assuming that the r.c.i.'s are identically, independently distributed beta random variables the sample moments of I can be used to estimate the parameters of the beta distribution. Such estimators, the method of moments estimators, are obtained by equating the first 2 sample moments, the sample mean and variance, to the first 2 moments of the distribution, the expectation and the variance given above (eqn. 1 and 2). Solving the 2 equalities for α and β yield the estimators

$$\hat{\alpha} = a = \frac{((1-X)\, X - S^2)\, X}{S^2}$$

and

$$\hat{\beta} = b = \frac{(1-X)^2 X - (1-X)}{S^2}$$

The method of moments estimators are unbiased but unfortunately are not minimum variance.

The least squares estimators are both minimum variance and unbiased. Least squares estimates of α and β were obtained using iterative least squares. The residual sum of squares was minimized using the Newton-Raphson algorithm with numerical derivatives. The method of moments estimates were used as the initial values in the iteration. The final estimates of α and β were substituted back into equations 1 and 2 to obtain least squares estimates of the mean and variance of the distribution.

The 95% confidence intervals were approximated as the mean $\pm$ 2 standard deviations. Trial calculations of exact 95% confidence intervals from beta tables showed that the approximate confidence intervals were conservative i.e. wider than the exact confidence intervals (Table 2).

Conversion Factors

The applicability of conversion factors to survey data was discussed by Koeller and Smith (1983). Their consideration that most sources of macro-scale variation are eliminated by side-by-side trawling is even more likely in the 1983 experiments given that in 1983 the two trawls in use were identical. It is also worth repeating here that the use of a conversion factor to compare means from a given year and division can be misleading. Small scale variation will cause the observed mean to vary from the parametric mean and applying a conversion factor will randomly reduce or increase such deviations. The impact of such random changes will be greatest on means with small sample sizes. Use of the beta distribution has allowed the calculation of confidence intervals for the relative catch index. These confidence intervals can be converted to conversion factor ranges. Such a range, which may include 1 (no conversion), gives a researcher both an estimate of the conversion factor and an indication of the precision of the estimate. The researcher has the flexibility to adjust the conversion factor to get optimal agreement between the vessels, particularly when the researcher is concerned with a subset of the data the conversion factor is based on.

The conversion factor, K, is calculated from the mean of I, based on the beta distribution, as $K = \bar{I}/(1-\bar{I})$.

For silver hake in all divisions a conversion factor of 1.0 is appropriate. Calculation of separate conversion factors for each division was not feasible due to small numbers of sets in most divisions. 4W was calculated separately and results of all divisions and 4W are given in Tables 2 and 3.

Further Investigations

1. Apply this approach to the A.T. Cameron-Lady Hammond surveys of 1979-81, and the data overlooked in the 1983 survey.

2. Compare the size composition for the 2 vessels and investigate the effect of size composition on the r.c.i.

3. Investigate the effects of factors such as time of day or depth on r.c.i. Additionally, consideration of effects due to individual techniques for shooting and hauling the trawls may be appropriate. Frequently the Lady Hammond pulled away from the Alfred Needler when hauling in the net (G.N. White, pers. comm.).

4. Inter-species effects (interactions) on the r.c.i. need to be considered.

5. Investigate the statistical properties of the r.c.i. with particular attention to hypothesis testing.

6. Investigations in points 2, 3, 4, and 5 above will require resampling and/or simulation techniques due to the small number of sets available.

References

Koeller P. and S.J. Smith. 1983. Preliminary analysis of A.T. Cameron - Lady Hammond comparative fishing experiments 1979-1981. CAFSAC Res. Doc. 83/59.

Mood A.M., F.A. Graybill and D.C. Boes. 1974. Introduction to the Theory of Statistics. 3rd Edition. McGraw-Hill Book Company. New York

Table 1. Summary of vessel and trawl characteristics of the two vessel-gear units used in comparative fishing experiments in 1983.

	Alfred Needler	Lady Hammond
Vessel type	Stern trawler	Stern trawler
B.H.P.	2000	2500
Tonnage	925	897
Length	50 m	58 m
Trawl	Western IIA	
Footrope	18" (inner) and 21" (outer) bobbins and 6 ¾" diameter 7" long spacers, all rubber	
Liner		
Belly extension	1¼"	
Lengthening piece	1¼"	
Codend	¾"	
Headline length (ft)	75	
Footrope length (ft)		
overall	106	
with netting	68	
Netting panel lengths (ft)		
top wings	27	
square & bunt	21	
bellies & 1' piece	41	
codend	38	
total	127	
Door type	Portugese (all steel)	
weight	1800 lb	
area	47 ft^2	
Mouth opening (ft)		
headline height	15	
wing spread	41	

Table 2. Estimates of relative catch index (I) with 95% confidence intervals for silver hake.

Division	I	Confidence Limits Upper	Confidence Limits Lower	Sample Size
All	0.4858	0.5242	0.4474	55
4W	0.4617	0.5189	0.4045	28

Table 3. Estimates of conversion factors with range bounds.

Division	Conversion Factor	Upper	Lower
All	.9448	1.0193	0.8095
4W	.8576	1.0784	0.6792

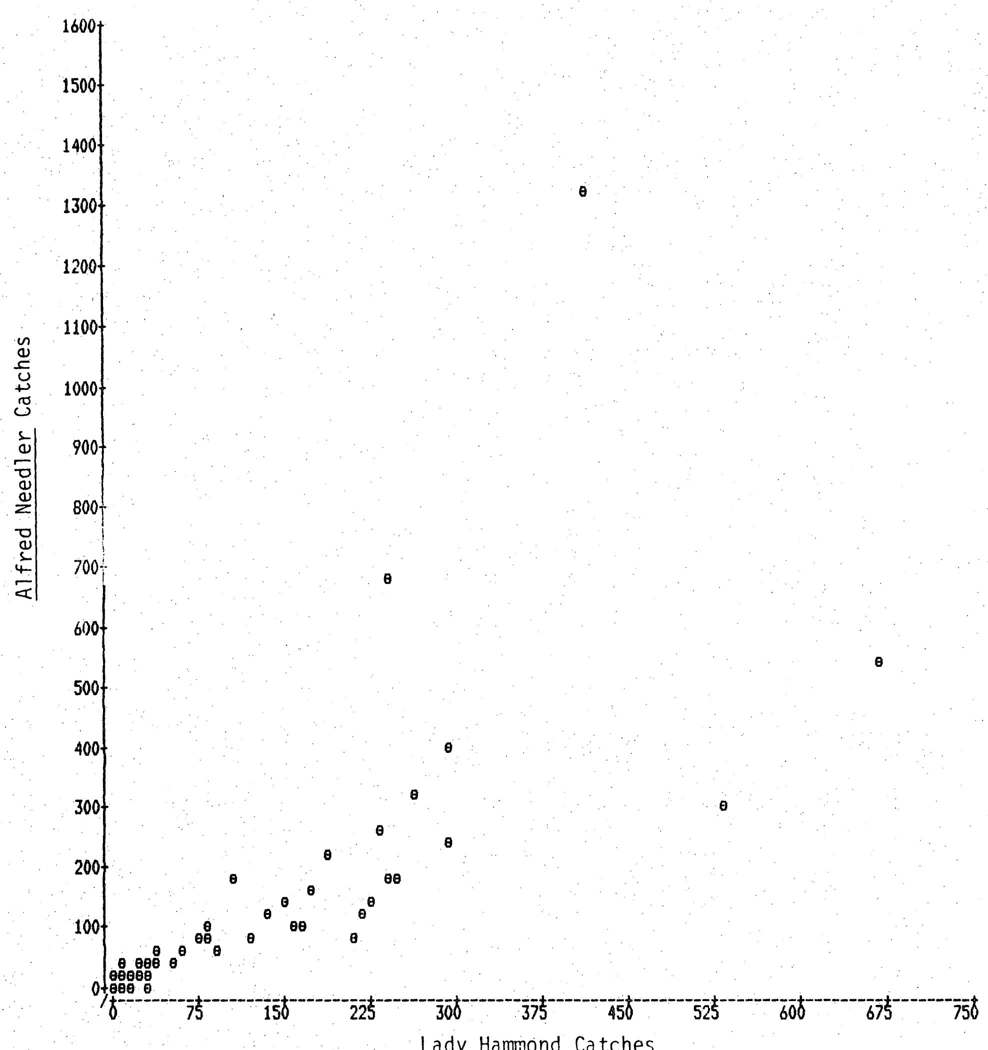

Figure 1. Number of silver hake caught by Alfred Needler and Lady Hammond in comparative sets in 1983.

Silver Hake

```
                Unit = 0.01

              1  2 rep 0.12
Depth
         (7) HI| 1,1,1,1,1,1,1
               *|
              9·|
  1            *| 5
  3           8·| 34
               *|
  4           7·| 2
  5            *| 8
 11           6·| 023344
 18            *| 5566677
 24           5·| 012244
(10)           *| 5566778899
 21           4·| 012234444
 12            *| 55777
  7           3·| 12
  5            *| 6
  4           2·| 334
  1            *| 7
              1·|
               *|
              0·|
         (6) LO| 0,0,0,0,0,0
```

$\bar{I}$ = 0.492552 (mean)

I = 0.480519 (median)

Figure 2. Stem and leaf plot of relative catch index for the Needler/Hammond comparative fishing cruises 1983.