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**An analysis of the day versus night catches
of the southern Gulf of St. Lawrence
groundfish cruises 1985-1988**

by

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ABSTRACT

Catches of cod, white hake, and American plaice from four southern Gulf of St. Lawrence groundfish surveys were examined for diel variation. Mean catch/tow and length frequency distributions were analyzed. The cruises were conducted during the month of September, from 1985 to 1988. There were no significant differences in the mean catch/tow for the three species. The length frequency distributions for cod and American plaice did not vary diurnally. Variations in the length frequencies for white hake were not consistent and are likely due to high variability in the surveys rather than to fish behavior.

RESUME

On a examiné les prises de morue de merluche blanche et de plie canadienne provenant de quatre relevés de recherche sur le poisson de fond dans le sud du golfe du Saint-Laurent afin de repérer toute différence nycthémerale. On a analysé les prises moyennes par trait et les distributions de fréquences des longueurs. Les relevés en question avaient en lieu au cours du mois de septembre, de 1985 à 1988. On n'a observé aucune différence significative dans les prises moyennes par trait pour les trois espèces considérées. Les distributions de fréquences des longueurs de la morue et de la plie canadienne ne présentaient pas de variation diurne. Par ailleurs, les variations relevées dans les distributions de fréquences des longueurs de la merluche blanche comportaient des contradictions, dues sans doute davantage à une grande variabilité des résultats expérimentaux qu'au comportement du poisson.

INTRODUCTION

Vertical migrations for many species of fish have been documented in the literature. Among others, Beamish (1965), LaCroix (1967), and Brunel (1972), concluded that cod are not as close to the bottom during the night as during the day. Beamish (op. cit.) found that American Plaice may be found off bottom at night.

From 1970 to 1984 the annual fall groundfish surveys of the southern Gulf of St. Lawrence were conducted using the research vessel E.E. Prince. In 1985 the E.E. Prince and the Lady Hammond were used, and since 1986, the Lady Hammond has been used to conduct the survey.

Surveys using the E.E. Prince were conducted in the daytime only while the Lady Hammond operates both day and night. Four years of day and night surveys (1985-1988) were available. An analysis of the catches from the day and the night sets was undertaken to determine whether or not the night fishing information can be included in the abundance estimates produced from the Lady Hammond surveys. This paper summarizes the results of the analysis.

METHODS

In 1985 the Lady Hammond was used to conduct a comparative survey, fishing alongside the E.E. Prince during the day, and continuing to fish at night when the E.E. Prince was idle. From 1985 to 1987, the fishing locations for all sets were selected using a fixed survey design, the daytime stations corresponding to a historical series of sets for the abundance estimate. In 1988 the daytime fishing locations were chosen using a random stratified design and the night locations were, as close as possible, a repeat of the day sets fished within the same 24 hour period.

For comparison of day versus night fishing, the cruise data were treated as if a day survey and a separate night survey were conducted. Only strata that were fished in both day and night were included in the analysis for each year. For the 1988 data, a paired t-test was used to analyze the difference between the day and night tows at the same location. The species of major interest in the groundfish surveys are cod, white hake, and American plaice. Separate analyses were made for these species.

The analysis consisted of two steps:

- a) Comparison of the mean catch/tow between day and night
- b) Comparison of the stratified length frequency distributions

a) Comparison of the mean catch/tow between day and night

The total catch in each set was adjusted to a standard tow of 1.75 nautical miles and then the logarithm was taken. Daytime sets were arbitrarily considered to start between 0700 and 1930 hours. The model used was:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \epsilon_{ijk}$$

where Y_{ijk} = the log of the k^{th} observed (catch/tow + 1)
for time i and stratum j

α_i = the effect of time of day
($i=1$ for day; $i=2$ for night)

β_j = the effect of the j^{th} stratum

$\alpha\beta_{ij}$ = the interaction effect of time i and stratum j

ϵ_{ijk} = random error

The hypothesis tested was that the time effect (day vs night) was not significant. If the interaction of stratum and time was not significant, it was excluded for the estimation of stratified day vs night difference. A generalized linear model procedure (PROC GLM from the SAS Institute Inc, 1981) was used for the analyses.

b) Comparison of the stratified length frequency distributions

The day and night stratified length frequency distributions were compared.

The numbers at length in each set were adjusted to a standard tow of 1.75 nautical miles and a sampling ratio of 100%. The length frequencies for each set within a stratum were averaged and then multiplied by the number of trawlable units in the stratum. The length frequencies for all the day sets were added to estimate the daytime abundance at length, and those for the night sets to estimate the nighttime abundance at length.

SAS procedures were used to generate these frequencies.

RESULTS

All cruises had between 2 and 5 strata missing from the day-night comparisons (Table 1). The numbers of non-zero sets for each species are summarized in Table 2.

a) Comparison of the mean catch/tow between day and night

The results of the analyses are summarized in Tables 3 to 5. Whether catch/tow is expressed as a weight or as numbers of fish does not change the results. The only instance of a significant stratum-time interaction is in the 1987 survey for white hake. So for all other analyses, the interaction term was excluded. In all

cases the stratum effect is significant and the time of day effect is not. In no case does the estimated stratified day mean catch/tow differ significantly from the estimated stratified night mean catch/tow. There are no obvious trends in the residuals and examination reveals no inconsistencies with the assumptions that they are independently and normally distributed (Figures 1 to 4). Using the pooled estimates of mean catch/tow results in slightly smaller standard errors than using either the day or the night data alone (Table 4). For all three species the daytime mean catch/tow (weight) is consistently greater than the nighttime mean catch/tow (weight), but minimally.

The paired t-test performed on the 1988 survey sets from the same locations show no difference between day and night sets (Table 6). For all species the day mean catch/tow was greater than the night mean catch, but in no instance was the difference significant.

b) Comparison of the stratified length frequency distributions

Percent numbers at length were calculated for all three species, all four cruises. The resulting cumulative proportions at length are shown in Figures 5 to 8. For cod and American plaice, there is no difference between day and night length frequency distributions. For white hake, however, there does appear to be a difference, except possibly for the 1987 survey. It is important to note that of the three species considered in this analysis, white hake is by far the most variable in the survey catches (Table 2). The difference in the 1986 and 1988 surveys for white hake can be almost entirely accounted for by the occurrence of two large night sets containing a high proportion of small fish. For the 1985 survey, the situation is more complicated, but it is likely that one or two unusual sets affected the results.

DISCUSSION

For the three species and four cruises analyzed, there is no statistical difference between the mean catch/tow from day sets and the mean catch/tow from night sets. For purposes of abundance estimates, therefore, both day and night sets could be used. The standard errors associated with the pooled (day and night) estimates of mean catch/tow are not much smaller than those associated with the day or night sets alone - the coefficients of variation are in the range of 2 to 4 percent smaller. Pooling the day and night sets for calculation of mean catch/tow (unlogged data) does not result in a significant increase in precision with these data, but a positive gain is evidenced (Table 7).

For both cod and American plaice, the length frequencies calculated from the day sets do not appear to be different from those calculated from the night sets. For white hake there are differences which may be explained by the fewer number of sets with hake and the greater effect that each individual set has on the whole. The differences between day and night sets for white hake are not consistent and thus may be due to high variability rather than fish behavior.

Because of the importance of abundance estimates in the assessment process, it would be prudent to use all the data - both day and night - from the Gulf of St. Lawrence groundfish cruises in calculating these estimates.

ACKNOWLEDGEMENTS

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Table 1. Numbers of night and day sets used in the day-night comparison.

STRATA	1985		1986		1987		1988	
	day	night	day	night	day	night	day	night
401	1	2	-	-	-	-	2	2
402	3	1	3	2	3	1	-	-
403	-	-	-	-	1	3	2	1
415	3	3	4	2	3	3	5	3
416	6	4	5	4	5	4	8	5
417	4	2	3	4	3	4	5	5
418	4	2	4	2	3	3	5	5
419	2	1	2	2	2	2	4	2
420	3	2	3	3	2	4	3	2
421	-	-	2	1	2	1	-	-
422	7	4	6	5	6	5	6	4
423	5	4	5	5	7	11	4	2
424	4	3	4	3	3	4	3	1
425	1	1	1	2	2	1	4	2
426	-	-	1	2	1	1	3	3
427	4	2	1	2	1	4	1	1
428	2	1	-	-	2	1	2	2
429	3	3	4	3	3	3	3	3
431	2	3	4	3	3	2	3	3
432	-	-	8	4	-	-	3	3
433	7	3	9	16	8	10	4	4
434	5	3	3	5	3	5	5	2
435	4	1	2	3	1	4	2	2
436	3	2	4	2	2	4	4	1
437	4	1	6	1	3	2	4	2
438	1	2	-	-	2	1	2	2
439	2	1	-	-	-	-	2	2
Total	80	51	84	76	71	83	89	64

Table 2. Number of non-zero catch by cruise and time.

YEAR	COD		WHITE HAKE		AMERICAN PLAICE	
	day	night	day	night	day	night
1985	72	46	28	17	69	45
1986	80	72	44	39	77	71
1987	63	76	23	25	59	93
1988	82	60	36	26	75	54

Table 3. GLM results of estimating mean catch/tow.

YEAR=1985	SOURCE	DF	SS	F	Prob>F
COD R ² = .75	Model	45	345.6	5.65	.0001
	Day-Night	1	.0	.02	.8750
	Stratum	22	277.6	9.82	.0001
	S*D-N	22	22.7	.76	.7652
	Error	85	115.6		
	Corr Tot	130	461.2		
HAKE R ² = .68	Model	45	208.4	3.95	.0001
	Day-Night	1	1.2	.98	.3238
	Stratum	22	161.0	6.25	.0001
	S*D-N	22	21.0	.82	.6977
	Error	85	99.6		
	Corr Tot	130	307.9		
PLAICE R ² = .68	Model	45	238.3	4.04	.0001
	Day-Night	1	.1	.11	.7402
	Stratum	22	206.8	7.17	.0001
	S*D-N	22	9.2	.32	.9983
	Error	85	111.5		
	Corr Tot	130	349.8		
YEAR=1986					
COD R ² = .77	Model	43	514.1	8.99	.0001
	Day-Night	1	.2	.17	.6804
	Stratum	21	462.0	16.54	.0001
	S*D-N	21	18.3	.65	.8693
	Error	116	154.3		
	Corr Tot	159	668.5		
HAKE R ² = .71	Model	43	402.7	6.73	.0001
	Day-Night	1	.4	.29	.5918
	Stratum	21	344.1	11.77	.0001
	S*D-N	21	24.0	0.82	.6881
	Error	116	161.5		
	Corr Tot	159	564.2		
PLAICE R ² = .67	Model	43	301.6	5.57	.0001
	Day-Night	1	.0	.00	.9617
	Stratum	21	277.0	10.47	.0001
	S*D-N	21	10.1	.38	.9932
	Error	116	146.1		
	Corr Tot	159	447.6		

Table 3. GLM results of estimating mean catch/tow (cont'd)

YEAR=1987	SOURCE	DF	SS	F	Prob>F
COD R ² = .61	Model	47	268.1	3.59	.0001
	Day-Night	1	.4	.13	.7222
	Stratum	23	221.6	6.57	.0001
	S*D-N	23	27.8	.76	.7723
	Error	107	170.0		
	Corr Tot	154	438.1		
HAKE R ² = .76	Model	47	214.9	7.34	.0001
	Day-Night	1	.6	1.01	.3160
	Stratum	23	171.7	11.98	.0001
	S*D-N	23	34.7	2.42	.0013
	Error	107	66.7		
	Corr Tot	154	281.6		
PLAICE R ² = .63	Model	47	216.1	3.92	.0001
	Day-Night	1	1.0	.68	.4105
	Stratum	23	221.8	6.78	.0001
	S*D-N	23	34.2	.95	.5312
	Error	107	152.2		
	Corr Tot	154	414.3		
<hr/>					
YEAR=1988	SOURCE	DF	SS	F	Prob>F
COD R ² = .72	Model	49	353.4	5.32	.0001
	Day-Night	1	.1	.06	.8072
	Stratum	24	319.6	9.38	.0001
	S*D-N	24	17.0	.52	.9646
	Error	103	139.5		
	Corr Tot	152	492.9		
HAKE R ² = .83	Model	49	348.7	10.45	.0001
	Day-Night	1	.1	.16	.6875
	Stratum	24	312.3	19.11	.0001
	S*D-N	24	13.3	.81	.7133
	Error	103	70.1		
	Corr Tot	152	418.9		
PLAICE R ² = .72	Model	49	320.6	5.51	.0001
	Day-Night	1	.3	.21	.5455
	Stratum	24	299.1	10.50	.0001
	S*D-N	24	11.6	.41	.9930
	Error	103	122.3		
	Corr Tot	152	442.8		

Table 4. Stratified mean catch/tow (log weight)
for day and night sets.

YEAR	COD		WHITE HAKE		AMERICAN PLAICE		
	mean	se	mean	se	Mean	se	
1985	day	4.02	.14	.90	.13	2.74	.13
	night	3.98	.17	.71	.16	2.73	.16
	combined	4.00	.12	.81	.11	2.74	.11
1986	day	4.06	.14	1.00	.14	2.97	.15
	night	4.00	.14	.97	.15	2.95	.18
	combined	4.03	.11	.99	.11	2.96	.10
1987	day	3.79	.16	.72	.11	2.74	.15
	night	3.72	.14	.57	.10	2.80	.14
	combined	3.75	.11	.64	.07	2.78	.11
1988	day	4.23	.14	.81	.10	2.94	.13
	night	4.12	.16	.81	.12	2.94	.15
	combined	4.18	.12	.81	.09	2.94	.11

Table 5. Stratified mean catch/tow (log numbers)
for day and night sets.

YEAR	COD		WHITE HAKE		AMERICAN PLAICE		
	mean	se	mean	se	Mean	se	
1985	day	4.23	.14	.84	.12	3.78	.16
	night	4.23	.16	.72	.14	3.93	.19
	combined	4.23	.11	.78	.10	3.85	.13
1986	day	4.30	.14	.98	.14	3.99	.15
	night	4.28	.14	.99	.15	4.16	.16
	combined	4.29	.11	.99	.11	4.07	.12
1987	day	3.98	.16	.72	.11	3.93	.19
	night	4.00	.15	.59	.10	4.03	.18
	combined	3.99	.11	.65	.07	3.98	.14
1988	day	4.39	.14	.79	.10	4.08	.16
	night	4.32	.17	.83	.11	4.17	.19
	combined	4.36	.12	.81	.08	4.12	.14

Table 6. Results of the paired t-test for the 1988 cruise
(log weight)

SPECIES	MEAN (DAY-NIGHT)	STD ERROR	T	PR> T
COD	.124	.108	1.15	.255
WHITE HAKE	.058	.103	.56	.578
AMERICAN PLAICE	.002	.087	.02	.984

Table 7. Stratified mean catch/tow (unlogged weight/tow)

YEAR	COD		WHITE HAKE		AMERICAN PLAICE		
	mean	se	mean	se	mean	se	
1985	day	192.4	93.9	13.0	7.5	40.6	14.0
	night	139.5	53.0	13.2	10.4	35.5	13.3
	combined	170.6	66.4	13.0	8.3	38.8	10.8
1986	day	154.0	64.8	20.5	11.2	53.9	24.0
	night	117.3	43.4	13.6	3.4	42.0	15.1
	combined	135.4	43.1	18.3	8.4	47.9	15.3
1987	day	109.3	46.8	9.2	3.4	48.9	20.2
	night	106.3	38.9	3.3	0.6	37.9	15.1
	combined	103.2	36.3	5.6	2.7	42.3	14.0
1988	day	170.8	71.8	10.4	4.0	51.0	23.3
	night	147.8	60.2	10.1	3.6	40.8	17.0
	combined	157.2	50.3	10.4	3.4	47.0	15.8

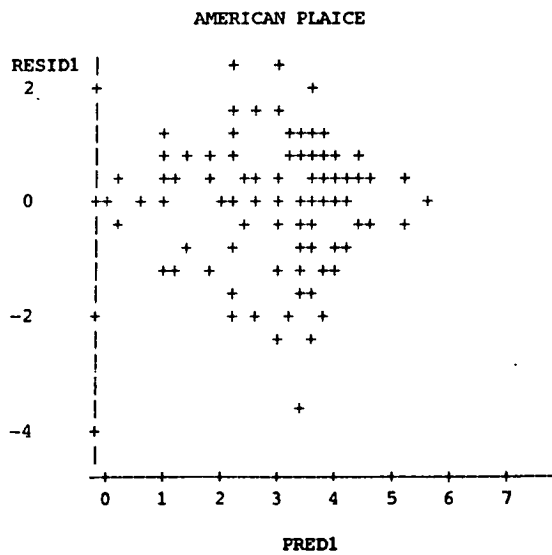
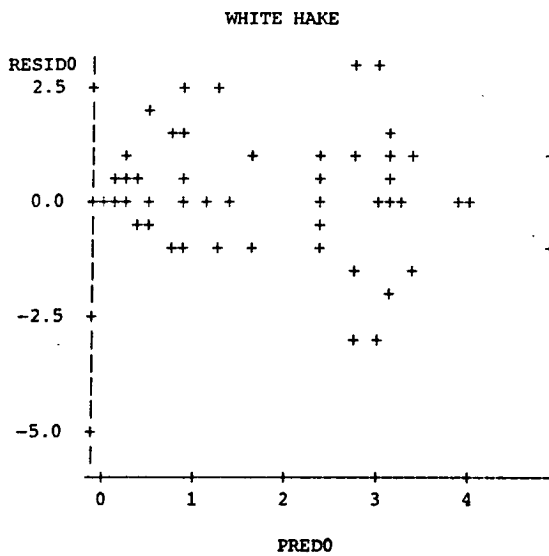
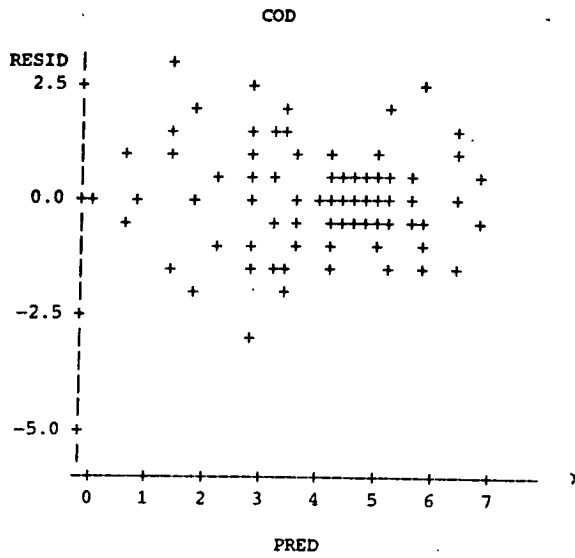


Figure 1. Plots of residual catch/tow versus predicted catch/tow for RVH141 (1985).
a) cod, b) white hake, c) American plaice

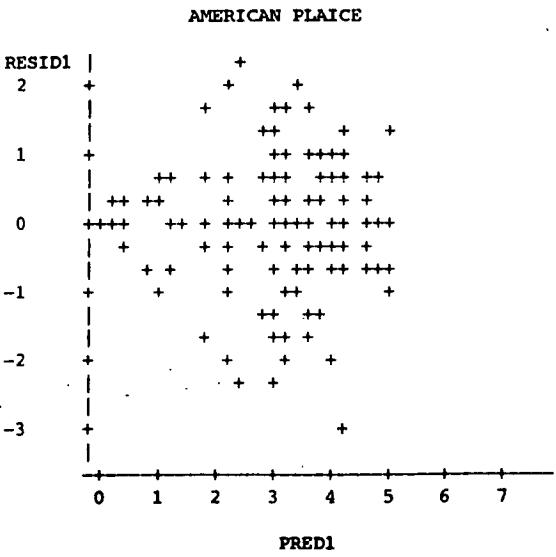
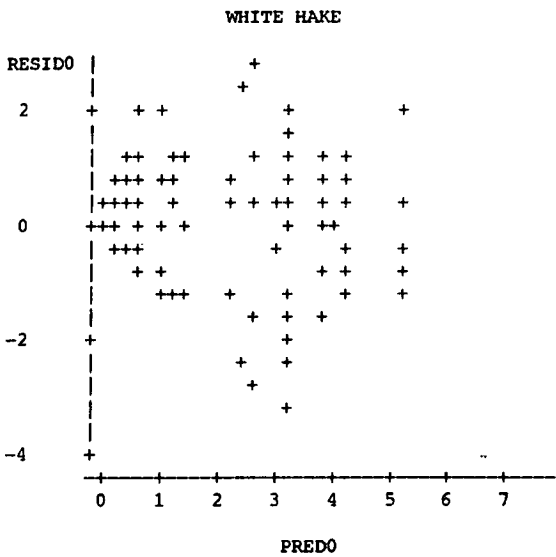
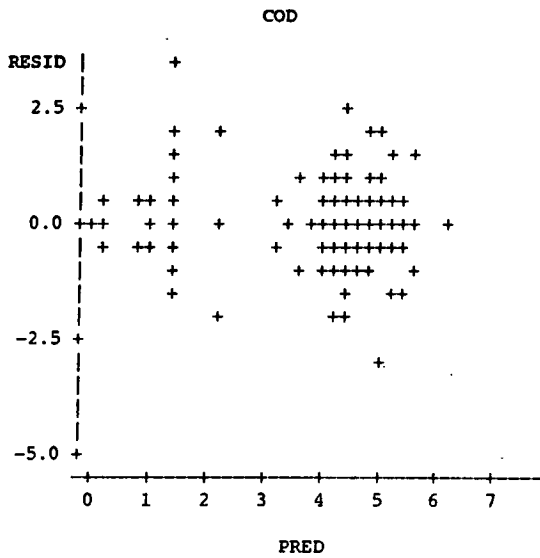


Figure 2. Plots of residual catch/tow versus predicted catch/tow for RVH159 (1986).
 a) cod, b) white hake, c) American plaice

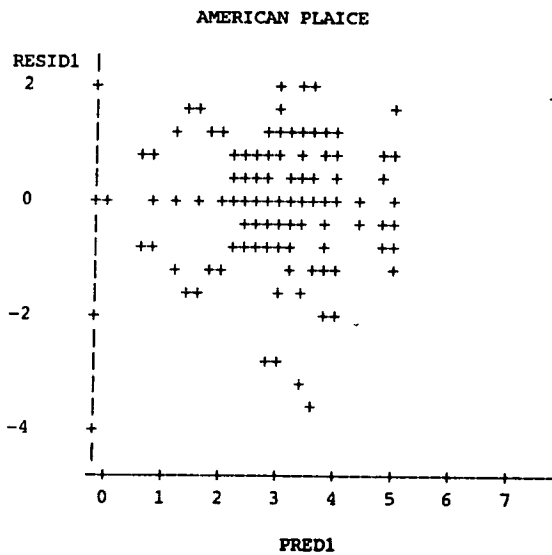
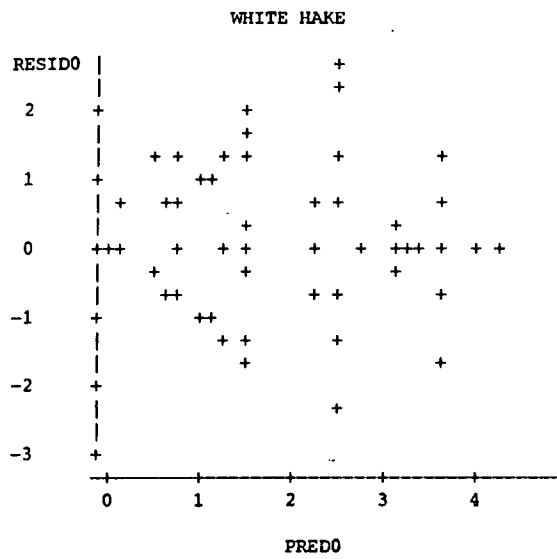
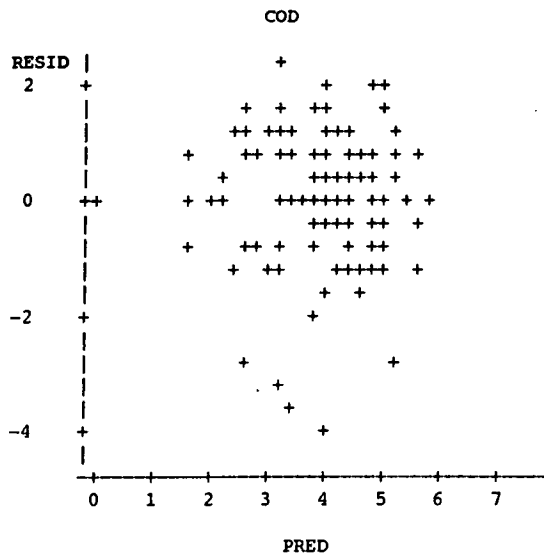


Figure 3. Plots of residual catch/tow versus predicted catch/tow for RVH179 (1987).
 a) cod, b) white hake, c) American plaice

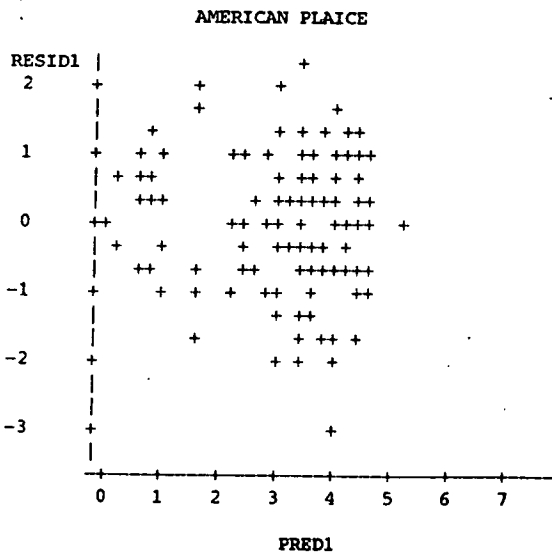
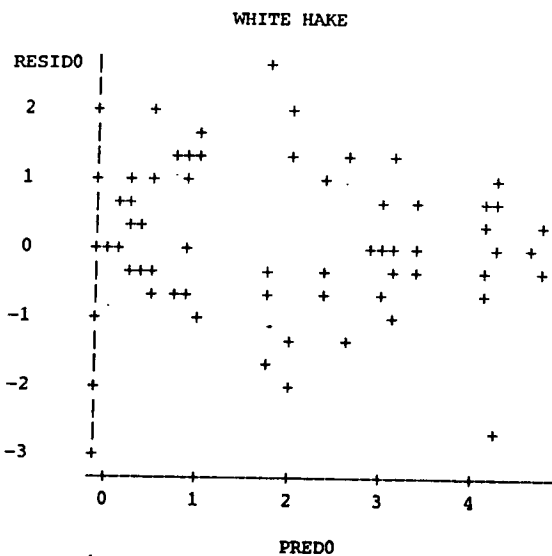
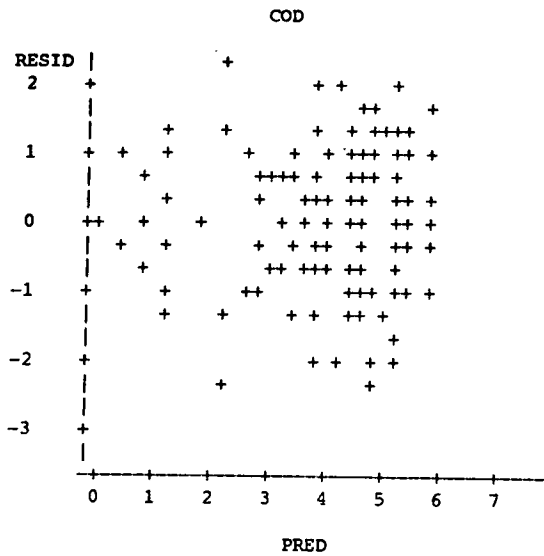


Figure 4. Plots of residual catch/tow versus predicted catch/tow for RVH192 (1988).
 a) cod, b) white hake, c) American plaice

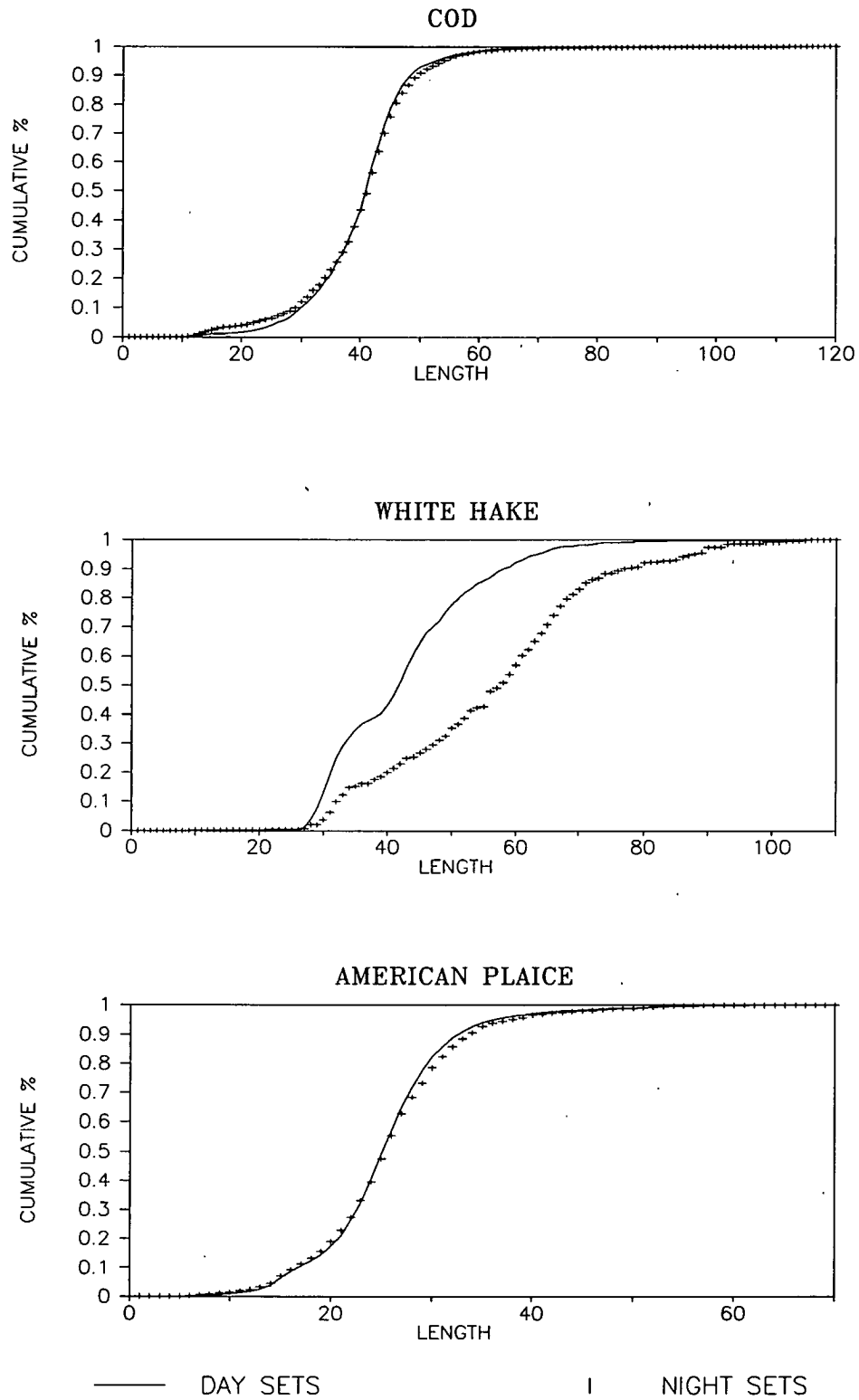


Figure 5. Cumulative length frequencies for RVH141 (1985)

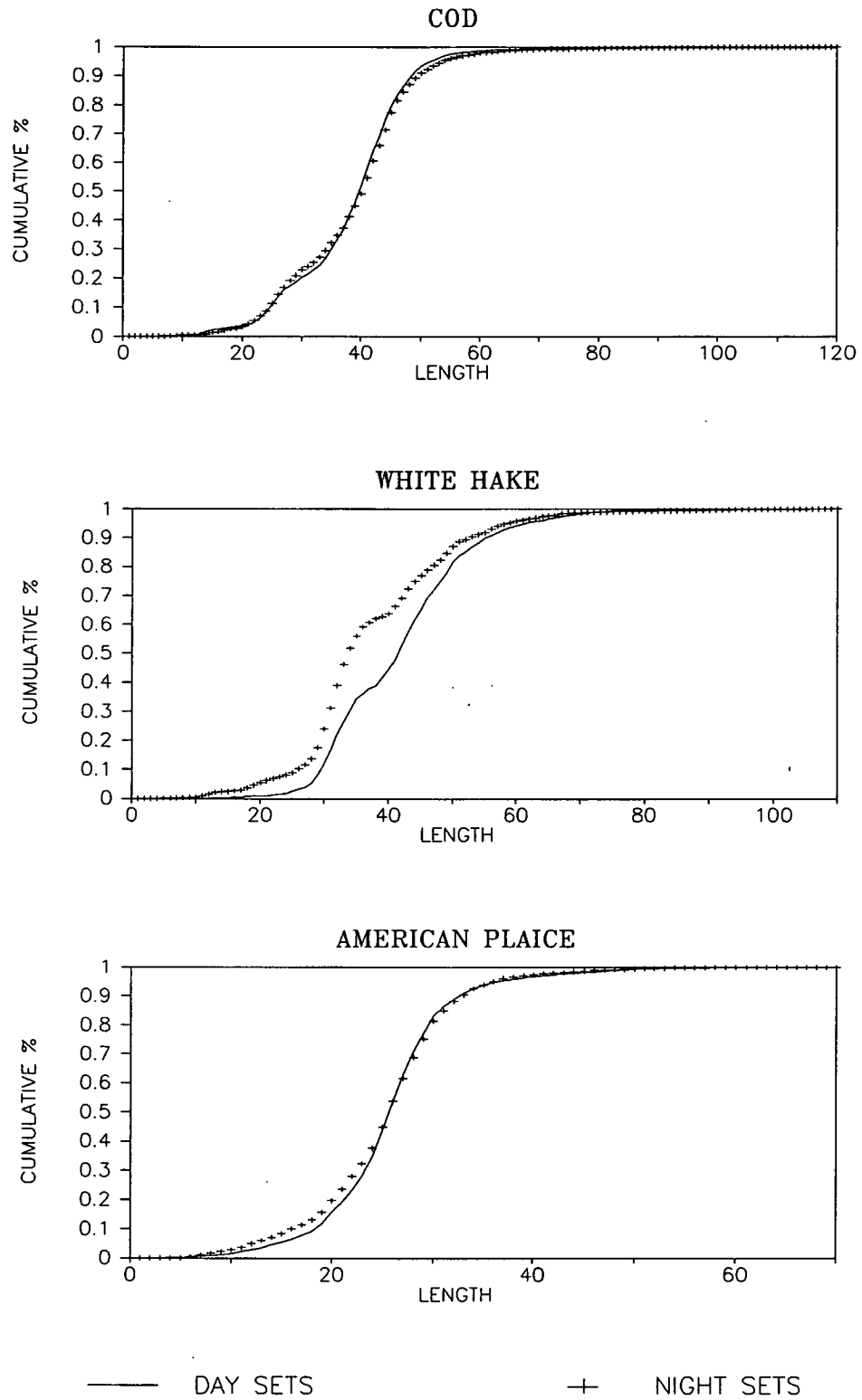
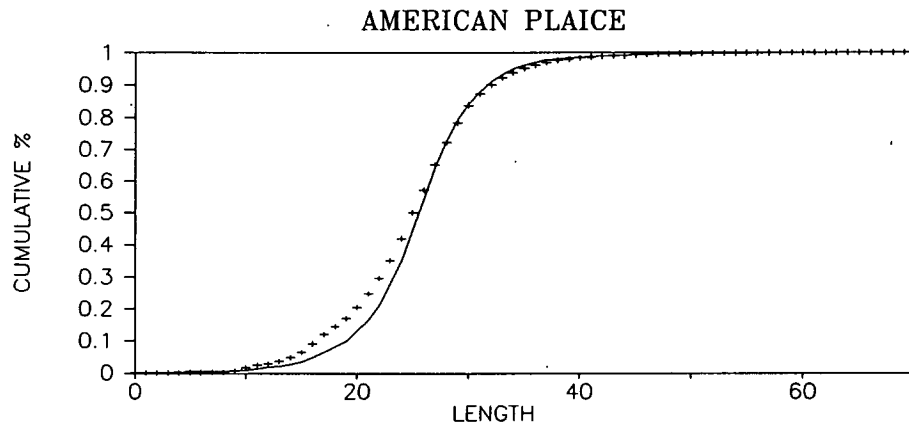
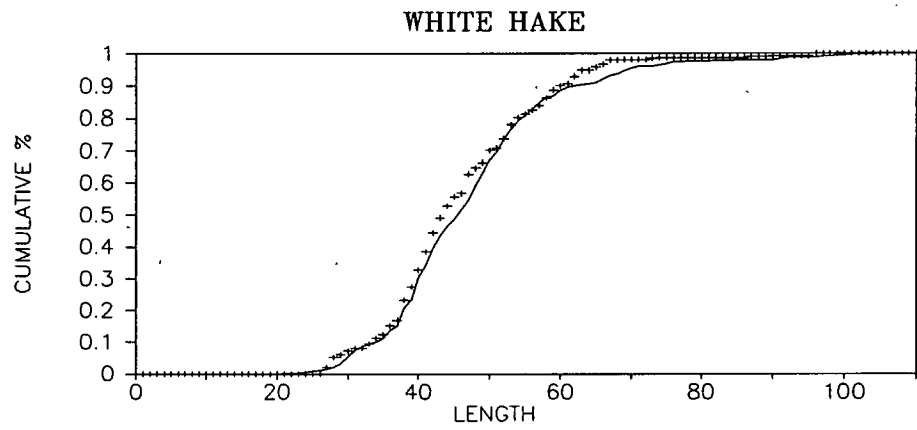
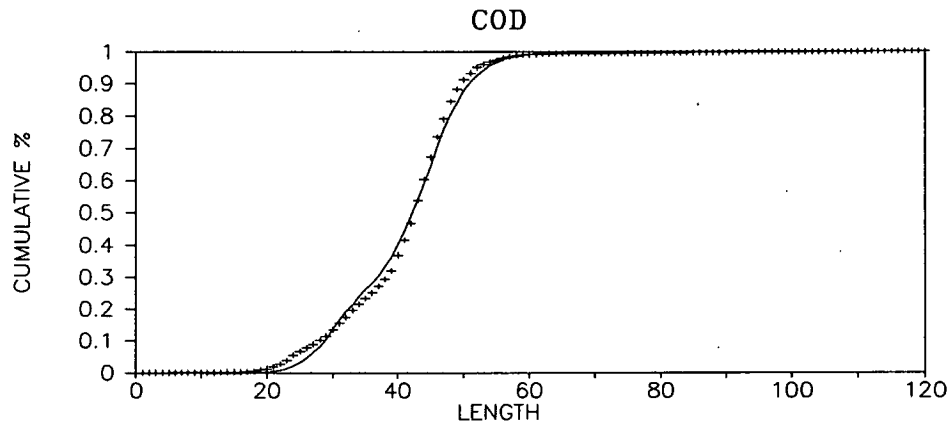


Figure 6. Cumulative length frequencies for RVH159 (1986)



— DAY SETS
+ NIGHT SETS

Figure 7. Cumulative length frequencies for RVH179 (1987)

