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Preliminary Results of a Groundfish Longline Survey on Georges Bank

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Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au secrétariat.

ISSN 1480-4883
Ottawa, 1999

Canada

Abstract

The objective of the Georges Bank groundfish longline survey, which has been underway since 1995, has been to provide a relevant index of abundance for Georges Bank cod and haddock. In order to ensure the validity of the survey, it was necessary to develop certain sampling protocol that would assure that any changes in catch rates between sets and between years could be attributed to changes in stock abundance and not to methods by which the population was sampled. Despite efforts to prioritize the importance of following protocol, there were several variations in sampling practices. Variability in fishing locations, numbers of hooks, and soak times were apparent throughout the survey. It is unknown what effects these variables have on the outcome of the survey, or what effect any attempts to standardize using data manipulation have on the results. However, similarities do exist between population estimates from the Virtual Population Analysis (VPA) and catch from the longline survey. Survey catch values have consistently followed trends that appear in VPA estimates, and a positive correlation exists. An index typically requires several years of consistent sampling before it can be used to evaluate trends in stock status, but so far the longline survey appears to demonstrate a potential for providing a relevant index of cod and haddock abundance.

Résumé

Le relevé à la palangre du poisson de fond, en cours sur le banc Georges depuis 1995, a pour objectif d'obtenir un indice d'abondance adapté à la morue et de l'aiglefin dans cette zone. Afin de garantir la validité du relevé, il a fallu mettre au point un protocole d'échantillonnage qui puisse fournir une assurance que les variations du taux de capture observées entre chaque mise à l'eau et chaque année soient attribuables aux variations de l'abondance des stocks et non aux méthodes employées pour l'échantillonnage des populations. Malgré les efforts déployés pour assurer la conformité au protocole, plusieurs sources de variabilité ont été constatées dans les méthodes d'échantillonnage. Des différences entre les lieux de pêche, dans le nombre d'hameçons et le temps de mouillage ont été manifestes tout au long du relevé. Les effets de ces variables sur les résultats du relevé ne sont pas connus, pas plus que ceux d'une tentative de normalisation qui serait obtenue par traitement des données. Des similarités existent néanmoins entre les estimations des populations, obtenues par analyse de populations virtuelle (APV), et les données sur les prises provenant du relevé à la palangre. Invariablement, les données sur les prises ont été conformes aux tendances des valeurs estimées par APV, et il existe une corrélation positive entre les deux. Certes, un indice doit reposer sur plusieurs années d'échantillonnage uniforme avant de pouvoir servir à étudier les tendances des stocks, mais le relevé à la palangre semble jusqu'ici un moyen prometteur pour mesurer l'abondance des stocks de la morue et de l'aiglefin.

Introduction

A groundfish longline survey has been underway in the Canadian waters of Georges Bank since 1995. The objective for the survey was to develop an unbiased and relevant index of abundance for Georges Bank cod and haddock that could be incorporated into the evaluation of stock status. The fishing industry requested that longline fishing be used to conduct the survey, believing that this fishing method could provide an index that would be independent of the DFO (March) and NMFS (Feb-Oct.) research survey indices already in use.

In order for the longline survey to provide an index that can be incorporated into the evaluation of stock status, it must meet certain design criteria that would ensure an unbiased estimate of abundance. This report outlines the objectives and design of the survey, the difficulties with implementing the design, and the survey results. Evaluation of the survey as a relevant index of abundance for cod and haddock on Georges Bank was based on comparison with population estimates from the 1999 assessment results (Hunt et al., 1999).

Methods and Materials

The longline survey was developed after discussions with industry representatives, which outlined the objectives of the study. To ensure the validity of the survey, it is necessary to maintain a time series of estimates that are derived using constant fishing practices and sampling protocol. This would ensure that any changes in catch rates between sets and between years are due to changes in stock abundance and not due to methods in which the population is sampled. It was important that fishing operations be defined from the outset and remain constant throughout the years of the longline survey.

The longline survey was initiated in 1995, using a box design with one set allocated to each box. The survey has been conducted each year since 1995, using a minimum of three and a maximum of five vessels per year. Gear was standardized between vessels to minimize vessel variance, and boxes were assigned to vessels in order to achieve a mix of high and low expected catch rates for each vessel. Details of the current survey design (1999) are found in Appendix A.

Development of Box Design and Station Positions :

In order to maintain even coverage and unbiased sampling, Georges Bank 5Zj,m (Canadian waters only) was partitioned into box areas of approximately 50 nm². The 1995 survey only sampled waters less than 50 fathoms deep. Therefore, a modification was made to the box design in 1996 that would incorporate the 50 and 100 fathom depth contours as basic box boundaries. A total of 73 boxes have been outlined for Georges Bank, with 34 of these designated for fishing by industry representatives. Boxes were designated based on the catchability of cod and haddock within each box. Industry excluded boxes which covered areas where past experience showed poor catch rates, and it could be assumed that fishing would result in negligible catches of cod or haddock.

One standardized fishing sample was to be taken from each of the 34 designated boxes in each survey since 1996 (1995).

For the first year of the survey, the initial choice for the sampling station position within each box was at the discretion of the vessel's captain. Once determined, this coordinate position was to be maintained for each successive year of the survey.

Captain's Protocol and Fishing Practices:

Participants of the longline survey were selected by industry representatives. The choice of survey participants necessitated that they be willing to follow proper sampling procedures established at the outset of the survey. Captains needed to be aware of the importance of following procedures and maintaining protocol in order to reach conclusions that were representative of Georges Bank groundfish stocks. This meant that captains were to remain unbiased of the outcome of the survey, and of their sampling.

Sampling was conducted from mid August to mid September. Three to five vessels of various sizes were used in each year of the survey. Vessel size plays an insignificant role in the outcome of the longline survey. Sampling results are due to the size and number of hooks used, and the amount of time the hooks remain in the water (soak time). For the longline survey, fishing at the pre-determined locations were standardized to 1500 hooks (size EZ 12) for each fishing sample. More than one set, with a combined total of 1500 hooks, could be used to equal one sample. Each set was to be completed within a 0.5 nautical mile radius of the designated site. Soak time was also standardized, with a range of six to eight hours.

Measurements and counts of the fish in each sample were conducted by an unbiased observer on board the survey vessel. The presence of the observer was intended to decrease any bias or influence by the captain. Once the lines were brought in, the observer measured the length and weight of each cod and haddock. The total number of fish, and the number at each length and weight were recorded for each set. The data was then entered into the Regional observer database.

Data Analysis:

1995 was removed from the analysis, due to the changes in box dimensions that were implemented in 1996. Nine of the 34 designated boxes were also removed from the data analysis. A box was removed if a sample was not taken within the box in each year, or if the coordinates of all the sets making up the sample were so far removed from the pre-determined coordinates that they were not representative of that sample location. If more than one set was taken to represent a sample in a given year, then it was possible to simply remove any stray sets from the sample, without having to remove the entire box from the analysis. For the sampling years 1996, 1997 and 1998, there were 25 boxes that were considered useful for data analysis.

The number of fish caught at length for each sample was multiplied by a conversion factor, (1500/actual number of hooks used for the given sample), in order to convert catch

and effort to a standard catch-per-unit-effort. This equated the number of fish caught to the number that would have been caught, had 1500 hooks been used for the sample. For samples consisting of multiple sets, fish from all sets were totaled at length and then multiplied by the conversion factor. Any deviations from the pre-determined soak time of 6-8 hours could not feasibly be standardized in the data analysis process.

Length frequency distributions were calculated each year, using the adjusted catch values, for each of the 25 boxes in the analysis. Catch rates from the 25 frequency distributions were then totaled for each year, which resulted in one length frequency distribution per year. The catch from each distribution was then aggregated to 3 cm length intervals for cod, and 2 cm length intervals for haddock. Age-length keys, calculated using data taken from Canadian Commercial Landings and the Observer Program (OP), (third quarter, all gear combined, combined sexes), were converted to proportional age-length keys for each year of the survey. The appropriate key was then applied to the length frequency for each year. This produced a measure of the catch at age for each year of the longline survey.

Comparisons were made between age groups from the Virtual Population Analysis (VPA) population estimates, calculated using ADAPT (Gavaris, 1988), and catch at age from the longline survey. For each year, the population estimates and the survey catch values were converted to percent population at age and percent catch at age respectively. Each age group from each analysis were plotted together in order to determine whether or not the longline survey followed population trends estimated for Georges Bank.

Scatter plots were created for both cod and haddock, which plotted each VPA estimate of abundance for a given age group in a given year against the longline survey catch rate for the same age group in the same year. The slope of the 'line of best fit' would determine whether a correlation existed between the VPA estimates of abundance and the age distribution of the catch from the longline survey. A positive correlation would show that the catch from the longline survey followed population trends in Georges Bank.

Results

Conformity to Design:

Despite efforts to prioritize the importance of following sampling procedures that were set out at the beginning of the survey, there were several variations in sampling practices. Although the coordinates of the sampling sets were fixed within each box, the locations that were actually fished varied so widely that some sets had to be removed from the analysis. In some cases, this was responsible for removing a box from the analysis. In other cases, no effort was made to sample at certain fixed locations. The absence of a sample for any of the three years (1996-98) that the survey data was analyzed resulted in the removal of a box. In total, 25 of the 34 boxes that were designated for fishing could be used for the analysis of the survey (Figure 1). Figure 2 shows the pre-determined fishing locations plotted against the actual set locations that were fished each year, demonstrating the variation of fishing locations.

The number of hooks per sample that were to be used for fishing was 1500. Variability in hook numbers forced standardization to be done in the analysis process. Cod and haddock catches were multiplied by a conversion factor. The box number, actual number of hooks used for fishing the sample, and the adjusted catch rates of cod and haddock are shown for each year in Table 1. Table 2 shows box numbers, individual sets that make up samples, the number of hooks per set and the soak time per set for cod and haddock. Soak times were also highly variable among sets, which could not be feasibly standardized to 6-8 hours with conversion factors.

Catch rate-at-age was calculated for cod and haddock (Table 3 and Figure 3). In 1998, the greatest numbers of cod caught were at age 3, while the greatest proportion caught in 1996 and 1997 were at age 4. Numbers of age 4 cod caught in 1998 were significantly lower than in previous years. However, 1998 saw a proportionately higher catch of cod aged 5 and over. For haddock, the 1992 yearclass was well represented in the numbers from the longline survey, as 4 year olds in 1996, 5 year olds in 1997 and 6 year olds in 1998. In 1998, the greatest number of haddock were caught at age 5. There was also a greater number of age 5+ haddock caught in 1998 than in previous years of the survey. For 1996 and 1997, the highest proportion of catch was of age 4 haddock.

Length frequency distributions were made for cod and haddock, representing each year of the survey (Figure 4). The length frequency distribution for cod shows a sharp peak at 60 cm in 1998, resulting from the high number of age 3 fish caught. There is a more gradual peak at 65 cm in 1996, and in 1997 a double peak appears at 50 cm and 70 cm. The distribution of haddock peaks at approximately 55 cm for every year of the survey. For both cod and haddock, the distribution plot shows that fewer haddock were caught in 1996 than in 1997 or 1998.

The length frequency distributions demonstrated a wide range of lengths sampled by the longline survey, particularly for cod. This demonstrates the potential for a longline survey to follow population trends in the stock. For cod in 1997, the distribution peak at 50 cm coincided with high VPA population estimates at age 2 (Figure 7). The second peak, at 70 cm, represented the large population of age 4 and 5 cod. The sharp peak at 60 cm in 1998 represented the high proportion of age 3 fish estimated by the VPA analysis.

The expanding circle distribution plots of cod (Figure 5) show low catch rates in 1996, with the highest catch occurring at the northwest portion of the survey area. High catch rates also occurred in the northwest section in 1997. Catch rates peaked at two locations in 1998, one at the northwest section and another at the northeast section of the Bank.

Haddock distribution plots (Figure 6) show low catch rates in 1996, with the highest catch occurring in the northeast portion of the Bank. Catch rates were fairly well dispersed in 1997. In 1998, the highest proportion of catch was found in the north-central section of Georges Bank.

Index of Abundance:

Comparisons of cod age groups, using proportional VPA estimates and proportional longline catch rates (Figure 7 and Table 4b), showed fairly good correlation between the two. The longline survey followed trends in the age 2 group, except in 1997. A population increase in age 2 cod was not consistent with the longline survey, which caught a fair number of 2 year olds. Also in 1997, the proportion of catch rates at age 3 cod did not follow the population decrease of the VPA analysis. Catch proportions followed population trends throughout the years for age 4 cod. In 1998, population estimates showed a decreased proportion of age 5 cod from the previous year, while the survey caught an increased proportion of cod aged 5. In 1996, the survey showed somewhat higher catch proportions of age 6 and 7 cod, while the VPA analysis showed fairly low proportions of population. The population trend was consistently followed by the survey for age 8 cod. In spite of a few exceptions, trends in the catch rates from the longline survey were consistent with trends in the population estimates from the VPA analysis.

Comparisons of haddock age groups (Figure 8 and Table 5b) also showed good correlation between the longline catch values and the VPA analysis of population. Trends in the proportion of catch in the survey showed an increase of age 2 haddock between 1996 and 1997, while the estimates of population showed a slight decrease. Trends in the proportion of catch consistently followed the VPA estimate for haddock aged 3 through 7. For age 8 haddock, a decrease in population was not picked up by the longline survey, which showed an increase in proportional catch of age 8 fish between 1997 and 1998.

Scatter plots, which plotted VPA population estimates against longline catch values (Figure 9, Table 4a, Table 5a) showed a positive correlation between the longline index and the VPA estimate of abundance for both cod and haddock. Catch rates in the longline survey generally showed increases or decreases in both cod and haddock, which coincided with fluctuations in VPA estimates of abundance.

Discussion

Variability in sampling procedures remains a problem for the longline survey. It is unknown what effects the variability of fishing methods, such as hook numbers and soak time, have on the outcome of the survey, or what effect the attempts to standardize using data manipulation have on the results. Using data manipulation, the results of several samples showed only an estimate of what may have been caught, had proper sampling methods been followed. Variability of soak time could not be corrected mathematically, and it is unknown what effect this would have had on results.

The incomplete sampling of Georges Bank stocks, due to fishing only the Canadian waters, may have caused some degree of bias in abundance estimates that is difficult to quantify. There was a further loss of area coverage where variability in sampling locations excluded several boxes from the analysis. For this report, it was necessary to

assume that distribution and density of the groundfish in the unsampled area were equal to that in the sampled area.

The participants of the longline survey were made aware of the importance of following pre-set procedures in order to produce an index that was representative of the Georges Bank groundfish stocks. Captains were to remain unbiased of whatever outcome that their sampling may take. However, bias among the participants is a possible reason for the variability problems that remain in the survey. Vessels are funded by the sample catches, which may influence a captain's capacity to adhere to proper sampling practices. A sample site that is suspected of being unprofitable may be fished less vigorously than a more profitable spot, or not fished at all. Hook numbers, soak time and sample locations all may be varied according to the profitability of the defined box, jeopardizing the integrity of the research survey and its results. The majority of the inconsistencies in the survey can be rectified, with improved awareness by the participants.

Notwithstanding the problems, similarities exist between population estimates from the VPA and catch rates from the longline survey. Throughout the years of the survey, catch rates have consistently followed trends that appear in the VPA population estimates. A positive correlation exists between the VPA measure of abundance and longline catch rates, which demonstrates the potential of the longline survey for providing a relevant index of abundance.

Despite inconsistent sampling practices, the results from the analysis demonstrate that the longline survey can measure cod and haddock abundance. An index requires several years of consistent sampling and data collection before it can be used to evaluate trends in stock status. The groundfish longline survey appears to be a worthwhile effort to continue.

References

Gavaris, S. 1988. An adaptive framework for the estimation of population size. CAFSAC Res. Doc. 88/29.

Hunt, J.J., and T.L. Johnston. 1999. Population Status of Eastern Georges Bank Cod (Unit Areas 5Zj,m) for 1978-99. CSAS Res. Doc. 99/77.

Figure 1: Boxes defined for the Groundfish Longline Survey of Georges Bank. The boxes designated for fishing are also shown.

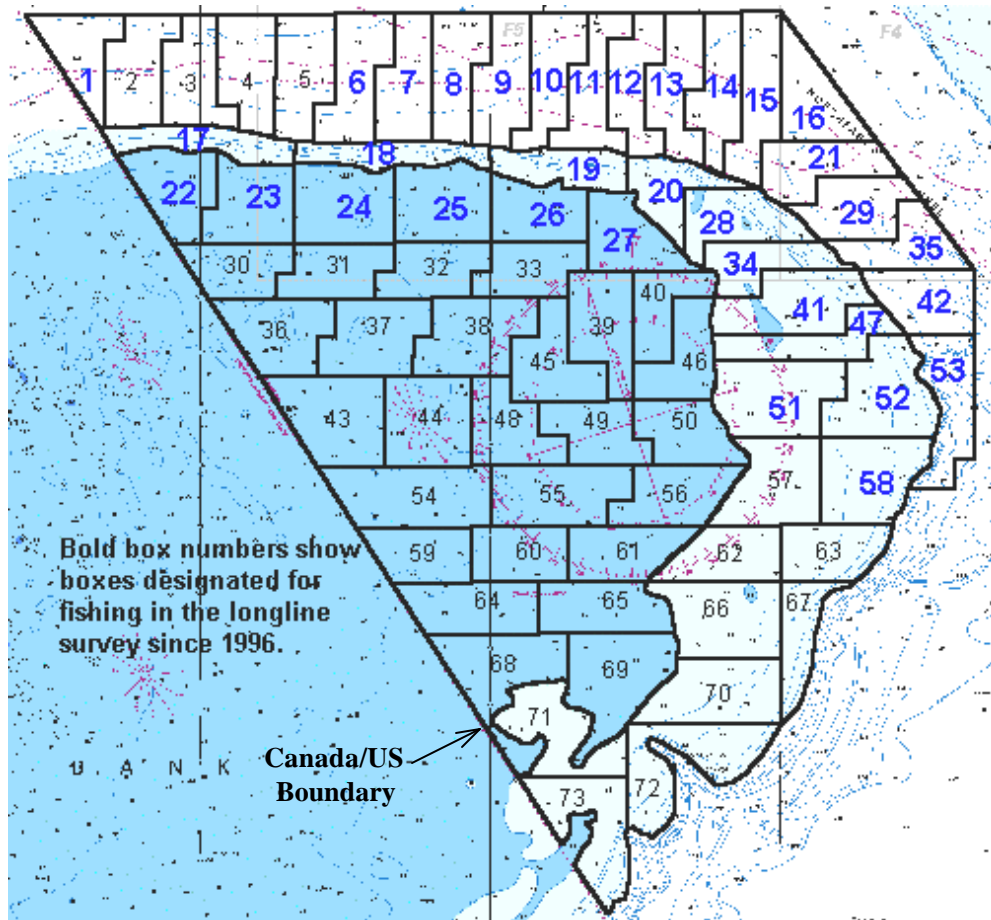


Figure 2: The location of designated fishing areas (diameter=1 nautical mile) for each fishing box, along with the actual sampling locations for each year of the survey.

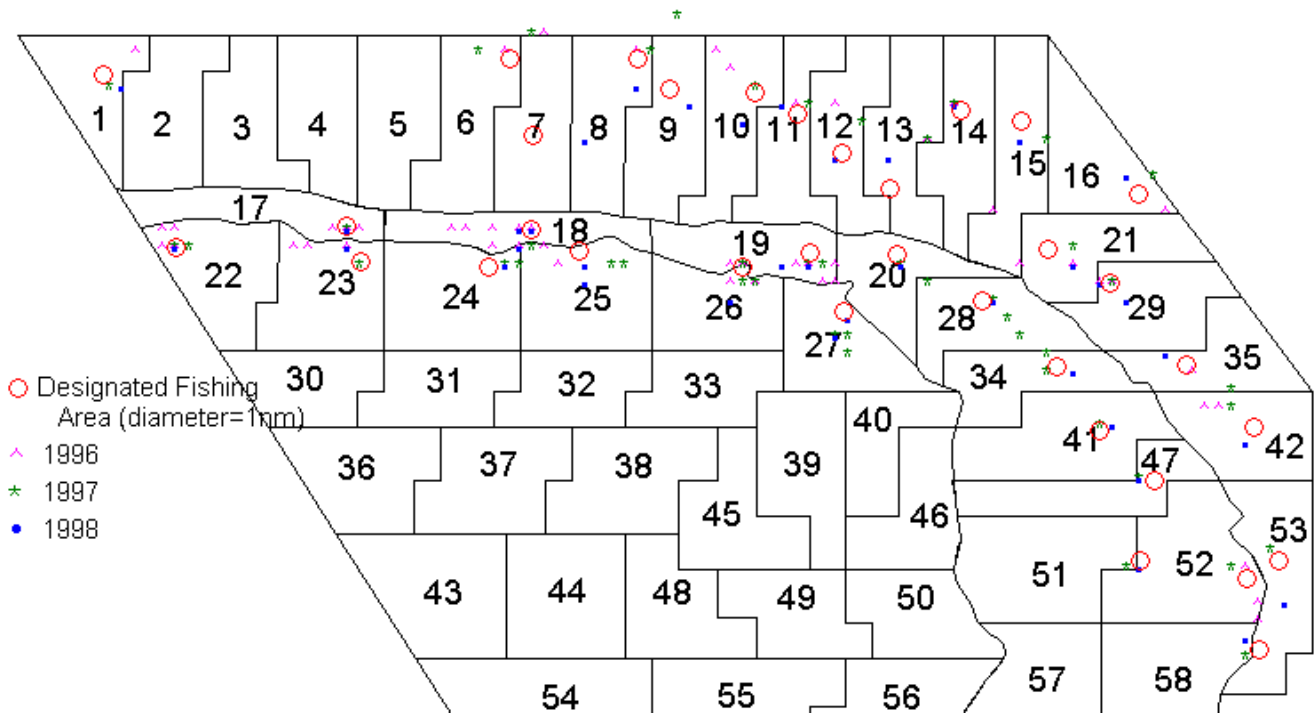


Table 1: Box number, number of hooks and adjusted catch (catch/1500 hooks) for cod and haddock. There is one table for each year of the survey.

1996

Box #	Hooks	Cod wt (kg)	# Cod	Had wt (kg)	# Had
1	450	33.33	13	150.00	43
7	1800	64.17	21	415.83	149
8	1800	181.67	33	321.67	149
10	3600	198.33	45	268.75	128
11	1800	351.67	116	181.67	93
12	1800	321.67	127	245.83	134
13	1800	255.00	103	245.83	178
14	1800	378.33	135	262.50	160
15	1500	668.00	146	365.00	181
16	1500	490.00	98	0.00	47
17	1500	1195.00	388	220.00	87
18	3750	1311.60	312	368.00	149
19	1750	2126.57	102	597.43	89
21	1500	580.00	147	115.00	57
22	1500	1475.00	489	2.00	1
23	1185	39.24	13	6.33	3
24	900	1833.33	558	150.00	63
25	1500	1897.00	156	256.00	56
26	2250	1777.33	74	75.33	4
27	750	2180.00	50	274.00	0
28	1250	336.00	113	1.20	1
29	1500	877.00	73	11.00	14
35	1500	247.00	51	370.00	183
42	1500	420.00	100	0.00	0
53	1500	85.00	46	48.00	33

1997

Box #	Hooks	Cod wt (kg)	# Cod	Had wt (kg)	# Had
1	1500	124.00	0	0.00	40
7	1500	83.00	16	710.00	236
8	1500	42.00	8	179.00	69
10	1500	182.00	53	199.00	100
11	1500	290.00	103	221.00	121
12	1500	304.00	114	205.00	101
13	1500	408.00	158	310.00	177
14	1500	204.00	77	284.00	158
15	1500	345.00	102	650.00	154
16	1500	530.00	117	145.00	59
17	1500	1498.00	586	402.00	199
18	1500	612.00	211	222.00	115
19	1440	1489.58	413	432.29	205
21	1500	705.00	117	590.00	146
22	1500	789.00	332	0.00	0
23	1500	367.00	219	56.00	38
24	1500	527.00	199	217.00	115
25	1440	1213.54	390	411.46	166
26	1440	215.63	80	56.25	31
27	1440	338.54	102	15.63	11
28	1620	597.22	166	86.11	25
29	1500	765.00	146	355.00	147
35	1500	590.00	93	235.00	121
42	1500	885.00	70	885.00	186
53	1500	650.00	24	135.00	170

Table 1 continued: Box number, number of hooks and adjusted catch (catch/1500 hooks) for cod and haddock in 1998.

1998					
Box #	Hooks	Cod wt (kg)	# Cod	Had wt (kg)	# Had
1	1710	3.51	34	114.91	0
7	1710	477.19	134	274.56	117
8	1710	95.61	27	95.61	43
10	1710	124.56	39	357.89	193
11	1505	139.53	16	368.77	184
12	1505	254.15	125	289.04	177
13	1505	363.79	186	269.10	172
14	1500	177.00	50	115.00	92
15	1505	697.67	163	657.81	217
16	1505	1196.01	193	448.50	148
17	1710	1415.79	468	231.58	128
18	1710	1217.54	347	382.46	183
19	1505	1644.52	284	179.40	108
21	1500	491.00	208	213.00	104
22	1710	2236.84	586	38.60	21
23	1710	515.79	243	71.93	40
24	1710	2530.70	521	113.16	61
25	1710	1450.88	608	152.63	120
26	1505	1026.58	164	598.01	225
27	1505	767.44	77	39.87	18
28	1500	491.00	193	191.00	144
29	3005	835.11	211	149.25	77
35	1505	1275.75	118	363.79	126
42	1505	916.94	199	174.42	86
53	1500	251.00	87	259.00	133

Table 2: Box number, set number, number of hooks and soak time for sets used in the analysis. There is one table for each year of the survey.

1996

Box #	Set #	Hooks	Soak (hrs.)	Box #	Set #	Hooks	Soak (hrs.)
1	18	450	1.58	23	4	435	9.25
6	9	1800	5.85	23	11	450	8.41
7	8	1800	6.07	23	12	300	8.91
8	7	1800	9.65	24	8	300	12.25
10	5	1800	7.16	24	10	600	5.66
10	6	1800	7.05	25	3	500	7.21
11	4	1800	9.24	25	4	500	5.5
12	3	1800	9.34	25	5	250	4.07
13	2	1800	9.8	25	6	250	4.65
14	1	1800	8.32	26	7	500	5.82
15	1	1500	8.08	26	8	250	5.05
16	5	1500	7.98	26	9	500	6.5
17	1	150	8.08	26	10	500	7.58
17	2	750	5.1	26	11	500	6.05
17	3	600	7	27	15	250	7.18
18	1	750	9.68	27	17	250	4.9
18	2	750	11.45	27	18	250	5.22
18	5	450	16.75	28	20	1250	4.26
18	6	600	10.46	29	2	600	8.27
18	7	600	8.17	29	3	900	9.3
18	9	600	6.67	35	6	600	6.73
19	12	500	10.96	35	7	900	7.72
19	13	500	12.58	42	8	600	9.43
19	14	250	6.75	42	9	900	8.33
19	16	250	8.08	52	1	600	6.17
19	19	250	5.61	52	2	600	6.75
21	4	1500	8.56	52	3	300	7.2
22	13	300	2.42	53	4	600	9.28
22	14	300	3.42	53	5	600	
22	15	300	4	53	6	300	7.8
22	16	300	3.66				
22	17	300	3.41				

1997

Box #	Set #	Hooks	Soak (hrs.)	Box #	Set #	Hooks	Soak (hrs.)
1	9	1500	3.42	25	13	540	10
6	1	1500	6.21	25	14	540	8.6
7	2	1500	8.48	25	15	360	7.22
8	3	1500	8.93	26	10	540	15.89
9	6	1520	9.62	26	11	540	13.95
10	5	1500	14.22	26	12	360	14.56
11	4	1500	12.02	27	1	360	9.72
12	9	1500	8.8	27	2	360	8.84
13	8	1500	11.8	27	3	360	7.8
14	7	1500	14.81	27	4	360	11.28
15	3	1500	15.47	28	16	540	5.28
16	1	1500	9.34	28	17	540	7.23
17	3	1500	8.95	28	18	540	6.15
18	5	1500	8.75	29	4	1500	9.73
19	5	540	11.12	34	1	900	7.16
19	6	360	9.03	34	4	600	7.17
19	7	540	9.65	35	5	1500	12.87
20	8	720	10.98	41	2	900	8.08
20	9	720	9.92	41	5	600	7.42
21	2	1500	12.72	42	6	1500	15
22	6	600	7.83	47	3	900	9.17
22	7	600	6.58	47	6	600	7.66
22	8	300	7.88	51	7	1500	8.58
23	4	1500	10.5	52	8	1500	9.17
24	1	1200	8.34	53	7	1500	17.33
24	2	300	9.21	58	9	1500	9.9

Table 2 continued: Box number, set number, number of hooks and soak time for sets used in the 1998 analysis.

1998

Box #	Set #	Hooks	Soak (hrs.)	Box #	Set #	Hooks	Soak (hrs.)
1	12	1710	3.96	23	15	1710	5.9
7	19	1710	8.89	24	1	570	12.17
8	18	1710	6.4	24	2	570	12.97
9	17	1710	14.33	24	3	570	13.59
10	16	1710	12.52	25	6	570	4.32
11	1	1505	12.68	25	7	570	5.2
12	7	1505	10.83	25	8	570	6.07
13	8	1505	14.65	26	2	1505	17.9
14	11	1500	4.9	27	5	860	7.4
15	12	1505	19.65	27	6	645	8.9
16	13	1505	10.83	28	9	1500	4.98
17	13	855	7.88	29	7	1500	7.33
17	14	855	8.95	29	10	1505	16.98
18	4	855	10.49	34	6	1500	7.63
18	5	855	8.75	35	11	1505	20.83
19	3	645	15.48	41	1	1500	7.43
19	4	860	13.91	42	9	1505	14.05
20	10	1500	6.36	47	2	1500	6.36
21	8	1500	9.08	51	5	1500	5.5
22	9	570	12.9	53	3	1500	8.05
22	10	570	13.5	58	4	1500	5.94
22	11	570	14.07				

Table 3: Catch rates at age for cod and haddock in each year of the survey.

Cod

Age	Year		
	1996	1997	1998
1	3.25	8.73	0.00
2	104.68	710.82	574.75
3	935.19	1204.00	2164.12
4	1662.34	1343.73	884.67
5	275.75	461.41	744.51
6	206.49	63.04	511.52
7	66.06	47.30	103.48
8	9.18	33.77	61.10
9+	9.18	21.31	30.56

Haddock

Age	Year		
	1996	1997	1998
1	0.00	0.00	0.00
2	23.94	123.15	334.08
3	398.78	121.16	459.13
4	908.36	1121.87	456.81
5	460.48	942.20	809.29
6	54.79	423.67	645.37
7	19.50	13.19	145.34
8	8.99	15.78	24.03
9	88.34	0.00	4.91
10	27.57	125.53	23.81

Figure 3: Catch at age plots for cod and haddock, comparing each year of the survey.

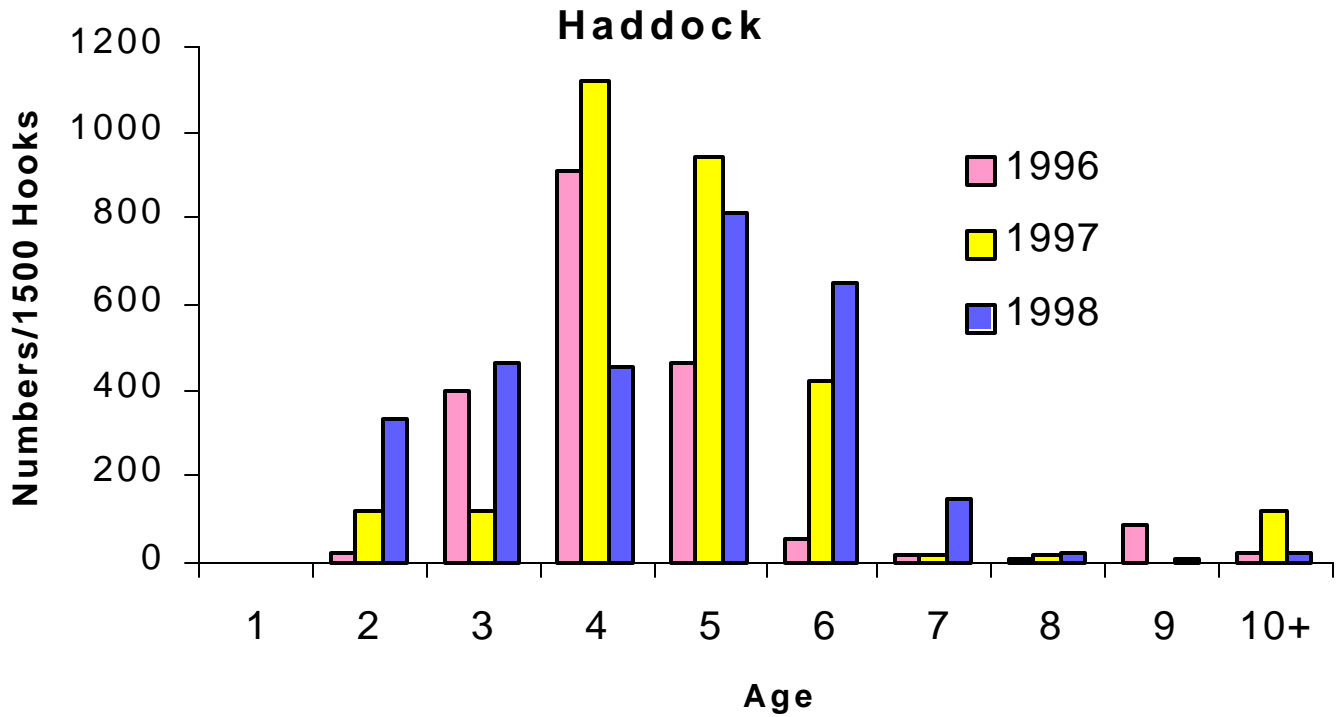
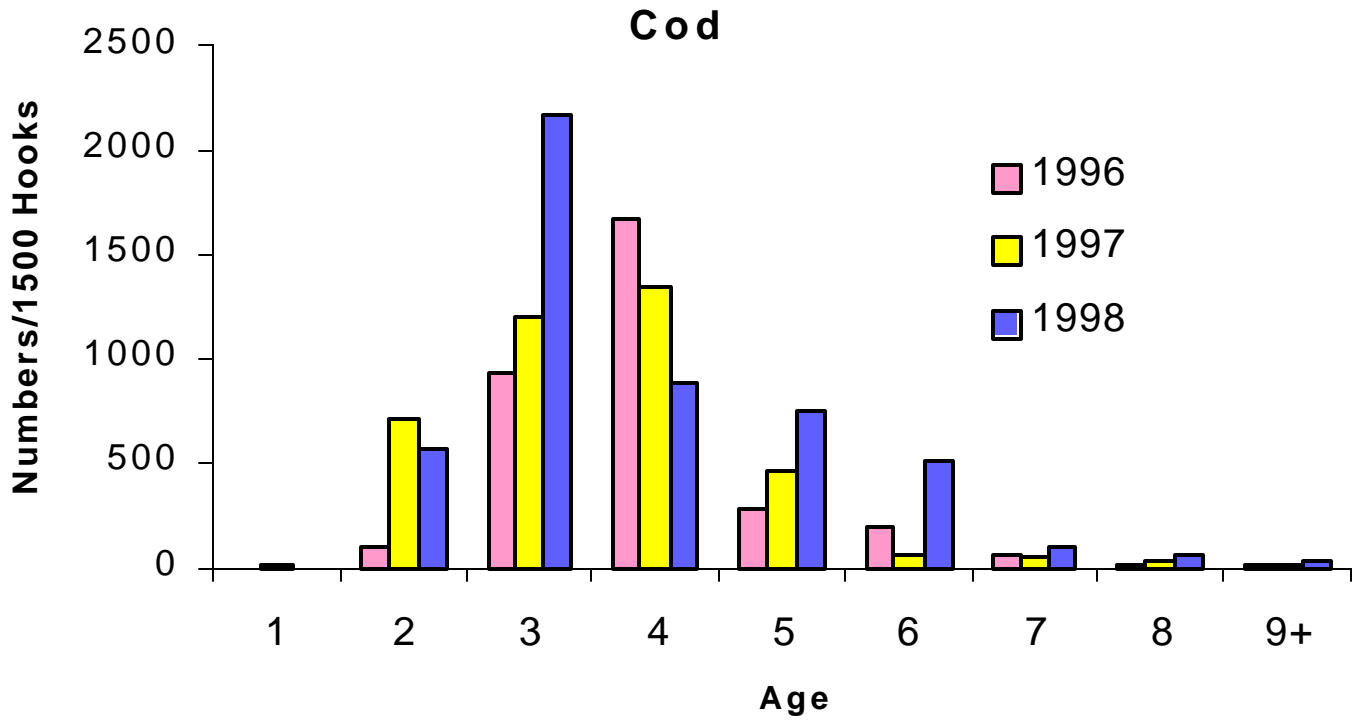


Figure 4: Length frequency distribution plots for cod and haddock, comparing each year of the survey.

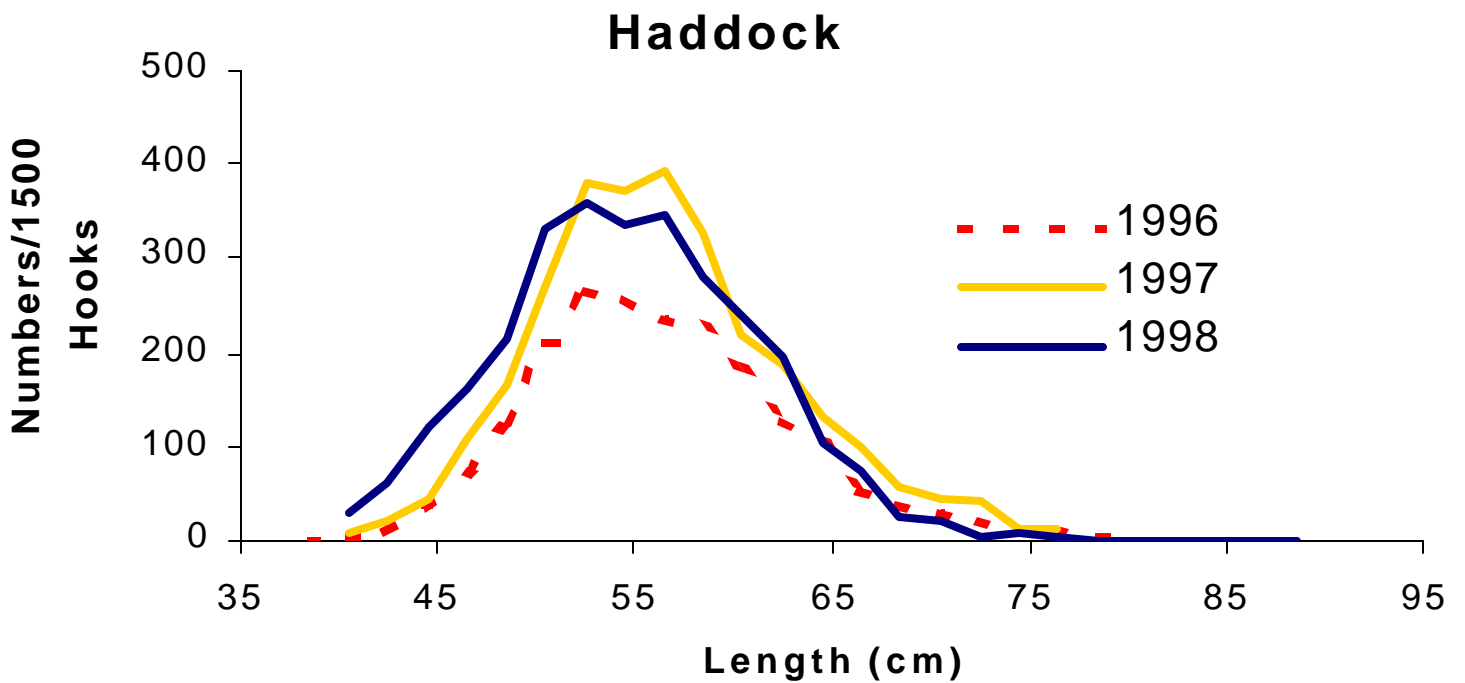
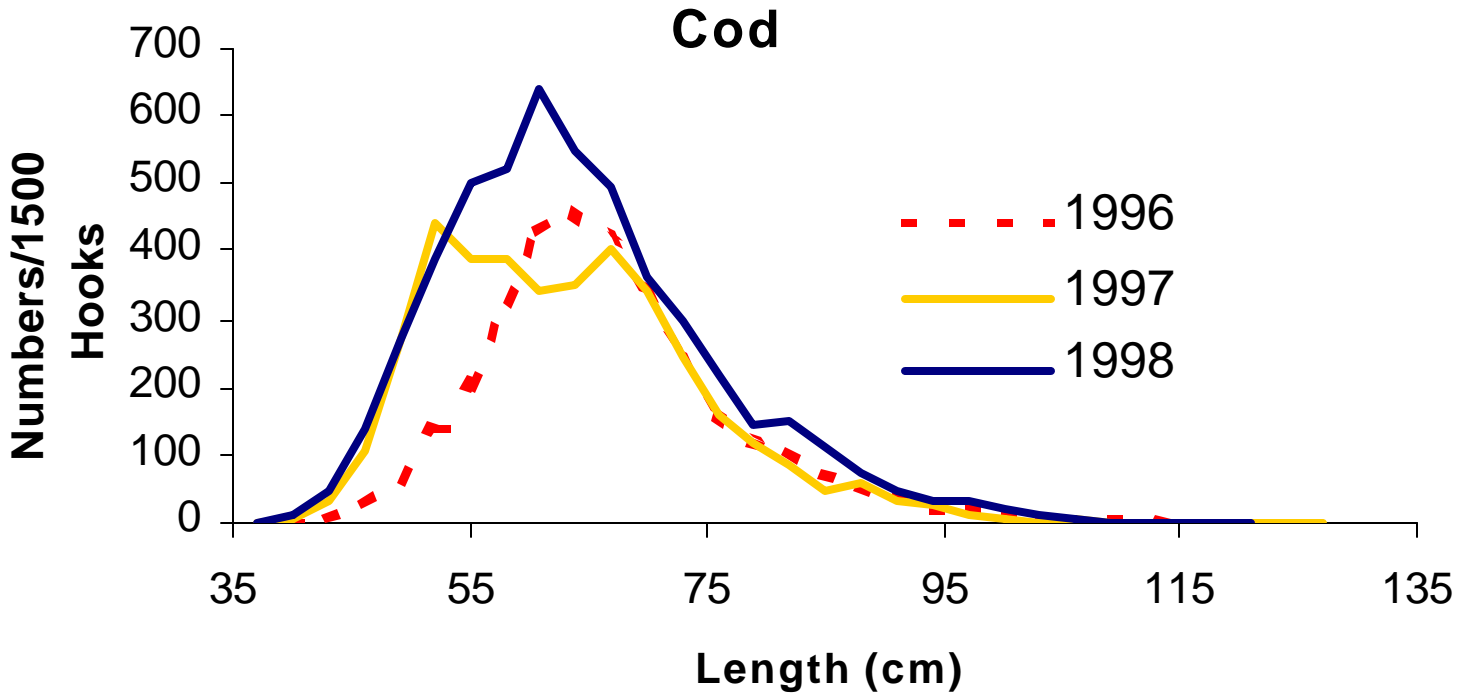


Figure 5: Distribution plots for cod, showing catch (per 1500 hooks) for each year of the longline survey. The Canada/US boundary is represented by a dashed line.

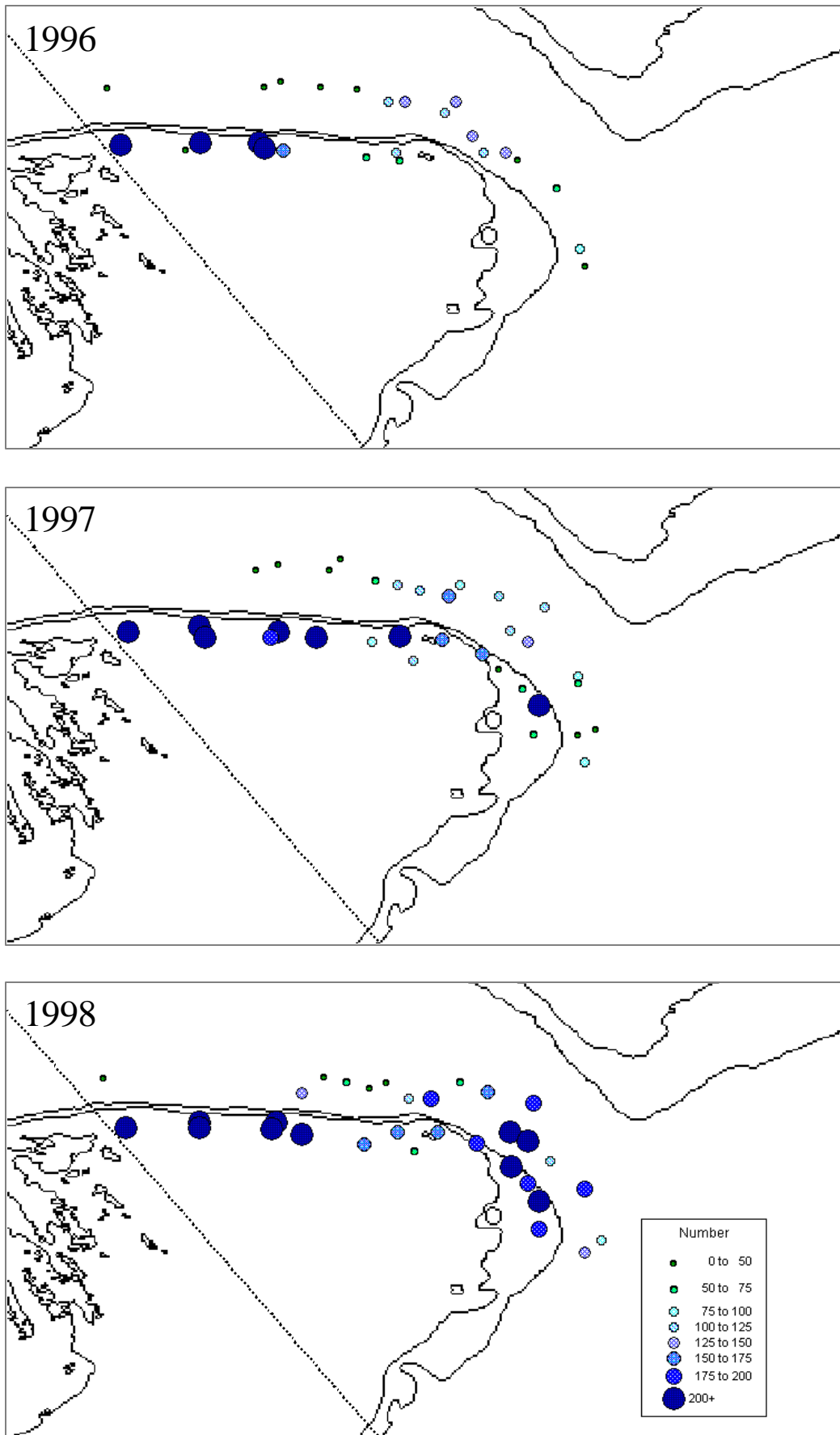


Figure 6: Distribution plots for haddock, showing catch (per 1500 hooks) for each year of the longline survey. The Canada/US boundary is represented by a dashed line.

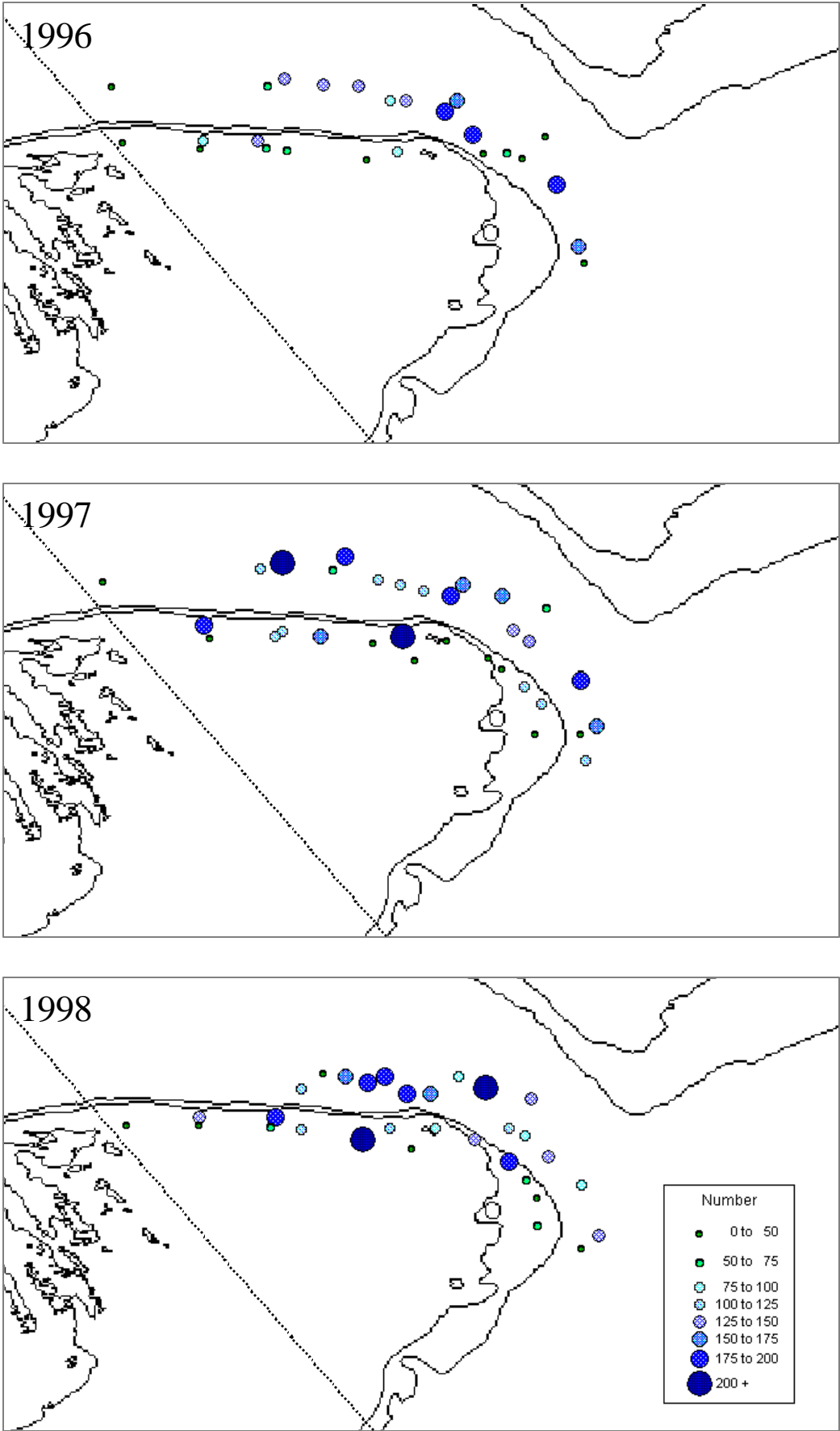


Table 4a: VPA population estimates vs. longline catch rates at age for cod.

	Age 2		Age 3		Age 4		Age 5	
	VPA	Longline	VPA	Longline	VPA	Longline	VPA	Longline
1996	1.32E+06	104.68	1.95E+06	935.19	2.15E+06	1662.34	4.18E+05	275.75
1997	4.12E+06	710.82	1.05E+06	1204.00	1.39E+06	1343.73	1.42E+06	461.41
1998	2.60E+06	574.75	3.28E+06	2164.12	7.16E+05	884.67	8.78E+05	744.51
	Age 6		Age 7		Age 8			
	VPA	Longline	VPA	Longline	VPA	Longline		
1996	2.17E+05	206.49	6.30E+04	66.06	1.30E+04	9.18		
1997	2.75E+05	63.04	1.35E+05	47.30	4.20E+04	33.77		
1998	8.96E+05	511.52	1.62E+05	103.48	8.20E+04	61.10		

Table 4b: VPA population estimates and longline catch rates for cod, converted to proportions of the total population (VPA) or catch (longline) for the given year.

	Age 2		Age 3		Age 4		Age 5	
	VPA	Longline	VPA	Longline	VPA	Longline	VPA	Longline
1996	11.82	3.21	17.46	28.66	19.27	50.95	3.74	8.45
1997	35.53	18.35	9.02	31.09	11.97	34.70	12.20	11.91
1998	27.57	11.39	34.78	42.90	7.60	17.54	9.32	14.76
	Age 6		Age 7		Age 8			
	VPA	Longline	VPA	Longline	VPA	Longline		
1996	1.94	6.33	0.56	2.02	0.12	0.28		
1997	2.37	1.63	1.16	1.22	0.36	0.87		
1998	9.51	10.14	1.72	2.05	0.87	1.21		

Table 5a: VPA population estimates vs. longline catch rates at age for haddock.

	Age 2		Age 3		Age 4		Age 5	
	VPA	Longline	VPA	Longline	VPA	Longline	VPA	Longline
1996	4.14E+06	23.94	6.52E+06	398.78	6.36E+06	908.36	1.89E+06	460.48
1997	5.22E+06	123.15	3.37E+06	121.16	4.89E+06	1121.87	4.41E+06	942.20
1998	1.32E+07	334.08	4.20E+06	459.13	2.68E+06	456.81	3.52E+06	809.29
	Age 6		Age 7		Age 8			
	VPA	Longline	VPA	Longline	VPA	Longline		
1996	1.68E+05	54.79	1.40E+05	19.50	4.00E+03	8.99		
1997	1.16E+06	423.67	8.10E+04	13.19	9.80E+04	15.78		
1998	3.18E+06	645.37	7.80E+05	145.34	5.50E+04	24.03		

Table 5b: VPA population estimates and longline catch rates for haddock, converted to proportions of the total population (VPA) or catch (longline) for the given year.

	Age 2		Age 3		Age 4		Age 5	
	VPA	Longline	VPA	Longline	VPA	Longline	VPA	Longline
1996	16.19	1.28	25.47	21.27	24.85	48.45	7.39	24.56
1997	14.74	4.46	9.51	4.39	13.82	40.63	12.46	34.13
1998	39.02	11.62	12.37	15.97	7.91	15.89	10.38	28.16
	Age 6		Age 7		Age 8			
	VPA	Longline	VPA	Longline	VPA	Longline		
1996	0.66	2.92	0.55	1.04	0.02	0.48		
1997	3.28	15.34	0.23	0.48	0.28	0.57		
1998	9.38	22.46	2.30	5.06	0.16	0.84		

Figure 7: Comparisons of cod age classes, using proportional VPA population estimates vs. proportional longline catch rates for each year.

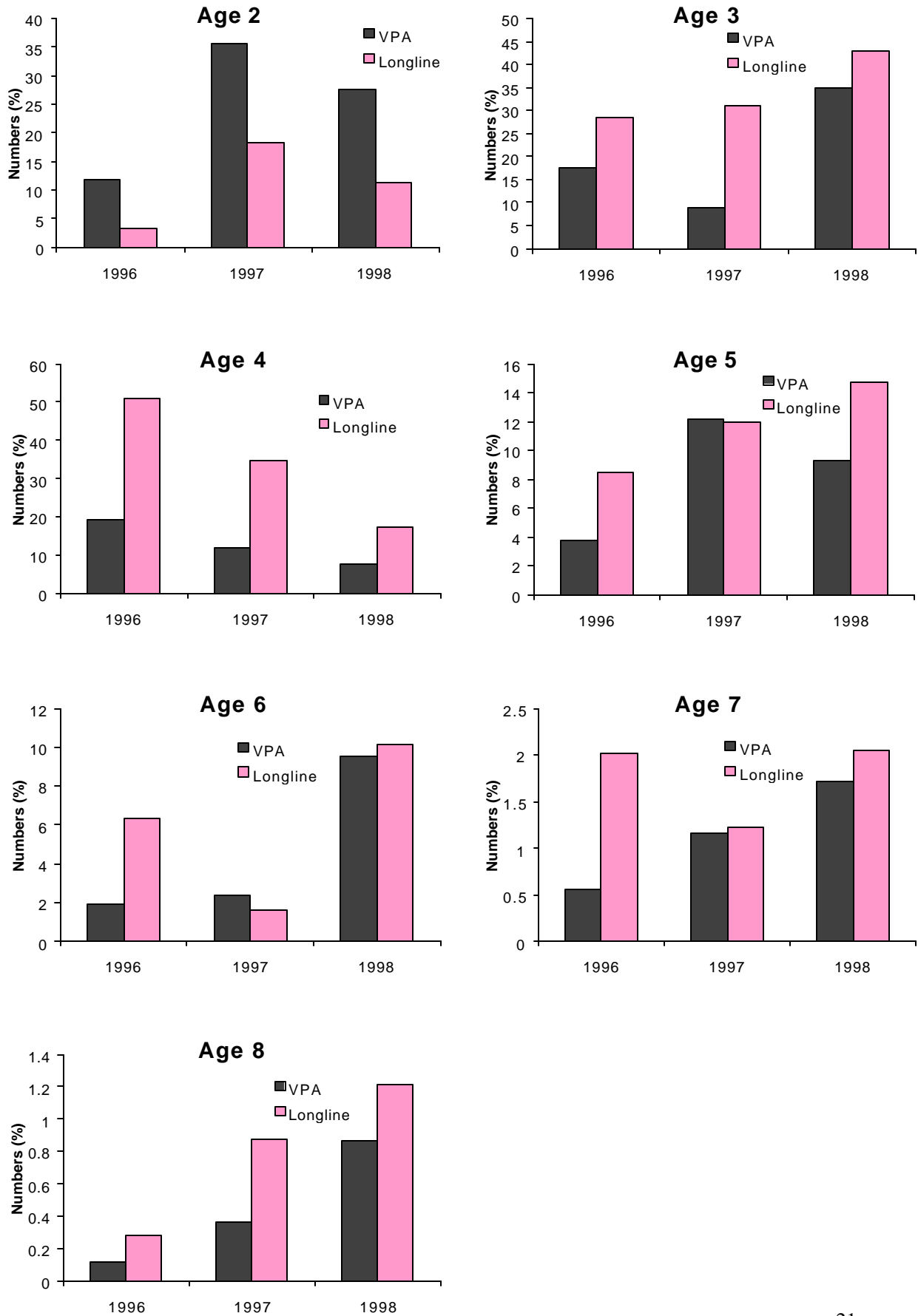


Figure 8: Comparisons of haddock age classes, using proportional VPA population estimates vs. proportional longline catch rates for each year.

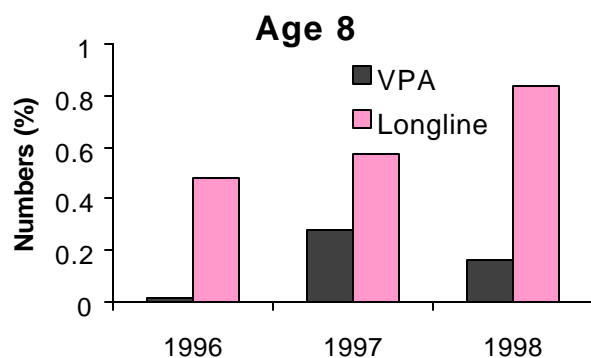
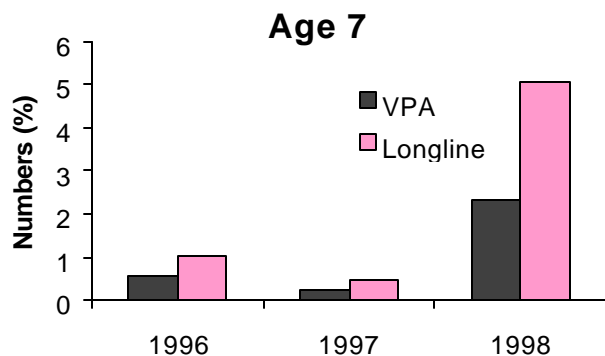
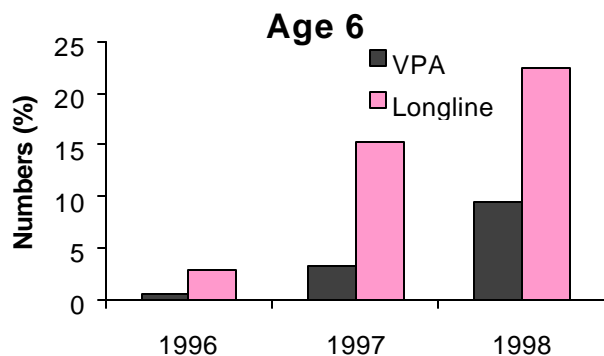
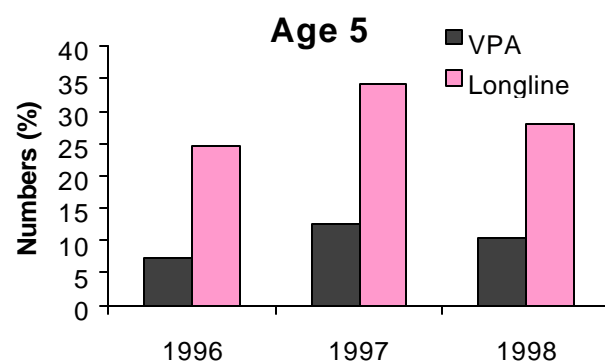
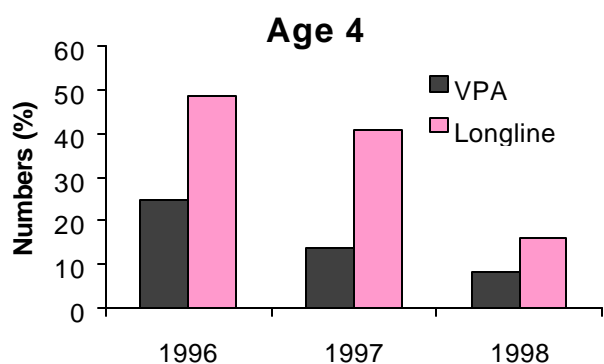
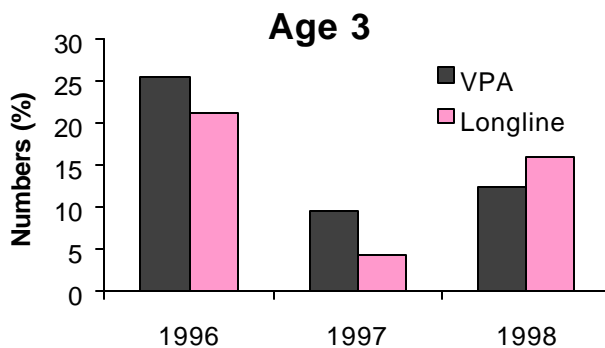
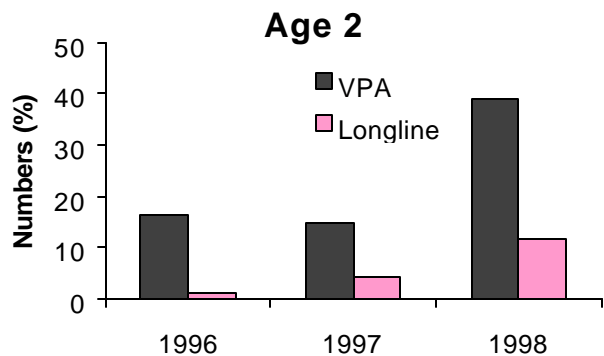
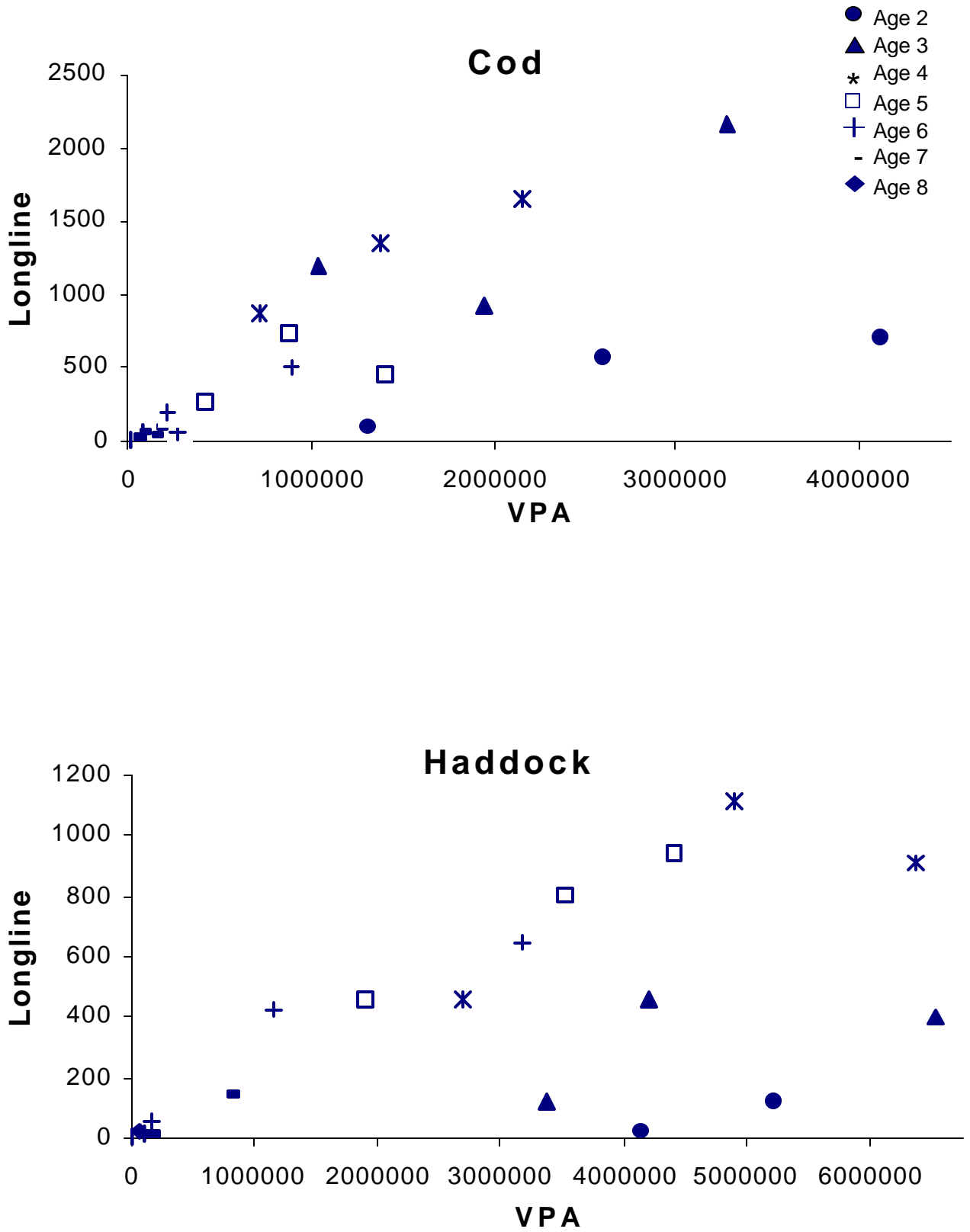


Figure 9: Scatter Plots for cod and haddock, correlating total VPA population estimates with age-specific catch rates from the longline survey.



Appendix A

Specifications for a Hook and Line Survey of Georges Bank

Introduction

To become a useful index of population abundance trends a survey must meet a number of conditions and objectives. It is essential that changes in catch rates between sets or between years are due to changes in population abundance and not because of changes in the way the population is sampled. This means that sampling methods (fishing operations) must be defined at the outset and must remain constant from year to year. An index requires several years of data before it can be used to evaluate trends in stock abundance.

1. Objectives

- to provide an unbiased estimate of cod and haddock abundance trends using hook and line fishing methods
- to develop a time series of estimates derived with constant fishing practices and sampling protocol
- to incorporate these estimates in the evaluation of stock status

2. Methods

- a **fixed station** survey design will be followed
- a minimum of three and maximum of five fishing vessels to be used for the survey and it is desirable that the same boats and Captains conduct the survey for several consecutive years
- participating Captains must have a demonstrated ability and history of fishing in the Georges Bank fishery
- predefined boxes will be identified with an approximate area of 50 nm² (see attached)
- each box will incorporate 50 and 100 fm depth contours as a boundary
- within each box, **one** standard fishing set will be completed at a site to be fixed and repeated for all subsequent surveys

3. Science Coordinator

- Joseph J. Hunt
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Email: Hunt@ sta.dfo.ca

4. Management Coordinator

- Jorgen Hansen
Fisheries Management
Scotia-Fundy Fisheries

Maritimes Region
(902) 426-9046

5. Industry Coordinator

- participants or their representative(s) to appoint a coordinator

6. Fishing Practices

- all participants to use the same fishing practices
- fishing operations to be completed within a ten day period in August
- each set to be completed within a 0.5 nm radius of the designated site and the entire string of gear must be within the boundaries of the designated box
- a total of **1,500, EZ 12** hooks to be fished at each site
- each set to be comprised of one or a maximum of two strings of gear fished adjacent to each other
- squid to be used as bait for all survey sets
- soak time (elapsed time from start of set to start of haul back) to be a minimum of **six** hours and maximum of **eight** hours
- set time within each box to be determined by time of day, tide and weather conditions but at the discretion of the fishing Captain
- valid sets for each of the assigned locations must be obtained
- any set judged to be unrepresentative (gear damage, storm conditions, saturated with none target species, etc) to be **repeated**
- any set not conforming to guidelines to be **repeated**
- any set not conforming to guidelines to be reviewed by the Science, Management and Industry Coordinators and, if excluded from the survey, catches from the set to be counted against the boat or association quota and not the survey allocation
- allocation of sets between participants to be based on a mix of areas with expected high and low catch rates of cod and haddock

7. Biological Sampling

- all sets to be monitored by an qualified observer
- complete set details (date, time, location, hooks set, weather conditions, etc) to be recorded on prescribed forms
- for each successful set, number of fish caught by species, estimate of total weight by species and length frequencies of all cod and haddock to be obtained
- all information to be recorded on prescribed Observer forms
- additional information to be recorded on science logs (see attached)

8. Data Recording

- all standard data collected by Observers to be entered on the Regional Observer database

- information collected on science logs to be forwarded to Science Coordinator for compilation

9. Reports

- a report summarizing operations and catches to be compiled by the Science Coordinator for review and approval by the industry coordinator prior to general distribution

10. Funding

- all costs associated with fishing operations, including Observers, to be covered by participants
- if fishing operation costs are to be offset with sale of catches, then provision should be made for **equitable sharing among participants** to ensure sets in areas of expected low catch rates are given equal representation

travel and associated costs for the Science Coordinator to be funded by DFO

1998 Georges Bank Hook and Line Survey

Vessel Name: _____ CFV Number: _____

Captain's Name: _____ Observer's Trip Number : _____

Wind Speed: _____ (knots) Wind Direction: _____ Current: _____ (knots)

Weather: (cloud, rain, fog, clear) _____ Tide: _____ (flood, ebb, slack)

Survey Set Number: _____ Survey Box Number: _____ (from chart)

Date: _____, 1998

Bait Used: squid Hook Size: EZ 12 Hooks Set: _____ Tubs: _____ Strings: _____

	Time	Latitude	Longitude	Depth (fm)
Start of Set	_____	_____	_____	(decimal minutes or seconds) _____
End of Set	_____	_____	_____	(decimal minutes or seconds) _____
Start of Haul	_____	_____	_____	(decimal minutes or seconds) _____
End of Haul	_____	_____	_____	(decimal minutes or seconds) _____

Catch Composition	Number Caught	Weight Caught (kg)
Species: COD	_____	_____
Species: HADDOCK	_____	_____
Species: POLLOCK	_____	_____
Species: _____	_____	_____
Species: _____	_____	_____
Species: _____	_____	_____
Species: _____	_____	_____

Remarks: (vessels/gear in area, bait in water, sand fleas etc)

Captain's Comment: Less than Expected About as Expected More than Expected
(check one)

Cod:	_____	_____	_____
Haddock:	_____	_____	_____
Pollock:	_____	_____	_____
Skates/Sharks:	_____	_____	_____