3.9 Trends in Relative Fishing Power for NEFSC Bottom Trawl Surveys during 2000-2002

Summary and Conclusions

1) Trends in relative fishing power of bottom trawls used in NEFSC surveys were characterized using an index calculated from NEFSC bottom trawl, DFO bottom trawl and NEFSC sea scallop survey data. Index trends were examined to determine if relative fishing power of NEFSC bottom trawls declined during 2000-2002 while mis-marked warps were used.
2) Twenty species were included in the analysis: American plaice, Atlantic mackerel, cod, spiny dogfish, fourspot flounder, goosefish, haddock, herring, little skate, ocean pout, Pollock, red hake, redfish, sea scallop, silver hake, white hake, windowpane flounder, winter flounder, witch flounder, and yellowtail flounder.
3) Catch rates for NEFSC bottom trawl and other surveys had similar trends.
4) There were a total of 323 index values in 22 comparisons. Of these, 63 (20%) were for years when NEFSC bottom trawls had mis-marked warps.
5) Results suggest that relative fishing power varies to some extent over time in all species and surveys. For all species as a group, relative fishing power in NEFSC bottom trawl surveys was somewhat above average during 2000-2002 while warps were mis-marked.
6) Based on these data, there is no evidence that mis-marked warps systematically reduced the fishing power of NEFSC bottom trawls during 2000-2002 for all species.

Introduction

Indices of relative fishing power were computed using survey data (number caught per standard tow) from NEFSC bottom trawl, DFO (Department of Fisheries and Oceans Canada)[1] bottom trawl, and NEFSC sea scallop surveys. Indices of relative fishing power for each species were examined qualitatively and statistically to determine if relative fishing power of NEFSC bottom trawls declined during 2000-2002 with mis-marked warps. Most of the comparisons involved NEFSC and DFO spring bottom trawl surveys but NEFSC winter bottom trawl, fall bottom trawl and scallop surveys were used as well. Species examined include American plaice, Atlantic mackerel, cod, spiny dogfish, fourspot flounder, goosefish, haddock, herring, little skate, ocean pout, pollock, red hake, redfish, sea scallop, silver hake, white hake, windowpane flounder, winter flounder, witch flounder, and yellowtail flounder. The data used in comparisons were similar in terms of area surveyed and survey timing.

As many species-survey comparisons as possible were included in the analysis and the statistical approaches used to analyze index trends accommodated all comparisons simultaneously because it would be difficult to detect a small or moderate size change in fishing power for any single species.

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Materials and Methods

NEFSC bottom trawl survey data were either spring, fall or winter survey catch rates (mean number per standard tow) in "successful" tows (database SHG values ≤ 136) in NEFSC offshore survey strata. Bottom trawl survey and scallop survey data were tabulated by combining strata that made the area covered by both surveys as similar as possible. In particular, DFO spring survey data used in comparisons for Georges Bank (GBK) were for DFO bottom trawl strata 5Za-5Zh. NEFSC bottom trawl survey data used in comparisons with DFO or scallop survey data for GBK were from NEFSC offshore bottom trawl survey strata 9-11, 13-14, 16-17 and 19-25. NEFSC offshore strata for GBK exclude the deepest NEFSC strata that are not sampled in the DFO survey. NEFSC bottom trawl survey data used in comparisons with scallop survey data for the Mid-Atlantic Bight (MAB) area were from NEFSC offshore bottom trawl survey strata 1, 2, 65-66, 69-70, and 73-74 and were chosen to maximize overlap with the MAB area assumed in sea scallop assessments. Scallop survey data used in comparisons were for NEFSC shellfish strata 46-47, 49-55, 58-63, 65-66, 71-72 and 74 (the GBK stock area used in sea scallop stock assessments) or 6-7, 10-11, 14-15, 18-19, 22-31 and 33-35 (the MAB stock area used in sea scallop assessments).

During the years included in this analysis (beginning in either 1979, 1982 or 1987, depending on the species and surveys), NEFSC spring and fall surveys used two vessels (*R/V Albatross IV* and *R/V Delaware II*), two types of bottom trawls (Yankee No. 41 in the spring survey during 1979-1981; Yankee No. 36 otherwise and in all years for the fall survey), and two types of trawl doors (BMV doors prior to 1985, polyvalent doors afterwards). The NEFSC winter survey began in 1992 and used both vessels with the standard 60-80 bottom trawl. Based on standard NEFSC procedures, vessel, trawl and door correction factors were applied where available to make catch rates on all surveys comparable to the Yankee No. 41 trawl with polyvalent doors fished by the *R/V Albatross IV*. Correction factors are probably imprecise but, fortunately, the majority of comparisons involved the NEFSC and DFO bottom trawl surveys beginning in 1987. Different vessels were used in the spring survey after 1986 in some years. However, only one type of bottom trawl and one type of trawl door was used after that date.

DFO spring bottom trawl data were compared to NEFSC spring bottom trawl survey data for GBK (see below). DFO data were survey catch rates (mean number per standard tow, adjusted for distance towed based on standard DFO procedures) for "good, random survey tows" in DFO ground fish strata 5Za-5Zh (at depths < 100 fathoms) during 1987-1992 and 1995-2002. There was no DFO survey over Georges Bank during 1993 and coverage was incomplete during 1994. Therefore, catch rates during 1993-1994 were excluded from comparisons. DFO survey data for Georges Bank used in this analysis were collected by a single vessel (*R/V Alfred Needler*) and one type of bottom trawl gear (Western 2A bottom trawl). Sea scallop was excluded from comparisons for GBK because trawls are relatively inefficient for sea scallop on rough grounds found across much of GBK.

Georges Bank Species	Years Comparing NEFSC and DFO Spring Surveys
American plaice	14
Atlantic mackerel	12
Cod	14
Spiny dogfish	14
Fourspot	14
Haddock	14
Herring	14
Little skate	14
Ocean pout	14
Pollock	14
Red hake	13
Redfish	14
Silver hake	14
White hake	14
Windowpane flounder	14
Winter flounder	14
Witch flounder	14
Yellowtail flounder	14
Total	249

Catch rates for fish and sea scallops in annual NEFSC sea scallop surveys were compared to NEFSC survey bottom trawl catch rates (see below). The scallop survey during 2000-2002 was not affected by mis-marked warps on the *R/V Albatross IV* because the survey scallop dredge is towed by a single wire. Comparisons with scallop survey catches are potentially important because the scallop survey takes species on the bottom that might be missed by the bottom trawl if mis-marked warps reduced trawl bottom contact during 2000-2002. The scallop survey is conducted annually in the summer using a standard 8' New Bedford style scallop dredge with 2" rings and a 1.75" plastic liner. However, in accord with standard procedures for scallop assessments, empty strata in some years were filled by borrowing catches from the same strata in the preceding and following year.

Scallop survey catch data used in this analysis were limited to sea scallops, goosefish and yellowtail flounder per standard tow because scallop survey catches have not been fully computerized for most fish species. Scallop survey data (mean number per standard tow) for the GBK and MAB regions were compared to the average of spring and fall NEFSC survey data during the same year because the scallop survey is carried out in the summer after the spring survey and before the fall survey. Comparisons involving average spring and fall survey data excluded 2002 because only the spring survey had mis-marked warps during 2002. In addition, catch rates for goosefish in MAB from the scallop survey were compared to NEFSC winter bottom trawl catch rate, because the winter survey takes substantial numbers of goosefish.

Goosefish were the only case of a comparison involving NEFSC winter survey and scallop survey data.

Catch rates used in species-comparisons were for all sizes with several exceptions. Data for GBK yellowtail < 20 cm TL in the scallop survey were excluded because survey bottom trawls are not efficient for yellowtail < 20 cm TL. Goosefish data for MAB from the scallop survey were for individuals 20-59 cm TL because survey bottom trawls are not efficient for goosefish smaller than 20 cm and scallop dredges are not efficient for goosefish larger than 60 cm. Comparisons of scallop catch rates were for scallops with shell heights of 9-13.9 cm because bottom trawls and scallop dredges both catch considerable numbers of scallops in this size range and because scallop dredges and commercial bottom trawls sample large (9-13.9 cm) and small (< 9 cm) scallops with different efficiency. Goosefish and yellowtail flounder comparisons began in 1982 because the scallop survey did not cover all of the Georges Bank strata in earlier years and because goosefish catches had not been recorded earlier.

MAB yellowtail and GBK goosefish were not used for comparisons because catch rates in NEFSC scallop, spring and fall surveys were too low and variable. The winter NEFSC winter survey takes substantial numbers of goosefish but does not cover the entire GBK region.

Mid-Atlantic Bight Species	Years Comparing GBK Scallop and Average NEFSC Spring & Fall	Years Comparing MAB Scallop and Average NEFSC Spring & Fall	Years Comparing MAB Scallop and NEFSC Winter	Total
Goosefish	--	20	11	31
Sea scallop	--	23	--	23
Yellowtail flounder	20	--	--	20
Total	20	43	11	74

Catch rates for NEFSC bottom trawl and other surveys followed similar trends in most cases (Figure 3.9-1). Correspondence in trends for scallops in the scallop, spring and fall surveys was surprisingly strong.

Standardized log catch rate ratios

The ratio of mean catch rates in two surveys during the same year is a measure of the relative fishing power of the two surveys. For each species in the analysis, we computed annual values of log survey catch ratios:

$$X_y = \ln\left(\frac{I_y}{K_y}\right)$$

where I_y is the catch rate (number per standard tow) during year y for the NEFSC bottom trawl survey, and K_y is the catch rate for the same species in the DFO or scallop survey. Log catch ratios have better statistical properties (i.e. symmetrical statistical distributions and constant variance) than the original values.

For ease in analysis and plotting, standardized log survey catch ratios for each species were standardized (Tables 3.9.1 and Figure 3.9.2):

$$\chi_y = \frac{\left(X_y - \bar{X}\right)}{\sigma}$$

where χ_y is the standardized log survey catch rate SLSCR index of relative fishing power, $\bar{X}$ is the average of X_y values prior to 2000 and σ is the standard deviation of X_y values prior to 2000. Means and standard deviations used in standardization calculations were for years prior to 2000 so that the mean SLSCR for years prior to 2000 would average zero and the standard deviation for years prior to 2000 would be one. This convention facilitated analyses but had no effect on results.

NEFSC spring, fall or winter catch rates were always in the numerator of ratios used to compute SLSCR index values. This is important because increases in ratios indicate possible increases in relative fishing power for bottom trawls used in NEFSC spring fall or winter surveys, and vice-versa. If mis-marked warps reduced the fishing power of bottom trawls used in the NEFSC spring survey relative to the DFO spring survey, for example, then SLSCR values for 2000-2002 in the comparison should tend to be small or negative. In addition, an abrupt change in index values may be evident in the index values for 1999-2000.

There were 22 species comparisons in the final data set with a total of 323 SLSCR index values. Of the total, 63 (20%) were for surveys with mis-marked warps during 2000-2002.

Interpretation of SLSCR index values

In theory, both the direction and magnitude of SLSCR index values have meaning. An index value of zero means no apparent change in relative fishing power, positive indices indicate above average relative fishing power, negative values indicate below average relative fishing power, and larger changes in index values suggest larger changes in relative fishing power. However, theory aside, there are a number of important issues to keep in mind while interpreting SLSCR index values (see below). In view of these issues, it is prudent to focus on results for groups of species and groups of years. In comparing index values for a single or few species over a short period of time, it is prudent to focus on the sign (positive or negative) of SLSCR values.

Changes in relative fishing power of both surveys in a comparison are confounded in SLSCR values. For example, increases in SLSCR could be due to values and increased relative fishing power in NEFSC bottom trawl surveys could be due to changes in either the numerator (NEFSC bottom trawl catch rates) or the denominator (DFO or scallop survey catch rates). This is an important because, in theory, variation in SLSCR values in a particular comparison could be due entirely to variability in fishing power of either the NEFSC bottom trawl (in the numerator) or the survey (DFO or scallop) used for comparison in the denominator.

Environmental factors likely influence both surveys in a comparison so that there is a covariance between catch rates and fishing power for both surveys. Further, trends in abundance will affect catch rates in both surveys so that catch rates are correlated. SLSCR was calculated using ratios, however, so that environmental "year effects" and "abundance" effects should cancel out.

SLSCR index values measure relative fishing power ***but can not be interpreted as percentage or proportional changes***. For example, if the SLSCR for a species was 0.0 for 1997, 0.1 for 1998, and -0.5 in 1999, one could conclude that relative fishing power was near average in 1997, apparently increased slightly in 1998 and apparently declined substantially in 1999. However, it would be incorrect to conclude that relative fishing power increased by 10% of the average value in 1998 and then declined by 60% of the average value during 1999.

The variance of SLSCR index values has not been measured and both the direction and magnitude of changes in the index may be largely random. Variance and statistical properties were not calculated in this analysis due to lack of time. Variance is likely considerable and the possibility of bias or autocorrelation in index values has not been fully explored. Survey catch rate data are intrinsically variable and there may be covariances between catches in two different surveys during the same year that do not cancel. Covariances may exist between SLSCR values for one species in adjacent years (autocorrelation) and among species in the same year. These types of correlations almost certainly increase uncertainty in SLSCR index values by reducing information about relative fishing power in the survey data. Therefore, patterns in these indices were evaluated for overall trends rather than for individual species/stocks in specific surveys.

Results

SLSCR index values indicate that relative fishing power for all species taken together was slightly above average (0.06) during 1999 and increased a small amount to 0.09 in 2000, the first year with mis-marked warps (Table 3.9.1). The average SLSCR value for all species taken together during 2000-2002 was 0.14, indicating that average fishing power for NEFSC bottom trawls was above average during 2000-2002 while warps were mis-marked. There was no obvious relationship between mean depth for each species and SLSCR values during 2000-2001 (Table 3.9.1). Depth is of interest because of hypotheses that effects of mis-marked warps increased with depth.

The sign of SLSCR values (i.e. positive for increased fishing power, negative for decreased fishing power; Table 3.9.2) also indicate about average overall fishing power for NEFSC bottom trawls with mis-marked warps during 2000-2002. SLSCR values were positive in 11 out of 22 (50%) comparisons for 1999 and 12 out of 22 (55%) comparisons for 2000. Considering all comparisons during 2000-2002, SLSCR values were positive in 34 out of 63 (54%) of cases, compared to 33 out of 66 (50%) during 1997-1999. Thus, the number of species for which fishing power of NEFSC survey bottom trawls was above average was about 50% before and after the introduction of mis-marked warps. There was no obvious relationship between species mean depth and the sign of SLSCR values during 2000-2001 (Table 3.9.2). There are a number of other such comparisons (e.g. between NMFS fall surveys and Canadian surveys) that could be pursued. However, results presented in section 3.8 indicate similar conclusions regarding the lack of a detectable intervention due to the warp offset issue.

Table 3.9.1. Standardized SLSCR indices of relative fishing power for NEFSC bottom trawls during 1991-2002. Positive values mean that the NEFSC bottom trawl survey had above average relative fishing power, and vice versa. Index values do not measure percentage or proportional changes in relative fishing power. For example, a value 0f 0.1 does not imply a 10% increase. Species are sorted roughly in order of average depth in spring NEFSC survey catches during 1968-2002 (shallow depths at the top). Few indices are available for 1993-1994 because DFO surveys were not carried out or were incomplete on Georges Bank.

Species	Surveys	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	1997-1999	2000-2002
Little Skate	Spring-DFO	0.93	2.16			-0.71	0.56	-1.31	-0.26	0.02	-0.59	0.31	0.92	-0.51	0.21
Windowpane	Spring-DFO	1.23	-0.23			-0.86	-0.96	-0.44	-1.09	-0.67	0.62	0.57	-0.17	-0.73	0.34
Winter Flounder	Spring-DFO	0.90	-0.28			-0.29	-0.26	-0.71	-0.18	2.41	1.69	0.29	1.30	0.51	1.09
Yellowtail	Spring-DFO	0.62	-0.66			0.67	-0.24	-0.89	0.66	-0.22	-0.47	-1.58	0.16	-0.15	-0.63
Yellowtail	Spr&Fall-Scallop	-1.04	0.37	-1.76	-0.55	-0.94	-1.23	-0.73	-0.64	0.29	-0.16	1.25		-0.36	0.55
Ocean Pout	Spring-DFO	0.63	-1.60			0.71	0.16	0.73	0.15	0.84	1.93	1.87	3.92	0.57	2.57
Mackerel	Spring-DFO	-1.60	-0.33			-0.14	0.24	0.84	-1.42	0.49	0.92	-0.69	-0.47	-0.03	-0.08
Herring	Spring-DFO	-0.84	0.66			0.03	0.08	-0.54	1.47	-0.86	-0.88	-0.89	0.94	0.02	-0.28
Scallop	Spr&Fall-Scallop	0.17	0.70	-0.08	0.75	-0.02	-1.32	0.31	0.96	0.63	0.70	-0.37		0.63	0.17
Cod	Spring-DFO	0.07	-1.26			0.73	-1.73	-0.31	2.05	-0.37	-0.96	-0.30	-0.88	0.46	-0.71
Haddock	Spring-DFO	-0.32	-1.97			0.13	1.34	1.27	-0.69	-0.68	-1.83	-0.54	-0.10	-0.03	-0.82
Red Hake	Spring-DFO	1.17				0.70	-2.01	-0.01	1.45	-0.03	0.53	-0.18	0.84	0.47	0.40
Fourspot	Spring-DFO	-0.35	-0.83			0.41	1.86	-0.32	0.29	-1.96	1.32	-0.81	0.45	-0.67	0.32
Dogfish	Spring-DFO	0.04	-1.59			-1.09	0.06	0.62	1.69	1.41	0.05	0.14	0.91	1.24	0.37
Goosefish	Spr&Fall-Scallop	0.88	-0.91	-0.33	-0.06	-0.47	-0.94	-0.50	-0.26	-0.15	0.69	-0.25		-0.31	0.22
Goosefish	Winter-Scallop		-0.31	0.88	-0.96	0.05	1.83	-0.50	0.26	-1.25	0.16	1.27	1.75	-0.49	1.06
Plaice	Spring-DFO	0.14	-2.25			0.56	0.63	-0.73	0.74	-0.79	0.49	0.14	-0.11	-0.26	0.17
Pollock	Spring-DFO	0.44	-1.58			1.86	-0.21	0.26	0.82	0.45	-0.39	0.16	-3.05	0.51	-1.09
Silver hake	Spring-DFO	-0.33	-1.32			-0.66	-1.19	-0.13	1.31	0.10	-1.44	-0.24	1.31	0.43	-0.12
Witch Flounder	Spring-DFO	0.29	-0.66			-0.29	0.22	-2.16	1.88	-0.35	-1.14	-0.79	0.01	-0.21	-0.64
Redfish	Spring-DFO	-1.54	1.76			-0.37	0.18	0.50	0.68	0.51	1.50	1.28	-0.29	0.57	0.83
White hake	Spring-DFO	-0.21	-1.13			-0.63	-0.10	-0.85	0.87	1.41	-0.66	-1.59	0.06	0.48	-0.73
Count All		21	21	4	4	22	22	22	22	22	22	22	19	66	63
Average All		0.06	-0.54			-0.03	-0.14	-0.25	0.49	0.06	0.09	-0.04	0.39	0.10	0.14

Table 3.9.2. The sign ("+" for above and "–" for below average) of SLSCR relative fishing power indices during 1991-2002. Species are sorted roughly in order of average depth in spring NEFSC survey catches during 1968-2002 (shallow depths at the top). Few indices are available for 1993-1994 because DFO surveys were not carried out or were incomplete on Georges Bank.

Species	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**1997-1999**	**2000-2002**
Little Skate	+	+			-	+	-	-	+	-	+	+	0.33	67%
Windowpane	+	-			-	-	-	-	-	+	+	-	0.00	67%
Winter Flounder	+	-			-	-	-	-	+	+	+	+	0.33	100%
Yellowtail	+	-			+	-	-	+	-	-	-	+	0.33	33%
Yellowtail	-	+	-	-	-	-	-	-	+	-	+		0.33	50%
Ocean Pout	+	-			+	+	+	+	+	+	+	+	1.00	100%
Mackerel	-	-			-	+	+	-	+	+	-	-	0.67	33%
Herring	-	+			+	+	-	+	-	-	-	+	0.33	33%
Scallop	+	+	-	+	-	-	+	+	+	+	-		1.00	50%
Cod	+	-			+	-	-	+	-	-	-	-	0.33	0%
Haddock	-	-			+	+	+	-	-	-	-	-	0.33	0%
Red Hake	+				+	-	-	+	-	+	-	+	0.33	67%
Fourspot	-	-			+	+	-	+	-	+	-	+	0.33	67%
Dogfish	+	-			-	+	+	+	+	+	+	+	1.00	100%
Goosefish	+	-	-	-	-	-	-	-	-	+	-		0.00	50%
Goosefish		-	+	-	+	+	-	+	-	+	+	+	0.33	100%
Plaice	+	-			+	+	-	+	-	+	+	-	0.33	67%
Pollock	+	-			+	-	+	+	+	-	+	-	1.00	33%
Silver hake	-	-			-	-	-	+	+	-	-	+	0.67	33%
Witch Flounder	+	-			-	+	-	+	-	-	-	+	0.33	33%
Redfish	-	+			-	+	+	+	+	+	+	-	1.00	67%
White hake	-	-			-	-	-	+	+	-	-	+	0.67	33%
Count All	21	21	4	4	22	22	22	22	22	22	22	19	66	63
Count (+) All	13	5	1	1	10	11	7	15	11	12	10	12	33	34
Percent (+) All	62%	24%			45%	50%	32%	68%	50%	55%	45%	63%	50%	54%

Figure 3.9.1. Time series of survey catch rates for all species comparisons in this analysis. Original catch rates were rescaled for ease in plotting to a mean value of zero and a standard deviation of one.

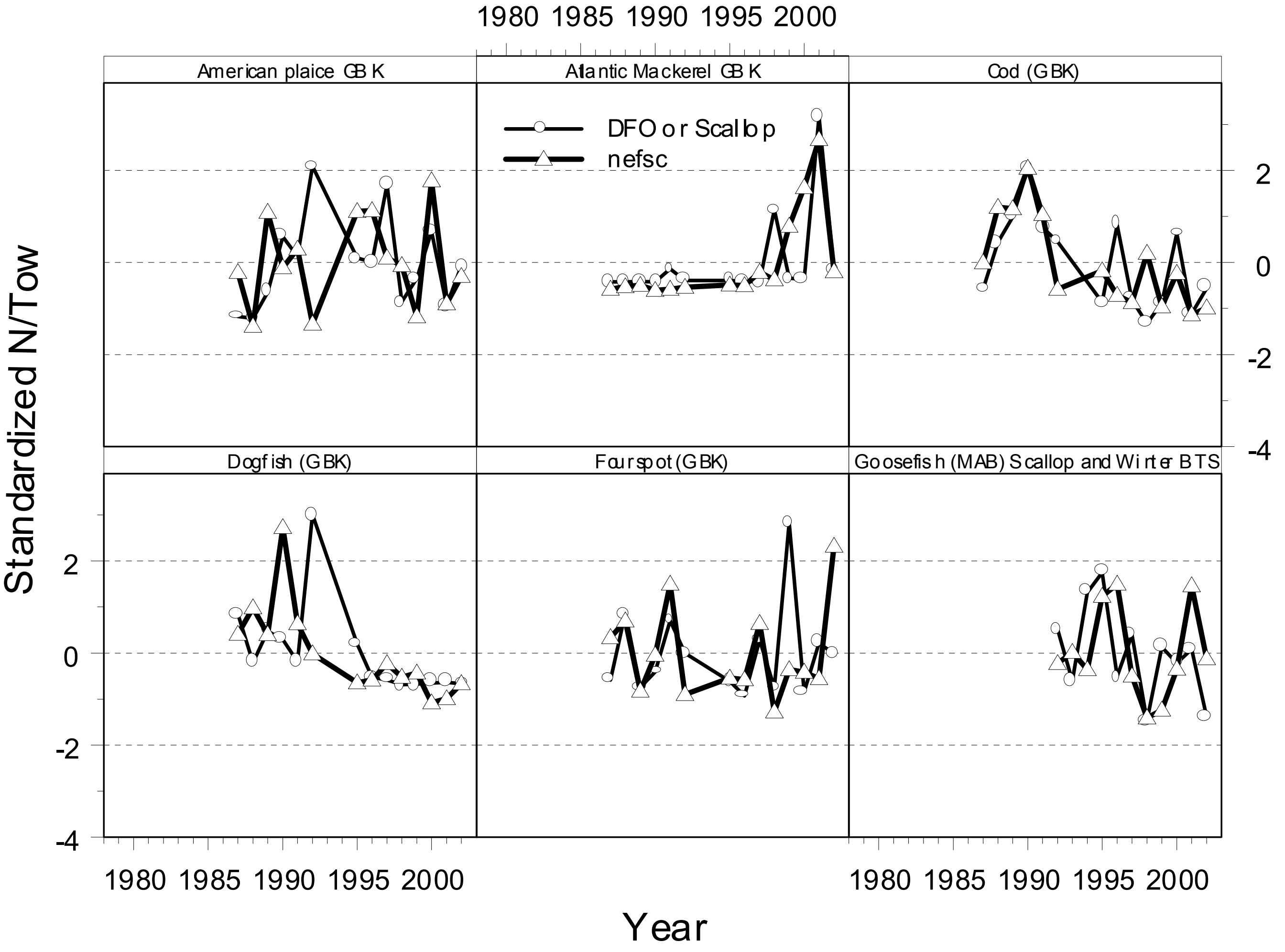

Figure 3.9.1. (cont.)

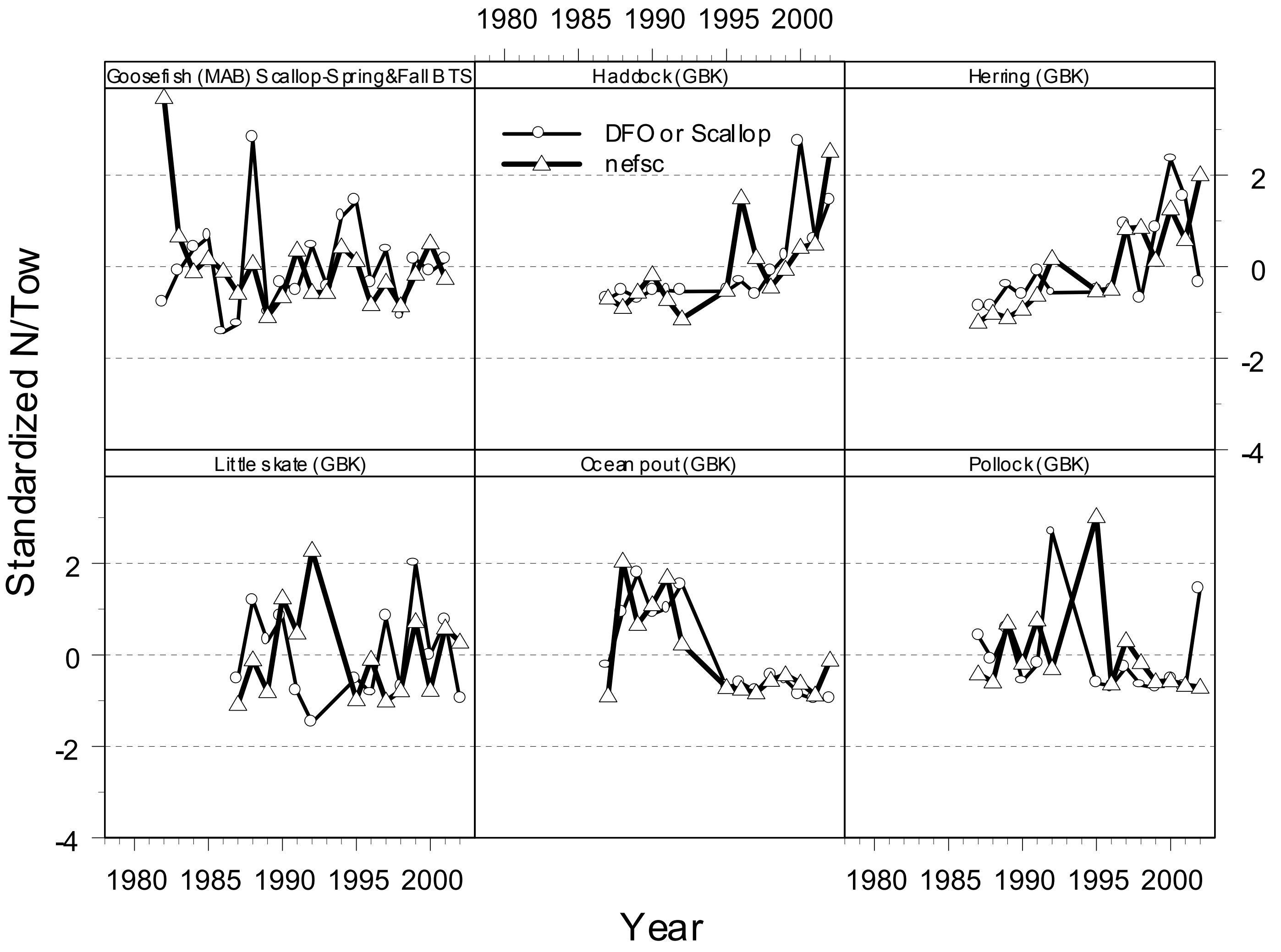

Figure 3.9-1. (cont.)

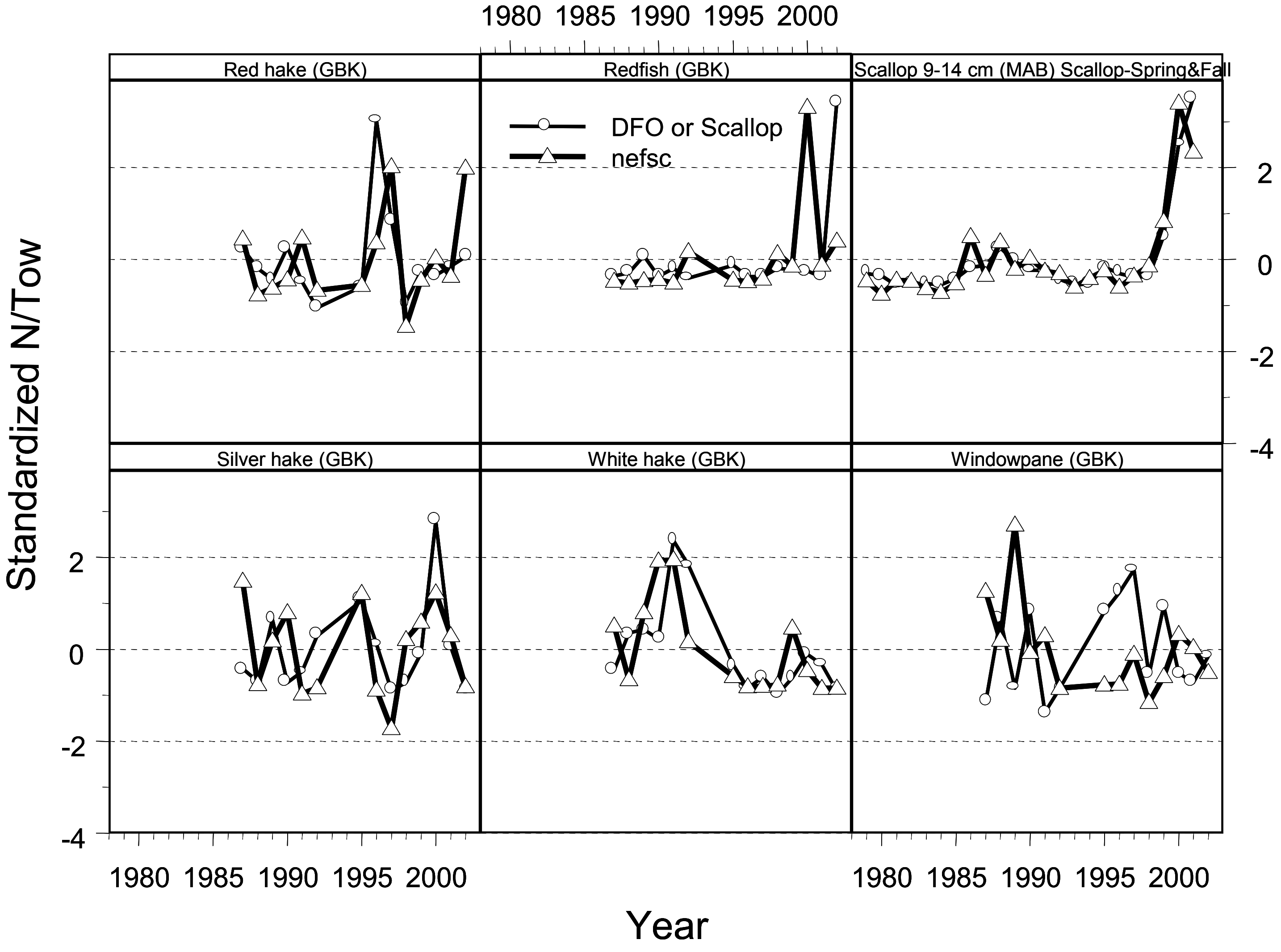

Figure 3.9.1. (cont.)

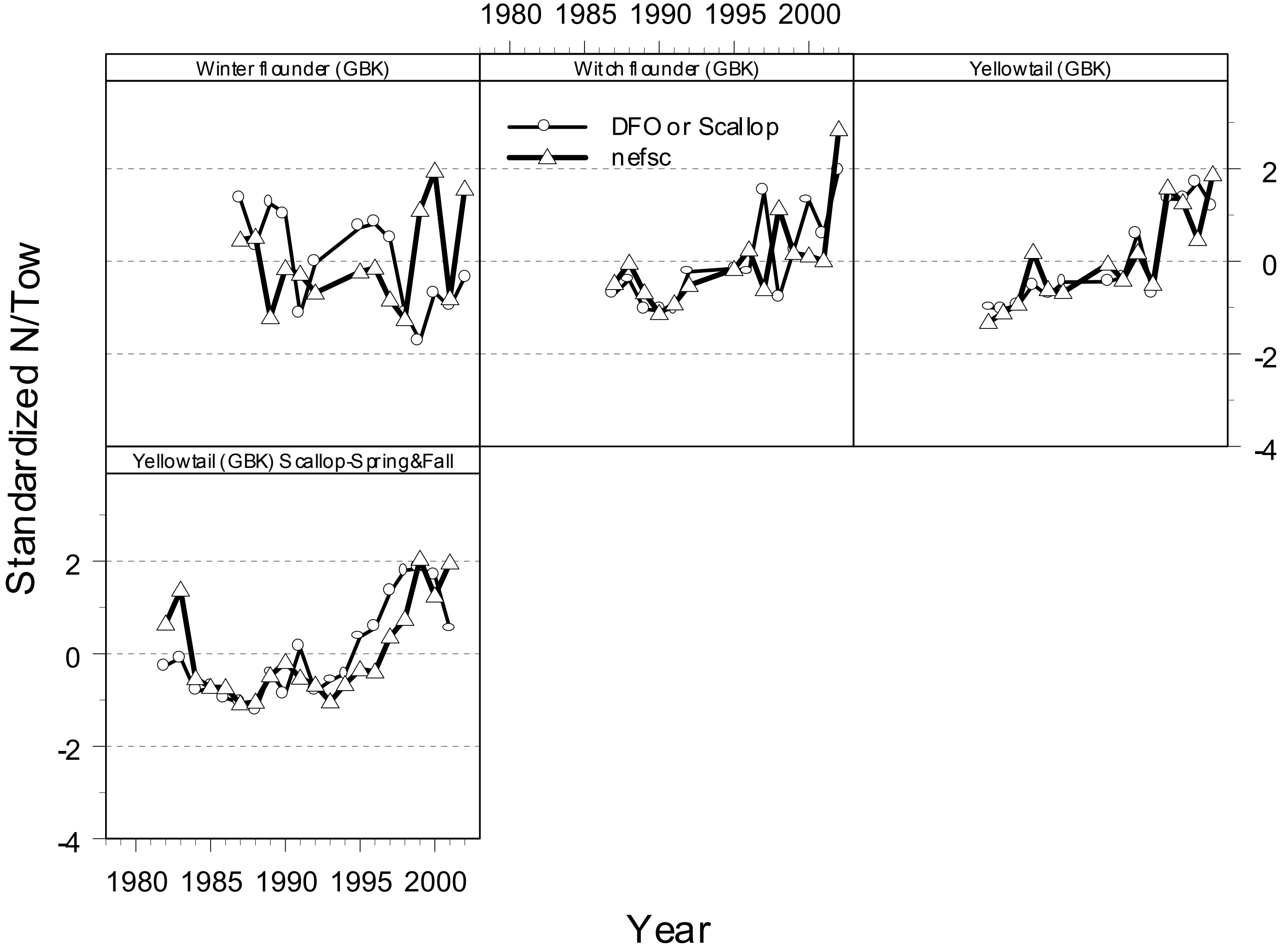

Figure 3.9.2. Time series of SLSCR indices of relative fishing power for all species comparisons in this analysis.

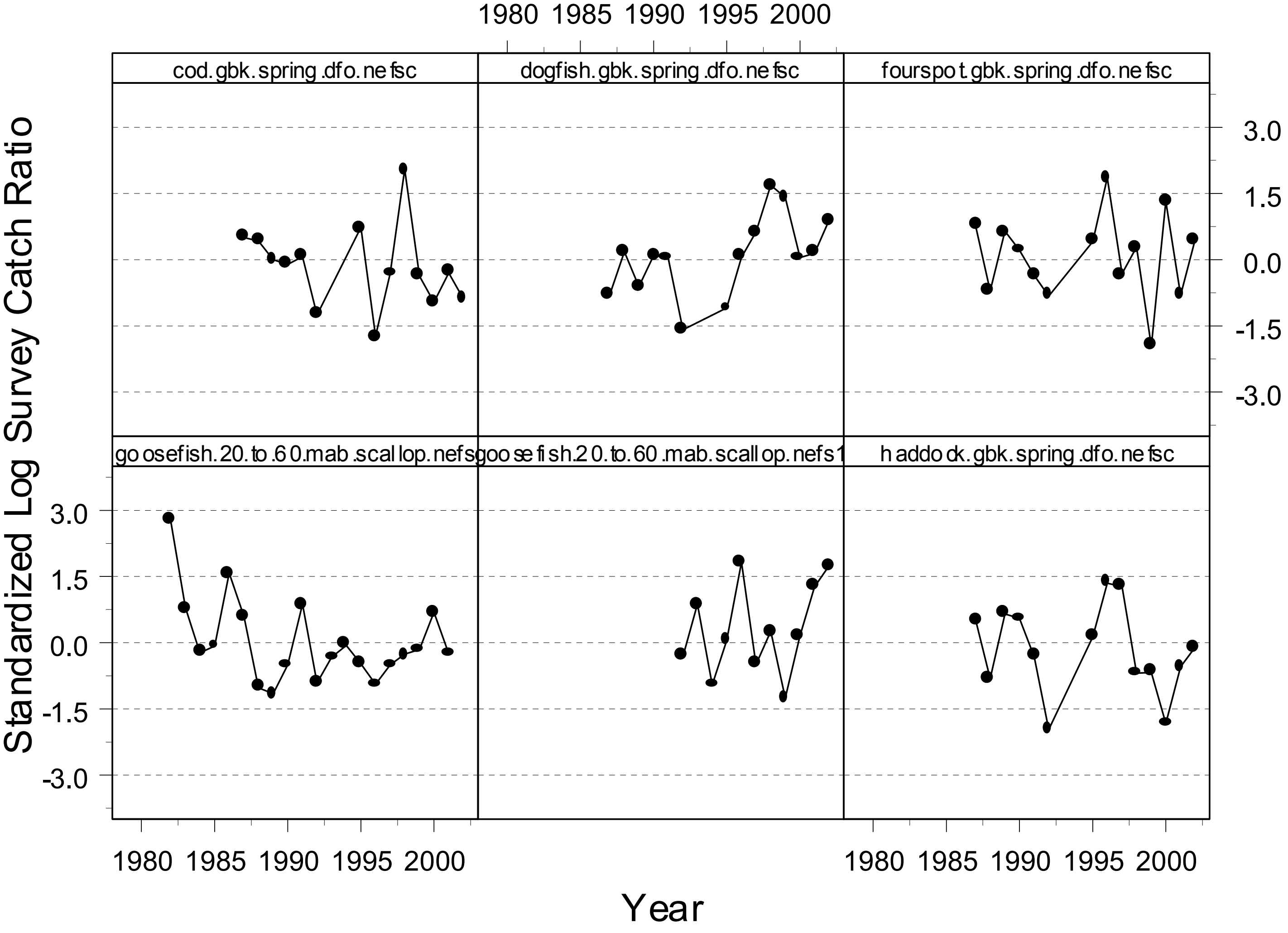

Figure 3.9.2. (cont.)

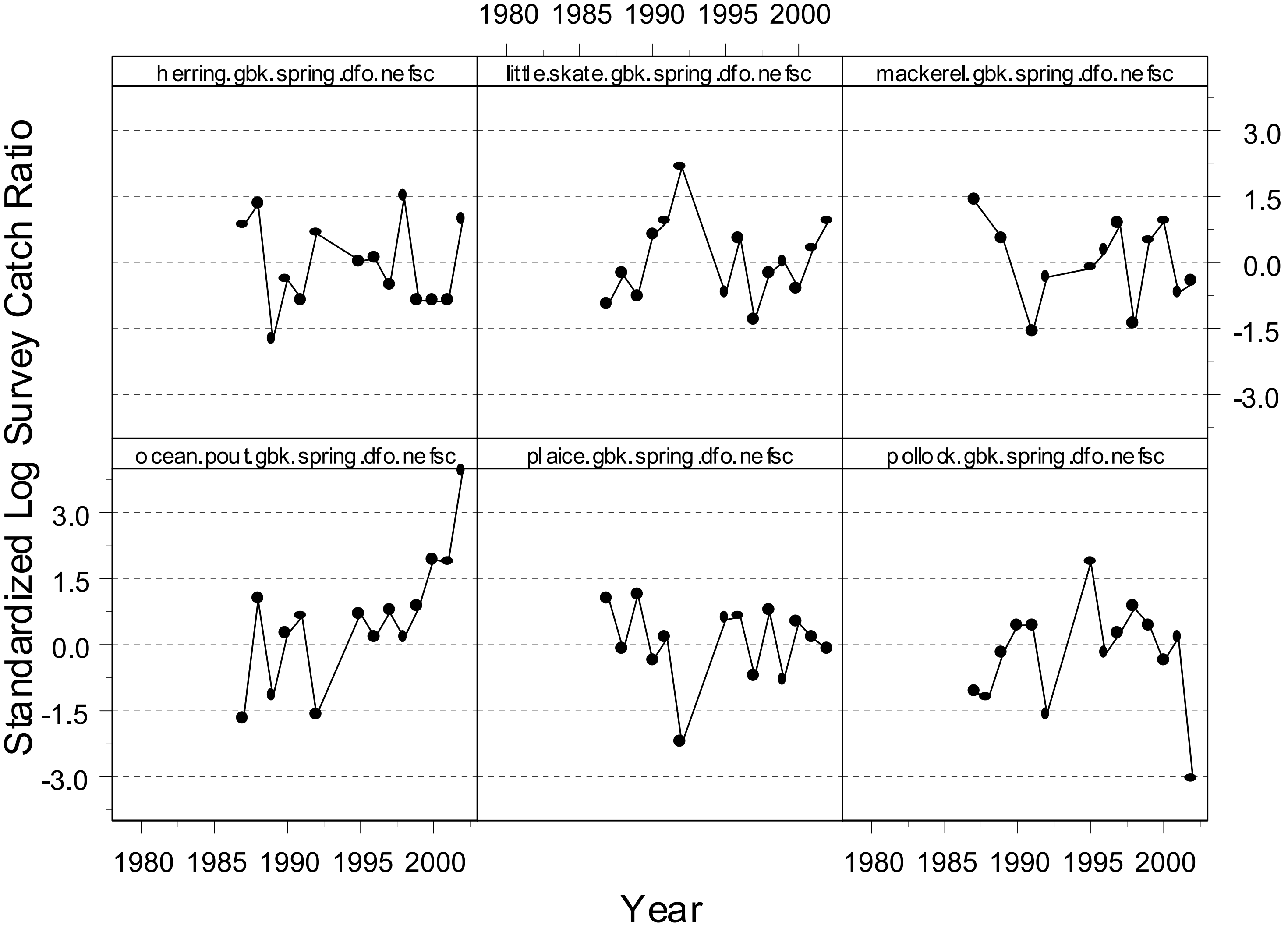

Figure 3.9.2. (cont.)

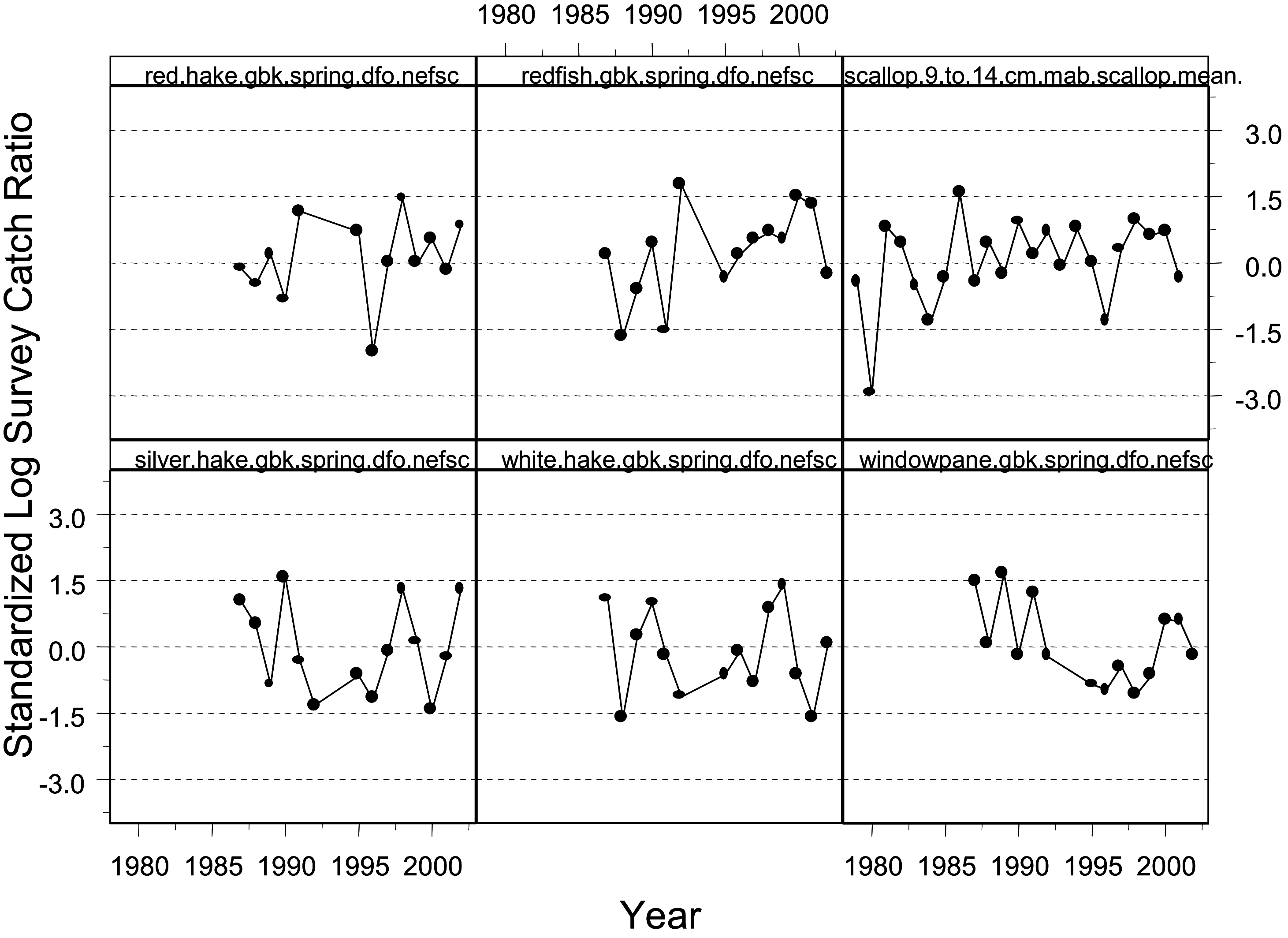

Figure 3.9-2. (cont.)