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Implications of Retrospective Patterns for Bias in Discard Rates and Unobserved Landings

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ABSTRACT

Previous analyses of retrospective patterns for Georges Bank yellowtail flounder have demonstrated that total catch would have to increase fivefold in order to compensate for the retrospective pattern. The increase in catch would require increases in unreported landings, or significant increases in discarding rates on unobserved trips. The implications of a five-fold increase in total catch were examined for three US fleets that constitute the majority of US catch of Georges Bank yellowtail flounder during 1989 to 2011. Bias factors required to achieve a five-fold increase in total catch as a function of bias in landings on unobserved trips and bias factors for bias in discard rates on unobserved trips were computed. Results suggest that bias factors greater than five are required to increase the total catch by a factor of five. We conclude that neither increased discarding rates on unobserved vessels nor illegal landings on unobserved vessels seem plausible given the extreme magnitude of change implied by our analyses. Trends in US fishing effort by otter trawls has declined in recent years, indicating that non-observed fishing mortality effects, such as due to injury from passing through meshes, is not a likely cause of the missing catch needed to explain the retrospective pattern.

Introduction

Previous analyses of retrospective patterns have demonstrated that total catch would have to increase fivefold in order to compensate for the retrospective pattern. Legault et al. (2012) demonstrated that such increase would eliminate the retrospective pattern. The increase in catch would require increases in unreported landings, or significant increases in discarding rates on unobserved trips. We examined this hypothesis using US data. Because large fractions of the total trips by US fleets are monitored with observers, the landings and discards on those trips are known. Hence the necessary increases of potential hidden landings or discarding rates on unobserved trips would have to be even greater than estimated by Legault et al. (2012). In this paper we examine the implications of a 5 fold increase in total catch for a number of US fleets that constitute the bulk of the US catch for Georges Bank yellowtail flounder. We examine the period 1989 to 2011 for the US large mesh and small mesh otter trawl fleets and the US scallop fleets fishing on Georges Bank. Bias factors required to achieve a five-fold increase in total catch as a function of bias in landings on unobserved trips were calculated. Similar bias factors are computed for bias in discard rates on unobserved trips. Equations for deriving the joint effects of bias in both landings and discards are derived. Trends in US fishing effort were also examined to explore whether there is the potential for non-observed fishing mortality, such as that caused by fish being injured passing through large mesh, could be a source of missing catch.

Methods

The total catch of a fleet $\boldsymbol{C_T}$ is the sum of total landings $\boldsymbol{L_T}$ and discards $\boldsymbol{D_T}$.

$$C_T = L_T + D_T \qquad (1)$$

The total landings and discards can be divided into two components corresponding to the observed $\boldsymbol{o}$ and unobserved $\boldsymbol{u}$ trips. Let

$$L_T = L_o + L_u \qquad (2)$$

$$D_T = D_o + D_u$$

Discards for the unobserved trips are estimated using a ratio estimator that expands the discard ratio for the observed trips by the total catch kept on the unobserved trips. Total landings of all species kept $\mathbf{K_u}$ is used as an expansion factor to estimate discards on the unobserved trips by assuming that the ratio of discards to kept $\mathbf{r_o}$ from random sample of observed trips is applicable to the unobserved fraction of the fleet. Hence

$$D_T = D_o + r_o K_u \qquad (3)$$

Suppose that the true total catch is defined as γC_T where γ represents the increase in catch necessary to offset the retrospective pattern. The increase can be achieved via an increase θ in landings on vessels without observers, an increase β of the discard rate on vessels without observers or both factors. Substituting into Eq. 1 yields

$$\gamma C_T = L_o + \theta L_u + D_o + \beta r_o K_u \qquad (4)$$

Equation 4 can be rearranged to express the increase in unobserved landings as a function of the increase in discarding rates β for a given value of γ. Solving for θ gives:

$$\theta = \frac{\gamma C_T - L_o - D_o}{L_u} - \beta r_o K_u / L_u \qquad (5)$$

Equation 5 describes the set of feasible combinations of θ and β sufficient to explain total catch raising factors equal to γ.

If one assumes that there is no observer effect such that β=1 then all of the increase in catch must be attributable to unreported landings. The value of θ corresponding this assumption is

$$\theta = \frac{\gamma C_T - L_o - D_o}{L_u} - r_o K_u / L_u \qquad (6)$$

Alternatively, if it assumed that θ =1, then

$$\beta = \frac{\frac{\gamma C_T - L_o - D_o}{L_u} - 1}{r_o K_u / L_u} \qquad (7)$$

Equation 6 and 7 can be used to estimate the boundary limits of ratios of unreported landings or increased discard rates that correspond to total catch raising factors equal to γ.

Prior to 1994, US port agents interviewed captains of commercial fishing trips to obtain fishing location and effort information such as days absent (time away from port) and days fished (time the gear is actively fishing). Not every trip was interviewed, and interview coverage varied by port and gear type. For non-interviewed trips, port agents used knowledge acquired through prior interviews of the vessel and the fleet to assign a statistical area and effort. For non-interviewed trips, the resolution of area fished was not as fine as for interviewed trips, and similarly, detailed effort information was not obtained; however, statistical area, days fished, and days absent were estimated. In early 1994, the commercial data collection program changed to a system consisting of two components: dealer reporting and vessel trip reporting. The vessel trip reports (VTR) contain information on area fished, effort, and catch. A trip-based multi-tier allocation scheme was developed to determine area fish and effort for dealer landings using the vessel trips reports (Wigley et al. 2008). Total effort in the dealer data is not known, hence dealer trips acquire fishing effort directly from corresponding VTR trips (Level A) or from fishing effort estimated using the median days fished and days absent from a group of VTRs possessing similar trip characteristics (Level B, C, and D). The first and third quartiles of days fished and days absent were also derived such that quartile deviations (Q3 – Q1)/2 can be derived.

Results

See Tables 1, 2 and 3 for bias factors needed to increase catch five-fold by US large mesh otter trawls, US small mesh otter trawls, and US scallop dredges.

A summary of Georges Bank yellowtail flounder landings (mt) and the days fished associated with commercial trips using otter trawl gear (050, 054, and 057) fishing in statistical areas (520, 522, 523, 524, 525, 541, 542, 543, 550, 551, 552, 560, 561, and 562) that reported groundfish landings from 1964 through 2012 are presented in Figures 1 and 2. Across the entire time series, the majority of days fished was obtained directly from an individual trip via an interview or a VTR.

While a detailed examination of stock landings resulting from the trip-based multi-tier allocation scheme compared favorably with the previous method (Wigley et al. 2007), examination of effort over the entire time series has not yet been undertaken. Thus, caution should be used in evaluating trends over the complete time series given the change in data collection systems that occurred in 1994.

Discussion and Conclusions

Results suggest that bias factors greater than five are required to increase the total catch by a factor of five. This occurs because a fraction of the landings and discards are observed, and therefore not subject to further adjustment. To achieve a five-fold increase in total yellowtail catch in large mesh otter trawls the discard rate on unobserved trips would have to increase by a factor of 15 to 590 times (Table 1). This follows from the low overall rate of yellowtail flounder discards on observed trips. If the five-fold increase in catch were attributed to an increase in landings only, the increase would range from 5 to 9.5-fold (Table 1). Increases in the small mesh groundfish fleet are even less plausible (Table 2).

For scallop dredges, landings of yellowtail flounder have been very low in recent years owing to management measures. In these fleets the increases in discarding rates on unobserved trips would have to increase by factors of 5 to 11 times for the 2001 to 2012 period (Table 3). If illegal landings were assumed to be responsible for a fivefold increase in yellowtail catch, the landings would have to increase by 50 to over 10,000 fold.

To the best of our knowledge, there is no empirical evidence to suggest that either discard rates or illegal landings on unobserved vessels could be as high as suggested by these analyses. Comparisons of performance of observed and unobserved trips in

Wigley et al. (2012) suggested that in general, such trips tended to have the same average total catches and trip durations; however, large mesh groundfish was a species group with statistically significant differences in mean kept pounds between unobserved and observed trips. We note that in all cases the differences in mean kept pounds were less than 505 pound, a relative small amount for this species group. Demarest (pers. comm.) found statistically significant difference in trip behaviors occurred on sector vessels with and without observers. However, the differences in trip durations and overall landings were relative small and far lower than the magnitude necessary to offset the retrospective patterns in our analyses.

We have not examined records of law enforcement actions to determine if illegal landings were widespread.

We conclude that neither increased discarding rates on unobserved vessels nor illegal landings on unobserved vessels seem plausible given the extreme magnitude of change implied by our analyses. We cannot exclude the possibility that such activity is occurring but our collective judgments are that such rates are unlikely. Our analyses do not include the possibility that discards and landings biases in conjunction with increased natural mortality would be sufficient to create a severe retrospective pattern. Trends in US fishing effort by otter trawls has declined in recent years, indicating that non-observed fishing mortality effects, such as due to injury from passing through meshes, is not a likely cause of the missing catch needed to explain the retrospective pattern.

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Tables

Table 1. Summary of extreme bias factors necessary to increase total yellowtail flounder catch by a factor of 5 in the large mesh otter trawl fleet fishing on Georges Bank

year	Gear	Trip Type	Mesh	Percent of Trips Observed	Percent of total catch observed	Observed Percent of Yellowtail Discards to Total Kept	Observed Percent of Yellowtail Landings to Total Landings	Estimated Total Yellowtail Catch (lb)	Yellowtail Catch Necessary to Remove Retro Pattern	Required Percent of yellowtail discard to total catch	Theta factor (increase in Landings) for beta=1.	Beta factor (increase in discards) for theta=1
1989	Otter Trawl	all	lg	0.8%	0.2%	0.185%	2.198%	2,162,781	10,813,906	19.8%	5.2	107.5
1990	Otter Trawl	all	lg	0.7%	0.1%	0.331%	2.480%	5,514,321	27,571,604	45.0%	5.1	136.4
1991	Otter Trawl	all	lg	0.7%	0.1%	0.944%	1.912%	3,945,304	19,726,519	29.7%	5.6	31.6
1992	Otter Trawl	all	lg	0.7%	0.1%	0.091%	1.674%	5,908,163	29,540,813	46.4%	5.0	511.3
1993	Otter Trawl	all	lg	0.7%	0.8%	1.892%	13.525%	4,916,037	24,580,185	43.1%	5.9	22.9
1994	Otter Trawl	all	lg	1.3%	1.2%	0.767%	8.217%	3,302,340	16,511,700	43.1%	5.4	57.0
1995	Otter Trawl	all	lg	2.9%	0.8%	0.333%	1.764%	842,245	4,211,223	15.4%	5.4	47.1
1996	Otter Trawl	all	lg	1.1%	1.7%	0.469%	13.033%	1,763,082	8,815,408	22.8%	5.4	48.8
1997	Otter Trawl	all	lg	0.6%	0.9%	1.716%	19.627%	2,380,862	11,904,312	36.8%	6.0	21.5
1998	Otter Trawl	all	lg	0.5%	0.0%	0.818%	3.437%	3,752,617	18,763,087	50.7%	5.3	62.1
1999	Otter Trawl	all	lg	0.6%	0.1%	0.085%	2.707%	3,878,554	19,392,772	49.9%	5.0	590.3
2000	Otter Trawl	all	lg	1.3%	0.6%	0.134%	9.673%	7,325,064	36,625,318	77.0%	5.1	581.1
2001	Otter Trawl	all	lg	2.2%	0.3%	0.232%	4.754%	7,863,001	39,315,006	72.4%	5.1	315.6
2002	Otter Trawl	all	lg	3.9%	1.1%	0.114%	4.593%	5,228,393	26,141,965	45.9%	5.1	415.6
2003	Otter Trawl	all	lg	7.6%	3.7%	0.512%	10.007%	7,340,539	36,702,695	56.7%	5.3	116.5
2004	Otter Trawl	all	lg	11.9%	6.3%	1.194%	17.194%	13,197,613	65,988,066	93.1%	5.5	84.7
2005	Otter Trawl	all	lg	48.8%	32.1%	0.932%	15.043%	6,558,682	32,793,410	63.5%	7.3	99.6
2006	Otter Trawl	all	lg	31.1%	32.7%	0.900%	12.469%	2,604,176	13,020,882	40.2%	7.5	58.5
2007	Otter Trawl	all	lg	30.2%	22.4%	1.885%	8.925%	2,864,318	14,321,591	39.6%	7.4	26.0
2008	Otter Trawl	all	lg	44.4%	32.8%	1.812%	8.451%	2,600,037	13,000,186	35.4%	8.6	26.4
2009	Otter Trawl	all	lg	30.8%	24.7%	3.507%	7.201%	3,341,199	16,705,994	40.5%	9.5	14.5
2010	Otter Trawl	all	lg	36.6%	26.3%	1.704%	5.592%	1,991,360	9,956,798	25.6%	8.6	18.9
2011	Otter Trawl	all	lg	56.4%	26.9%	0.434%	7.618%	2,059,217	10,296,083	30.1%	6.8	92.1
2012	Otter Trawl	all	lg	55.1%	22.0%	0.271%	5.663%	987,477	4,937,387	20.4%	6.4	92.7

Table 2. Summary of extreme bias factors necessary to increase total yellowtail flounder catch by a factor of 5 in the small mesh otter trawl fleet fishing on Georges Bank

year	Gear	Trip Type	Mesh	Percent of Trips Observed	Percent of total catch observed	Observed Percent of Yellowtail Discards to Total Kept	Observed Percent of Yellowtail Landings to Total Landings	Estimated Total Yellowtail Catch (lb)	Yellowtail Catch Necessary to Remove Retro Pattern	Required Percent of yellowtail discard to total catch	Theta factor (increase in Landings) for beta=1.	Beta factor (increase in discards) for theta=1
1989	Otter Trawl	all	sm	7.1%	9.7%	0.125%	0.161%	21,187	105,935	1.1%	10.0	9.5
1990	Otter Trawl	all	sm	4.2%	6.4%	0.499%	0.457%	61,623	308,116	3.1%	18.9	6.4
1991	Otter Trawl	all	sm	4.8%	1.8%	0.000%	0.032%	7,387	36,935	0.3%	5.1	1341.0
1992	Otter Trawl	all	sm	3.1%	0.2%	0.000%	0.017%	17,383	86,917	0.5%	5.0	1152.5
2000	Otter Trawl	all	sm	1.5%	63.5%	0.997%	20.588%	161,872	809,358	6.5%	40.7	6.6
2001	Otter Trawl	all	sm	2.6%	25.2%	0.170%	9.481%	97,517	487,586	3.2%	7.9	19.2
2002	Otter Trawl	all	sm	2.7%	53.3%	0.003%	3.511%	10,049	50,247	0.4%	9.8	129.5
2003	Otter Trawl	all	sm	3.5%	1.2%	0.019%	0.211%	55,857	279,286	1.4%	5.3	77.8
2007	Otter Trawl	all	sm	3.5%	0.0%	1.373%	0.000%	181,325	906,626	6.9%	263.5	5.2
2009	Otter Trawl	all	sm	12.7%	0.0%	0.812%	0.000%	48,434	242,172	4.0%	7457.2	5.4

Table 3. Summary of extreme bias factors necessary to increase total yellowtail flounder catch by a factor of 5 in the scallop dredge fleet fishing on Georges Bank

year	Gear	Trip Type	Mesh	Percent of Trips Observed	Percent of total catch observed	Observed Percent of Yellowtail Discards to Total Kept	Observed Percent of Yellowtail Landings to Total Landings	Estimated Total Yellowtail Catch (lb)	Yellowtail Catch Necessary to Remove Retro Pattern	Required Percent of yellowtail discard to total catch	Theta factor (increase in Landings) for beta=1.	Beta factor (increase in discards) for theta=1
1991	Scallop Dredge	LIM	all	0.1%	0.0%	2.109%	1.981%	2,481,302	12,406,512	12.6%	21.8	6.0
1992	Scallop Dredge	LIM	all	0.5%	0.0%	0.361%	0.140%	698,497	3,492,485	3.6%	8.2	10.0
1993	Scallop Dredge	LIM	all	0.7%	0.2%	0.398%	0.546%	700,531	3,502,657	5.7%	6.7	14.3
1994	Scallop Dredge	LIM	all	1.7%	0.1%	0.106%	0.075%	89,504	447,518	3.2%	5.6	30.5
1995	Scallop Dredge	LIM	all	1.5%	0.4%	0.160%	0.181%	31,559	157,794	1.5%	8.5	9.7
1996	Scallop Dredge	LIM	all	2.0%	1.0%	0.726%	0.368%	130,615	653,074	4.1%	30.5	5.7
1997	Scallop Dredge	LIM	all	2.0%	1.2%	1.712%	0.140%	319,236	1,596,180	9.1%	52.2	5.4
1998	Scallop Dredge	LIM	all	0.8%	1.9%	3.597%	0.432%	675,585	3,377,923	18.3%	180.1	5.1
1999	Scallop Dredge	GEN	all	4.5%	0.0%	1.831%	0.000%	73,472	367,358	9.8%	51.3	5.4
1999	Scallop Dredge	LIM	all	6.8%	11.0%	1.721%	0.301%	1,303,177	6,515,886	9.0%	72.3	5.5
2000	Scallop Dredge	LIM	all	34.9%	47.7%	2.493%	0.418%	1,389,791	6,948,953	12.7%	126.0	6.3
2001	Scallop Dredge	LIM	all	7.9%	0.5%	0.187%	0.030%	131,749	658,747	1.8%	8.3	10.2
2002	Scallop Dredge	LIM	all	3.4%	0.0%	0.345%	0.000%	61,709	308,547	1.7%	459.8	5.1
2003	Scallop Dredge	LIM	all	0.9%	0.0%	1.488%	0.000%	643,920	3,219,602	7.4%	11199.6	5.0
2004	Scallop Dredge	LIM	all	13.1%	22.3%	0.486%	0.059%	177,986	889,928	2.5%	150.2	5.4
2005	Scallop Dredge	GEN	all	12.8%	0.0%	0.084%	0.000%	2,730	13,651	0.5%	41.4	5.5
2005	Scallop Dredge	LIM	all	8.9%	3.1%	0.404%	0.008%	431,056	2,155,280	2.1%	103.4	5.4
2006	Scallop Dredge	LIM	all	8.1%	2.4%	0.454%	0.002%	575,743	2,878,714	2.3%	451.6	5.2
2007	Scallop Dredge	GEN	all	9.6%	0.0%	0.185%	0.000%	5,611	28,054	1.8%	8.2	11.2
2007	Scallop Dredge	LIM	all	10.8%	5.0%	0.344%	0.000%	266,673	1,333,363	1.7%	11227.7	5.3
2008	Scallop Dredge	LIM	all	15.7%	12.4%	0.743%	0.004%	283,727	1,418,636	3.7%	1740.5	5.3
2009	Scallop Dredge	LIM	all	11.9%	50.8%	0.442%	0.032%	362,057	1,810,285	2.2%	709.4	5.4
2010	Scallop Dredge	LIM	all	8.5%	4.4%	0.160%	0.003%	26,271	131,354	0.8%	271.4	5.2
2011	Scallop Dredge	LIM	all	12.0%	53.5%	0.167%	0.154%	171,884	859,418	0.9%	94.5	5.7
2012	Scallop Dredge	GEN	all	8.1%	0.0%	0.171%	0.000%	2,687	13,436	1.1%	14.2	6.8
2012	Scallop Dredge	LIM	all	16.3%	30.3%	0.285%	0.136%	343,392	1,716,959	1.5%	57.8	5.8

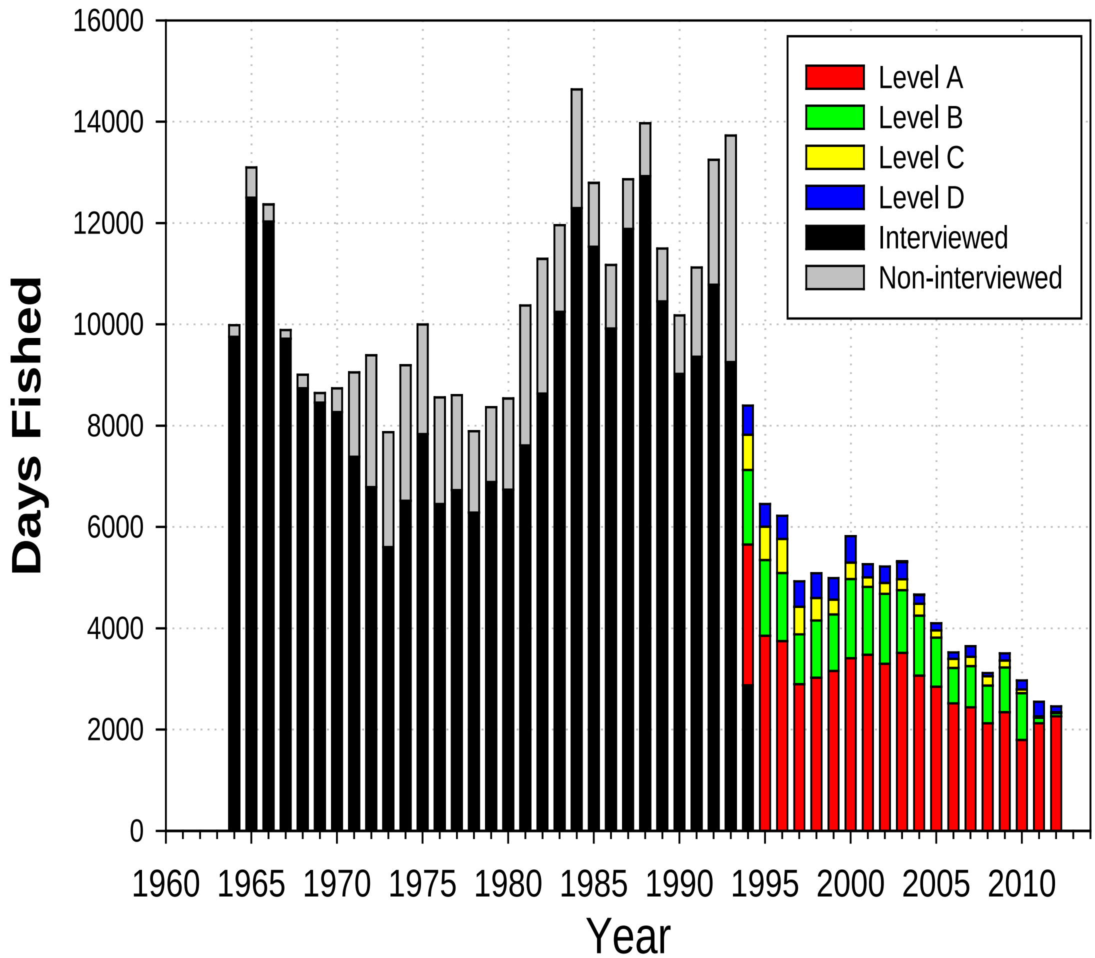

Figure 1. Summary of days fished associated with commercial trips using otter trawl gear (050, 054, and 057) fishing in statistical areas (520, 522, 523, 524, 525, 541, 542, 543, 550, 551, 552, 560, 561, and 562) that reported groundfish landings from 1964 through 2012. Prior to 1994, days fished were obtained (interview) or estimated (non-interviewed) by port agents; from 1994 onward, days fished were obtained (Level A) or estimated (Level B, C, or D) from Vessel Trip Reports.

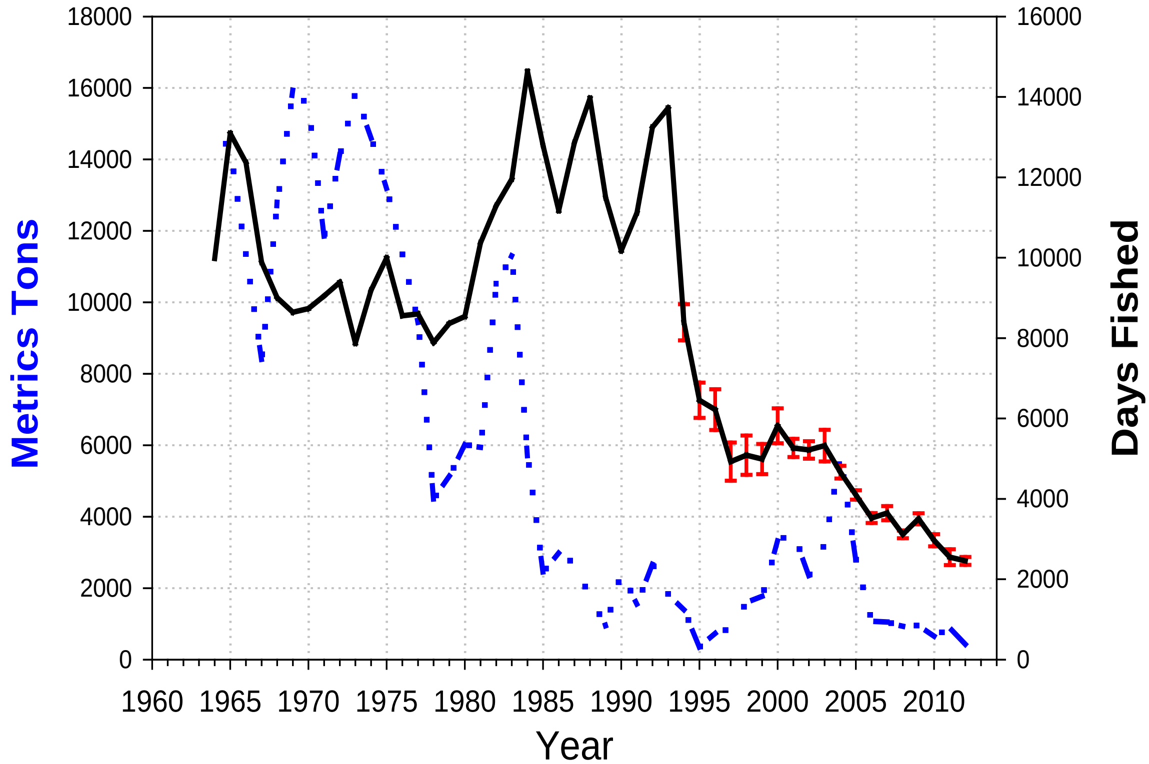

Figure 2. Trends in Georges Bank yellowtail flounder landings (mt; dashed line) and days fished (solid line with quartile deviation) associated with commercial trips using otter trawl gear (050, 054, and 057) fishing in statistical areas (520, 522, 523, 524, 525, 541, 542, 543, 550, 551, 552, 560, 561, and 562) that reported groundfish landings from 1964 through 2012.