APPENDIX 1

SAW 47 Working Paper 1 (TOR 1) – Commercial Fishery Discards

December 10, 2007

Estimation of Commercial Fishery Discards of Summer Flounder: Update 2007 or Revise the 1989-2007 Time Series?

Background

In the 1993 SAW 23 assessment for summer flounder (NEFSC 1993), an analysis of variance of fishery observer data for summer flounder was used to identify stratification variables for an expansion procedure to estimate total landings and discards from the observer data kept and discard rates (weight per day fished) in the commercial fishery. Initial models included year, quarter, fisheries statistical division (2-digit area), area (divisions north and south of Delaware Bay), and tonnage class as main effects. Quarter and division consistently emerged as significant main effects without significant interaction with the year effect. The estimation procedure expanded transformation bias-corrected geometric mean catch (landings and discards) rates in year, quarter, and division strata by total days fished (days fished on trips landing any summer flounder by any mobile gear, including fish trawls and scallop dredges) to derive fishery landings and discards (hereafter called the "mean log ratio with correction" method). The "days fished" effort metric was found to correlate better with the observed summer flounder discards on a per trip basis than other potential expansion factors such as total summer flounder landings or total trip landings of all species. The use of fishery effort as the multiplier (raising factor) also allowed estimation of landings from the fishery observer data for comparison with dealer reported landings, to help judge the potential accuracy of the procedure and/or sample data.

For strata with no fishery observer sampling, catch rates from adjacent or comparable strata were substituted as appropriate (except for Division 51, which generally has very low catch rates and negligible catch). Estimates of discard were stratified by 2 gear types (scallop dredges; trawls) for years when data were adequate (1992 and later years). Estimates at length and age were stratified by gear for 1994-2000 and 2002-2006, again due to sample size considerations. Only 11 fish were sampled from the sea scallop dredge fishery 2001, and so the scallop dredge discards were assumed to have the same length and age composition as the trawl fishery discards in 2001.

The change in mid-1994 from the interview/weighout data reporting system to the VTR/mandatory dealer report system required a change in the estimation of effort (days fished) to estimate total discards. An initial examination of days fished and catch per unit effort (CPUE; landings per day fished) for cod conducted at SAW 24 (NEFSC 1997a) compared these quantities as reported in the full weighout and VTR data sets (DeLong *et al.*, 1997). This comparison indicated a shift to a higher frequency of short trips (trips with one or two days fished reported), and to a mode at a lower rate of CPUE. It was not clear at SAW 24 if these changes were due to the change in reporting system (units reported not comparable), or real changes in the fishery, and so effort data reported by the VTR system were not used quantitatively in the SAW 24 assessments. In the SAW 25 assessment for summer flounder (NEFSC 1997b), a slightly different comparison was made. The port agent interview data for 1991-93 and merged dealer/VTR data for 1994-1996 (the matched set data), which under each system serve as the Asample@ to characterize the total commercial landings, were compared in relative terms (percent frequency). For summer flounder, the percent frequency of short trips (lower number of days fished per trip) increased during 1991-1996, but not to the degree observed for cod, and the mode of CPUE rates for summer flounder increased in spite of lower effort per trip. For the summer flounder fishery, these may reflect actual changes in the fishery, due to increased restrictions on allowable landings per trip (trip landings limits might lead to shorter trips) and stock size increases (higher CPUE). As for cod, however, the influence of each of these changes (reporting system, management changes, stock size changes) has not been quantified. Total days fished in the summer flounder fishery were comparable between 1989-1993 period and 1994. Since 1994, total days fished have ranged from 20,700 days in 1999 to 9,300 days in 2004, with a mean of about 12,000 days, a substantial decline relative to the 1989-1993 mean of 22,000 days. Because the effort measure is critical to the estimation of discards for summer flounder, the VTR data were used as the best data source to estimate summer flounder fishery days fished for 1994-2006.

Two adjustments were made to the dealer/VTR matched data subset days fished estimates to fully account for summer flounder fishery effort during 1994-2006. First, the landings to days fished relationship in the matched set was assumed to be the same for unmatched trips, and so the days fished total in each discard estimation stratum (2-digit area and quarter) was raised by the dealer to matched set landings ratio. This step in the estimation accounted for days fished associated with trips landing summer flounder, and provided an estimate of discard for trips landing summer flounder. Given the restrictions on the fishery however, there is fishing activity which results in summer flounder discard, but no landings, especially in the scallop dredge fishery. The days fished associated with these trips was accounted for by raising strata discard estimates by the ratio of the total days fished on trips catching any summer flounder (trips with landings and discard, plus trips with discard only) to the days fished on trips landing summer flounder (trips with landings and discard), for VTR trips reporting discard of any species (DeLong *et al.* 1997). For this step, it is necessary to assume that the discard rate (as indicated by the fishery observer data, which includes trips with discard but no landings, and which is used in previous estimation procedure steps) is the same for trips with only discards as for trips with both landings and discards.

This “mean log ratio with correction” estimation procedure has been used in every assessment since 1993, including the 2006 update (Terceiro 2006). Discard estimates using this method for 1989-2006 are summarized in Table 1 (see ASSESS estimates). Discards as a proportion of the fishery observer data estimated landings were highest in 2001 (53%), and lowest in 1995 and 1996 (5 and 7%). Estimates of landings from observer data ranged from +53% (1999) to -70% (2001) of the reported landings in the fisheries, with discards ranging from 41% (1990) to 6% (1995) of the reported landings (Tables 1-2). Total discards estimated for 2003, 2004, and 2005 were 10%, 4%, and 4% of the reported landings. Scallop dredge fishery discard to landed ratios are much higher than trawl fishery ratios, purportedly because of closures and trip limits. Although the scallop dredge landings of summer flounder are less than 5% of the total, the discards of summer flounder have been estimated to be of the same order of magnitude as in the trawl fishery (see ASSESS estimates, Table 1).

Estimation of discards for groundfish: GARM 2007

Rago et al. (2005) described methods recently adopted by the NEFSC to estimate the discards of trawl, gillnet, longline, scallop, and herring fisheries of the Northeast U.S. The Rago et al. (2005) work focused on the use of stratified discard to kept weight ratios (d/k) as the primary estimator, with the "d" portion for the stocks (or group of stocks) of interest, and the "k" portion most often for the kept of all species, or the species that comprised the dominant portion of the catch.

The method developed by Rago et al. (2005) was subsequently modified and used in an expanded exercise to develop discard estimates for 45 different fishing fleets and 60 fish stocks, encompassing all of the federally managed fisheries in the Northeast. This work is documented in Wigley et al. (2007) – the "SBRM Report." Recently, these general methods were reviewed as part of the Groundfish Assessment Review Meeting (GARM) 2007 Data Methods Workshop. The working paper of Wigley et al. (MS2007) documents revisions to the Rago et al (2005) and Wigely et al. (2007) methods, and provides details on the methodology used to develop the National Bycatch Report for 2005, and proposes this method for use in the GARM 2008 assessments for New England groundfish. That general estimation method is used in this work, and is hereafter called the National Bycatch Report Discard method 2 (NBRD2).

The working paper of Legault (MS2007), also prepared for the GARM 2007 Data Methods Workshop, presented results of simulations designed to rank the utility of different methods to estimate commercial fishery discards. Among the methods compared were the approach currently used in the Terceiro (2006) summer flounder assessment ("mean log ratio with correction" in Legault MS2007) and the Wigley et al. (MS2007) NBRD2 approach ("ratio of sums" in Legault MS2007). Legault (MS2007) concluded that the "mean log ratio with correction" was not a good estimator for total discards, due to the potential for large bias in the estimates; the Wigley et al. (MS2007) "ratio of sums" was recommended as a good estimator, with use of "all species kept" appearing to produce less biased results than kept of only the species of interest. The Wigley et al. (MS2007) "ratio of sums" estimation method (NBRD2) has been used here to estimate discards and landings of summer flounder in the trawl, scallop dredge, and sink gillnet fisheries at different spatial and temporal stratifications, for comparison with estimates made in the Terceiro (2006) stock assessment using the "mean log ratio with correction" (ASSESS) method.

Comparative Results

Trawl Fishery

Discard estimation results for the current method (ASSESS) and the proposed NBRD2 method for trawl gear are compared in Table 1 and Figure 1. Discard estimates in Figure 1 are plotted with +/- one standard error (1 SE) bars. Over the 18 year (1989-2006) time series, the NBRD2 method provides higher discard estimates in 14 years. Of those 14 years, the +/- 1 SE error bars of the NBRD2 estimates overlap those of the ASSESS estimates in 7 years, suggesting that the estimates are comparable in those years – i.e., the two methods produce comparable estimates in 7 of the 18 total years. In 3 of those 7 years, the estimates match very closely (1997, 1999, 2002).

In general, the coefficient of variation (CV) for discard estimates are smaller for NBRD2 discard ratios calculated at a region/quarter stratification than at wider temporal scales (annual or semi-annual), and at the quarterly time stratification are comparable to, but generally slightly higher than, the ASSESS discard rate CVs (Table 1, Figure 1). The ASSESS discard rate data are from "more directed" observed summer flounder trips (trips must have summer flounder discard and/or landings to be included) and so the discard rates tend to be less variable than the wider universe of trips used in the NBRD2 approach. In addition, the ASSESS method effort expansion factor (days fished) is from VTR trips reporting summer flounder discard and/or landings, which tend to be more "directed" in nature than the "all species landings" (i.e., all trips) expansion factor used in the NBRD2 method. These combined factors generally result in slightly better precision of the ASSESS discard estimates, in spite of the smaller number of observed trips used to calculate the discard rates.

The estimation of landings from the two methods can potentially be used a means to verify the accuracy of the discard estimates. Landings estimation results for the ASSESS and NBRD2 methods and DEALER reported landings for trawl gear are compared in Table 2 and Figure 2. The ASSESS method estimates of trawl landings are closer to the DEALER reported landings in 12 of the 18 years. There are time blocks (ASSESS: 1989-1997, 2001-2003; NBRD2: 1998-2000, 2004-2006) during which one method performs better than the other. Over the 1989-2006 period, DEALER reported landings averaged 4,853 mt, NBRD2 estimates averaged 5,914 mt (+22% above DEALER), and ASSESS estimates averaged 4,602 mt (-5%). The precision of the ASSESS method landings estimates is consistently better than for the NBRD2 method, due to the same factors as for the discards.

Scallop Dredge Fishery

Discard estimation results for the current method (ASSESS) and the proposed NBRD2 method for trawl gear are compared in Table 1 and Figure 3. Discard estimates in the figure are plotted with +/- one standard error (1 SE) bars. Over the 15 year (1992-2006) time series, the NBRD2 method provides higher discard estimates in 12 years. Of those 12 years, the +/- 1 SE error bars of the NBRD2 estimates overlaps those of the ASSESS estimates in 4 years, suggesting that the estimates are comparable in those years – i.e., the two methods produce comparable estimates in 4 of the 15 total years. In 3 of those 4 years, the estimates match closely (1992, 1998, 2001).

In general, as with the trawl fishery estimates, the coefficient of variation (CV) for discard estimates are smaller for NBRD2 discard ratios calculated at the region/quarter stratification than at wider temporal scales (annual or semi-annual), and at the quarterly time stratification are comparable to the ASSESS discard rate CVs (Table 1, Figure 3). The ASSESS discard rate data are from more "directed" observed summer flounder trips (trips must have summer flounder discard and/or landings to be included) and so the discard rates tend to be less variable than the wider universe of trips used in the NBRD2 approach. In addition, the ASSESS method effort expansion factor (days fished) is from VTR trips reporting summer flounder discard and/or landings, which tend to be more "directed" (although still mainly bycatch in nature) than the "all scallop landings" (i.e., all scallop dredge trips) expansion factor used in the NBRD2 method. These combined factors generally result in slightly better precision of the ASSESS discard estimates, especially early in the time series when the total number of scallop dredge trips observed is small (< 50 trips annually).

The estimation of landings from the two methods can potentially be used a means to verify the accuracy of the discard estimates. Landings estimation results for the ASSESS and NBRD2 methods and DEALER reported landings for scallop dredge gear are compared in Table

2 and Figure 4. Summer flounder are generally a small bycatch in the scallop dredge fishery, and the DEALER reported landings have ranged from 25 to 284 mt over the series. The NBRD2 method estimates of summer flounder landings are closer to the DEALER reported landings in 12 of the 15 years. Over the 1992-2006 period, DEALER reported landings averaged 81 mt, NBRD2 estimates averaged 79 mt (-3%), and ASSESS estimates averaged 102 mt (+26%). The precision of the landings estimates are comparable for the two estimation methods over the time series.

Gillnet Fisheries

Discard estimates for the gillnet fishery (sink, drift, and anchor combined) have not previously been estimated in the summer flounder assessment, due to the small magnitude of summer flounder landings in the DEALER reported data and the small absolute magnitude of summer flounder discards in the gillnet observer data. The Wigley et al (2007) report indicated, however, that in 2005 about 25 mt of summer flounder were discarded in the gillnet fisheries (mainly using extra large mesh and targeting monkfish), and so in this exercise discard estimates were made using the NBRD2 method (Table 1, Figure 5). Discard estimates in the Figure 5 are plotted with +/- one standard error (1 SE) bars. Over the 13 year (1994-2006) time series, the NBRD2 method provides discard estimates of 1 to 37 mt annually, with quarterly time strata CVs ranging from 59% (1994) to 18% (2005). The NBRD2 discard estimates for the gillnet fishery are relatively imprecise (CV > 30% in 9 of 13 years) because summer flounder are encountered relatively rarely in the gillnet fishery, and both the observer discard and landings rates are highly variable.

Landings estimation results for the NBRD2 method and DEALER reported landings for gillnet gear are compared in Table 2 and Figure 6. In the gillnet fishery, summer flounder generally are a small bycatch, and the DEALER reported landings have ranged from 8 to 143 mt over the series. NBRD2 method estimates of gillnet landings generally do not match the DEALER reported landings very well over the 13 years; DEALER reported landings averaged 67 mt, while NBRD2 estimates averaged 29 mt (-57%). NBRD2 landings estimates for quarterly time strata have CVs ranging from 78% (1997) to 19% (2004), exceeding 30% in 8 of the 13 years.

Summary

This material was presented and discussed as part of a Post-GARM review session by the NEFSC Population Dynamic Branch (December 6, 2007). The results of that discussion are summarized as follows:

- GARM simulations suggested ASSESS method would prove to be positively biased…
- But, NBRD2 generally produced higher discard estimates for both trawl and scallop fisheries
- For trawl fishery NBRD2 discards average 900 mt; ASSESS discards average 500 mt
- ASSESS method precision was generally slightly better at region/quarter stratification
- ASSESS method estimates of trawl landings more consistently match DEALER over the 18 years (12 of 18 years); DEALER landings average 4,853 mt, NBRD2 estimates average 5,914 mt (+22%); ASSESS estimates average 4,602 mt (-5%)
- But, there are time blocks (ASSESS: 1989-1997, 2001-2003; NBRD2: 1998-2000, 2004-2006) during which one method performs better for the trawl fishery

- For scallop fishery NBRD2 discard estimates average 470 mt; ASSESS discards average 225 mt
- NBRD2 method estimates of scallop dredge landings more consistently match DEALER over the 15 years (12 of 15 years); DEALER landings average 81 mt, NBRD2 estimates average 79 mt (-3%); ASSESS estimates average 102 mt (+26%)
- For gillnet fishery NBRD2 discard estimates average 14 mt
- NBRD2 method estimates of gillnet landings generally don't match DEALER very well over the 13 years; DEALER averages 67 mt, NBRD2 averages 29 mt (-57%)
- The statistical diagnostics (i.e., CV indicating the precision of the discards and landings estimates) do not indicate that the NBRD2 approach represents an improvement over the current ASSESS method
- The verification method (i.e., matching the DEALER reported landings) do not indicate that the NBRD2 approach represents an improvement over the current method for trawl gear; the NBRD2 approach does seem to perform better than the current ASSESS approach for scallop dredge gear
- Given the lack of discard length frequency samples for summer flounder for gillnet gear, those discards may accounted for in the trawl fishery estimate by "raising" of the expansion factor
- Significantly more research into the sensitivity of the NBRD2 method to alternative stratification schemes is needed before the NBRD2 estimates are adopted in the assessment, and therefore…
- For now, make no changes to the discard estimation approach used in the assessment - update for 2008 benchmark assessment using the current ASSESS method
- For future work, focus on trawl and scallop dredge gear; try other approaches using sums of ratio (NBRD2) estimator, possibly with d/df for "directed" fluke trips (ASSESS) or for a "characteristic" group of landed species trips in the trawl fishery (e.g., fluke, scup, BSB, loligo, ilex, yellowtail flounder, winter flounder, cod, haddock, silver hake, etc.)

References

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Table 1: Comparison of summer flounder estimated discards using the NBRD2 method for alternative stratification of the discard rate. For trawl gear (negear = 050-059), d/k =d_fluke/k_allspecies; for scallop dredge gear (negear = 132), d/k = d_fluke/k_scallop; for gillnet (negear = 100,110,500), d/k = d_fluke/k_allspecies. N (number) of OB trips is the same for stratification levels within years. ASSESS row provides the discard estimates (based on geometric means of trip discard/days_fished ratios) used in the current assessment; N OB trips are based on different criteria (required fluke catch) than current (NBRD2) method; no gillnet gear estimates made.

1989		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	176	881	36	0			0		
Semi		844	39						
Quarter		827	38						
ASSESS	57	642	33	n/a	n/a			n/a	

1990		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	138	1538	38	0			0		
Semi		1455	39						
Quarter		1603	38						
ASSESS	61	1121	32	n/a	n/a			n/a	

1991		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	256	308	47	0			0		
Semi		291	50						
Quarter		419	33						
ASSESS	82	993	31	n/a	n/a			n/a	

Table 1 continued.

1992		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	186	1747	34	18	156	272	0		
Semi		1766	35		159	239			
Quarter		1780	35		306	150			
ASSESS	66	517	33	8	237	62		n/a	

1993		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	66	1337	40	22	147	61	0		
Semi		1535	35		141	60			
Quarter		1604	34		141	59			
ASSESS	37	477	21	15	340	31		n/a	

1994		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	63	270	249	23	112	57	262	5	51
Semi		686	79		104	39		5	58
Quarter		756	72		107	38		5	59
ASSESS	51	429	36	14	591	30		n/a	

1995		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	225	534	21	27	445	42	552	11	63
Semi		514	22		437	43		17	40*
Quarter		500	23		800	14*		15	44*
ASSESS	134	130	17	19	212	27		n/a	

Table 1 continued.

1996		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	194	330	72	40	401	34	450	1	33
Semi		411	57		433	31		1	34
Quarter		630	35		442	26		1	34
ASSESS	111	319	18	24	135	12		n/a	

1997		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	112	126	89	29	654	25	403	2	23
Semi		153	73		556	28		2	23
Quarter		276	29		433	12		2	25
ASSESS	59	299	24	23	108	24		n/a	

1998		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	70	293	70	26	223	33	447	5	40
Semi		437	36		207	33		5	42
Quarter		638	27		191	13		5	43
ASSESS	53	318	18	22	169	27		n/a	

1999		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	108	872	70	31	194	106	222	7	45
Semi		672	89		224	88		7	42
Quarter		1462	34		205	95		7	42
ASSESS	56	1476	33	10	459	39		n/a	

Table 1 continued.

2000		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	187	304	32	261	745	51	255	5	33
Semi		342	29		745	52		5	34
Quarter		459	21		780	38		4	36
ASSESS	115	740	21	23	167	19		n/a	

2001		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	282	1016	42	106	360	13	197	8	35
Semi		911	46		357	13		13	28
Quarter		971	44		358	12		14	27
ASSESS	137	287	35	68	297	12		n/a	

2002		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	325	379	25	94	536	20	150	29	72
Semi		407	20		550	19		33	63
Quarter		418	19		547	16		37	56
ASSESS	175	384	21	55	178	25		n/a	

2003		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	533	364	37	122	650	25	516	22	30
Semi		709	26		608	25		22	30
Quarter		697	21		619	22		20	32
ASSESS	212	556	19	79	194	14		n/a	

Table 1 continued.

2004		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	952	801	17	249	814	15	1058	31	26
Semi		841	16		844	14		33	22
Quarter		867	15		824	12		30	24
ASSESS	546	213	18	132	92	11		n/a	

2005		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	1736	996	9	290	515	13	940	25	18
Semi		1061	9		554	12		27	17
Quarter		1080	8		551	12		24	18
ASSESS	906	191	16	136	96	13		n/a	

2006		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	873	937	15	207	753	15	234	20	52
Semi		982	14		752	15		19	53
Quarter		1154	12		713	15		22	43*
ASSESS	578	268	3	117	93	3		n/a	

*NOTE THAT USE OF IMPUTED CELLS OFTEN REDUCES VARIANCE

Table 2. Comparison of summer flounder estimated landings using the NBRD2 method for alternative stratification of the landings rate. For trawl gear (negear = 050-059), k/k =k_fluke/k_allspecies; for scallop dredge gear (negear = 132), k/k = k_fluke/k_scallop; for gillnet (negear = 100,110,500), k/k =k_fluke/k_allspecies. N (number) of OB trips is the same for stratification levels within years. ASSESS row provides the landings estimates (based on geometric means of trip landings/days_fished ratios) used in the current assessment; no comprehensive CVs available; N OB trips are based on different criteria (required fluke catch) than current (NBRD2) method; no gillnet gear estimates made. DEALER row provides the reported dealer landings by gear.

1989	Trawl			Scallop			Gillnet		
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	176	9494	33	0			0		
Semi		7913	40						
Quarter		7992	36						
ASSESS	57	7255	22	n/a			n/a		
DEALER		6003			108			8	

1990	Trawl			Scallop			Gillnet		
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	138	4768	38	0			0		
Semi		5573	37						
Quarter		4454	42						
ASSESS	61	2959	21	n/a			n/a		
DEALER		2798			89			5	

1991	Trawl			Scallop			Gillnet		
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	256	1638	30	0			0		
Semi		1541	33						
Quarter		1887	24						
ASSESS	82	4133	13	n/a			n/a		
DEALER		4344			176			16	

Table 2 continued.

1992		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	186	10364	33	18	196	168	0		
Semi		10317	34		203	152			
Quarter		11532	34		364	65			
ASSESS	66	4532	12	8	811	28		n/a	
DEALER		5943			284			18	

1993		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	66	10494	37	22	117	68	0		
Semi		10028	38		114	70			
Quarter		10946	33		129	64			
ASSESS	37	3823	20	15	209	38			
DEALER		4176			140			8	

1994		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	63	5750	56	23	16	141	262	9	78
Semi		6839	45		19	221		11	62
Quarter		5971	48		23	86		11	62
ASSESS	51	5858	15	14	145	61		n/a	
DEALER		4240			178			16	

1995		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	225	15253	16	27	97	65	552	5	37
Semi		14413	17		92	70		5	37
Quarter		13000	19		126	45*		5	37
ASSESS	134	5855	10	19	36	59		n/a	
DEALER		4507			92			13	

Table 2 continued.

1996 d/k strata	N OB trips	Trawl MT	CV(%)	N OB trips	Scallop MT	CV(%)	N OB trips	Gillnet MT	CV(%)
Annual	194	2831	141	40	48	57	450	2	25
Semi		3932	94		54	54		2	24
Quarter		7851	41		48	59		2	24
ASSESS	111	4982	32	24	42	55		n/a	
DEALER		3718			42			12	

1997 d/k strata	N OB trips	Trawl MT	CV(%)	N OB trips	Scallop MT	CV(%)	N OB trips	Gillnet MT	CV(%)
Annual	112	274	128	29	21	59	403	72	95
Semi		511	71		29	33		77	92
Quarter		950	41		29	33		95	78
ASSESS	59	2646	34	23	17	35		n/a	
DEALER		3657			25			63	

1998 d/k strata	N OB trips	Trawl MT	CV(%)	N OB trips	Scallop MT	CV(%)	N OB trips	Gillnet MT	CV(%)
Annual	70	1704	78	26	82	43	447	4	32
Semi		3209	49		87	45		4	30
Quarter		4810	28		88	42		4	30
ASSESS	53	3602	23	22	75	32		n/a	
DEALER		4585			52			89	

1999 d/k strata	N OB trips	Trawl MT	CV(%)	N OB trips	Scallop MT	CV(%)	N OB trips	Gillnet MT	CV(%)
Annual	108	1693	97	31	42	96	222	23	68
Semi		1143	114		47	76		27	58
Quarter		4307	38		67	33		27	58
ASSESS	56	7214	24	10	182	52		n/a	
DEALER		4429			71			50	

Table 2 continued.

2000		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	187	1589	116	261	34	118	255	42	63
Semi		1682	115		26	109		42	63
Quarter		7558	16		34	86		57	57
ASSESS	115	6668	18	23	34	50		n/a	
DEALER		4625			25			52	

2001		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	282	580	38	106	10	38	197	25	39
Semi		840	31		10	39		24	40
Quarter		912	30		10	37		21	47
ASSESS	137	1509	28	68	3	123		n/a	
DEALER		4512			44			79	

2002		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	325	5115	30	94	14	36	150	16	43
Semi		5997	25		15	34		14	51
Quarter		5201	29		14	33		14	49
ASSESS	175	6609	18	55	4	58		n/a	
DEALER		6054			36			102	

2003		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	533	1318	132	122	33	36	516	69	25
Semi		5500	40		35	35		61	26
Quarter		6223	41		39	28		58	26
ASSESS	212	5990	17	79	8	35		n/a	
DEALER		5935			44			116	

Table 2 continued.

2004		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	952	4202	17	249	66	29	1058	36	20
Semi		5243	18		75	26		39	18
Quarter		5270	16		65	28		38	19
ASSESS	546	4992	10	132	5	47		n/a	
DEALER		6950			42			109	

2005		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	1736	4213	16	290	51	29	940	20	34
Semi		4178	17		49	30		21	32
Quarter		4530	14		45	30		22	30
ASSESS	906	3425	9	136	9	29		n/a	
DEALER		5793			55			143	

2006		Trawl			Scallop			Gillnet	
d/k strata	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)	N OB trips	MT	CV(%)
Annual	873	1363	40	207	131	25	234	16	53
Semi		1383	40		107	25		14	57
Quarter		3057	23		102	25		17	43
ASSESS	578	1787	2	117	9	16		n/a	
DEALER		5066			86			41	

*NOTE THAT USE OF IMPUTED CELLS OFTEN REDUCES VARIANCE

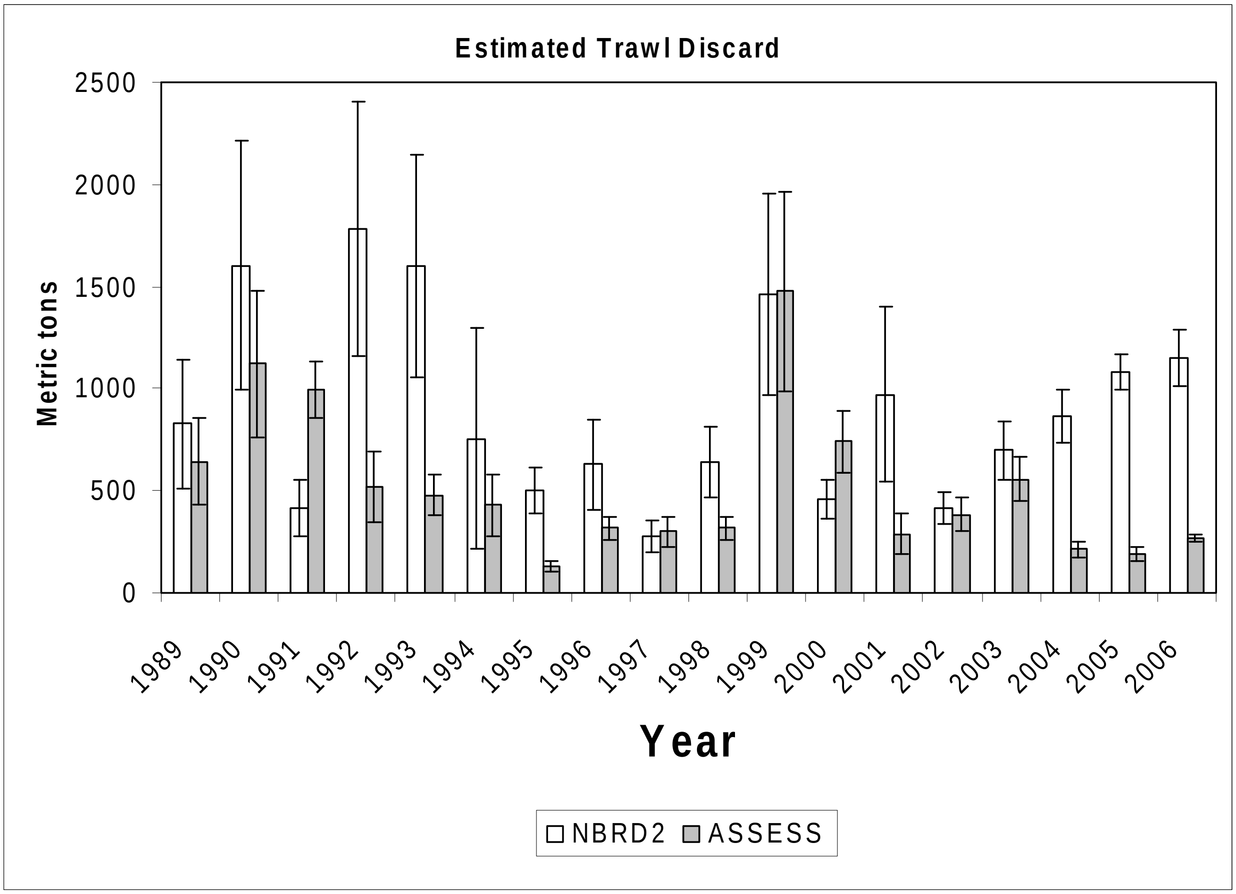
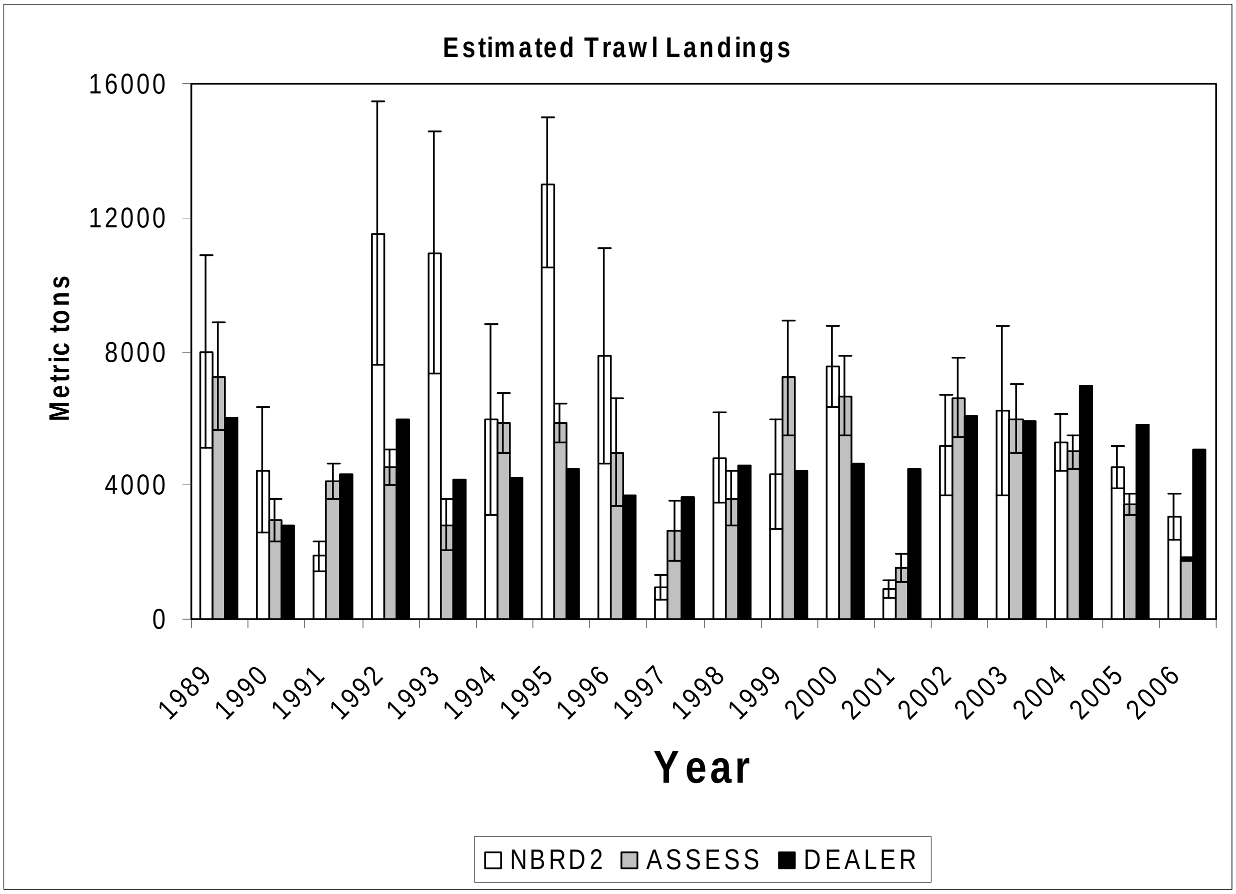

Estimated Trawl Discard
Metric tons
2500
2000
1500
1000
500
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Year
NBRD2
ASSESS

Figure 1.



Estimated Trawl Landings
16000
12000
8000
4000
0
Metric tons
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Year
NBRD2
ASSESS
DEALER

Figure 2.

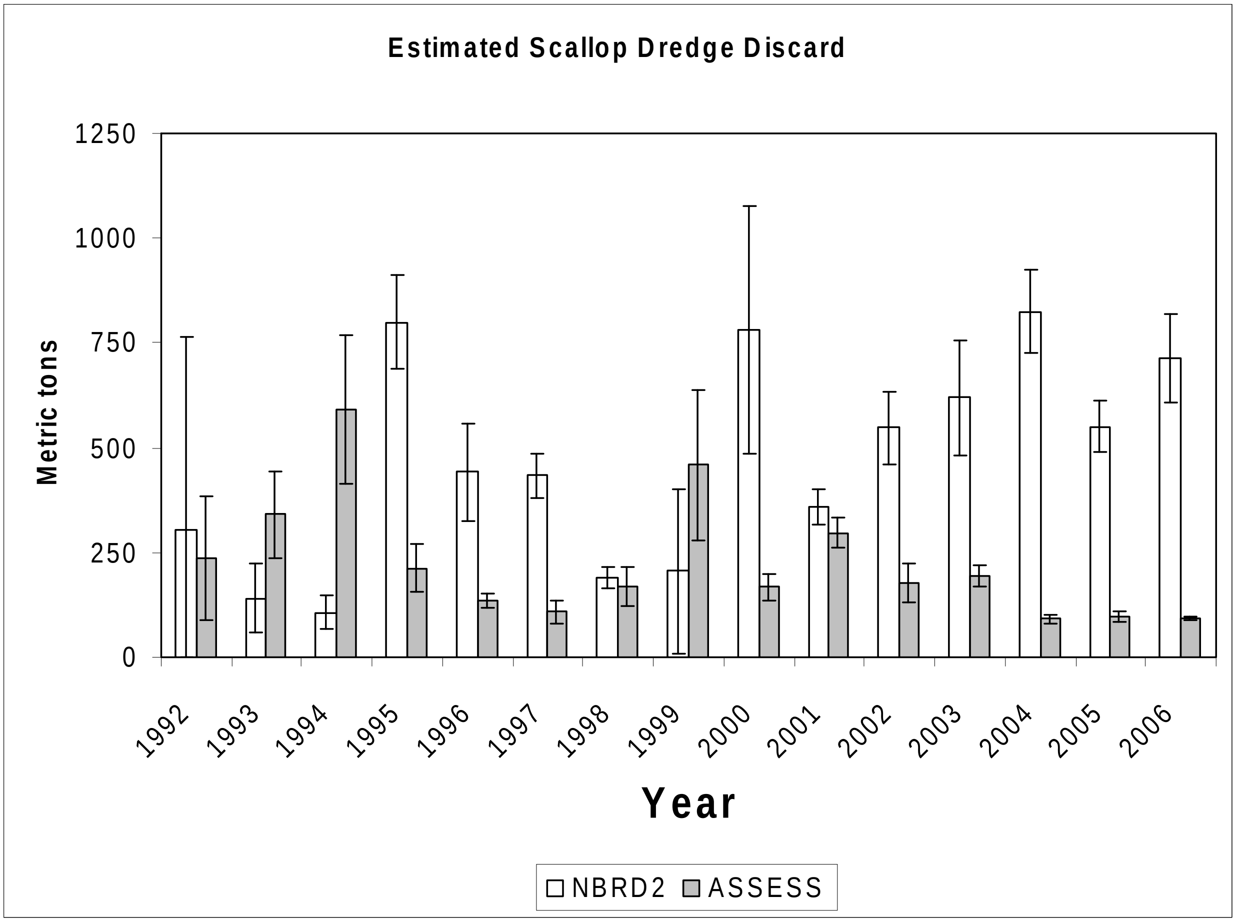

Estimated Scallop Dredge Discard
1250
1000
750
500
250
0
Metric tons
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Year
NBRD2
ASSESS

Figure 3.

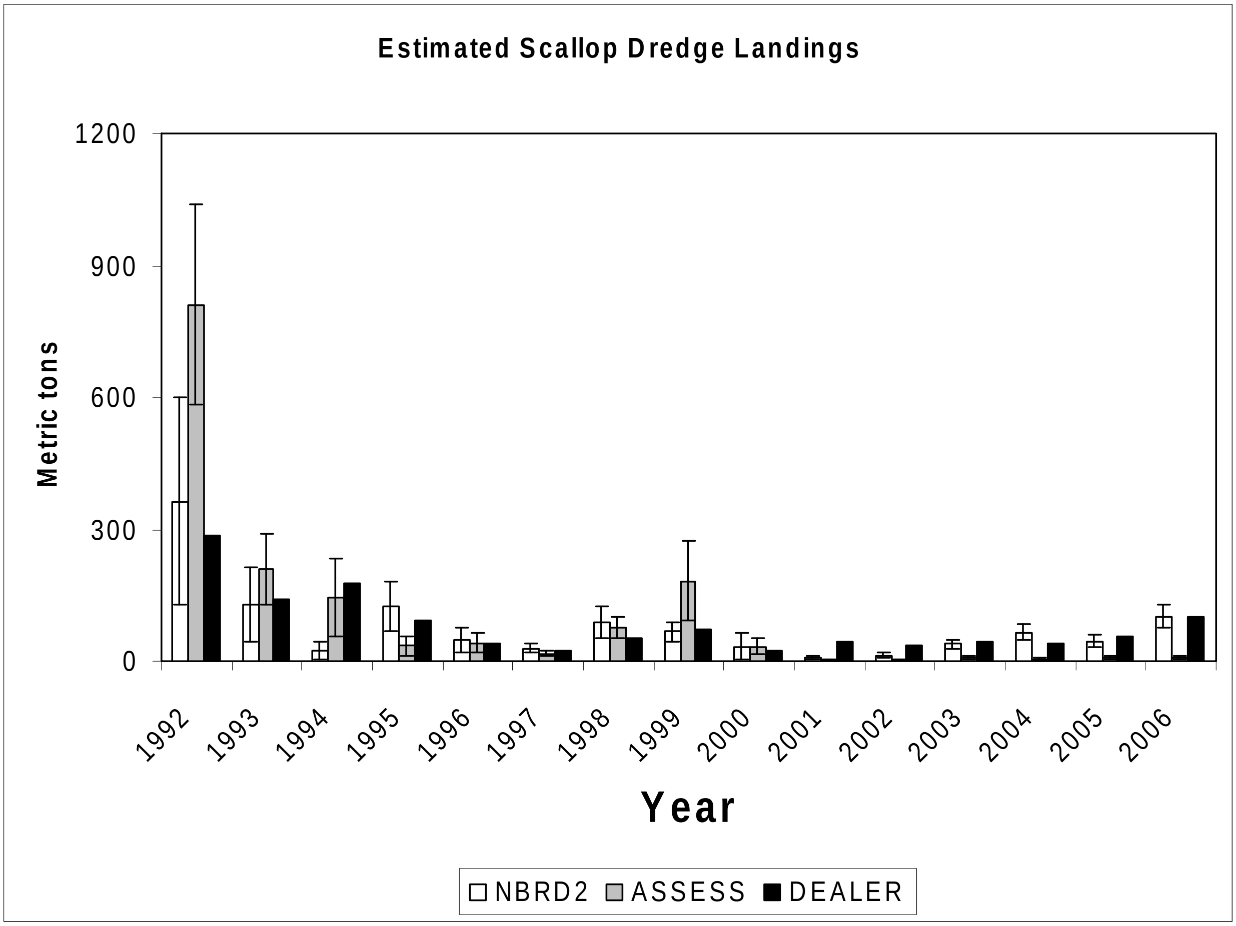

Estimated Scallop Dredge Landings
1200
900
600
300
0
Metric tons
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Year
NBRD2
ASSESS
DEALER

Figure 4.

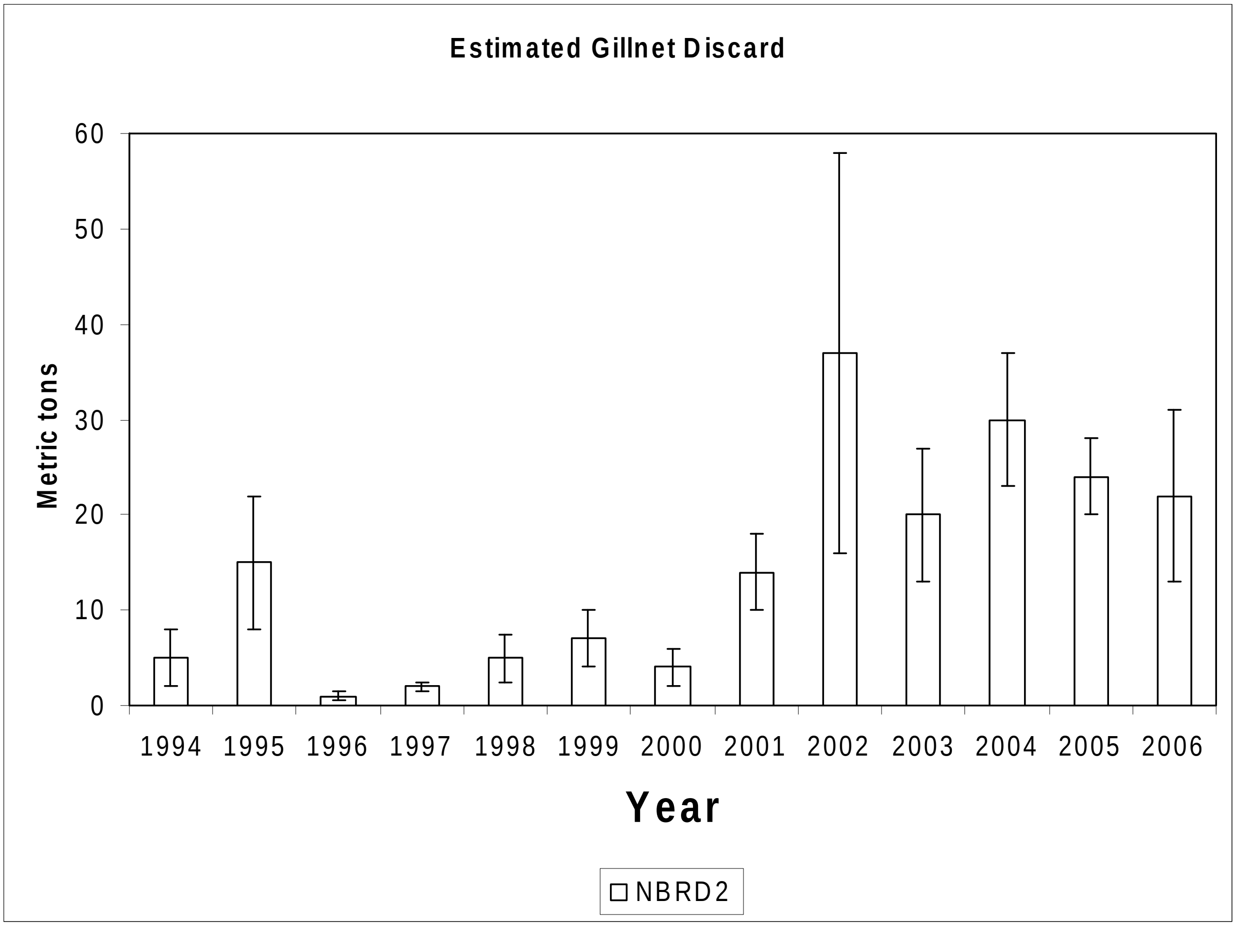

Estimated Gillnet Discard
Metric tons
60
50
40
30
20
10
0
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
Year
NBRD2

Figure 5

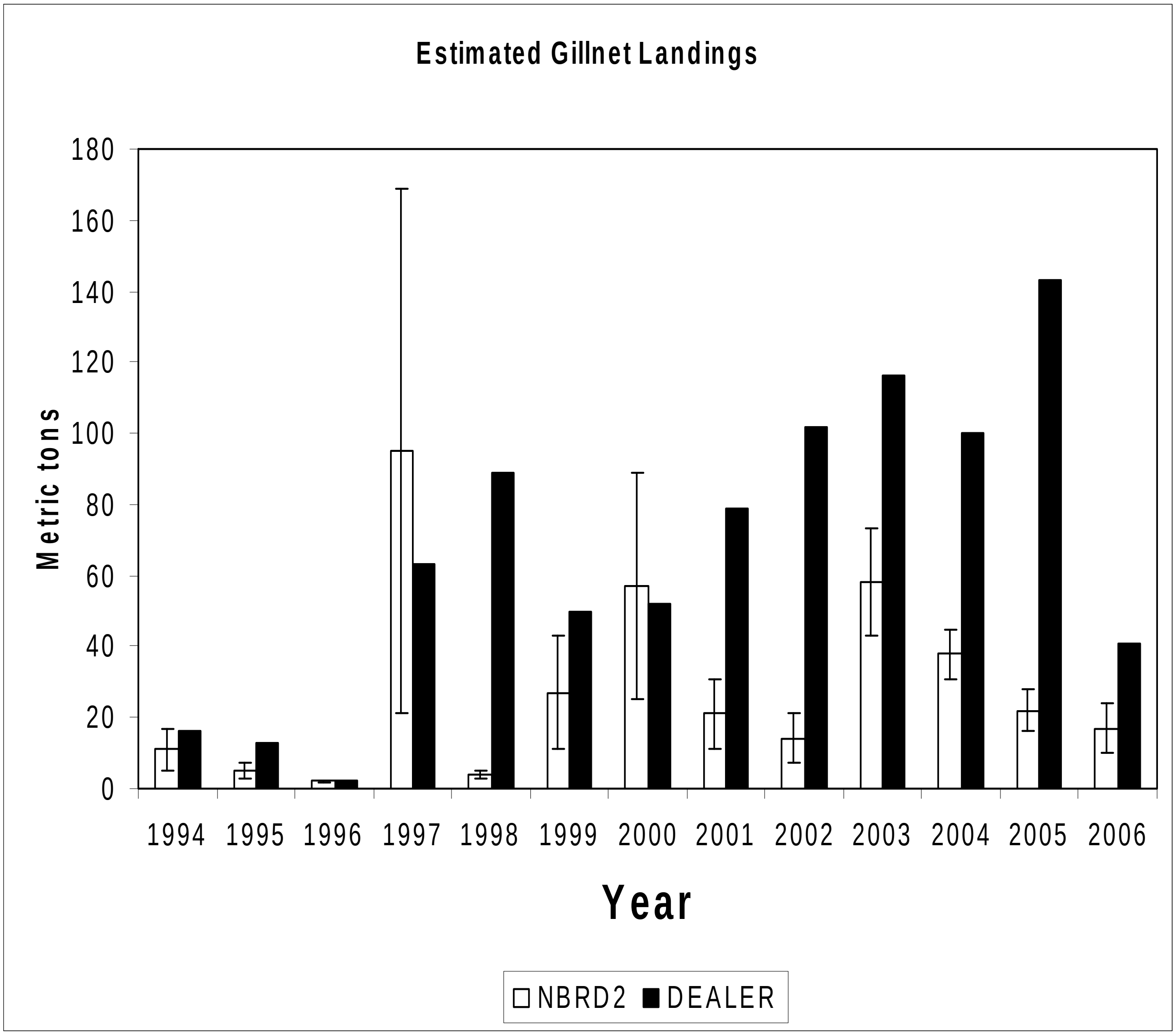

Estimated Gillnet Landings
Metric tons
0
20
40
60
80
100
120
140
160
180
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
Year
NBRD2
DEALER

Figure 6.

WORKING PAPER:

DISCARD MORTALITY OF SUMMER FLOUNDER IN THE INSHORE TRAWL FISHERY

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SUMMARY

In 2007, Cornell University Cooperative Extension received a RSA grant to determine the discard mortality in the inshore summer flounder trawl fishery. Fieldwork was carried out successfully from May through October 2007 off Long Island, New York. Ten scientific trips were made on commercial draggers working the traditional mixed trawl fishery. A goal of the project was to determine discard mortality relative to tow duration, fish size, and the amount of time fish were on the deck of the vessel. Tows of 1, 2 and 3 hours in duration were conducted. Fish were culled both immediately (from 0-10 minutes on deck) and after being held on deck for a delayed period of time (25-35 minutes on deck). Approximately 20 live fish were removed from the immediate and delayed culls upon haul-back of each tow. These live fish were weighed, tagged, and graded by condition before being transferred to a flow through seawater holding system where they were held on deck for the duration of the trip. The total catch of fluke was weighed and sorted between live and dead at consistent intervals of time to determine the effect of culling for a long as it took to clear the deck. Other variables were examined including total catch weight, species composition of total catch, fish condition factors, gear size, water temperature and air temperature. Upon arrival at the dock, live fish were transferred to a dockside net pen holding system and monitored for mortality over a 14-day period. Discard mortality rates were calculated based on the live/dead fraction of fish sorted on deck as well as the mortality rate of the live fish held in the monitoring net pen system over a 14 day period. Mortality rates were calculated by tow duration, cull time and overall. Mortality rates for the one and two hour tows were less than for the three hour tow. Mortality rates for the immediate cull

and delayed cull were similar. Overall median mortality was similar to the value assumed in recent summer flounder assessments.

METHODS

The research design of this study was dictated by the specific proposal requirements, i.e. to conduct ten one-day fishing trips incorporating different gear types, and areas fished, reflective of the inshore mixed trawl fishery. The selection of gear, fishing area, target species was left to the participating commercial fisherman to determine in consultation with CCE. This was done with the hope of not skewing the results in any one given direction, by letting the natural conditions dictate the project activity to reflect a more realistic picture of the existing inshore trawl fishery including summer flounder. Ten research trips were completed and have met the design criteria outlined in the proposal. Each trip consisted of a one, two and three hour tow, with an immediate and delayed cull for each specific tow. A specific culling procedure was adopted, so as to maintain random sampling protocol. The following time line was used after haul back:

- 0-10 minutes (immediate cull) – collection of 20 live fish for cages plus sorting of live and dead fish from one half of the pile.
- 10-25 minutes – sorting of live and dead fish only.
- 25-35 minutes (delayed cull) – collection of 20 live fish for cages plus sorting of live and dead fish from second half of the pile.
- 35-50 minutes – sorting of live and dead fish only.

Processing the catch continued until all summer flounder were sorted by live or dead in 15 minute increments of time until all fish were sorted. In addition, all other species in each tow were recorded. For each of the three tows conducted, forty live fish randomly selected were tagged, weighed, measured and rated as to condition utilizing a scale of excellent, good, poor with specific trawl damage noted.

The live fish selected for the mortality monitoring component of the project were held during the trip in an on board holding system. Twenty live fish were selected from each cull time for each tow duration. 120 total live fish were held for each trip. The on board holding system and plan adopted was similar to that used in the commercial fishery for holding and transport of live fish. Two 35 cubic foot, 268 gallon capacity Bonar insulated holding containers were used in addition to 22 holding cages constructed of plastic coated wire. The live fish were placed in the cages, and the cages were stacked in the Bonar containers filled with seawater. Each Bonar container held up to eight cages, with each cage typically holding ten fish. This system allowed for optimum holding and transport of the fish. The cages kept the fish from sloshing in the containers, kept the weight of fish off of each other and allowed for maximum water flow around each individual fish.

Two (2) twelve volt battery operated aerator compressor systems utilizing four large capacity air stones per container were used to aerate the holding system. This method has proven to be very effective in terms of maintaining fish condition and was very practical for fish handling purposes. The on board holding system was continually monitored for water temperature and dissolved oxygen levels during each trip. Surface and bottom temperatures and dissolved oxygen were also monitored in the targeted fishing areas and correlated with the temperatures and oxygen levels in the on board holding system.

The ability to safely hold and monitor all study fish was necessary to fully measure summer flounder trawl discard mortality. Through consultation with aquaculture specialists, commercial fishermen and gear specialist we were able to design, construct and install a 15' diameter by 15' deep pentagon shaped net pen attached to a stake system incorporating a pulley rope system which allowed the raising and lowering of the net pen similar to a pound net installation. This design allowed easy access to stock and the ability to monitor and finally release study fish with minimum impact. The net pen was installed next to the Inlet Seafood Dock at Montauk. The location was adjacent to the Montauk Harbor Inlet and provided excellent water quality and good flushing and exchange with Block Island Sound.

At the end of each of the scheduled discard mortality harvest trips all fish held live in the on-board live holding system from each tow and cull, were transferred to the dockside net pen holding system. They were held in the net pen system for 14 days to monitor mortality. Scuba certified staff conducted net pen monitoring on days 1, 2, 3 and then every other day during the 14 day holding period. Information collected included dead fish vitals, fish tag numbers, surface and bottom water temperature/ DO levels. Scales and otoliths were also collected from dead fish.

On day 14 the net pen was lifted and all remaining fish including live fish, dead fish and control fish, were removed from the net pen. Tag information and fish condition index were recorded for all fish. All live control and experimental fish were released in adjacent waters. The net pen was then re-set and prepared to receive a new set of control fish as well as the new set of experimental fish being harvested on board the mortality harvest trip. We utilized two CCE crews on each day that we had a scheduled harvest trip (every 14 days). One crew went out on the trawler and performed all scientific components associated with the collection and harvest of fish. The other crew was the net pen shore side crew and took care of all scientific components related to: collecting and releasing fish from the net pen after their 14 day study; accepting and processing new control fish; transferring the new set of experimental fish into the net pen when the harvest vessel and crew returned to the dock at the end of the day. This two crew procedure provided for efficiency of the overall process and allowed us to stick to a schedule of a new harvest trip every 14 days in order to accomplish the number of trips needed before the end of October. Also, local baymen were hired to lift and re-set the net pen on each release day.

RESULTS

We calculated the cumulative mortality for each tow on trips 3-10 using the mortality on board and estimating the number of live fish culled that would have died using the 14-day survivorship observed in the dockside holding/monitoring pen. First, for each trip, tow, and cull time we calculated a weight for dead fish in the pen that was corrected for the mortality rate of control fish in the pen, $\hat{w}t_d$:

$$\hat{w}t_d = w_d - [(1 - surv_c)(w_d + w_l)] \qquad (1)$$

where w_d is the weight of dead fish in the pen, $surv_c$ is the fraction of control fish living after 14 days in the pen, and w_l is the weight of live fish released from the pen after 14 days.

The survivorship of live fish in the pen, SP, was determined as:

$$SP = wt_l / (wt_l + \hat{w}\, t_d) \qquad (2)$$

The survivorships from equation (2) were used to calculate the ratio of survivorship between the immediate and delayed cull times, ΔS:

$$\Delta S = SP_{\tau=D} / SP_{\tau=I} \qquad (3)$$

where $SP_{\tau=D}$ is the survivorship of fish in the pen at the delayed cull time and $SP_{\tau=I}$ is the survivorship of fish in the pen at immediate cull time.

We calculated the elapsed time between the immediate and delayed cull times, t as:

$$t = [(t_e - t_s)/2 + t_s]_{\tau=D} - [(t_e - t_s)/2 + t_s]_{\tau=I} \qquad (4)$$

where t_e is the end of the time interval in question, from the time the net was brought onboard, and t_s is the start of the time interval in question, both in cumulative minutes.

The change in the survival fraction, ΔS, between the two cull times is converted to a rate, fm, that can be used to estimate the change from any other cull time, under the assumption that the rate is linear with time:

$$fm = (-\ln(\Delta S)) / t \qquad (5)$$

Thus, to calculate the amount of surviving summer flounder, we apply this rate to each 10-15 minute cull period, using equation (4) to determine the elapsed time. Then, the estimated fish surviving, EL, is:

$$EL = \sum_{i=1}^{n} (L_{up} + L_p) e^{-fm \times t} \qquad (6)$$

where L_{up} is the weight of live fish that were not placed into the pen and L_p is the weight of the live fish that were placed into the pen.

The estimated weight of dead fish for each tow, ED, is then:

$$ED = wt_c - EL \qquad (7)$$

where wt_c is the total catch weight for all summer flounder.

Finally, the % mortality for the tow can be calculated as:

$$\%Mortality = ED / (ED + EL) \qquad (8)$$

The discard mortality for each tow length duration, as well as for all tow durations combined, is shown in Table 1. These mortality rates are for the entire summer flounder catch for each tow duration and reflect the total mortality for each tow from the time the fish were dumped on deck until the deck is cleared. The median mortality for all tows combined at 78.7% is very close to the estimated overall discard mortality of 80% currently used in the summer founder assessment. The mean of 64.6% however is considerably less. Also the mean and median mortality rates for the one hour and two hour tows are considerably less than the currently estimated 80% mortality. In order to use a mortality rate representative of the overall inshore fishery for summer flounder, tow length parameters of the fishery should be evaluated. Observer data and VTR data should be analyzed for average tow time across the fishery. Our calculated mortality rate for the tow duration that is most representative of the Observer/VTR data could then be used in the assessment.

An *a posteriori* least squares means test on tow time shows that mortality was greater in 3-hour tows than 2-hour tows and greater in 2-hour tows than 1-hour tows. Additionally, 1-hour tows and 3-hour tows were significantly different from each other ($p = .0044$).

The calculated mortality by tow duration and cull time is shown in Table 2. All of these values are considerably different, for both the mean and median, from the currently used 80% rate and exhibit a considerable range. Interestingly there is not much difference between the overall mortality rate for all tows combined at the immediate cull and at the delayed cull.

Table 1. Mean, standard deviation in parentheses, median, 25th to 75th percentiles for the percent mortality by tow time and overall.

% MORTALITY	MEAN	MEDIAN	25TH-75TH PERCENTILE
TOW 1	**57.8(35.5)**	**63.9**	**27.7-96.0**
TOW 2	**61.4(31.4)**	**63.3**	**32.7-89.1**
TOW 3	**76.6(29.5)**	**86.9**	**60.0-98.0**
ALL	**64.6(32.2)**	**78.7**	**31.0-96.0**

Table 2. Mean, standard deviation in parentheses, median, 25th to 75th percentiles for the percent mortality by tow time, cull time, and overall. I=initial cull. D=delayed cull.

% MORTALITY	MEAN	MEDIAN	25TH-75TH PERCENTILE
TOW 1 I	**44.9(39.2)**	**34.6**	**9.0-96.0**
TOW 1 D	**44.3(41.7)**	**31.8**	**1.6-87.3**
TOW 2 I	**47.8(36.1)**	**48.5**	**11.2-78.4**
TOW 2 D	**68.4(28.9)**	**68.5**	**43.2-97.8**
TOW 3 I	**62.7(36.7)**	**68.8**	**32.1-97.0**
TOW 3 D	**68.5(27.7)**	**63.8**	**45.6-97.4**
ALL I	**51.3(36.8)**	**50.1**	**12.5-96.0**
ALL D	**59.2(34.9)**	**59.4**	**32.6-95.6**