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Discards of Atlantic Cod, Haddock and Yellowtail Flounder from the 2010 Canadian Scallop Fishery on Georges Bank

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ABSTRACT

Discards of Atlantic cod, haddock and yellowtail flounder from the 2010 Canadian scallop fishery on Georges Bank were estimated from 24 trips that were monitored by at-sea observers. Data were insufficient to determine spatial differences among discard rates per hour. Temporal discard trends were estimated by applying the monthly discard rate per hour (obtained by a 3-month moving window calculation) to the total monthly effort in hours of the scallop fleet. In 2010 total annual estimated discards were highest for yellowtail flounder, at 200 mt, while those for Atlantic cod and haddock were 44 mt and 14 mt, respectively.

RÉSUMÉ

Les rejets de morue franche, d'aiglefin et de limande à queue jaune dans la pêche canadienne du pétoncle sur le banc Georges en 2010 ont été estimés d'après les résultats de 24 sorties de pêche au cours desquelles un observateur était présent. Les données étaient insuffisantes pour cerner les différences spatiales dans les taux de rejets par heure. On a estimé les tendances temporelles des rejets en appliquant le taux mensuel de rejets à l'heure (découlant du calcul effectué à l'aide du créneau mobile de trois mois) à l'effort mensuel total, exprimé en heures, de la flottille de pétoncliers. En 2010, parmi les rejets annuels totaux estimés, ce sont les rejets de limande à queue jaune qui étaient les plus importants (200 tm), les rejets de morue franche et d'aiglefin s'élevant respectivement à 44 tm et 14 tm.

INTRODUCTION

Incidental catch not landed (*i.e.*, not recorded in the fishery statistics records) is designated as “discards”. Canadian management measures established in 1996 prohibit the landing of groundfish (except monkfish) by the Canadian scallop fishery on Georges Bank. Therefore, all incidental catches of Atlantic cod, haddock and yellowtail flounder in 2010 were discarded. Discards of Atlantic cod, haddock and yellowtail flounder from the Canadian scallop fishery for 1960-2004 were estimated first by Van Eeckhaute *et al.* (2005) and updated for 2005-2008 by Gavaris *et al.* (2007, 2008, 2009) and for 2009 by Van Eeckhaute *et al.* (2010). The Canadian scallop fishery discard estimates for 2010 are described in this report.

At the 2010 Transboundary Resources Assessment Committee (TRAC) meeting, concern was expressed that the moving window estimates may be biased. To address this concern, four methods of calculating the discards (moving window, monthly, quarterly and annual) were compared and precision estimates determined.

DATA AND METHODS

Prorating

Following Gavaris *et al.* (2007), discards of Atlantic cod, haddock and yellowtail flounder in the Canadian scallop fishery on Georges Bank were estimated by applying a 3-month moving window to discard rates in kg/hour. Discard rates obtained from observed trips (trips monitored by DFO accredited at-sea observers) were applied to total monthly effort of the scallop fleet, in hours, as follows:

$$\text{discards} = \text{total scallop effort} \times (\text{observed discards} / \text{observed scallop effort}).$$

This approach is dependent on the assumption that the population density of the incidentally caught species experienced by observed trips, *i.e.* the (*observed discards / observed scallop effort*) ratio, is representative for the whole scallop fishery. The results, therefore, can be sensitive to inadequate sampling of the spatial/temporal variation in the population density of the incidentally caught species.

For this calculation, effort refers to hours towed, usually with 2 dredges being towed at the same time. Since there is no information on the number of dredges or size of dredges for unobserved vessels, the gear used on observed trips is assumed to be representative of that typically used by the fleet. Effort information for observed trips may be obtained from observer records or from fishery statistics. However, because the total fleet effort must be obtained from fishery statistics, observed trip effort also was determined in this way to ensure consistency.

The fishery statistics effort represents the hours fished for an entire observed trip. Discards from observed trips are only reported for the portion of the fishing activity that was witnessed. Therefore, it is necessary to prorate witnessed discards to the discards for an entire observed trip. The number of dredge hauls (two dredges are usually towed but, here, a dredge haul is equivalent to one dredge per tow) that are observed and the total number of dredge hauls made on the trip are recorded. The total discards for a trip are obtained by prorating the witnessed discards by the ratio of total number of dredge hauls to observed number of dredge hauls recorded for the trip.

Discard Mortality

Scallop fishing practice may result in intensive localised fishing activity. Observers on scallop trips have noted, on occasion, that what appears to be the same fish may be caught more than once. Counting a fish more than once if it is captured multiple times may result in over-estimation of discards. A program for marking discarded fish using fin clipping was instituted in 2007 to prevent multiple counting of the same discards. A recapture rate was calculated as the ratio of the number of fin-clipped fish that were recaptured to the total number of fin-clipped fish released. The 2007 prorated trip discards were adjusted downwards using the recapture rate: $adjusted\ discards = discards / (1 + recapture\ rate)$. The magnitude of this adjustment was inconsequential (Gavaris *et al.* 2008); therefore, the practice was not continued.

Effort Standardization

Prior to 2004, virtually none of the scallops landed were caught by freezer trawlers. The prevalence of freezer trawlers has increased rapidly in recent years with freezer trawler landings accounting for 34%, 57%, 63%, 67%, 69%, 67% and 69% of landings for 2004 to 2010, respectively. Freezer trawlers operate differently than the conventional scallop fleet and use somewhat larger dredges. Therefore, the effective fishing intensity exerted by an hour of fishing by a freezer trawler is not equivalent to that of a wet-fish trawler. The conversion factor of 1.2 for standardising wet-fish hours to freezer-trawler hours derived by Gavaris *et al.* (2007) was applied to 2010 data. Inadvertently, the inverse of the conversion factor was applied to 2005–2007 data in Gavaris *et al.* (2007 and 2008). This error was corrected and the updated results reported in Gavaris *et al.* (2009).

Comparison with Alternative Methods

The moving window, monthly, quarterly and annual discard estimates and estimates of variance determined using analytical and bootstrapping techniques were compared (see Appendix A).

The spatial coverage of observed trips in relation to the fishery is derived from a vessel monitoring system (VMS). Spatial distribution was analyzed on a quarterly basis.

RESULTS AND DISCUSSION

Estimates of Atlantic cod, haddock and yellowtail flounder discards from the 2010 Canadian scallop fishery on Georges Bank were based on observed discards from 24 observed trips (Table 1) which represented 10.7% of the total trips. The effort (standardized) for observed trips in 2010 comprised 11.0% of total effort (standardized). Quarterly fishing locations for observed trips appear to be generally representative of the spatial distribution of fishing locations by the fleet (Figure 1). However, the fleet activity in 5Zm had limited observer coverage and differences among discard rates by area were not taken into account.

Results from the comparison of alternate methods of calculating discards indicate that the moving window average does not produce consistently higher or lower estimates than the other methods, and performs at least as well or better than the other methods (Appendix A: Table A1, Figure A1). It has the advantage of smoothing out the effect of outliers when compared with the monthly or quarterly methods (Appendix A). The 3-month moving window method should continue to be used to calculate Canadian scallop fishery discards.

Seasonal differences in discard rates are accounted for by calculating discards on a monthly basis with 3-month moving window discard rates (Figure 2), which were applied to the total monthly effort of the scallop fleet to estimate monthly and annual cumulative discards (Table 2). Similar to previous years, the 2010 discard rates (kg/hr) for yellowtail flounder were higher during the spring and early summer and decreased in mid-summer (Figure 2). Discard rates for cod were lowest in mid-summer and were highest during the winter and early spring. Haddock were discarded at the highest rate during the early part of the year and the rate decreased in the summer and fall.

Summary

Total annual estimated discards in 2010 were greatest for yellowtail flounder, at 200 mt, while those for Atlantic cod and haddock were 44 mt and 14 mt, respectively. Yellowtail flounder discards increased from 2009 while cod and haddock decreased. Discard amounts may reflect voluntary gear modifications (DFO 2009) and avoidance fishing practices as well as area/time closures for yellowtail flounder (DFO 2007) and Atlantic cod (DFO 2006). In the absence of reliable survival estimates, all discarded Atlantic cod, haddock and yellowtail flounder are assumed to be dead for the purpose of stock assessment computations.

The 3-month moving window method should continue to be used to calculate Canadian scallop fishery discards since it tends to smooth out the effect of outliers and performs as well as other methods.

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**Discards from the 2010 Canadian
Scallop Fishery on George Bank**

Table 1. Observed trips from the Canadian Georges Bank scallop fishery in 2010. Effort hours are standardised to freezer-trawler hour equivalents.

Trip ID	Board Date	Land Date	Proration			Discards (kg)						Effort (hr)
			Dredges		Yellowtail Flounder		Cod		Haddock			
			Obs.	Total	Prop.	Observed	Prorated	Observed	Prorated	Observed	Prorated	
T2010-01	2010-01-04	2010-01-20	462	950	0.49	76	156	416	855	158	325	197
T2010-02	2010-01-20	2010-02-06	624	1244	0.50	49	98	164	327	29	58	229
T2010-03	2010-02-06	2010-02-21	547	1101	0.50	23	46	62	125	10	20	209
T2010-04	2010-03-08	2010-03-13	80	156	0.51	31	60	38	74	10	20	44
T2010-05	2010-03-08	2010-03-29	787	1617	0.49	531	1091	1011	2077	189	388	292
T2010-06	2010-03-14	2010-03-29	605	1228	0.49	292	593	69	140	23	47	238
T2010-07	2010-04-06	2010-04-16	340	418	0.81	112	138	43	53	21	26	72
T2010-08	2010-04-13	2010-04-28	534	1124	0.48	761	1602	85	179	39	82	229
T2010-09	2010-05-19	2010-06-02	346	750	0.46	290	629	69	150	39	85	160
T2010-10	2010-05-25	2010-06-04	300	538	0.56	5111	9166	91	163	3	5	126
T2010-11	2010-06-03	2010-06-18	405	828	0.49	286	585	129	264	20	41	134
T2010-12	2010-06-25	2010-07-16	596	1224	0.49	491	1008	89	183	31	64	200
T2010-13	2010-07-18	2010-08-02	473	916	0.52	568	1100	56	108	37	72	164
T2010-14	2010-07-23	2010-08-02	233	441	0.53	136	257	36	68	22	42	68
T2010-15	2010-08-16	2010-08-31	582	1189	0.49	459	938	96	196	27	55	179
T2010-16	2010-08-31	2010-09-15	531	1030	0.52	56	109	9	17	6	12	171
T2010-17	2010-09-07	2010-09-16	201	360	0.56	69	124	90	161	17	30	93
T2010-18	2010-09-30	2010-10-15	253	498	0.51	35	69	0	0	34	67	236
T2010-19	2010-10-11	2010-10-15	93	147	0.63	45	71	1	2	22	35	30
T2010-20	2010-10-19	2010-10-29	280	420	0.67	17	26	6	9	18	27	99
T2010-21	2010-11-05	2010-11-21	558	1093	0.51	109	214	156	306	77	151	233
T2010-22	2010-11-14	2010-11-24	352	620	0.57	10	18	14	25	4	7	126
T2010-23	2010-12-02	2010-12-12	220	372	0.59	5	8	16	27	2	3	65
T2010-24	2010-12-07	2010-12-23	544	1046	0.52	42	81	82	158	42	81	232

**Discards from the 2010 Canadian
Scallop Fishery on George Bank**

Table 2. Discards from the Canadian scallop fishery on Georges Bank for 2010 calculated using a 3-month moving window discard rate. Effort hours are standardised to freezer-trawler hour equivalents.

2010	Discard Rate (kg/hr)			Effort (hr)	Discard (mt)			Cum. Annual Discard (mt)		
	Yellowtail	Cod	Haddock		Yellowtail	Cod	Haddock	Yellowtail	Cod	Haddock
Jan	0.473	2.059	0.634	1514	1	3	1	1	3	1
Feb	1.691	2.976	0.709	1831	3	5	1	4	9	2
Mar	3.257	2.443	0.537	2480	8	6	1	12	15	4
Apr	11.440	2.443	0.562	3771	43	9	2	55	24	6
May	16.820	1.122	0.331	3491	59	4	1	114	28	7
Jun	14.970	1.099	0.362	2984	45	3	1	158	31	8
Jul	5.223	1.100	0.367	3465	18	4	1	177	35	9
Aug	4.045	0.840	0.314	3366	14	3	1	190	38	10
Sep	1.653	0.477	0.280	2938	5	1	1	195	39	11
Oct	0.637	0.526	0.333	3394	2	2	1	197	41	12
Nov	0.476	0.515	0.363	3160	2	2	1	199	42	13
Dec	0.488	0.785	0.369	2224	1	2	1	200	44	14

Discards from the 2010 Canadian Scallop Fishery on George Bank

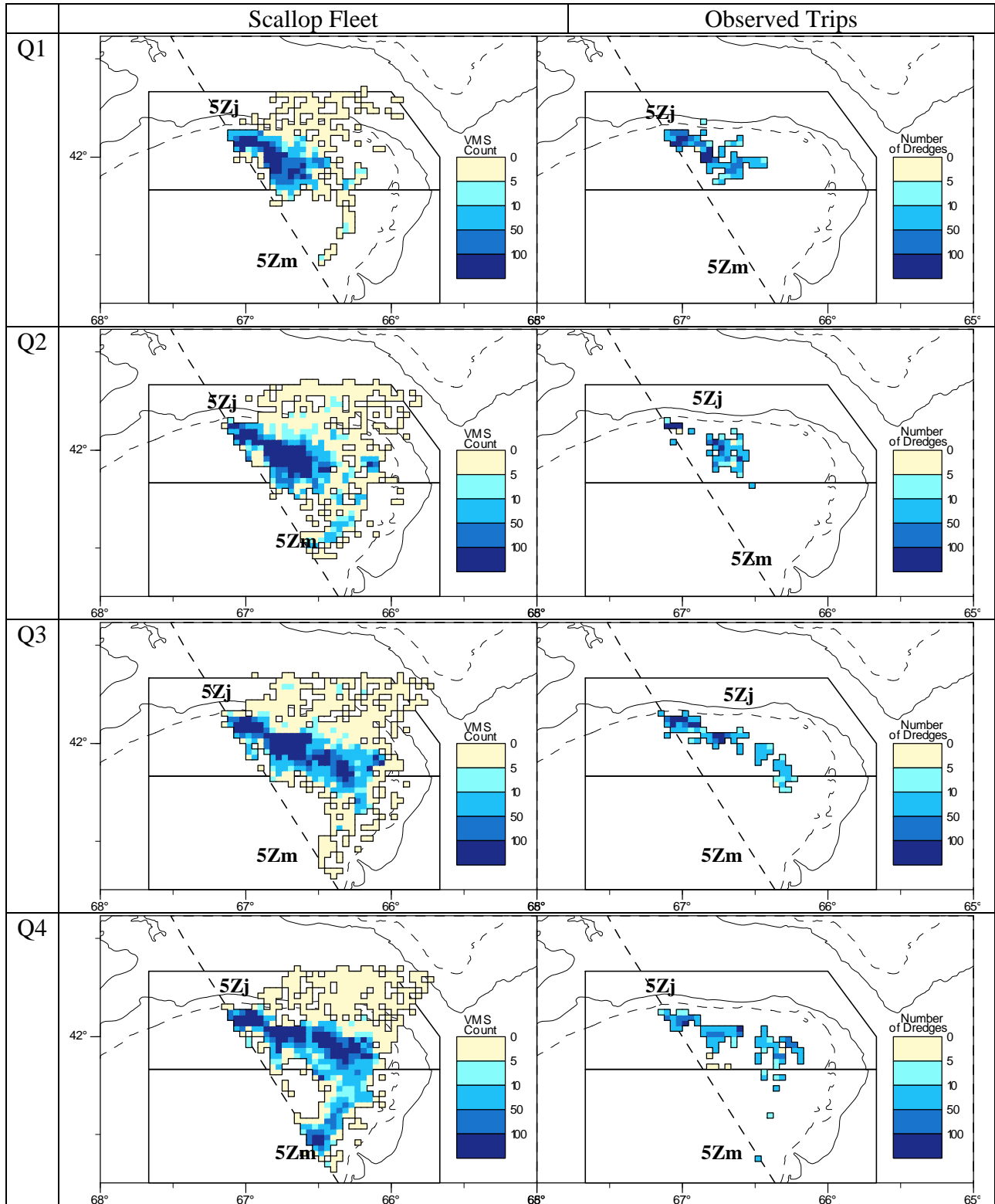


Figure 1. Quarterly fleet fishing locations based on count of Vessel Monitoring System polls (left panels) compared to locations of observed fishing based on count of dredges (right panels) for the 2010 Canadian scallop fishery on Georges Bank.

Discards from the 2010 Canadian Scallop Fishery on George Bank

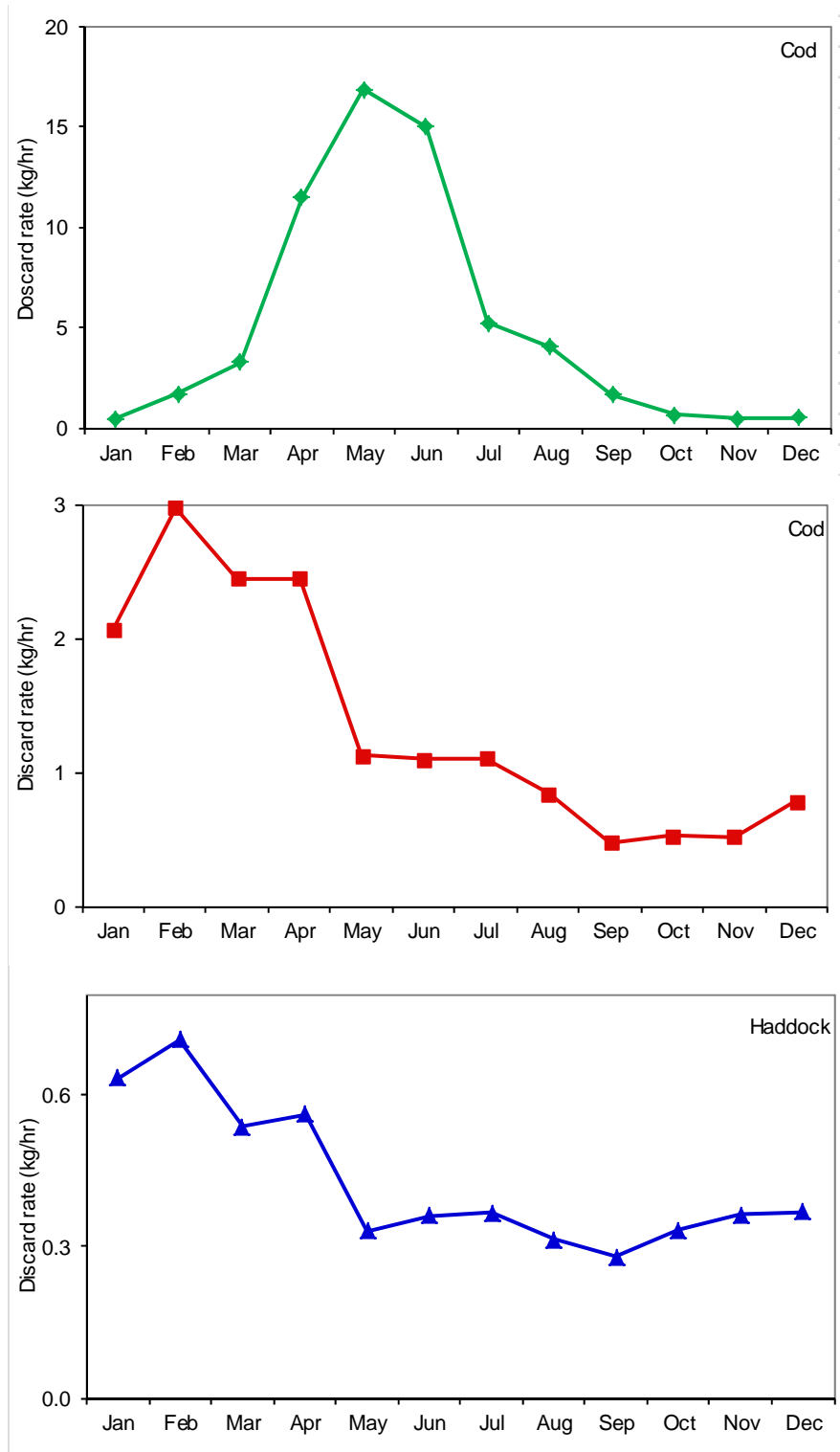


Figure 2. Seasonal patterns in discard rates (kg/hr) of yellowtail flounder, Atlantic cod and haddock from the Canadian scallop fishery on Georges Bank in 2010 (calculated using a 3-month moving window).

Appendix A. Comparison of four methods of calculating cod, haddock and yellowtail flounder discards from the Georges Bank scallop fishery.

Four methods of calculating annual discards from the scallop fleet were compared, the 3-month moving window, monthly, quarterly and annual methods, for 2005 to 2010. The method with the smallest variance would be preferable, assuming negligible bias.

Method

For the annual method, the prorated discards and effort from all observed trips were summed to obtain a single discard rate (kg/hr), which was then applied to the total fleet effort to obtain annual discards. Monthly and quarterly estimates were obtained similarly but on a monthly or quarterly basis and summed to obtain annual discards.

Estimates of variance for the annual discards could be determined for the 3-month moving window, quarterly and annual methods and were determined using bootstrapping and analytical techniques. Variance for the monthly method was not calculated because often only one observed trip was available for a month.

Analytical estimates of variance of discard rates for the quarterly and annual methods were obtained by,

$$\text{var}(r) = \sum_{i=1}^n (D_i - rX_i)^2 / \bar{X}^2 (n(n-1)) \text{ (Cochran 1977)}$$

where D represents observed discards, X represents observed scallop effort, r and n are the discard rate and sample size, respectively, for the quarter or the year.

For the quarterly method, the variance of the annual discards was calculated as,

$$\text{var}(C) = \sum_i E_i^2 \text{var}(r_i)$$

and, for the annual method, the variance of the annual discards was calculated as,

$$\text{var}(C) = E^2 \text{var}(r)$$

where C represents the annual discards, E_i represents fishing effort in quarter i and E for fishing effort in a year. The analytical method could not be used to calculate the variance of the annual discards for the moving window method because of time-series autocorrelation.

Bootstrap resampling of observed prorated discards and observed effort with 5,000 replicates was used to obtain estimates of variance for the moving window, quarterly and annual methods. The estimated variance of the discards was calculated as the variance of those 5,000 bootstrap discard estimates.

Results and Discussion

All four methods produced similar results and none produced consistently higher or lower estimates (Table A1, Figure A1), therefore, no method is producing biased results on this basis.

Discard estimates are likely impacted by seasonal patterns in the discard rates (Figure A2) but the annual method, which does not take into account seasonal discard patterns, produced results comparable to the methods that did take season into account (MW, quarterly and monthly). CVs are more similar for haddock than for cod and yellowtail, possibly because there is less seasonal variability in discard rates.

No one method of calculating discards appears to be superior when comparing the coefficients of variation (in percent) for the variance estimates (Table A2, Figure A3). The annual method had CVs that were much larger than the other methods for yellowtail flounder in 2005 and 2006, but, were comparable to the other methods at other times. The monthly method is hampered by limited samples per month and low sample numbers can result in biased estimates. In comparison to quarterly estimates the 3-month moving window is robust to outliers and more often has the lowest CV, is tied or very close to the lowest CV.

References

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**Discards from the 2010 Canadian
Scallop Fishery on George Bank**

Table A1. Annual discards (mt) of yellowtail founder, cod and haddock from the 2005 to 2010 Georges Bank scallop fishery, calculated using four different methods: 3-month moving window (MW), monthly, quarterly and annual.

	Yellowtail					
	2005	2006	2007	2008	2009	2010
MW	246	504	96	117	84	200
Monthly	213	466	94	130	79	207
Quarterly	290	541	100	120	78	226
Annual	295	563	73	90	79	165
	Cod					
	2005	2006	2007	2008	2009	2010
MW	84	112	114	37	69	44
Monthly	88	121	98	42	64	41
Quarterly	102	121	117	37	68	42
Annual	87	128	90	39	70	51
	Haddock					
	2005	2006	2007	2008	2009	2010
MW	48	62	56	33	54	14
Monthly	53	63	48	30	47	13
Quarterly	47	66	56	34	54	14
Annual	54	66	47	34	56	16

Discards from the 2010 Canadian Scallop Fishery on George Bank

Table A2. The bootstrap (BS) and analytical (Anal.) coefficients of variation (CV; in percent) of yellowtail flounder (YTL), cod and haddock discard estimates for the 2005 to 2010 Georges Bank scallop fishery using three different methods: 3-month moving window, quarterly and annual. The * indicates the lowest bootstrap values for each species/year. Quarterly CVs could not be calculated when only one observed trip was available.

	2005					2007					2009				
	Moving Window	Quarterly		Annual		Moving Window	Quarterly		Annual		Moving Window	Quarterly		Annual	
	BS	Anal.	BS	Anal.	BS	BS	Anal.	BS	Anal.	BS	BS	Anal.	BS	Anal.	BS
Yellowtail flounder	29*	NA	NA	47	45	31*	34	33	38	38	24*	24	24*	28	28
Cod	20	NA	NA	15	15*	24*	30	30	34	35	17	15	16*	16	16*
Haddock	23	NA	NA	18	18*	29*	32	33	33	33	20	19	19*	21	21
	2006					2008					2010				
YTL	36	30	31*	55	55	45	47	49	40	42*	50*	54	60	48	51
Cod	27*	40	41	38	40	19*	20	22	19	19*	26	19	21*	32	32
Haddock	17	16	20	16	16*	26	29	29	20	20*	17	14	16*	21	21

Discards from the 2010 Canadian Scallop Fishery on George Bank

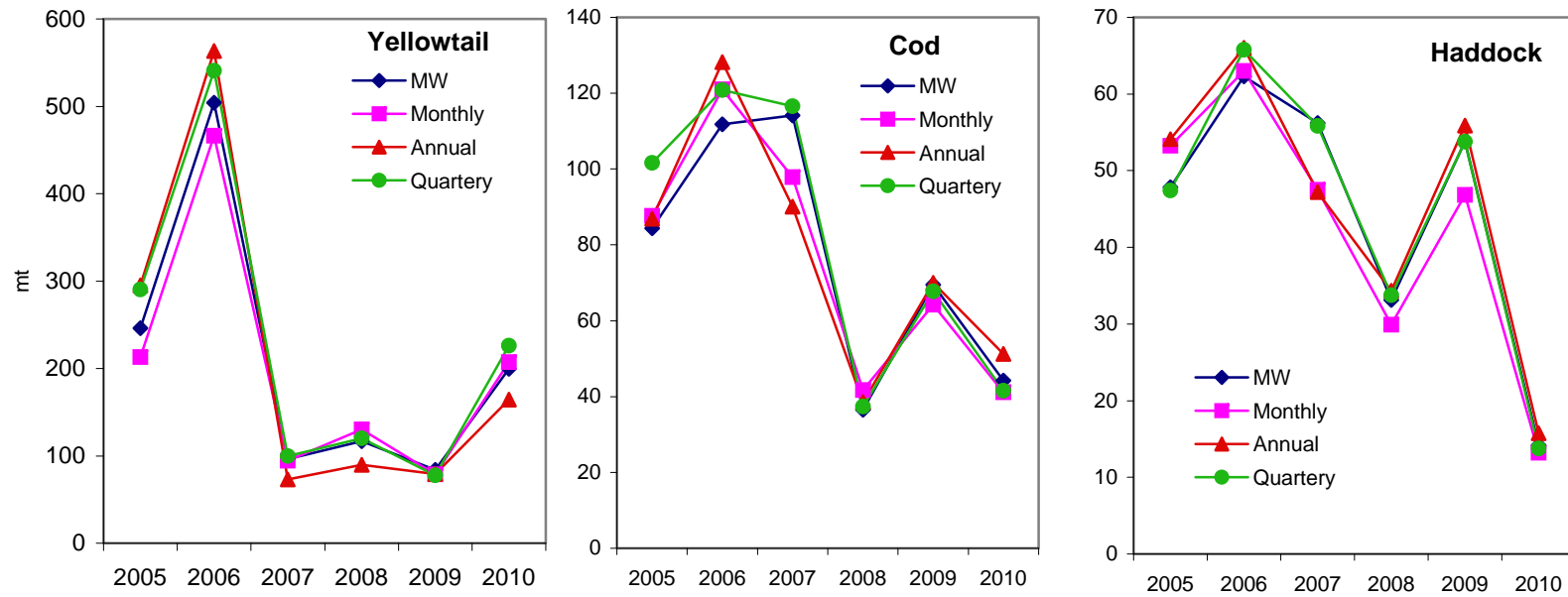


Figure A1. Discard estimates (mt) of cod, haddock and yellowtail flounder from the Canadian scallop fishery on Georges Bank for 2005 to 2010 using four methods: 3-month moving window (MW), monthly, quarterly and annual.

Discards from the 2010 Canadian Scallop Fishery on George Bank

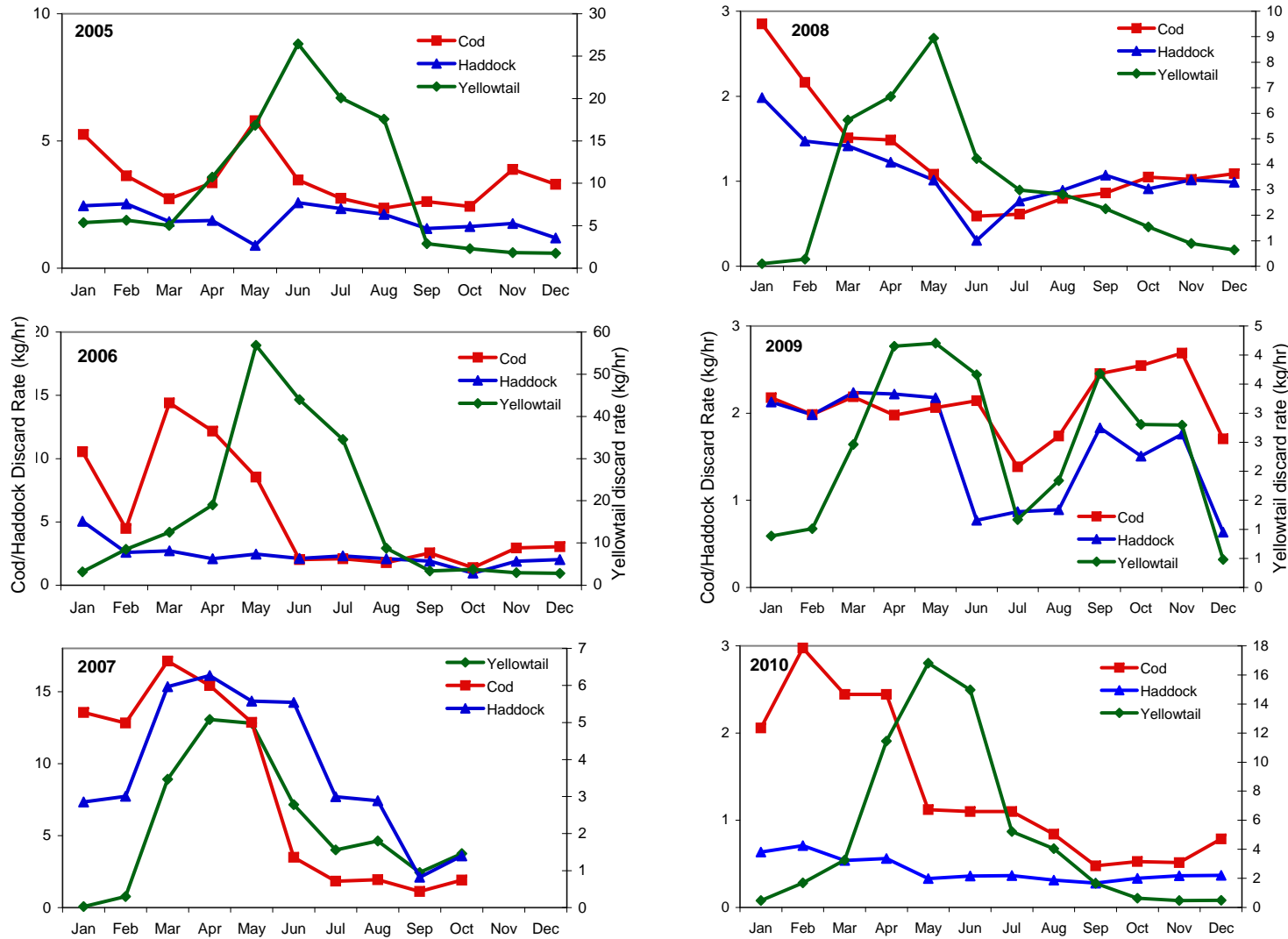


Figure A2. Seasonal patterns in discard rates (kg/hr) for cod, haddock and yellowtail flounder from the Canadian scallop fishery on Georges Bank for 2005 to 2010 calculated using a 3-month moving window.

Discards from the 2010 Canadian Scallop Fishery on George Bank

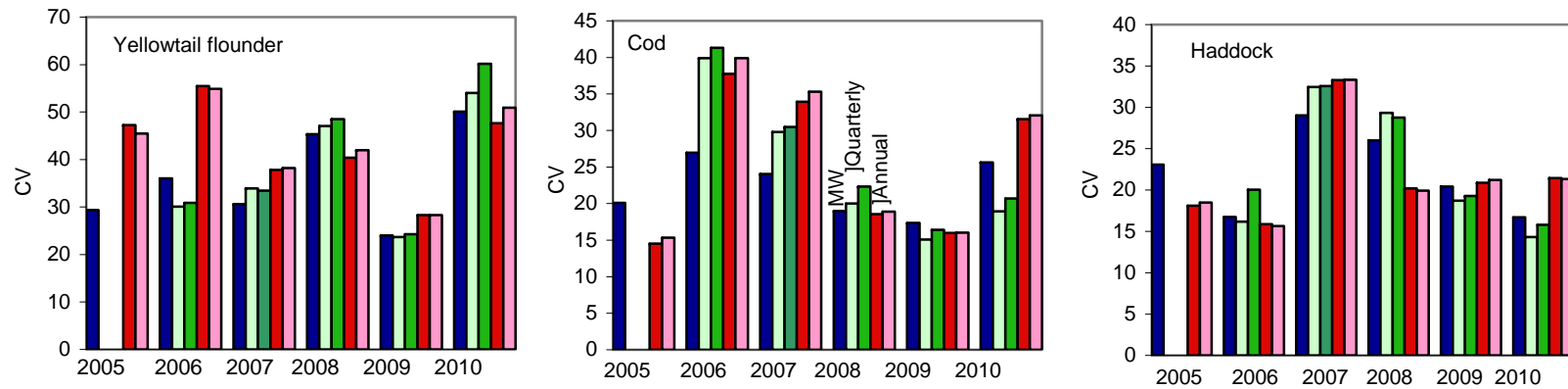


Figure A3. Comparison of analytical and bootstrap coefficients of variation (CVs; in percent) of cod, haddock and yellowtail flounder discard estimates from the Canadian scallop fishery on Georges Bank from 3-month moving window (MW; blue), quarterly (green) and annual (red) methods. Except for the MW method, which has no analytical estimate due to time-series autocorrelation which could not be accounted for, the first bar in a pair is the analytical estimate and the second bar is the bootstrap estimate. Quarterly CVs could not be calculated for 2005 since one quarter only had one observed trip.