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Atlantic salmon return and spawner estimates for Insular Newfoundland

Estimations des retours et des reproducteurs de saumon atlantique dans l'île de Terre Neuve

D.G. Reddin and G.I. Veinott

Science Branch
Fisheries and Oceans Canada
P.O. Box 5667
St. John's NL A1C 5X1

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ABSTRACT

In this paper, the small, large, and two-sea winter (2SW) returns and spawner estimates for insular Newfoundland Atlantic salmon stocks are presented for the years 1971-2008. The catch statistics used to derive returns and spawner estimates are updated for 2007 from those used previously and new return and spawner estimates are presented for 2008. Data for 2008 should be considered preliminary. The returns and spawner estimates are derived from exploitation rates of small retained salmon in the angling fishery for rivers with enumeration facilities, and utilizing ratios of large:small salmon to estimate large salmon. These exploitation rates are then used to provide estimates of both small and large salmon for all rivers in Insular Newfoundland with and without enumeration facilities but with angling catches. Estimates of 2SW abundance are based on the expected proportion of 2SW fish in the large category. The recruits show a decline for small salmon that began in the mid-1980s while large show an overall decline for the entire time series. Overall, there were approximately 450,000 small salmon in the early 1970s which has declined in recent years to around 200,000. For large salmon, the 1970s showed around 225,000 salmon which by the 2000s had declined to around 50,000. Returns and spawners on other hand have been increasing in recent years in the small and large categories while returns of 2SW fish declined by 3% over the 5 year average.

RÉSUMÉ

Dans la présente étude, les estimations des retours des petits, des gros et des saumons dibermarins ainsi que des reproducteurs dans les stocks de saumon atlantique de l'île de Terre-Neuve sont présentées pour les années 1971 à 2008. Les statistiques sur les prises utilisées pour obtenir les estimations de retours et de reproducteurs ont été mises à jour en 2007 par rapport à celles utilisées précédemment, et de nouvelles estimations des retours et des reproducteurs sont présentées pour 2008. Les données pour 2008 sont des données préliminaires. Les estimations des retours et des reproducteurs proviennent des taux d'exploitation des petits saumons conservés par les pêcheurs sportifs dans les rivières avec installations de dénombrement et se servent de ratios entre les petits et les gros saumons pour évaluer le nombre de gros saumons. Ces taux d'exploitation servent ensuite à produire des estimations tant du nombre des petits que des gros saumons dans toutes les rivières de l'île de Terre-Neuve, avec et sans installations de dénombrement, mais avec des prises de pêche sportive. Les estimations de l'abondance des saumons dibermarins sont fondées sur la proportion attendue de poissons dibermarins dans la catégorie des gros saumons. On note une baisse de recrues parmi les petits saumons, baisse qui a commencé au milieu des années 1980, tandis qu'on note une baisse générale dans toute la série chronologique parmi les gros saumons. Dans l'ensemble, il y avait environ 450 000 petits saumons au début des années 1970 et ce nombre a diminué à environ 200 000 au cours des dernières années. Il y avait environ 225 000 gros saumons dans les années 1970, et ce nombre a baissé à environ 50 000 dans les années 2000. Le nombre de retours et de reproducteurs a par contre augmenté au cours des dernières années dans les catégories des petits et des gros saumons, tandis que les retours de saumons dibermarins ont diminué de 3 % par rapport à la moyenne sur cinq ans.

INTRODUCTION

The ICES North Atlantic Salmon Working Group has been using estimates of pre-fishery abundance of North American origin 2SW salmon to provide catch advice for the West Greenland fishery since 1993 (Anon. 1993a, 1994, and 1995). The pre-fishery abundance estimates are derived from returns to counting facilities, angling catches, and commercial catches using raising factors when appropriate. Salmon available for harvest are derived by subtraction of target spawners from the forecasts of pre-fishery abundance. Rago et al. (1993a and b) and Reddin et al. (1993) provided details on calculation of pre-fishery abundance and how it is forecasted. Thus, the catch advice is predicated on having estimates of target spawners required for salmon stocks producing 2SW salmon in the rivers of Atlantic Canada and accurate forecasts of pre-fishery abundance. Accuracy of the forecasts will not only depend on the strength of the relationship with the independent variable but on the accuracy and precision of the estimates of pre-fishery abundance.

In this paper, the small and large returns and spawner estimates for insular Newfoundland salmon stocks are presented for the years 1971-2008. The catch statistics used to derive returns and spawner estimates are updated for 2007 from those used previously and new estimates are presented for 2008. Estimates for 2008 should be considered preliminary. The updated catch statistics are the result of information collected during telephone surveys of anglers who did not respond (non-respondents) to the prompts to return their angling log with a record of angling activities. Non-respondent surveys were carried out in years 1998-2007 (those for 2008 are being presently done but have not yet been incorporated in angling catches). Year-specific information for non-respondents has been incorporated into catch and effort estimates for 1998-2007 and average values of catch and effort per angler (1998-2000) for years prior to 1998. Average non-respondent information for all years is used for the preliminary estimates for 2008. This material was prepared for the 2009 meeting of the ICES North Atlantic Salmon Working Group and for a DFO held pre-COSEWIC review conducted in February, 2009 in Halifax, NS.

METHODS

Estimation of an aggregate measure of abundance has utility for identifying trends, evaluating management measures, and investigating the influence of the marine environment on survival, distribution, and abundance of salmon. Estimation methods for calculating total returns to geographic regions included direct methods such as traps, counting fences, and mark-recapture studies. Indirect methods include reliance on catch data (both recreational and commercial) and plausible ranges of in-river and commercial fisheries exploitation rates. This includes transferring these rates to areas and rivers with no enumeration facilities. Some of the parameters used to estimate abundance in this paper are known with poor precision, are difficult or impossible to determine, and vary annually; where this is so, plausible ranges of values are used instead.

A map of the east coast of Canada is provided showing the various salmon fishing areas (SFAs) (Fig. 1). Regional stock status information for insular Newfoundland uses separate parameter values grouped as follows: northeast and south coast of Newfoundland (SFAs 3-12), southwest coast (SFA 13), and northwest coast (SFA 14A).

Returns of small (<63 cm), large (≥ 63 cm), and 2SW salmon to each area were derived using a variety of methods using data available for individual river systems and groupings of various SFAs. The methods used to derive these estimates include counts of salmon at various enumeration facilities throughout each region, population estimates from mark-recapture studies, and the application of angling and commercial catch statistics, angling exploitation rates, and measurements of freshwater habitat. For Newfoundland, "recruits" include catches of Newfoundland origin salmon caught in home water commercial fisheries and at West Greenland. Returns for Newfoundland refer to salmon prior to entering freshwater. Spawners are the salmon remaining for spawning after the angling fishery, other in-river fisheries, and mortalities due to hook and release, etc are removed.

NEWFOUNDLAND (SFAS 3–14A)

Angling And Commercial Fisheries Data

The basis of estimates of small, large, and 2SW salmon returns and spawners for insular Newfoundland are the catch data from angling and commercial fisheries. Catch and effort data from the angling fishery were collected by Department of Fisheries and Oceans (DFO) enforcement staff, angling reports submitted by fishing camp operators and processed by DFO Science Branch personnel, and by a licence stub return system. Commercial catch data were collected by DFO enforcement staff from fish plant landing slips and processed by DFO Statistics and Informatics Branch personnel. Procedures for the collection and compilation of commercial and angling fishery data are described in Ash and O'Connell (1987) for fishery years 1974-1996. For years 1969-1974, commercial catch data came from Anon. (1978). In 1997, the angling catch statistics were converted to a licence stub return system (O'Connell et al. 1998) and has been updated to 2008.

For the years, 1969-2008, the technique used for deriving total returns of small, large, and 2SW salmon for Newfoundland SFAs 3-14A was based on converting angling catches of small salmon to total returns prior to the commercial fishery using exploitation rates as follows:

(1) SRR = SC / ERA where,

SRR - small returns to river
SC - angling catch of small salmon (retained only)
ERA - exploitation rate angling

(2) SSR = SRR / (1-ERC) where,

SSR - small salmon recruits
ERC - exploitation rate commercial

The number of small salmon spawners (SS) is calculated as:

(3) SS = SRR - (SC + (0.1 * SR) where,

SR - the number of small salmon released in the angling fishery applying a rate of 10% mortalities for hooked-and-released salmon.

The returns of large salmon are estimated from the small salmon to the river (SRR) and the ratio of large to small salmon in the angling catches for the years 1974-1984.

(4) LRR = SRR * RL where,

LRR - large returns to river
RL - ratio of large to small salmon at counting facilities in SFAs 3-12 and 14A separately from SFA 13,

The large spawners (LS) are:

(5) LS = LRR - (LC + LCR) where,

LC - large catch (retained) in angling fishery
LCR - 10% of the hooked-and-released salmon.

The 2SW returns to the river, 2SW salmon spawners, and 2SW recruits are then calculated by multiplying the large salmon returns, spawners, and recruits by the proportion of 2SW salmon (P_{2SW}) derived from samples taken in angling fisheries and at counting facilities.

(6) $LLR_{2SW} = LRR * P_{2SW}$

(7) $LS_{2SW} = LS * P_{2SW}$

An index of precision was developed to track reliability of the estimates of returns and spawners. The index is based on what we know with the greatest accuracy which in Newfoundland are the counts of small and large salmon at enumeration facilities. The precision index (PI) is simply the estimate of returns divided by the count of small or large salmon adjusted for 2SW salmon.

Parameter Values For SFAs 3-12 And 14A

The estimates of 2SW returns and spawners for Newfoundland are based on exploitation rates from counting facilities applied to small angling catches as there is no retention fishery for large salmon, proportions of large:small salmon at counting facilities, and the proportion of large salmon that are 2SW. Ratios of large:small salmon are weighted to returns at counting facilities. Analysis of variance indicated that ratios of large:small salmon were significantly different based on year and river (Table 1). Exploitation rates were calculated by dividing the catch (retained) by the total count from rivers with enumeration facilities at Exploits, Campbellton, Middle Brook, Gander River, Indian Bay Brook, Terra Nova River, Northeast River (Placentia), Biscay Bay River, Humber River, Lomond River, and Torrent River. No values were available for Biscay Bay River and Grand Bank Brook in 1999-2003 and Humber River in 2000 to present. Results of analysis of variance for exploitation rates indicated that exploitation varied depending on year and river nested within SFA (Table 2).

Commercial exploitation rates used for the years 1969-1983 ranged from 0.5 to 0.7 for small salmon which came from smolt tagging studies conducted on the Exploits River (Anon. (1991) and Western Arm Brook (Reddin 1981; Chadwick et al. 1985).

Exploitation rates on large salmon were derived from a smolt tagging study on Sand Hill River, Labrador (Reddin 1981). The ratio of large:small for SFAs 3-14A was measured at enumeration facilities in those SFAs. Returns to counting facilities are presented in Tables 3a and 3b. Parameter values are shown in Table 4. For the years 1983-1991, exploitation rates in the range of 30 to 60% for small salmon and 60 to 85% for large salmon were applied to calculate numbers of recruits.

Parameter Values For SFA 13

In 1969 to present, for SFA 13, estimates of small, large, and 2SW returns and spawners were based on dividing SFA 13 into two areas. The first of these areas is Bay St. George which includes the only stocks on the island of Newfoundland with a high proportion of MSW salmon. The second area includes rivers north of Bay St. George up to the SFA 13 boundary with SFA 14A which have salmon population structures similar to the other SFAs on the island of Newfoundland. Also, this second area includes Humber River which is the second largest river on the island of Newfoundland.

For the Bay St. George area of SFA 13 in years 1969-1994, estimates of small, large and 2SW returns and spawners were based on exploitation rates from counting facilities in SFA 13 applied to small and large angling catches and the proportion of large salmon that were 2SW. Raising factors were used to adjust catches to a full angling season where shortened seasons were thought to have seriously compromised catches in 1978-1984 and 1985-1995. Estimates for small, large, and 2SW salmon were made for each of 14 rivers in the Bay St. George of SFA 13 and then summed (Reddin et al. 1996; Mullins and Reddin 1996).

For the years 1995 to present, for Bay St. George area, total returns were based on: the results of spawner surveys in Crabbes, Robinsons, Fischells, Middle Barachois, and Flat Bay Brook; the returns to a counting fence on Highlands River; and a combination of spawner surveys and counting fence data from Harry's River, depending on the year and project results available. These rivers included a variable amount of the habitat in the Bay St. George area of SFA 13 which ranged annually from a high of 58% to a low of 15% of the watershed in SFA 13. The results from the rivers with estimates of returns were then expanded to the entire watershed of SFA 13 by multiplication.

For the second area of SFA 13 which includes Humber River, for the years 1969 to present, estimates of returns and spawners were based on the angling catches and parameter values similar to rivers in SFA 3-12 and 14A.

Sea Age Distribution

The conversion of large salmon to 2SW salmon requires sea age distributions from samples collected randomly on various rivers. In the past the proportion of large salmon that were 2SW salmon came from a sample of large salmon from various enhancement facilities in SFAs 4-10. Out of 269 salmon sampled 45 of them, or 16.7%, were virgin 2SW salmon (C. Bourgeois, pers. comm.). Furthermore, the results of sampling programs on several rivers in insular Newfoundland (SFAs 4, 5, and 9) indicated that the large salmon component consisted of 12.1% virgin 2SW salmon (O'Connell et al. 1997). Therefore, plausible ranges of 0.1 to 0.2 were used for SFAs 3-12 to estimate numbers of 2SW salmon in the large component. Similar samples for rivers in SFAs 13 and 14A indicate the large component is 48.6% virgin 2SW salmon (O'Connell et al. 1997).

However, these analyses depended on a fairly restricted number of samples with very poor distribution. In spite of that, a range of 0.4-0.6 was used for SFAs 13 and 14A and 0.1 –0.2 for SFAs 3-12 until 1994.

For Exploits River, 1984-2000, age analysis indicates that out of 372 large salmon sampled that 48 or 12.9% were virgin 2SW salmon. For Gander River, 1978-1999, age analyses indicate that out of 171 large salmon sampled, there were 3 or 1.8% virgin 2SW salmon. For Conne River, 1986-2000, out of 3,714 large salmon sampled 240 or 6.5% were 2SW virgin salmon. For the swim through rivers in Bay St. George, 44% of the large salmon sampled were virgin 2SW salmon. For Harrys River, 1992-1999, out of 29 large salmon sampled there were 8 or 24% virgin 2SW salmon. For Humber River, 1984-1999, out of 641 large salmon sampled, there were 211 or 33% virgin 2SW salmon. For Lomond River, out of 47 large salmon sampled, there were 29 or 62% virgin 2SW salmon. For Torrent River, out of 207 large salmon sampled, there were 66 or 32% virgin 2SW salmon. For Western Arm Brook, out of 82 large salmon sampled, there were 9 or 11% virgin 2SW salmon. It would appear that 10 to 20% 2SW salmon in the large category may be too high for SFAs 3-12; as is 40 to 60% for SFAs 13 and 14A.

Bootstrap estimates of the proportion 2SW indicated that for SFAs 3-12, a range of 0.06 to 0.14 (95th percentiles) and for SFAs 13-14A, a range of 0.24 to 0.46 (95th percentiles) would be more reasonable based on data for the period of 1994 to 2004.

2005-2008 Age Distributions

The age distribution was updated for 2005-09 using samples collected from 2000 to 2005. Available samples were pooled separately for SFAs 3-12, 14A and SFA 13 due to the higher number of 2SW salmon in the large salmon category in SFA 13. In total, there were 508 large salmon and 5,359 small salmon available for analysis in SFAs 3-12 and 14A. In SFA 13, there were 683 small salmon and 96 large salmon available. A randomization procedure was used to bootstrap estimates of variability in numbers of various sea age groups including 2SW in the large category. For SFAs 3-12 and 14A, data sets of 3500 small and 300 large salmon were selected randomly 500 times. For SFA 13, data sets of 350 and 50 were selected randomly 500 times. Bootstrap estimates of the proportion 2SW indicates that for SFAs 3-12 and 14A, a range of 0.043 to 0.093 (95th percentiles) and for SFA 13, a range of 0.186 to 0.357 (95th percentiles) would be appropriate, which is used for the period of 2005 to 2009. Some 2SW salmon fall into the “small” category because of their length. However, it was felt that the proportion of 2SW in the small category was not significant and, therefore, no further adjustment to the number of small salmon returns and spawners was made.

New Method - Total Returns And Spawners For Newfoundland (SFAs 3-14A)

For 1999, the method used as described above as the ‘previous method’ was modified to take into consideration the changes first implemented in the 1999-2001 Salmon Management Plan. The Management Plan introduced, for the first time in 1999, a river classification scheme with different season retention limits for each of river Classes I-IV and, in addition, some other rivers were placed in a special class with a different management plan for each river. Since the intent of the Management Plan was to alter exploitation for rivers in the various classes, it was necessary to model the estimation procedure for returns and spawners individually for each class of river. Another

important aspect of this new method was to include total returns for rivers with assessment facilities rather than estimate their returns from angling catches. For rivers without counting facilities, angling catches, exploitation rates and proportions large:small are then used to generate total returns. Also, rivers that were completely closed to angling or that were not included in the river classification scheme were individually dealt with if there was an estimate of total returns from assessment information. Class I rivers included Humber and Gander and for these rivers returns and spawners were derived from their assessments (DFO D2-01 2000). Exploits River is a special case as it is labelled as a potential Class 1 river but with Class 2 retention until returns achieve spawning requirements. Returns and spawners are derived from assessment information from counting facilities. Since there was only one river, viz. Terra Nova River, in Class III with which to estimate exploitation rates and large salmon to small salmon ratios, it was decided to use all ten rivers for which exploitation rates were available to develop parameter values. So as not to bias parameter values due to river size, unweighted means and their incumbent standard deviations were used. A non-parametric bootstrap technique whereby exploitation rates from rivers with angling fisheries and ratios of large:small salmon also from rivers with enumeration facilities were chosen at random with replacement (exclusive of Bay St. George swim-through assessed rivers and Highlands). This was repeated 500 times and the mean and standard deviation calculated. The 95th confidence interval of the mean exploitation rate (0.1162-0.1819) and large:small salmon ratio (0.1296-0.2071) was applied to catch statistics for retained small salmon on rivers in Classes II-IV for which full assessment information was not available. Catches for assessment rivers were subtracted from those statistics for the overall class to avoid double counting. Data for the rivers used in the analysis is as follows:

River	Exploitation Rate	Retained Small catch	Small returns	Large Returns	*Large:small*
Exploits	0.153	4407	28802	2236	0.0776
Campbellton	0.141	433	3076	493	0.1603
Gander	0.130	2429	18742	4822	0.2608
Indian Bay	0.185	421	2270		0.1607
Middle Brook	0.092	180	1948	130	0.0667
Terra Nova	0.063	120	1892	343	0.1818
Northeast Placentia	0.190	76	401	167	0.4165
Humber	0.090	2491	27585	4433	0.1607
Lomond	0.296	359	1212	123	0.0990
Torrent	0.148	720	4857	416	0.0867
Little		No fishery	313	49	0.1566
Northwest		No fishery	314	93	0.2962
Northeast Trepassey		No fishery	95	18	0.1895
Rocky		No fishery	327	77	0.2355
Conne		No fishery	2358	241	0.1022
Western Arm Br		No fishery	1046	22	0.0210

For the Class IV rivers, as most are in Bay St. George area of SFA 13, the entire area returns and spawners were estimated based on assessments for 7 rivers expanded to the total drainage based on their proportionate contribution. Four rivers in a class with individual management plans were included from their assessment information and four other rivers were not included at all due to a lack of information. These four rivers are

very small and represent only a small portion of the overall drainage area of Newfoundland. There were two rivers not listed in the River Classification System which were included based on their assessed information.

For 2000, the new method used in 1999, as described above, was again used after taking into consideration the changes implemented in 2000 from the 1999-2001 Salmon Management Plan. The Management Plan for 2000 once again used the same river classification scheme as in 1999. That is there were different season retention limits for each of river Classes I-IV and, in addition, some other rivers were placed in a special class with a different management plan for each river. Since the intent of the Management Plan was to alter exploitation for rivers in the various classes, it was necessary to model the estimation procedure for returns and spawners individually for each class of river. Also, rivers that were completely closed to angling or that were not included in the river classification scheme were individually dealt with if there was assessment information. Class I rivers included Humber and Gander and, for these rivers, returns and spawners were derived from their assessments (DFO D2-01 2001). Since there were too few rivers in several classes with which to estimate exploitation rates, it was decided to use all rivers for which exploitation rates were available to develop parameter values. So as not to bias parameter values due to river size, unweighted means and 95th percentiles were used. A non-parametric bootstrap technique whereby exploitation rates from rivers with angling fisheries and ratios of large:small salmon from rivers with enumeration facilities were chosen at random with replacement (exclusive of Bay St. George swim-through assessed rivers and Highlands). This was repeated 500 times and the 95th confidence interval of the mean exploitation rate (0.0877-0.1722) and large:small salmon ratio (0.1169-0.2322) was applied to catch statistics for retained small salmon on rivers in Classes I-IV for which full assessment information was not available. Catches for assessment rivers were subtracted from those statistics for the overall class to avoid double counting.

Data for the rivers used in the analysis is as follows:

River	Exploitation Rate	Retained Small catch	Small returns	Large Returns	*Large:small*
Exploits	0.1216	1467	12063	684	0.0567
Campbellton	0.1257	226	1798	208	0.1157
Gander	0.0645	1318	14074	1942	0.0937
Middle Brook	0.0640	112	1749	190	0.1086
Terra Nova	0.0855	146	1707	236	0.1383
Northeast Placentia	0.1978	123	622	258	0.4148
Conne	0.0626	324	5177	216	0.0417
Robinsons	0.1019	153	1501	320	Not used
Flat Bay	0.0609	146	2397	494	Not used
Lomond	0.3657	392	1072	90	0.0840
Torrent	0.0864	359	4154	359	0.1435
NWR		No fishery	272	106	0.3897
NET		No fishery	83	14	0.1687
Rocky		No fishery	277	104	0.3755
WAB		Restricted	1492	120	0.0804
Little		No fishery	564	52	0.0922

The five rivers in a class with individual management plans were included from their assessment information.

For 2001, the new method used in 1999 as described above was again used after taking into consideration the changes implemented in 2001 from the 1999-2001 Salmon Management Plan. The Management Plan for 2001 once again used the same river classification scheme as in 1999. That is there were different season retention limits for each of river Classes I-IV and, in addition, some other rivers were placed in a special class with a different management plan for each river. Since the intent of the Management Plan was to alter exploitation for rivers in the various classes, it was necessary to model the estimation procedure for returns and spawners individually for each class of river. Also, rivers that were completely closed to angling or that were not included in the river classification scheme were individually dealt with if there was assessment information. Class I rivers included Exploits, Humber and Gander and, for these rivers, returns and spawners were derived from their assessments (DFO D2-01 2002). Since there were too few rivers in several classes with which to estimate exploitation rates, it was decided to use all rivers for which exploitation rates were available to develop parameter values. So as not to bias parameter values due to river size, unweighted means and 95th percentiles were used. A non-parametric bootstrap technique whereby exploitation rates from rivers with angling fisheries and ratios of large:small salmon from rivers with enumeration facilities were chosen at random with replacement (exclusive of Bay St. George swim-through assessed rivers and Highlands). This was repeated 500 times and the 95th confidence interval of the mean exploitation rate (0.1244-0.1897) and large:small salmon ratio (0.1148-0.2070) was applied to catch statistics for retained small salmon on rivers in Classes I-IV for which full assessment information was not available. Catches for assessment rivers were subtracted from those statistics for the overall class to avoid double counting.

Data for the rivers used in the analysis is as follows:

River	Exploitation Rate	Retained Small catch	Small Returns	Large Returns	*Large:small*
Exploits	0.125	2430	19370	1347	0.0695
Campbellton	0.069	148	2151	119	0.0553
Gander	0.149	1865	12517	1682	0.1344
Middle Brook	0.256	391	1525	62	0.0407
Terra Nova	0.112	254	2261	330	0.1460
Northeast Placentia	0.179	56	312	65	0.2083
Conne	0.066	99	1503	140	0.0932
Robinsons	0.056	106	1909	232	Not used
Fischells	0.137	34	248	45	Not used
Flat Bay	0.148	170	1150	176	Not used
Lomond	0.397	227	572	75	0.1311
Torrent	0.143	376	2637	443	0.1680
NWR		No fishery	102	50	0.4902
NET		No fishery	56	8	0.1429
Rocky		No fishery	233	60	0.2575
WAB		Restricted	563	28	0.0497
Little		No fishery	125	35	0.2800

The five rivers in a class with individual management plans were included from their assessment information.

All other equations for deriving spawning escapement, large salmon and 2SW salmon were the same as in the previous model.

For 2002, the new method used in 1999 as described above was again used after taking into consideration the changes implemented in 2002 from the 2002-06 Salmon Management Plan. The Management Plan for 2002 once again used the same river classification scheme as initiated in 1999. That is there were different season retention limits for each of river Classes I-IV and, in addition, some other rivers were placed in a special class with a different management plan for each river. Since the intent of the Management Plan was to alter exploitation for rivers in the various classes, it was necessary to model the estimation procedure for returns and spawners individually for each class of river. Also, rivers that were completely closed to angling or that were not included in the river classification scheme were individually dealt with if there was assessment information. Class I rivers included Humber; while Exploits was in the special class and Gander was a Class II; and, for these rivers, returns and spawners were derived from their assessments (CSAS 2003). Since there were too few rivers in several classes with which to estimate exploitation rates, it was decided to use all rivers for which exploitation rates were available to develop parameter values. So as not to bias parameter values due to river size, unweighted means and 95th percentiles were used. A non-parametric bootstrap technique whereby exploitation rates from rivers with angling fisheries and ratios of large:small salmon from rivers with enumeration facilities were chosen at random with replacement (exclusive of Bay St. George swim-through

assessed rivers and Highlands). This was repeated 500 times and the 95th confidence interval of the mean exploitation rate (0.1093-0.1617) and large:small salmon ratio (0.0775-0.1438) was applied to catch statistics for retained small salmon on rivers in Classes I-IV for which full assessment information was not available. Values used for 2002 in last years assessment were for exploitation rate (0.1163-0.1859) and large:small salmon ratio (0.0815-0.1957). Catches for assessment rivers were subtracted from those statistics for the overall class to avoid double counting.

Data for the rivers used in the analysis is as follows:

River	Exploitation Rate	Retained Small catch	Small returns	Large Returns	*Large:small*
Exploits	0.175	2730	15589	890	0.0571
Campbellton	0.069	136	1974	123	0.0623
Gander	0.131	1726	13183	1835	0.1392
Middle Brook	0.128	117	916	69	0.0753
Terra Nova	0.102	146	1435	271	0.1889
Northeast Placentia	0.071	38	534	40	0.0749
Conne	0.072	184	2573	167	0.0649
Robinsons	0.135	123	909	201	Not used
Middle Barachois	0.076	43	569	164	Not used
Flat Bay	0.139	224	1612	198	Not used
Lomond	0.349	282	808	66	0.0817
Torrent	0.169	822	4861	432	0.0889
NWR		No fishery	442	114	0.2573
NET		No fishery	65	2	0.0308
Rocky		No fishery	276	78	0.2826
Little		No fishery	487	41	0.0842
WAB		Restricted	1465	48	0.0328

The six rivers in a class with individual management plans were included from their assessment information. All other equations for deriving spawning escapement, large salmon and 2SW salmon were the same as in the previous model.

For 2003, the new method used in 1999 as described above was again used after taking into consideration the changes implemented in 2003 from the 2002-06 Salmon Management Plan. The Management Plan for 2003 once again used the same river classification scheme as initiated in 1999. That is there were different season retention limits for each of river Classes I-IV and, in addition, some other rivers were placed in a special class with a different management plan for each river. Since the intent of the Management Plan was to alter exploitation for rivers in the various classes, it was necessary to model the estimation procedure for returns and spawners individually for each class of river. Also, rivers that were completely closed to angling or that were not included in the river classification scheme were individually dealt with if there was assessment information. In 2003, Class I rivers included only Humber while Exploits was in the special class and Gander was Class II for which returns and spawners were derived from their assessments (CSAS 2004). Since there were too few rivers in several classes with which to estimate exploitation rates, it was decided to use all rivers for which exploitation rates were available to develop parameter values. So as not to bias

parameter values due to river size, unweighted means and 95th percentiles were used. A non-parametric bootstrap technique whereby exploitation rates from rivers with angling fisheries and ratios of large:small salmon from rivers with enumeration facilities were chosen at random with replacement (exclusive of Bay St. George swim-through assessed rivers and Highlands). This was repeated 500 times and the 95th confidence interval of the mean exploitation rate (0. 0773-0.1261) and large:small salmon ratio (0.1288-0.0679) was applied to catch statistics for retained small salmon on rivers in Classes I-IV for which full assessment information was not available. Catches for assessment rivers were subtracted from those statistics for the overall class to avoid double counting.

Data for the rivers used in the analysis is as follows:

River	Exploitation Rate	Retained Small catch	Small Returns	Large Returns	*Large:small* ratio
Exploits	0.124	3633	29195	1331	0.0460
Campbellton	0.077	170	2219	152	0.0685
Gander	0.127	1735	13657	1853	0.1357
Middle Brook	0.082	97	1183	74	0.0626
Terra Nova	0.046	105	2271	330	0.1453
Conne	0.080	156	1953	51	0.0261
Robinsons	0.087	106	1212	182	Not used
Flat Bay	0.053	82	1537	189	Not used
Lomond	0.290	244	840	83	0.0988
Torrent	0.149	588	3955	341	0.0862
NWR	0.050	51	1012	273	0.2698
Harrys	0.039	91	2334	422	Not used
NET		No fishery	115	11	0.0957
Rocky		No fishery	402	73	0.1816
Little		No fishery	322	13	0.0404
WAB		Restricted	1406	23	0.0164

The seven rivers in a class with individual management plans were included from their assessment information.

All other equations for deriving spawning escapement, large salmon and 2SW salmon were the same as in the previous model.

For 2004, the new method used in 1999 as described above was again used after taking into consideration the changes implemented in 2004 from the 2002-06 Salmon Management Plan. The Management Plan for 2004 once again used the same river classification scheme as initiated in 1999 with some minor adjustments. That is there were different season retention limits for each of river Classes I-IV and, in addition, some other rivers were placed in a special class with a different management plan for each river. Since the intent of the Management Plan was to alter exploitation for rivers in the various classes, it was necessary to model the estimation procedure for returns and spawners individually for each class of river. Also, rivers that were completely closed to angling or that were not included in the river classification scheme were individually dealt with if there was assessment information. In 2004, Class I rivers included only Humber

while Exploits was in the special class and Gander was Class II for which returns and spawners were derived from their assessments (CSAS 2004). Since there were too few rivers in several classes with which to estimate exploitation rates, it was decided to use all twelve rivers for which exploitation rates were available to develop parameter values. So as not to bias parameter values due to river size, unweighted means and 95th percentiles were used. A non-parametric bootstrap technique whereby exploitation rates from rivers with angling fisheries and ratios of large:small salmon from rivers with enumeration facilities were chosen at random with replacement (exclusive of Bay St. George swim-through assessed rivers and Highlands). This was repeated 500 times and the 95th confidence interval of the mean exploitation rate (0. 0776-0.1559) and large:small salmon ratio (0.0501-0.1370) was applied to catch statistics for retained small salmon on rivers in Classes I-IV for which full assessment information was not available. Catches for assessment rivers were subtracted from those statistics for the overall class to avoid double counting.

Data for the rivers used in the analysis is as follows:

River	Exploitation Rate	Retained Small catch	Small Returns	Large Returns	*Large:small* ratio
Exploits	0.121	3292	27195	949	0.0349
Campbellton	0.081	222	2726	161	0.0591
Gander	0.072	1325	18521	2668	0.1441
Middle Brook	0.125	190	1520	88	0.0579
Terra Nova	0.045	134	3006	397	0.1321
Conne	0.132	503	3818	175	0.0458
Robinsons	0.067	134	1989	167	Not used
Flat Bay	0.038	77	2004	184	Not used
Lomond	0.342	275	803	99	0.1233
Torrent	0.132	674	5110	549	0.1074
NWR		Restricted	1207	265	0.2196
Harrys	0.079	223	2828	498	Not used
NET		No fishery	70	11	0.1571
Rocky		No fishery	169	235	1.391
Little		No fishery	656	31	0.0643
WAB		Restricted	1151	74	0.0473

The seven rivers in a class with individual management plans were included from their assessment information. All other equations for deriving spawning escapement, large salmon and 2SW salmon were the same as in the previous model.

For 2005, the new method used in 1999 as described above was again used after taking into consideration the changes implemented in 2004 from the 2002-06 Salmon Management Plan. The Management Plan for 2005 once again used the same river classification scheme as initiated in 1999 with some minor adjustments. That is there were different season retention limits for each of river Classes I-IV and, in addition, some other rivers were placed in a special class with a different management plan for each river. Since the intent of the Management Plan was to alter exploitation for rivers in the various classes, it was necessary to model the estimation procedure for returns and spawners individually for each class of river. Also, rivers that were completely closed to angling or that were not included in the river classification scheme were individually dealt

with if there was assessment information. In 2005, Class I rivers included only Humber while Exploits was in the special class and Gander was Class II for which returns and spawners were derived from their assessments (CSAS 2005). Since there were too few rivers in several classes with which to estimate exploitation rates, it was decided to use all rivers for which exploitation rates were available to develop parameter values. A non-parametric bootstrap technique whereby exploitation rates from rivers with angling fisheries and ratios of large:small salmon from rivers with enumeration facilities were chosen at random with replacement (exclusive of Bay St. George swim-through assessed rivers and Highlands). This was repeated 500 times and the 95th confidence interval of the mean exploitation rate (0. 0759-0.1264) and large:small salmon ratio (0.0752-0.1424) was applied to catch statistics for retained small salmon on rivers in Classes I-IV for which full assessment information was not available. Catches for assessment rivers were subtracted from those statistics for the overall class to avoid double counting.

Data for the rivers used in the analysis is as follows:

River	Exploitation Rate	Retained Small catch	Small Returns	Large Returns	*Large:small* ratio
Exploits	0.138	3879	28050	1967	0.0701
Campbellton	0.039	145	3746	276	0.0737
Gander	0.106	1893	17828	2461	0.1380
Middle Brook	0.092	141	1538	62	0.0403
Terra Nova	0.080	193	2417	316	0.1307
Conne	0.048	95	1978	105	0.0531
Robinsons	0.152	209	1372	118	Not used
Flat Bay	0.078	201	2591	307	Not used
Crabbes	0.067	62	920	307	Not used
Torrent	0.105	455	4342	780	0.1796
NWR	Not used	Restricted	1210	305	0.2521
NET		No fishery	69	5	0.0725
Rocky		No fishery	427	95	0.2225
Little		No fishery	216	15	0.0694
WAB		Restricted	1019	43	0.0422

The seven rivers in a class with individual management plans were included from their assessment information. All other equations for deriving spawning escapement, large salmon and 2SW salmon were the same as in the previous model.

For 2006, the new method used in 1999 as described above was again used after taking into consideration the changes implemented in 2004 from the 2002-06 Salmon Management Plan. The Management Plan for 2006 once again used the same river classification scheme as initiated in 1999 with some minor adjustments. That is there were different season limits for each of river Classes I-IV and, in addition, some other rivers were placed in a special class with a different management plan for each river. Since the intent of the Management Plan was to alter exploitation for rivers in the various classes, it was necessary to model the estimation procedure for returns and spawners individually for each class of river. Also, rivers that were completely closed to angling or

that were not included in the river classification scheme were individually dealt with if there was assessment information. In 2006, Class I rivers included Gander and Humber while Exploits was a Class II for stock rebuilding purposes. For Gander River, returns and spawners were derived from the relationship at Salmon Brook to total river returns during the years a counting fence was operated just above the mouth of the river (1988-1999) (CSAS 2005). Since there were too few rivers in several classes with which to estimate exploitation rates, it was decided to use all rivers for which exploitation rates were available to develop parameter values. A non-parametric bootstrap technique whereby exploitation rates from rivers with angling fisheries and ratios of large:small salmon from rivers with enumeration facilities were chosen at random with replacement (exclusive of Bay St. George swim-through assessed rivers and Highlands). This was repeated 500 times and the 95th confidence interval of the weighted exploitation rate (0.0777-0.1124) and large:small salmon ratio (0.1095-0.1931) was applied to catch statistics for retained small salmon on rivers in Classes I-IV for which full assessment information was not available. Catches for assessment rivers were subtracted from those statistics for the overall class to avoid double counting.

Data for the rivers used in the analysis is as follows:

River	**Exploitation Rate**	**Retained Small catch**	**Small Returns**	**Large Returns**	***Large:small* ratio**
Exploits	0.010	2515	24924	3365	0.1350
Campbellton	0.054	150	2768	328	0.1185
Gander	0.086	1199	13959	1927	0.1381
Middle Brook	0.130	152	1173	115	0.0980
Terra Nova	0.050	127	2546	438	0.1720
Conne	0.151	395	2623	170	0.0648
NWR	0.079	62	783	197	0.2516
Torrent	0.142	574	4030	1431	0.3551
Harrys	0.070	209	3004	680	Not used
NET		No fishery	69	5	0.0658
Rocky		No fishery	427	95	0.1591
Little		No fishery	216	15	0.1912
WAB		Restricted	1019	43	0.0339

The eight rivers in a class with individual management plans were included from their assessment information. All other equations for deriving spawning escapement, large salmon and 2SW salmon were the same as in the previous model.

For 2007, the new method used in 1999 as described above was again used after taking into consideration the changes implemented in 2007 from the 2007-11 Salmon Management Plan. The Management Plan for 2007 once again used the same river classification scheme as initiated in 1999 with some minor adjustments. That is there were different season retention limits for each of river Classes I-IV and, in addition, some other rivers were placed in a special class with a different management plan for each river. Since the intent of the Management Plan was to alter exploitation for rivers in the various classes, it was necessary to model the estimation procedure for returns and spawners individually for each class of river. Also, rivers that were completely closed to

angling or that were not included in the river classification scheme were individually dealt with if there was assessment information. In 2007, Class I rivers included Gander and Humber while Exploits was in Class II to allow for stock rebuilding. Returns and spawners for Gander River were derived from the relationship at Salmon Brook to total river returns during the years a counting fence was operated just above the mouth of the river (1988-1999) (CSAS 2005). Since there were too few rivers in several classes with which to estimate exploitation rates, it was decided to use all rivers for which exploitation rates were available to develop parameter values. A non-parametric bootstrap technique whereby exploitation rates from rivers with angling fisheries and ratios of large:small salmon from rivers with enumeration facilities were chosen at random with replacement (exclusive of Bay St. George swim-through assessed rivers and Highlands). This was repeated 500 times and the 95th confidence interval of the weighted exploitation rate (0.08-0.12) and large:small salmon ratio (0.11-0.17) was applied to catch statistics for retained small salmon on rivers in Classes I-IV for which full assessment information was not available. Catches for assessment rivers were subtracted from those statistics for the overall class to avoid double counting.

Data for the rivers used in the analysis is as follows:

River	Exploitation Rate	Retained Small catch	Small Returns	Large Returns	*Large:small* ratio
Exploits	0.1133	2459	21713	3956	0.1822
Campbellton	0.1065	197	1849	487	0.2634
Gander	0.0423	489	11571	1243	0.1074
Middle Brook	0.1343	141	1050	141	0.1343
Terra Nova	0.1039	174	1674	241	0.1440
Conne	No fishery	-	1174	49	0.0417
NWR	0.0489	33	675	94	0.1393
Torrent	0.1289	384	2979	519	0.1742
NET		No fishery	37	3	0.0811
Rocky		No fishery	174	35	0.2012
Little		No fishery	39	8	0.2051
WAB		No fishery	793	17	0.0214

The seven rivers in a class with individual management plans were included from their assessment information. All other equations for deriving spawning escapement, large salmon and 2SW salmon were the same as in the previous model.

For 2008, the new method used in 1999 as described above was again used after taking into consideration the changes implemented in 2008 from the 2007-11 Salmon Management Plan. The Management Plan for 2008 once again used the same river classification scheme as initiated in 1999 with some minor adjustments. That is there were different season limits for each of river Classes I-IV and, in addition, some other rivers were placed in a special class with a different management plan for each river. Since the intent of the Management Plan was to alter exploitation for rivers in the various classes, it was necessary to model the estimation procedure for returns and spawners individually for each class of river. Also, rivers that were completely closed to angling or that were not included in the river classification scheme were individually dealt with if there was assessment information. In 2007, Class I rivers included Gander and Humber

while Exploits was in Class II to allow for stock rebuilding. Returns and spawners for Gander River were derived from the relationship at Salmon Brook to total river returns during the years a counting fence was operated just above the mouth of the river (1988-1999) (CSAS 2005). Since there were too few rivers in several classes with which to estimate exploitation rates, it was decided to use all rivers for which exploitation rates were available to develop parameter values. A non-parametric bootstrap technique whereby exploitation rates from rivers with angling fisheries and ratios of large:small salmon from rivers with enumeration facilities were chosen at random with replacement (exclusive of Bay St. George swim-through assessed rivers and Highlands). This was repeated 500 times and the 95th confidence interval of the weighted exploitation rate (0.07-0.11) and large:small salmon ratio (0.07-0.12) was applied to catch statistics for retained small salmon on rivers in Classes I-IV for which full assessment information was not available. Catches for assessment rivers were subtracted from those statistics for the overall class to avoid double counting.

Data for the rivers used in the analysis is as follows:

River	Exploitation Rate	Retained Small catch	Small Returns	Large Returns	*Large:small* ratio
Exploits	0.1188	3782	31823	4575	0.1438
Campbellton	0.0838	335	3998	432	0.1081
Gander	0.0612	1374	22442	1560	0.0695
Middle Brook	0.1025	222	2167	143	0.0660
Terra Nova	0.0361	129	3575	430	0.1203
Conne	0.1364	385	2823	144	0.0510
NWR	0.0796	100	1257	229	0.1822
Torrent	0.0994	581	5847	1298	0.2220
NET		No fishery	97	4	0.0412
Rocky		No fishery	695	56	0.0806
Little		No fishery	71	3	0.0423
WAB		No fishery	1920	15	0.0078

The seven rivers in a class with individual management plans were included from their assessment information. All other equations for deriving spawning escapement, large salmon and 2SW salmon were the same as described in the model section.

RESULTS AND DISCUSSION

The revised precision index for both small and large salmon remains below unity (Fig. 2). Although there is some improvement in 2008 due to the resuming of the snorkel surveys in Bay St. George, overall the precision Index has been declining in recent years as the number of counting facilities also declined. Major changes occurred in 2000 when both Humber and Gander rivers, and in 2005 when Lomond River were no longer directly assessed. The Gander River assessment continues based on the relationship between the Gander River counting fence and the counting fence at Salmon Brook, a tributary of Gander River where counting continues. Another major change occurred in 2000 with the beginning of the snorkel surveys in Bay St. George. In 2006-07, snorkel surveys could not be completed and in 2007 only Harry's River was available for this analysis. In

2008, the snorkel surveys did take place in Bay St. George and that is reflected in the improvement in the Precision Index.

Results of an analysis of variance on ratios of large to small salmon and exploitation rates are available in Tables 1 and 2. The results show that both ratios of large to small and exploitation rates vary significantly by year and river. This would suggest that having annual values for the various parameters is important, as is keeping high the number of rivers used to base parameter values on.

RETURNS AND RECRUITS FOR NEWFOUNDLAND

The following description of returns and spawners uses the mid-points of the minimum and maximum values in Fig. 3-5. The numbers of salmon returning to freshwater does not give the total picture of salmon production for the island of Newfoundland. This is because commercial removals were very high in the years of commercial operation from pre-history up to 1991. In 1992, the commercial fishery was closed and remains so. Thus, solely looking at data without consideration for the commercial removals portrays returns to freshwater, which is important as an index of spawning, but does not capture total potential production. In order to conduct analyses to discern population trends, only total production including commercial exploitation should be used. Unfortunately, this is difficult to do as the commercial landings also include salmon not originating from rivers on the island of Newfoundland. Additionally, it is difficult to partition the commercially caught salmon into their appropriate SFAs. Salmon originating in one SFA can be caught in another due to migration patterns. The patterns of returns compared to recruits can be seen in Figure 4. The returns when summed for SFAs show similar patterns as described above for individual SFAs. The recruits show a decline for small salmon (Fig. 4) that began in the mid-1980s while large show an overall decline for the entire time series (Fig. 3). Overall, there were approximately 450,000 small salmon in the early 1970s which has declined in recent years to around 200,000. For large salmon, the 1970s showed around 225,000 salmon which by the 2000s had declined to around 50,000.

The mid-point of the estimated returns (248,970) of small salmon to Newfoundland rivers in 2008 is 16% higher than the average small returns (214,103) for the past five years (Fig. 4). The mid-point (4,009) of the estimated 2SW returns to Newfoundland rivers in 2008 was 4% lower than in 2007 and 3% lower than the recent 5-year average of 4,129 (Fig. 3).

The mid-point of the estimated numbers of 2SW spawners (3,945) in 2007 was 4% below that estimated in 2007 (4,102) and was 98% of the total 2SW CL for all rivers (Fig. 3). The 2SW conservation limit has been met or exceeded at the mid-point of spawner estimates in five years out of the last ten (Fig. 3). The small spawner abundance (225,163) in 2008 was 26% higher than in 2007 (167,691). The abundance of small spawners in 1992 was higher than in 1989–1991 and similar to levels in the late 1970s and 1980s (Fig. 4), although in 1995–1996 it was unusually high. There was a general increase in both 2SW and small spawners during the period 1992–1996 and 1998–2000, which is consistent with the closure of the commercial fisheries in Newfoundland.

Issues

The use of exploitation rates and large:small salmon ratios from SFAs with counting facilities to those with none could lead to significant over and under-estimates of returns. This is especially a problem for SFAs 3 and 12 where exploitation may be lower than in general for other SFAs on the island from reduced exploitation due to their isolation. The lack of annual exploitation rates for some SFAs draws into question the interpretation of trends except in a very broad way.

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Table 1. Results of analysis of variance for ratio of large:small salmon and year, Salmon Fishing Area, and river within Salmon Fishing Area.

Dependent Variable: ratio

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	45	0.70095966	0.01557688	3.05	<.0001
Error	190	0.97143314	0.00511281		
Corrected Total	235	1.67239280			

R-Square	Coeff Var	Root MSE	ratio Mean
0.419136	76.32256	0.071504	0.093686

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	35	0.48612579	0.01388931	2.72	<.0001
river	10	0.21483388	0.02148339	4.20	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	35	0.47413067	0.01354659	2.65	<.0001
river	10	0.21483388	0.02148339	4.20	<.0001

Table 2. Results of analysis of variance for exploitation rate for river and year.

Dependent Variable: exp

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	43	5.15649571	0.11991850	17.55	<.0001
Error	181	1.23693082	0.00683387		
Corrected Total	224	6.39342652			

R-Square	Coeff Var	Root MSE	exp Mean
0.806531	40.29459	0.082667	0.205157

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	33	1.49004327	0.04515283	6.61	<.0001
river	10	2.33556046	0.23355605	34.18	<.0001

Source	DF	Type IV SS	Mean Square	F Value	Pr > F
year	33	1.49004327	0.04515283	6.61	<.0001
river	10	2.33556046	0.23355605	34.18	<.0001

Table 3a. Returns of small salmon to rivers in Newfoundland corrected for angling removals downstream from the counting facility for 1984-2008. 2008 returns are based on preliminary angling catches.

	SFA 4			SFA 5			SFA 9		SFA 10	SFA 11		SFA 13							SFA 14A		
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1984	19028			1675	1534		89		459										986	1805	235
1985	17555			1283	2012		124		519										393	1621	470
1986	10343			1547	1459		158		879		8302								725	3155	528
1987	9481			1053	1404		91	80	350	64	10155								652	2647	437
1988	9496			1337	2114		97	313	637	65	7627								841	2388	422
1989	7577		7743	626	1377		62	168	809	102	4968								652	1510	455
1990	6995		7740	1070	1518		71	401	699	158	5368								777	2518	444
1991	5659		6745	763	1127		99	211	368	55	2411								731	1590	233
1992	13508		18179	1563	1780		49	237	956	104	2523							888	794	2829	480
1993	22253	4001	26205	2247	3050		79	292	980	169	2703	137						1808	816	4215	947
1994	17603	2857	18494	1751	1809		99	158	737	73	1533	145						1791	1292	3737	954
1995	16226	3035	22432	1390	2515	498	80	385	811	118	3502	172						2213	1529	6346	823
1996	30425	3208	24191	2044	2251	593	73	356	1532	674	4440	199	870	818	882		1233	1798	1242	7475	1230
1997	15263	1975	10637	1352	1732	466	50	435	749	399	3200	398	1168	1056	1107	863	1320	1747	1468	4158	509
1998	27093	3275	19060	2625	1868	540	91	423	1075	264	2931	96	494			205		1659	787	5388	1718
1999	28802	3076	18742	1948	1892	314	95	327	401	307	2358	146	717	563	1452	1264	2276	1713	1212	4857	1046
2000	12063	1798	14074	1749	1629	272	83	277	622	564	5177	58	1027	1142	1501	1800	2397	1271	1072	4154	1492
2001	19370	2151	12517	1525	2261	102	56	233	313	125	1503	75	688	937	1909	248	1150	1028	572	2637	563
2002	15589	1974	13444	916	1435	443	65	276	534	487	2573	169	627	569	909	414	1612	1640	815	4861	1465
2003	29198	2219	13657	1183	2271	1012	115	402		322	1953	294	1104	743	1211	1071	1540	2334	840	3955	1406
2004	27195	2726	18521	1520	3006	1207	70	169		656	3818	507	2149	1087	1989	1254	2004	2828	836	5110	1151
2005	28050	3746	17828	1538	2417	1210	69	427		216	1978	101	920	593	1372	1390	2591	2495		4342	1019
2006	24924	2768	13959	1173	2546	783	76	352		136	2623	233						3004		4030	1300
2007	21676	1849	11571	1050	1674	675	37	174		39	1174							1394		2979	793
2008	31722	3997	22442	2167	3575	1257	97	695		71	2823			455	1786	1681	2288	3526		5847	1920

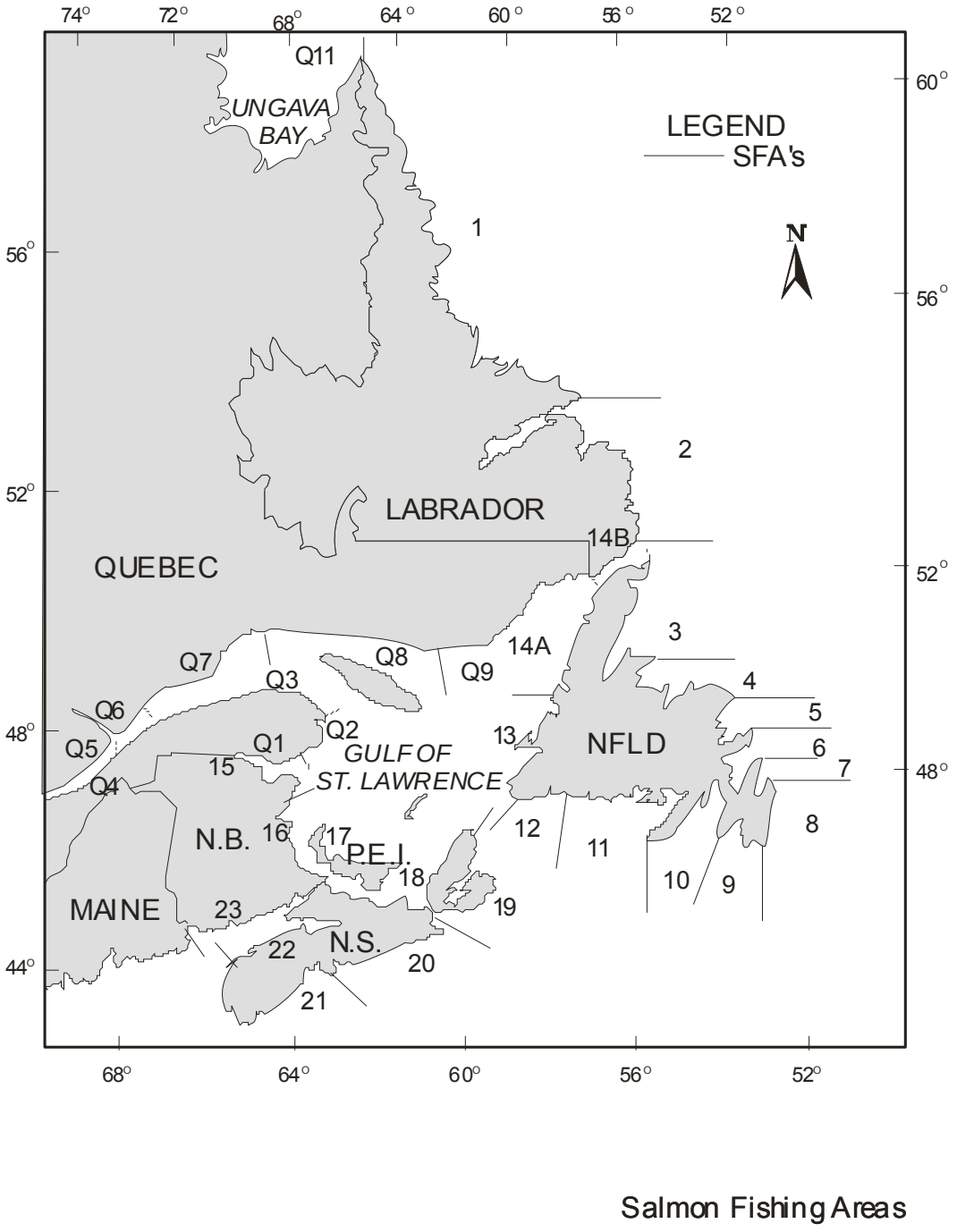
Table 3b. Returns of large salmon to rivers in Newfoundland corrected for angling removals downstream from the counting facility for 1984-2008. 2008 returns are based on preliminary angling catches.

	SFA 4			SFA 5			SFA 9		SFA 10	SFA 11		SFA 13							SFA 14A		
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1984	529			57	107		33		44										75	288	0
1985	183			27	112		41		0										14	30	1
1986	355			15	140		30		39		412								37	93	0
1987	310			19	56		30	1	16	3	516								12	68	1
1988	147			14	206		19	6	11	3	420								24	44	1
1989	89		473	19	142		18	9	15	5	320								22	60	0
1990	122		508	13	144		9	17	25	15	372								19	82	0
1991	99		670	14	114		13	16	8	6	89								21	71	1
1992	314		4162	43	270		10	46	46	21	159							16	86	170	8
1993	627	145	1734	88	472		17	72	65	11	100	78						115	38	224	8
1994	916	191	1072	91	243		15	19	70	11	100	148						128	64	334	31
1995	945	218	1121	169	637	135	12	39	74	17	110	120						80	103	617	33
1996	2057	560	1753	161	467	203	15	45	123	127	179	142	249	38	138		132	126	101	517	50
1997	881	321	1883	262	528	182	9	89	185	79	185	157	361	189	195	89	174	201	78	676	55
1998	1959	402	3649	196	394	104	11	130	287	49	294	117	239			72		191	128	761	128
1999	2236	493	4815	130	344	93	18	77	167	49	241	82	265	66	204	246	235	176	120	421	22
2000	684	208	1942	190	232	106	14	104	258	52	216	67	156	155	320	276	494	49	90	596	120
2001	1347	119	1682	62	330	50	8	60	65	36	140	65	180	142	232	45	176	132	75	443	28
2002	890	123	1898	69	271	114	2	78	40	41	167	87	134	164	201	42	198	285	66	432	48
2003	1336	152	1853	74	330	273	11	73		13	51	166	265	107	188	180	193	422	83	341	23
2004	949	161	2668	88	397	265	11	235		31	175	252	275	100	164	190	184	498	99	549	74
2005	1967	276	2461	62	316	305	5	95		15	105	153	307	97	118	169	307	453		780	43
2006	3365	328	1927	115	438	197	5	56		26	170	114						680		1431	44
2007	3956	487	1243	141	241	94	3	35		8	49							289		519	17
2008	4554	434	1560	143	430	229	4	56		3	144			20	102	98	130	398		1298	15

*Table 4. Parameter values used to determine returns and recruits for small and large salmon in SFAs 3 to 12 and 14A, 1969-2008. * uses mean Min and Max values from counting fences in 1974-1978 for large:small ratio.*

	Small salmon exploitation rates				Large:small at		Large exploitation rates			
	Angling		Commercial		counting facilities		Commercial		Proportion 2SW	
Year	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1969	0.30	0.15	0.5	0.7 *	0.0246	0.0868	0.70	0.90	0.1	0.2
1970	0.30	0.15	0.5	0.7 *	0.0246	0.0868	0.70	0.90	0.1	0.2
1971	0.30	0.15	0.5	0.7 *	0.0246	0.0868	0.70	0.90	0.1	0.2
1972	0.30	0.15	0.5	0.7 *	0.0246	0.0868	0.70	0.90	0.1	0.2
1973	0.30	0.15	0.5	0.7 *	0.0246	0.0868	0.70	0.90	0.1	0.2
1974	0.30	0.15	0.5	0.7	0.0868	0.0868	0.70	0.90	0.1	0.2
1975	0.30	0.15	0.5	0.7	0.0316	0.0316	0.70	0.90	0.1	0.2
1976	0.30	0.15	0.5	0.7	0.0584	0.0584	0.70	0.90	0.1	0.2
1977	0.30	0.15	0.5	0.7	0.0350	0.0350	0.70	0.90	0.1	0.2
1978	0.30	0.15	0.5	0.7	0.0246	0.0246	0.70	0.90	0.1	0.2
1979	0.30	0.15	0.5	0.7	0.0106	0.0106	0.70	0.90	0.1	0.2
1980	0.30	0.15	0.5	0.7	0.0556	0.0556	0.70	0.90	0.1	0.2
1981	0.30	0.15	0.5	0.7	0.0556	0.0556	0.70	0.90	0.1	0.2
1982	0.30	0.15	0.5	0.7	0.1949	0.1949	0.70	0.90	0.1	0.2
1983	0.30	0.15	0.5	0.7	0.1345	0.1345	0.70	0.90	0.1	0.2
1984	0.2834	0.1330	0.3	0.6	0.0157	0.0717	0.60	0.85	0.1	0.2
1985	0.2745	0.1326	0.3	0.6	0.0151	0.0691	0.60	0.85	0.1	0.2
1986	0.2732	0.1309	0.3	0.6	0.0247	0.0701	0.60	0.85	0.1	0.2
1987	0.2538	0.1263	0.3	0.6	0.0259	0.0713	0.60	0.85	0.1	0.2
1988	0.2651	0.1287	0.3	0.6	0.0240	0.0701	0.60	0.85	0.1	0.2
1989	0.2457	0.1207	0.3	0.6	0.0299	0.0754	0.60	0.85	0.1	0.2
1990	0.2545	0.1454	0.3	0.6	0.0349	0.0779	0.60	0.85	0.1	0.2
1991	0.2329	0.1418	0.3	0.6	0.0342	0.0808	0.60	0.85	0.1	0.2
1992	0.1368	0.0684	0	0	0.0364	0.1793	0.00	0.00	0.1	0.2
1993	0.1255	0.0652	0	0	0.0352	0.0711	0.00	0.00	0.1	0.2
1994	0.2803	0.1276	0	0	0.0588	0.1137	0.00	0.00	0.06	0.14
1995	0.2537	0.1053	0	0	0.0597	0.1084	0.00	0.00	0.06	0.14
1996	0.1789	0.0800	0	0	0.0737	0.0979	0.00	0.00	0.06	0.14
1997	0.1826	0.1002	0	0	0.1042	0.1852	0.00	0.00	0.06	0.14
1998	0.1487	0.1058	0	0	0.0997	0.2536	0.00	0.00	0.06	0.14
1999	0.1457	0.1001	0	0	0.0920	0.2062	0.00	0.00	0.06	0.14
2000	0.1135	0.0842	0	0	0.0759	0.1432	0.00	0.00	0.06	0.14
2001	0.1522	0.1163	0	0	0.0772	0.1368	0.00	0.00	0.043	0.093
2002	0.1659	0.1107	0	0	0.0651	0.1275	0.00	0.00	0.043	0.093
2003	0.0960	0.0793	0	0	0.0505	0.1332	0.00	0.00	0.043	0.093
2004	0.1220	0.0783	0	0	0.0495	0.1354	0.00	0.00	0.043	0.093
2005	0.1925	0.0654	0	0	0.0759	0.1417	0.00	0.00	0.043	0.093
2006	0.1162	0.0727	0	0	0.1163	0.1884	0.00	0.00	0.043	0.093
2007	0.1161	0.0573	0	0	0.1134	0.1813	0.00	0.00	0.043	0.093
2008	0.1139	0.0669	0	0	0.0771	0.1455	0.00	0.00	0.043	0.093

* derived as the minimum and maximum of 1974-78



Salmon Fishing Areas

Figure 1. Salmon fishing areas in Canada.

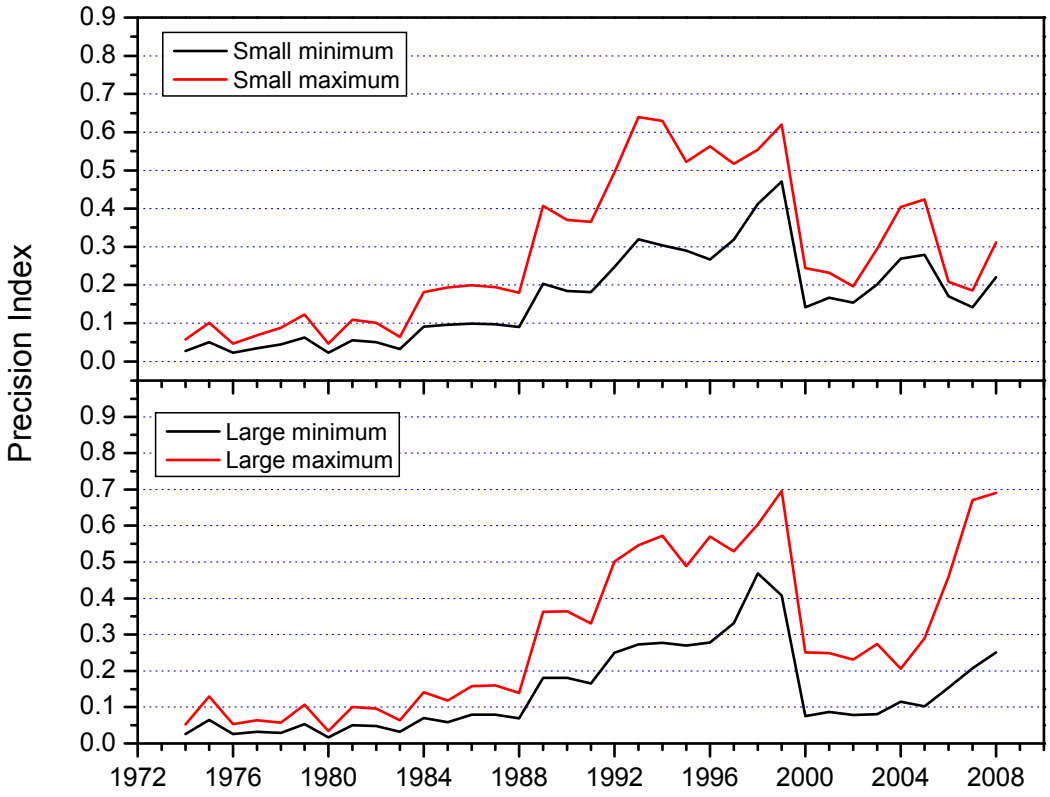


Figure 2. Precision index for Newfoundland small and large salmon based on the counts at various facilities compared to the estimated number of returns.

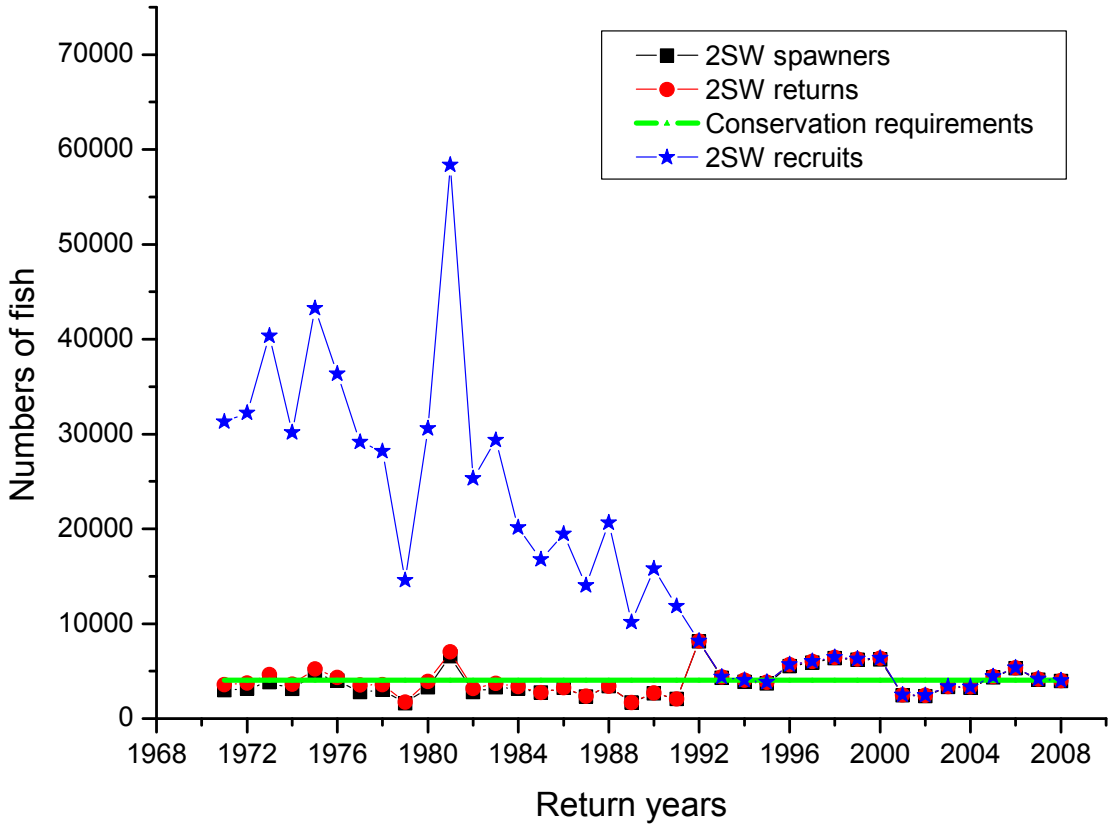


Figure 3. Spawners, returns and recruits of 2SW salmon to Insular Newfoundland.

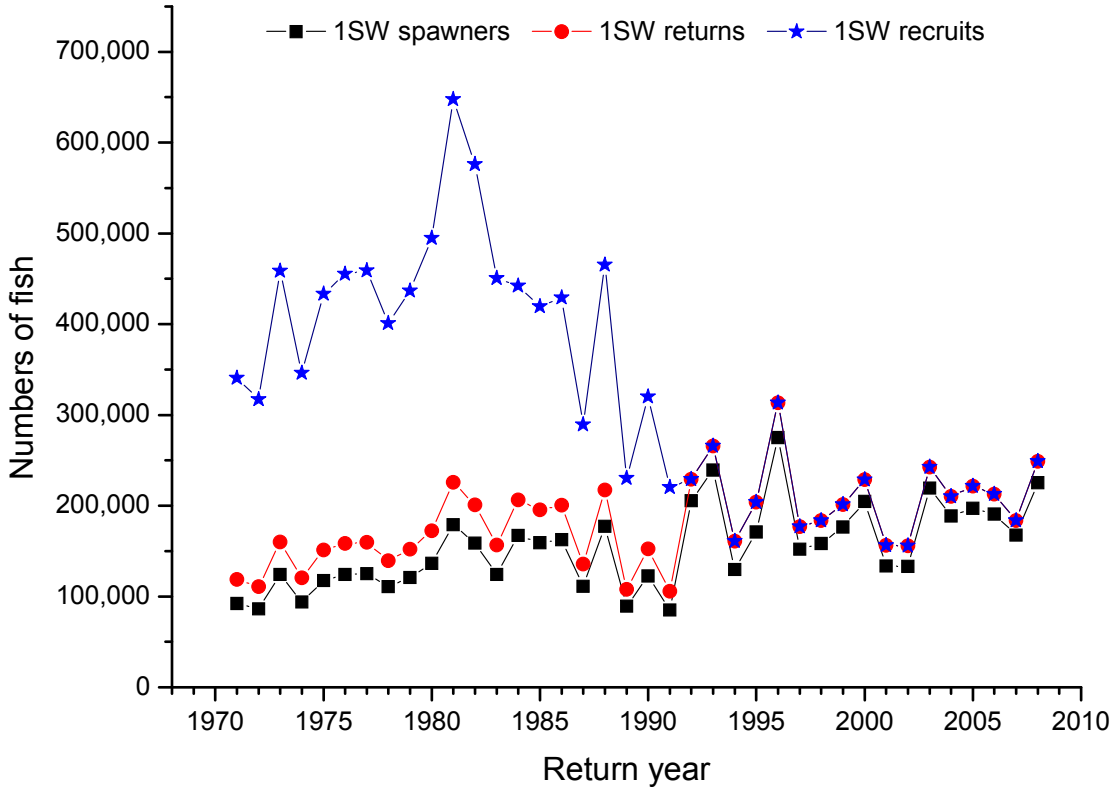


Figure 4. Spawners, returns and recruits of small (1SW) salmon to Insular Newfoundland.

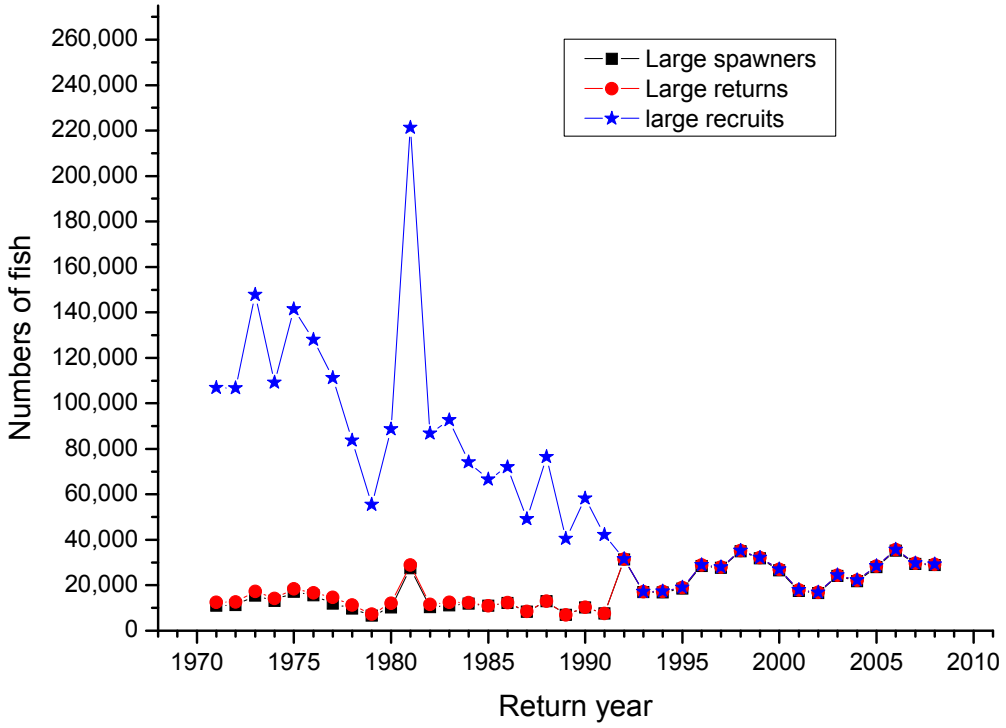


Figure 5. Spawners, returns and recruits of large salmon to Insular Newfoundland.