ATLANTIC SALMON FISHERIES SCENARIO ANALYSIS FOR THE MARGAREE RIVER (NS) FOR 2012

Context

First Nations communities of Nova Scotia requested an increase in the food, social, and ceremonial (FSC) fishery allocations of small salmon and large salmon from the Margaree River for 2012 based on their aboriginal right to first access to fish for FSC purposes, after conservation requirements are met. In the most recent stock assessment of Atlantic salmon (Salmo salar) (DFO 2012), it was concluded that the returns and the spawning escapement of large salmon to the Margaree River, located in Salmon Fishing Area 18 of DFO Gulf Region, exceeded the conservation requirements every year since 1987. No forecasts of returns of either small salmon or large salmon to the Margaree River in 2012 were provided (DFO 2012).

To support the consultation process, DFO Gulf Fisheries and Aquaculture Management requested science advice on the risks to meeting conservation for Atlantic salmon of the Margaree River in 2012 for various Atlantic salmon fisheries scenarios for the Margaree River. Specifically, the request was for an increasing range of aboriginal peoples FSC allocations from the 2011 allocation level of 345 large salmon and 135 small salmon combined with recreational fishery management scenarios of:

1) recreational fisheries management measures as in 2011 (mandatory catch and release of large salmon (>= 63 cm fork length), season retention limit of 4 small salmon per licence, season June 1 to Oct. 31),

2) recreational fishery in October only and mandatory catch and release for small salmon and large salmon, and

3) no recreational fishery.

An estimate of the potential surplus to conservation requirements of large salmon in 2012, given the objective that there should be a low probability (< 5%) of failing to meet conservation, was also requested.

Given that the most recent stock assessment includes the 2011 return year (DFO 2012) and given the urgency of negotiating a harvesting plan for the First Nations FSC fisheries for 2012, a special science response process was initiated. This Science Response Report results from the Science Special Response Process of August 9, 2012 on the review of Atlantic salmon fisheries scenario analysis for the Margaree River (NS) for 2012. The advisory report was finalized on August 24 after a revised objective for small salmon was agreed and the model re-runs were completed as recommended during the initial review of August 9, 2012.

Based on the forecast of returns of large salmon to the Margaree River in 2012, a potential fishery harvest option of 917 large salmon would result in a low probability (5% or less) of failing to meet the conservation requirement. This harvest level represents an exploitation rate of 27.5% of the predicted large salmon return in 2012. The probability of meeting conservation declines from >99% to < 75% for increasing large salmon FSC harvest scenarios from 345

large salmon to 1,645 large salmon. At a similar exploitation rate of 27.5% on small salmon, a harvest option of 271 small salmon would be available for 2012.

Background

The Margaree River (western Cape Breton Island, Nova Scotia, Salmon Fishing Area 18) has the largest Atlantic salmon (*Salmo salar*) population in Nova Scotia. The Atlantic salmon returns to the Margaree River are predominantly large salmon (fork length >= 63 cm; multi-sea-winter or MSW) which are the majority female (Breau et al. 2009). Small salmon (fork length < 63 cm), generally referred to as grilse, are less abundant than the large salmon and are the majority male. Salmon return to the Margaree River from early June to November with the fall run (after August) usually more abundant than the early run.

Atlantic salmon in the Margaree River are exploited in aboriginal peoples food, social and ceremonial (FSC) fisheries and in recreational fisheries. Fisheries management measures vary by user group. FSC allocations of Atlantic salmon to First Nations in Nova Scotia from the Margaree River in 2011 totalled 345 large salmon and 135 small salmon. In addition, the Native Council of Nova Scotia (off-reserve aboriginal peoples) had an FSC allocation of 1,820 fish (small salmon and large salmon combined) from a large number of rivers in Nova Scotia including the Margaree River (DFO 2008) but the licence stipulates that only small bright salmon can be harvested whereas male and female large salmon and small salmon may be harvested as kelts.

Recreational fisheries in Nova Scotia are managed on the basis of daily, seasonal and size retention limits, seasons, and gear restrictions. An angling licence issued by the province of Nova Scotia is required to fish recreationally for Atlantic salmon. Only artificial flies are permitted and only small salmon can be retained, all large salmon must be released back to the river after capture. The daily and season retention limits for small salmon apply to individual licences and are 2 and 4 fish, respectively. The season retention limit for small salmon was reduced from eight fish to four fish in 2008. All retained small salmon must be marked with single use carcass tags which are issued with each provincial fishing licence. The maximum daily catch and release limit is four fish, regardless of size. The angling season in the Margaree River is open from June 1 to October 31, in most years. A catch report stub is attached to each angling licence and anglers are required to return to authorities the catch report of catches and effort by river even if they did not fish during the year.

Conservation requirement for the Margaree River

Conservation for Atlantic salmon is defined as an egg deposition rate of 2.4 eggs per m2 of wetted habitat area for juvenile production (CAFSAC 1991a). Conservation, as defined, is equivalent to a limit reference point and DFO policies are to manage the resource such that there is a very low probability (5% or less) of falling below this limit reference point (DFO 2009).

The egg deposition rate is multiplied by the estimated fluvial habitat area used for juvenile production (2.798 million m2) which gives a conservation egg requirement of 6.714 million eggs. Because the majority of the salmon run to the Margaree are large salmon and these are mostly female, the objective is to obtain all the eggs for conservation from large salmon (CAFSAC 1991b). At an assumed fecundity of 6,483 eggs per large salmon spawner, the conservation egg requirement would be provided by 1,036 large salmon.

CAFSAC (1991b) also provides a secondary objective of ensuring a 1:1 male to female ratio at spawning time, corresponding to the conservation requirement for large salmon. This secondary objective has in the past been used to manage access for fisheries on small salmon in cases where the large salmon returns were below conservation. Based on average biological characteristics, the 1,036 large salmon would be comprised of 777 females (0.75 * 1,036) and 259 males (0.25 * 1,036). The deficit males (518 fish) in the large salmon component required to meet the 1:1 male to female objective can come from the small salmon. At a male proportion of 0.89 in the small salmon, the 518 deficit males are equivalent to 582 small salmon.

An alternative objective to the 1:1 male to female ratio is proposed for small salmon for the Margaree River because large salmon are more abundant than small salmon and the secondary objective has been difficult to attain in the past. The new objective is to manage for a similar exploitation rate (fisheries losses relative to returns) for small salmon and large salmon. Managing fisheries such that the exploitation rate applies equally to all age and size groups of salmon is consistent with principles of precluding size-selective or age-selective fishing pressures. The exploitation rate objective is determined as the ratio of fisheries losses of large salmon to the predicted returns of large salmon in 2012, the former being the losses that results in a 5% or lower chance of not meeting the conservation objective for large salmon. The small salmon harvest would be assessed relative to a 50% chance (risk neutral) of being at or below the large salmon exploitation rate.

Analysis and Response

The following three inputs are required to conduct a risk analysis of catch options relative to the objective of meeting or exceeding the large salmon conservation requirement and the objectives for small salmon in 2012:

- a model to predict abundance of large salmon and small salmon in 2012,
- a forecast of the catches and losses from the recreational fishery in 2012 for different management scenarios, and
- quantification of catch option scenarios for the Atlantic salmon fisheries.

Model to predict abundance of large salmon and small salmon in 2012

Mark and recapture experiments conducted in Margaree River during 1988 to 1996 were used to estimate the returns of small salmon and large salmon annually. Angling catch and effort data were used in conjunction with the mark and recapture experiments and the return estimates for those years to estimate catchability coefficients for small salmon and large salmon per rod-day of effort by logbook anglers and the anglers returning licence stubs. For 1987 and during 1997 to 2011, the returns of Atlantic salmon to the Margaree River are estimated from the catchability coefficients developed during the mark and recapture period applied to the angling catch and effort data in logbooks and returned license stubs. A Bayesian model is used to assess returns and status of Atlantic salmon to the Margaree River.

The assessment model for the Margaree River incorporates a hierarchical structure to the annual estimates of returns of small salmon and large salmon (Breau and Chaput 2012). In the absence of a relationship that could explain annual variations in abundance, it was assumed that the annual returns of small salmon and large salmon were exchangeable and under this assumption, the best estimate of returns in a given year without auxiliary information (catch and

effort data) is described by the distribution of the average returns observed over a selected time period in the past. The hierarchical structure incorporates the variability in the annual return estimates as well as the uncertainty associated with the individual annual estimates. The forecast of returns of large salmon in 2012 is based on the hierarchical model structure for all the available years, 1987 to 2011. The forecast of returns of small salmon in 2012 is based on the hierarchical model structure for all the available years, 1987 to 2011, but excluding the 1996 year (see following explanation). The predictions for 2012 were corrected for the autocorrelation in the annual residuals of predicted returns of large salmon and small salmon.

The posterior distributions of the large salmon return estimates show large annual variations during 1987 to 2011 (Fig. 1; Appendix Table 1). The highest return was about 5,700 large salmon (median value) in 2011 whereas the lowest estimated returns were less than 2,000 large salmon for 1993 and 2002 (Fig. 1; Appendix Table 1). There was significant autocorrelation in the predicted residuals of large salmon returns (median = 0.19 median, 5th to 95th percentile range 0.13 to 0.32). The predicted return of large salmon in 2012 uncorrected for autocorrelation is 2,921 fish (median value) with a 95% probability that the returns would be greater than 1,692 fish (Fig. 1; Table 1). The predicted value corrected for autocorrelation is 3,338 fish (median value) with a 95% probability that the returns would be at least 1,953 fish.

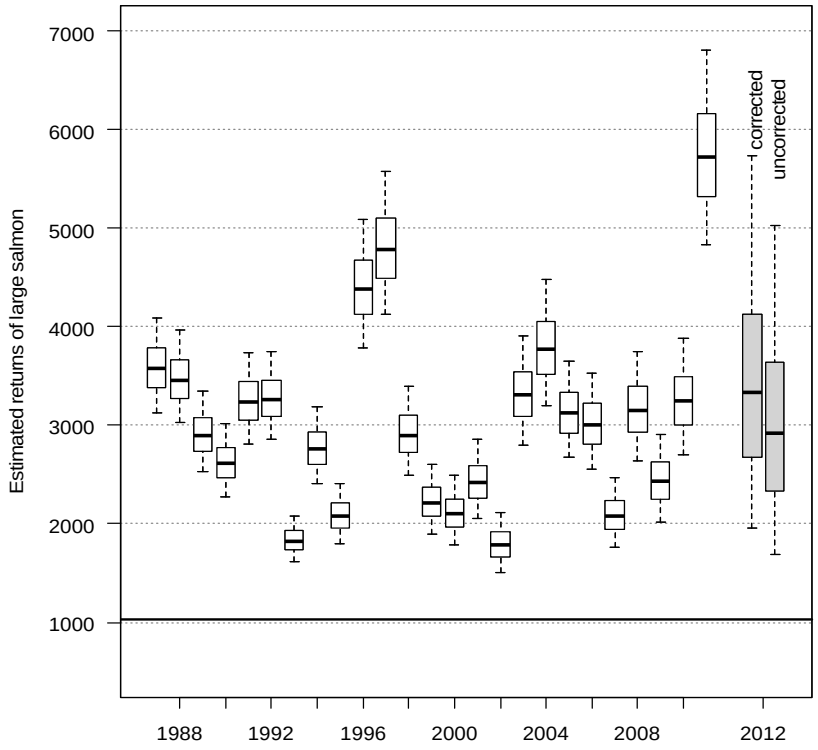

Figure 1. Posterior distributions of the estimated returns of large salmon (number of fish) to the Margaree River for 1987 to 2011 and the forecast return of large salmon for 2012. The values in grey shading are the forecasts for 2012, corrected and uncorrected for autocorrelation. The box plots are interpreted as follows: horizontal line is the median, the boxes describe the interquartile range, the dashed lines show the 5th to 95th percentile range. The solid horizontal line is the conservation requirement of 1,036 large salmon.

Table 1. Large salmon estimated returns (median, 5th to 95th percentile range), estimated catch in the recreational fishery, catch rates, estimated catch in October, and proportion of total annual catch which occurs in October from the Margaree River, 2007 to to 2011. The predicted values for 2012 are shown at the bottom of the table. The results for 1987 to 2011 are provided in Appendix Table 1.

Large salmon

Year	Estimated return (Median; 5th to 95th perc.)	Estimated recreational catch	Catch rate (Median; 5th to 95th perc.)	Recreational catch in October	Prop. of recreational catch in October
2007	2,082 (1,766 – 2,464)	784	0.38 (0.32 - 0.44)	242	0.31
2008	3,149 (2,641 – 3,752)	1,391	0.44 (0.37 - 0.53)	412	0.30
2009	2,428 (2,016 – 2,910)	1,023	0.42 (0.35 - 0.51)	357	0.35
2010	3,243 (2,702 – 3,877)	1,227	0.38 (0.32 - 0.45)	189	0.15
2011	5,726 (4,837 – 6,806)	2,159	0.38 (0.32 - 0.45)	368	0.17
Predicted 2012					
Corrected for autocorrelation	3,338 (1,953 – 5,730)	1,175 (627 – 2,035)	0.35 (0.26 - 0.45)	414 (220 - 721)	0.35 (0.35 - 0.36)
Uncorrected for autocorrelation	2,921 (1,692 – 5,027)				

The posterior distributions for small salmon returns also show large annual variation (Fig. 2; Appendix Table 2). The highest estimated return of 2,700 small salmon occurred in 1996 and was exceptional relative to all other years. The very high return in 1996 was in large part attributed to a very high abundance of hatchery-origin small salmon in the river that year. Since 1997, median return estimates of small salmon have varied between 390 and 1,437 fish annually (Appendix Table 2). The forecast return of small salmon in 2012, uncorrected for autocorrelation, is 940 fish with a high probability (95%) that there will be at least 493 fish (Fig. 2; Table 2). There was a positive and significant autocorrelation in the residuals of the small salmon returns (median = 0.10, 5th to 95th percentile range 0.01 to 0.23). The forecast return corrected for autocorrelation is 985 fish with a 95% probability the returns will be greater than 523 fish.

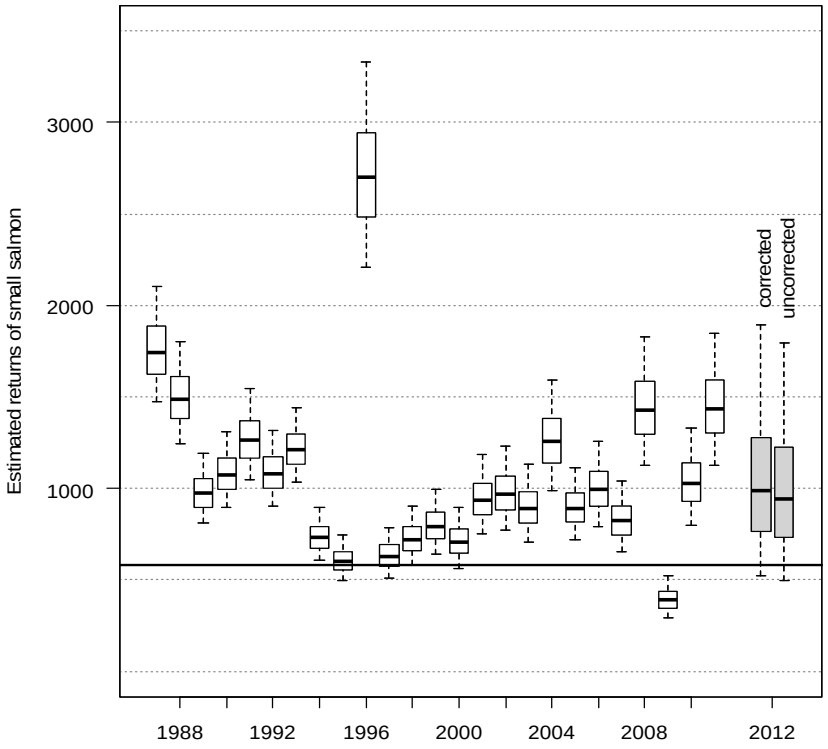

Figure 2. Posterior distributions of the estimated returns of small salmon (number of fish) to the Margaree River for 1987 to 2011 and the forecast return of small salmon for 2012. The box plots are interpreted as in Figure 1. The solid horizontal line is the secondary objective of 582 small salmon.

Table 2. Small salmon estimated returns (median, 5th to 95th percentile),estimated catch in the recreational fishery, catch rates, estimated retained, proportion of catch released, estimated catch in October, and proportion of total annual catch which occurs in October from the Margaree River, 1987 to 2011. The predicted values for 2012 are shown at the bottom of the table. The results for 1987 to 2011 are provided in Appendix Table 2.

Small salmon							
Year	Return (Median; 5th to 95th perc.)	Estimated catch	Catch rate (Median; 5th to 95th perc.)	Estimated retained	Prop. released	Estimated catch in October	Prop. of catch in October
2007	823 (656 – 1,041)	341	0.41 (0.33 - 0.52)	186	0.45	84	0.25
2008	1,430 (1,124 – 1,830)	684	0.48 (0.37 - 0.61)	331	0.52	115	0.17
2009	390 (292 - 523)	171	0.44 (0.33 - 0.59)	50	0.71	37	0.22
2010	1,027 (797 – 1,329)	426	0.41 (0.32 - 0.53)	182	0.57	49	0.12
2011	1,437 (1,126 – 1,845)	590	0.40 (0.31 - 0.51)	196	0.67	70	0.12
Predicted 2012							
Corrected for autocorrelation	985 (523 – 1,896)	371 (184 - 717)	0.38 (0.27 - 0.50)	144 (70 - 277)	0.60 (0.56 – 0.62)	79 (37 - 157)	0.21 (0.21 - 0.22)
Uncorrected for autocorrelation	940 (493 – 1,794)						

Forecast of the catches and losses from the recreational fishery in 2012 for different management scenarios

Anglers are required to return information of effort, small salmon retained, small salmon released, large salmon released by river and date using a licence stub which is attached to the provincial angling licence. Although reporting is indicated to be mandatory, only a portion of the licence stubs are returned. Estimated catch and effort in the recreational fishery are adjusted based on the proportion of reports returned. Catch refers to the sum of fish which are caught and released and fish which are retained.

Catch rates for small salmon and for large salmon size groups by year are calculated as estimated total catch divided by the estimated total returns. The proportion of the small salmon catch retained is the ratio of estimated retained small salmon catch to total small salmon catch. The proportion of the catch which is taken in October is the ratio of estimated catch in October to total catch for the season. A catch and release mortality value of 5% is assumed for salmon angled in the Margaree (CAFSAC 1991b). Losses from the angling fishery are estimated as the sum of retained fish and the estimated mortality from caught and released fish.

For the risk analysis for 2012, catches from the recreational fishery were forecast as follows. First, the catch rate of small salmon and large salmon in 2012 was estimated from the predicted effort in 2012, based on effort of the past four years, and the predicted catchability coefficients (Tables 1, 2). Second, the proportion of small salmon retained in 2012 was assumed to be the average of the proportions retained for the years 2008 to 2011. These years were selected because the proportion of small salmon released has been increasing over time and was among the highest values in 2008 to 2011 (Appendix Table 2), corresponding to the years when the season retention limit was reduced from eight to four tags. Finally, for the scenario with a catch and release angling fishery in October only, the catch in October in 2012 is estimated from the catch rate for the season adjusted by the mean (over years with available data, 1997 to 2011) proportion of the catch which occurred in October.

Under the recreational fishery management plan as in 2011, the predicted catches of large salmon in 2012 are 1,175 fish (5^{th} to 95^{th} percentile range 627 to 2,035) (Table 1). For small salmon, 371 fish are predicted to be caught (5^{th} to 95^{th} percentile range 184 to 717) (Table 2).

Risk analysis of fishery scenarios

The potential forecast surplus to conservation requirements of large salmon in 2012 that provides a low probability (5% or less) of failing to meet the conservation requirements is calculated directly as the difference between the 5^{th} percentile of the forecast returns for 2012 and the conservation requirement.

The spawners are calculated as the difference between forecast returns and expected losses in all the fisheries. The probability of meeting conservation for large salmon is calculated from the posterior distribution of spawners for each fishery scenario relative to the conservation objective of 1,036 large salmon. The following fishery scenarios were analysed for large salmon (Table 3):

- Increasing FSC allocations from 345 fish by 50 fish increments to a maximum of 1,645 large salmon and

    a. Recreational fishery management in 2012 as in 2011,

b. Recreational fishery open only in October and with mandatory catch and release for all sizes of salmon, and

c. Recreational fishery closed.

For small salmon, the risk analysis is presented as the probability of exceeding the median exploitation rate as derived from the large salmon conservation objective, and also of exceeding a requirement of 582 small salmon to meet the 1:1 male to female ratio for spawners. The following fishery scenarios were analysed for small salmon (Table 4):

- Increasing small salmon FSC allocations from 135 fish by 50 fish increments to a maximum of 635 small salmon, and recreational fishery scenarios as described for large salmon.

Large salmon

At a 5% risk level of failing to meet the conservation requirement, a projected surplus to conservation for 2012 is 917 large salmon (1,953 minus 1,036). The projected surplus of 917 large salmon equates to a median (over the predicted distribution of large salmon returns) exploitation rate of 27.5%. For each of the recreational fishery scenarios:

a) Expected losses of large salmon from catch and release mortality are 59 fish (5^{th} to 95^{th} percentile range 29 to 104 fish). Total losses (median value) over the range of FSC allocations examined represent exploitation rates of 13% to 54% of the total returns of large salmon. There is a greater than 99% chance of meeting conservation for large salmon for an FSC allocation of 445 large salmon or less and with recreational fisheries as in 2011 (Table 3). For a 5% or lower risk of failing to meet conservation and with a recreational fishery as in 2011, the FSC large salmon allocation would be around 895 fish. The probability of meeting conservation declines to less than 75% for an FSC allocation greater than 1,595 large salmon (Table 3).

b) For a recreational catch and release fishery in October only, the expected losses from catch and release mortality are 21 large salmon (5^{th} to 95^{th} percentile range 9 to 38 fish). Total losses (median value) over the range of FSC allocations examined represent exploitation rates of 12% to 53% of the total returns of large salmon. There is a greater than 99% chance of meeting conservation for large salmon for an FSC allocation of 445 large salmon or less (Table 3). For a 5% or lower risk of failing to meet conservation and with a recreational fishery open only in October for catch and release, the FSC large salmon allocation would be around 895 fish. The probability of meeting conservation declines to less than 75% for an FSC allocation greater than 1,595 large salmon (Table 3).

c) With the recreational fishery closed, the probability of meeting conservation for large salmon is >99% with an FSC allocation of about 495 large salmon (Table 3). At a 5% risk level of failing to meet the conservation requirement, the projected surplus to conservation for 2012 is 917 large salmon. The probability of meeting conservation declines to 75% for an FSC allocation of 1,645 large salmon (Table 3). The exploitation rate on large salmon ranges from a low of 11% for an FSC allocation of 345 large salmon to 52% at an FSC allocation of 1,645 fish (Table 3).

Table 3. For large salmon, the probability (%) of meeting or exceeding the conservation requirement of 1,036 large salmon and the exploitation rate (%, median, fisheries losses divided by returns) in the Margaree River in 2012 under various fisheries management scenarios. Recreational fishery scenarios are: (a) management as in 2011, (b) fishery in October only, mandatory catch and release, and (c) fishery closed.

FSC allocation (large salmon)	Probability (%) of meeting or exceeding 1,036 large salmon spawners			Exploitation rate (%, median)		
	Recreational fishery scenarios			Recreational fishery scenarios		
	(a)	(b)	(c)	(a)	(b)	(c)
345	99.5	99.6	99.6	12.7	11.6	10.9
395	99.3	99.4	99.5	14.3	13.1	12.5
445	99.0	99.1	99.1	15.9	14.7	14.1
495	98.8	98.9	98.9	17.4	16.3	15.7
545	98.5	98.6	98.7	19.0	17.9	17.3
595	98.1	98.3	98.4	20.6	19.5	18.8
645	97.7	97.9	98.0	22.2	21.1	20.4
695	97.3	97.5	97.6	23.8	22.6	22.0
745	96.8	97.0	97.1	25.4	24.2	23.6
795	96.2	96.4	96.6	26.9	25.8	25.2
845	95.6	96.0	96.1	28.5	27.4	26.8
895	94.7	95.2	95.3	30.1	29.0	28.4
945	93.9	94.3	94.5	31.7	30.6	29.9
995	92.9	93.5	93.8	33.3	32.1	31.5
1045	91.8	92.3	92.6	34.9	33.7	33.1
1095	90.6	91.2	91.5	36.4	35.3	34.7
1145	89.4	90.0	90.4	38.0	36.9	36.3
1195	88.1	88.8	89.1	39.6	38.5	37.9
1245	86.8	87.4	87.8	41.2	40.1	39.4
1295	85.4	86.2	86.5	42.8	41.6	41.0
1345	83.7	84.7	85.1	44.4	43.2	42.6
1395	82.1	83.1	83.6	46.0	44.8	44.2
1445	80.6	81.4	81.9	47.5	46.4	45.8
1495	78.9	79.8	80.5	49.1	48.0	47.4
1545	77.0	78.0	78.7	50.7	49.6	48.9
1595	75.1	76.4	76.9	52.3	51.1	50.5
1645	73.1	74.4	75.0	53.9	52.7	52.1

Small salmon

At an exploitation rate of 27.5%, the median predicted removal of small salmon for 2012 is 271 fish (5^{th} to 95^{th} percentile 144 to 521 fish). At a 50% risk level, a surplus of 403 small salmon is predicted relative to the secondary objective of achieving 582 small salmon. For each of the recreational fishery scenarios:

a. For 2012, the expected losses of small salmon in the recreational fishery are 155 fish (median; 5^{th} to 95^{th} percentile 76 to 300 fish) including 144 fish retained (median; 5^{th} to 95^{th} percentile 70 to 277 fish) and 11 fish from catch and release mortality (median; 5^{th} to 95^{th} percentile 4 to 24 fish). With these expected recreational fishing losses and for the objective of not exceeding a 27.5% exploitation rate (50% risk level), the FSC allocation would correspond to 116 fish (median value; 5^{th} to 95^{th} percentile range 0 to 195 fish). Total losses (median value) over the range of FSC allocations examined represent exploitation rates of 31% to 85% of the small salmon returns in 2012 (Table 4). The probabilities of meeting or exceeding the 27.5% exploitation rate objective range from 63% to 100% (Table 4) and the

probabilities of meeting or exceeding the small salmon spawner objective of 582 fish ranges from 65% down to 19% (Table 4).

b. For a recreational fishery in October only with mandatory catch and release of small salmon, the expected losses from catch and release mortality are 4 small salmon (median; 5th to 95th percentile 1 to 9 fish). At a 27.5% exploitation rate on the predicted small salmon returns, the corresponding FSC removals (after accounting for recreational fisheries losses) could be 267 small salmon (5th to 95th percentile range 262 to 270 fish). Total losses (median value) for 2012 from all fisheries represent exploitation rates of 15% to 70% over the range of small salmon FSC allocations examined (Table 4). The probabilities of meeting or exceeding the 27.5% exploitation rate objective range from 4% to 98% (Table 4) and the probabilities of meeting or exceeding the small salmon spawner objective of 582 fish ranges from 80% down to 29% (Table 4).

c. At an exploitation rate of 27.5%, the median predicted available harvest of small salmon for 2012 is 271 fish (5th to 95th percentile 144 to 521 fish). At a 50% risk level, a surplus of 403 small salmon is predicted relative to the secondary objective of achieving 582 small salmon. With the recreational fishery closed, total losses from FSC fisheries only for 2012 represent exploitation rates of 15% to 69% over the range of small salmon FSC allocations examined (Table 4). The probabilities of meeting or exceeding the 27.5% exploitation rate objective range from 3% to 98% (Table 4) and the probabilities of meeting or exceeding the small salmon spawner objective of 582 fish ranges from 80% down to 30% (Table 4).

Table 4. For small salmon, the estimated exploitation rate (%, median, fisheries losses divided by returns), the probability (%) of meeting or exceeding a 27.5% exploitation rate, and the probability (%) that the spawners after fisheries losses will be greater than or equal to 582 small salmon in the Margaree River in 2012 under various fisheries management scenarios. Recreational fishery scenarios are: (a) management as in 2011, (b) fishery in October only, mandatory catch and release of small salmon, and (c) fishery closed.

FSC allocation (small salmon)	*Exploitation rate (%, median)*			*Probability (%) exploitation rate >= 27.5%*			*Probability (%) small salmon spawners >= 582 fish*		
	Recreational fishery scenarios			*Recreational fishery scenarios*			*Recreational fishery scenarios*		
	(a)	*(b)*	*(c)*	*(a)*	*(b)*	*(c)*	*(a)*	*(b)*	*(c)*
135	30.5	15.1	14.7	63.2	3.8	3.4	65.0	80.0	80.3
185	35.9	20.5	20.1	83.5	16.2	15.4	58.3	74.6	74.9
235	41.4	26.0	25.6	92.4	36.4	35.0	51.6	69.1	69.5
285	46.8	31.4	31.0	96.4	56.6	55.1	45.5	63.4	63.6
335	52.2	36.9	36.5	98.2	72.0	70.7	39.7	57.6	58.0
385	57.7	42.3	41.9	99.2	82.5	81.8	34.8	51.7	52.1
435	63.1	47.8	47.4	99.6	89.2	88.6	30.6	46.4	46.9
485	68.6	53.2	52.8	99.8	93.4	93.0	26.5	41.3	41.7
535	74.0	58.6	58.2	99.9	95.9	95.6	22.8	36.7	37.1
585	79.4	64.1	63.7	99.9	97.5	97.3	19.6	32.9	33.2
635	84.9	69.5	69.1	100.0	98.4	98.2	16.8	29.1	29.5

Conclusions

The advice on catch options for Atlantic salmon for the Margaree River applies to the 2012 fishery. Because of the positive autocorrelation in estimated returns, advice for other years' fisheries will require annual updates based on the most recent estimates of returns of large salmon and small salmon.

The predicted return of large salmon to the Margaree River in 2012 is 3,338 fish with a 95% probability of at least 1,953 fish (corrected for autocorrelation). Fishery options with a total loss of 917 large salmon or less result in a low probability (<5%) of failing to meet conservation for large salmon in 2012. This harvest level corresponds to an exploitation rate of 27.5% (median value) of the large salmon return. For the secondary objective of managing for a similar maximum exploitation rate on small salmon, total fisheries losses in 2012 could be 271 small salmon (median; 5^{th} to 95^{th} percentile range 144 to 521 fish). At a 50% risk level, a surplus of 403 small salmon is predicted relative to the secondary objective of achieving 582 small salmon.

The returns of small salmon and large salmon in a given year are very uncertain. Marine survival rates of Atlantic salmon in eastern Canada are highly variable among populations and among years, have generally declined in the past two decades, and returns of adult salmon are often unrelated to the corresponding smolt production.

Forecasted returns to the Margaree River in 2012 are very uncertain. First, the forecast is based on the average of the estimated returns over the 1987 to 2011 time period. Over that time period, estimated returns varied annually but there is no discernible trend in abundance. As a consequence of the large annual variations in abundance seen over that time period and the uncertainties in the annual estimates, the uncertainties in the forecast for 2012 are large (coefficient of variation of 34%). However, the Bayesian hierarchical model is an appropriate framework for incorporating these two levels of uncertainty. Second, assessments of annual returns during 1997 to the present are based on catch and effort data from logbook anglers and from returned angling licence stubs, adjusted by catchability coefficients estimated for the 1988 to 1996 return years. It is assumed that the catchability coefficients estimated for the earlier time period are still appropriate and that the data reported by anglers have been consistently tabulated over the entire time series. It would be prudent to update the estimates of catchability to assess if this assumption is valid.

Catch and harvest data in the recreational fisheries are incomplete and estimates are made by raising the reported licence stub statistics to total licence sales. Predicting recreational catches in 2012 is very uncertain. Effort in 2012 is predicted based on estimated effort of the previous four years and the catchability coefficients in the recreational fishery are assumed to be similar to those estimated from the 1988 to 1996 time period. All these add uncertainty to the advice and in the context of the precautionary approach, using the 5^{th} percentile of predicted returns for 2012 against which to assess the risks of fishery catch options, is appropriate.

It is assumed that the incidental mortality rate on caught and released salmon is 5%. This value has not been estimated from observations in the Margaree River but is within the range of values assumed in other fisheries of Gulf Region. Since most of the angling catches occur in the fall season when water temperatures are reasonably cool (< 20 °C), the 5% value is considered to be reasonable.

Harvests in the aboriginal FSC fisheries are also incomplete. As FSC allocations increase, the control and reporting of fishing activities becomes more important in the assessment of stock status and the evaluation of risks to conservation of Atlantic salmon in the Margaree River.

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Sources of information

This Science Response Report results from the Science Special Response Process of August 9, 2012 on the review of Atlantic Salmon Fisheries Scenario Analysis for the Margaree River (NS) for 2012. Additional publications from this process will be posted as they become available on the Fisheries and Oceans Canada Science Advisory Schedule at www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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Appendix

Appendix Table 1. Large salmon estimated returns (median, 5th to 95th percentile range), estimated catch in the recreational fishery, catch rates, estimated catch in October and proportion of total annual catch which occurs in October from the Margaree River, 1987 to 2011.

Year	Estimated return (Median; 5th to 95th perc.)	Estimated catch	Catch rate (Median; 5th to 95th perc.)	Catch in October	Prop. of catch in October
1987	3,575 (3,131 – 4,090)	1,847	0.52 (0.45 - 0.59)		
1988	3,461 (3,030 – 3,970)	1,979	0.57 (0.5 - 0.65)		
1989	2,900 (2,530 – 3,343)	1,607	0.55 (0.48 - 0.64)		
1990	2,616 (2,280 – 3,016)	1,520	0.58 (0.5 - 0.67)		
1991	3,237 (2,812 – 3,742)	1,808	0.56 (0.48 - 0.64)		
1992	3,262 (2,860 – 3,743)	1,999	0.61 (0.53 - 0.7)		
1993	1,829 (1,618 – 2,085)	1,090	0.60 (0.52 - 0.67)		
1994	2,765 (2,403 – 3,192)	1,478	0.53 (0.46 - 0.62)		
1995	2,077 (1,798 – 2,408)	1,091	0.53 (0.45 - 0.61)		
1996	4,385 (3,782 – 5,089)	1,938	0.44 (0.38 - 0.51)		
1997	4,790 (4,121 – 5,581)	2,105	0.44 (0.38 - 0.51)	859	0.41
1998	2,900 (2,491 – 3,397)	1,341	0.46 (0.39 - 0.54)	477	0.36
1999	2,215 (1,894 – 2,598)	808	0.36 (0.31 - 0.43)	328	0.41
2000	2,106 (1,783 – 2,494)	696	0.33 (0.28 - 0.39)	285	0.41
2001	2,422 (2,050 – 2,854)	854	0.35 (0.3 - 0.42)	449	0.53
2002	1,786 (1,507 – 2,119)	611	0.34 (0.29 - 0.41)	291	0.48
2003	3,304 (2,802 – 3,905)	1,138	0.34 (0.29 - 0.41)	470	0.41
2004	3,779 (3,196 – 4,480)	1,408	0.37 (0.31 - 0.44)	551	0.39
2005	3,123 (2,672 – 3,654)	1,340	0.43 (0.37 - 0.5)	399	0.30
2006	3,005 (2,553 – 3,533)	1,256	0.42 (0.36 - 0.49)	416	0.33
2007	2,082 (1,766 – 2,464)	784	0.38 (0.32 - 0.44)	242	0.31
2008	3,149 (2,641 – 3,752)	1,391	0.44 (0.37 - 0.53)	412	0.30
2009	2,428 (2,016 – 2,910)	1,023	0.42 (0.35 - 0.51)	357	0.35
2010	3,243 (2,702 – 3,877)	1,227	0.38 (0.32 - 0.45)	189	0.15
2011	5,726 (4,837 – 6,806)	2,159	0.38 (0.32 - 0.45)	368	0.17

Appendix Table 2. Small salmon estimated returns (median, 5th to 95th percentile),estimated catch in the recreational fishery, catch rates, estimated retained, proportion of catch released, estimated catch in October and proportion of total annual catch which occurs in October from the Margaree River, 1987 to 2011.

Year	Return (Median; 5th and 95th percentiles)	Estimated catch	Catch rate (Median; 5th and 95th percentiles)	Estimated retained	Prop. released	Estimated catch in October	Prop. of catch in October
1987	1,743 (1,472 – 2,106)	972	0.56 (0.46 - 0.66)	822	0.15		
1988	1,486 (1,247 – 1,804)	901	0.61 (0.5 - 0.72)	771	0.14		
1989	973 (808 – 1,189)	574	0.59 (0.48 - 0.71)	444	0.23		
1990	1,074 (896 – 1,312)	655	0.61 (0.5 - 0.73)	502	0.23		
1991	1,263 (1,050 – 1,548)	773	0.61 (0.5 - 0.74)	575	0.26		
1992	1,080 (904 – 1,314)	699	0.65 (0.53 - 0.77)	568	0.19		
1993	1,208 (1,032 – 1,442)	769	0.64 (0.53 - 0.75)	556	0.28		
1994	732 (607 - 898)	427	0.58 (0.48 - 0.7)	290	0.32		
1995	602 (495 - 743)	343	0.57 (0.46 - 0.69)	205	0.4		
1996	2,700 (2,209 - 3331)	1,239	0.46 (0.37 - 0.56)	284	0.77		
1997	630 (512 - 786)	311	0.49 (0.4 - 0.61)	195	0.37	65	0.21
1998	721 (582 - 900)	352	0.49 (0.39 - 0.6)	209	0.41	62	0.18
1999	794 (642 - 992)	311	0.39 (0.31 - 0.48)	197	0.37	55	0.18
2000	708 (563 - 898)	262	0.37 (0.29 - 0.47)	133	0.49	73	0.28
2001	937 (750 – 1,187)	364	0.39 (0.31 - 0.49)	142	0.61	150	0.41
2002	971 (774 – 1,229)	363	0.37 (0.3 - 0.47)	161	0.56	108	0.30
2003	891 (705 – 1,133)	327	0.37 (0.29 - 0.46)	184	0.44	81	0.25
2004	1,254 (990 – 1,590)	518	0.41 (0.33 - 0.52)	251	0.52	112	0.22
2005	891 (718 – 1,111)	418	0.47 (0.38 - 0.58)	206	0.51	67	0.16
2006	993 (789 – 1,254)	444	0.45 (0.35 - 0.56)	253	0.43	78	0.18
2007	823 (656 – 1,041)	341	0.41 (0.33 - 0.52)	186	0.45	84	0.25
2008	1,430 (1,124 – 1,830)	684	0.48 (0.37 - 0.61)	331	0.52	115	0.17
2009	390 (292 - 523)	171	0.44 (0.33 - 0.59)	50	0.71	37	0.22
2010	1,027 (797 – 1,329)	426	0.41 (0.32 - 0.53)	182	0.57	49	0.12
2011	1,437 (1126 – 1,845)	590	0.40 (0.31 - 0.51)	196	0.67	70	0.10

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