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For Information

Council

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Recent investigations into the stock composition of the Labrador Atlantic salmon subsistence fisheries

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Recent investigations into the stock composition of the Labrador Atlantic Salmon subsistence fisheries

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Atlantic salmon, *Salmo salar*, in eastern Canada were historically fished in rivers, estuaries and in the marine coastal waters in commercial, recreational and aboriginal fisheries. As a result of declining stock abundance, the commercial fisheries were progressively closed beginning as early as the 1940s, with important closures in 1984, 1992, 1998 and finally closed overall in eastern Canada in 2000. In addition to the closure of the commercial fisheries, restrictive management measures were introduced in the recreational fisheries that included mandatory catch and release of large salmon (>= 63 cm fork length) in most areas of eastern Canada along with season and daily retention limits on small salmon (< 63 cm fork length). Aboriginal peoples of eastern Canada have access to Atlantic salmon for food, social, and ceremonial (FSC) purposes. The Supreme Court of Canada, in the case of Regina vs Sparrow affirmed the constitutional right of aboriginal peoples to priority access to natural resources after conservation requirements are met.

In the western Atlantic, salmon migrate to the Labrador Sea or the waters west of Greenland to feed and may move into coastal regions of Labrador and Newfoundland during the summer months where fisheries targeting mixtures of populations have traditionally occurred. Marine fisheries that harvest Atlantic salmon originating from rivers of eastern Canada and the US occur at Greenland, in estuarine and coastal waters of Labrador and at Saint-Pierre et Miquelon off the southeast coast of Newfoundland

Labrador subsistence fisheries

The Labrador FSC fishery is practiced by several groups located in different parts of the region. These fisheries occurring in estuaries and marine coastal waters of Labrador are essentially artisanal fisheries using fixed gillnets, set in bays and around coastal islands from small boats. Three aboriginal peoples groups (Labrador Inuit Association, the Innu First Nation, and the NunatuKavut Community Council) fish for salmon based on negotiated fisheries agreements. A bycatch of three Atlantic salmon is provided to registered Labrador residents under a food fishery licence targeting sea-run speckled trout and Arctic charr. These fisheries are managed by season, location, gear, and quota allocations to the respective groups. In all cases, the sale or bartering of Atlantic salmon is prohibited.

Total annual harvests of Atlantic salmon in the Labrador subsistence (aboriginal FSC and resident food) fisheries ranged from 6,500 to 15,600 salmon of all sizes, equivalent to 15.6 to 41.4 metric tons of fish, during 2000 to 2013 (Fig. 1). By number of fish, the harvest is predominantly small salmon, ranging from 4,800 to 11,100 fish compared to large salmon numbers ranging from 1,400 to 6,500 fish annually. Most of the harvests of small salmon occur

in southern Labrador whereas large salmon harvest numbers are relatively similar among the three salmon fishing areas of Labrador (Fig. 1).

Progress in assigning origin of salmon in the Labrador subsistence fisheries

Differences in biological characteristics and more recently, genetic stock identification techniques, have been used to assign the origin of salmon sampled from the Labrador subsistence fisheries to a region of origin.

There is a positive relationship between latitude of the river and the freshwater age of smolts with proportionally older smolts produced in the more northern areas (Fig. 2). Freshwater ages of Atlantic salmon sampled from the fishery indicated that there were very few age 1 and age 2 year old smolts with most (>75%) of the salmon sampled having a freshwater age of 4 years and older (ICES 2013). These older smolts could potentially include salmon from northern Quebec, Newfoundland and Labrador populations.

Recent developments in genetic stock identification techniques are being used to address the questions of the origin of Atlantic salmon captured in marine fisheries. The application of these techniques to the catches of the subsistence fisheries of Labrador required the following steps:

- Establishment of an eastern North American baseline,
- Definition of regional groups,
- Obtaining samples from the fishery,
- Assigning origin of salmon from the fishery samples

The establishment of the eastern North American baseline was supported by the Natural Sciences and Engineering Research Council of Canada (NSERC) grant to Dr. L. Bernatchez from Université Laval (Quebec, Canada) with collaborations from scientists at Fisheries and Oceans Canada (P. O'Reilly and I. Bradbury), from the Government of Quebec (M. Dionne), and the USA (T. King). A total of 12,000 individual fish samples were obtained from 189 individual river systems from Ungava Bay (Quebec) (58.8ºN) to Maine (USA) (44.8ºN). Analyses were standardized for three different laboratories.

Microsatellite polymorphisms were scored at 15 loci: Ssa85, Ssa202, Ssa197, SSOSL417, SsaD85, SsaD58, SsaD71, SsaD144, SsaD486, MST-3, SSsp2201, SSsp2210, SSsp2215, SSsp2216 and SSspG7. Genotyping of fishery samples follows the methods outlined in Bradbury et al. (2014). The database also includes data from an EST-based medium-density SNP array which provides data on over 5000 SNPs for 20-25 individuals for each of 46 sampling locations (Bourret *et al.* 2013). The SNP dataset is divided into neutral and potentially adaptive markers based on a genome scan analysis.

Reporting groups for assignment purposes represent regional clusters identified in previous landscape analyses of population structure (; Dionne et al. 2008; Bradbury et al. 2014) In total, 12 reporting groups were used for individual assignment and mixture analysis (Fig. 2), based on both new data and previously published data from Quebec, Labrador, and New Brunswick from Dionne et al. (2008) and Newfoundland and Labrador from Bradbury et al. (2014).

A program to collect representative samples from the fishery in 2006-2011 was conducted by NunatuKavut Community Council Aboriginal guardians, and Conservation Officers of the Nunatsiavut Government. Samples collected for genetic analyses were comprised of both scales (2006-2010) and fin clips in 95% ethanol (2011). In total 1,772 samples of individual catches collected in the fishery over the six year period were available. The spatial distribution of

samples from the fishery varied from year to year. In 2006 and 2007, fishery samples were limited in northern regions whereas sampling in the south was limited in 2007. Coverage was more evenly distributed across the region in 2009, 2010, and 2011. Temporally, the majority of the samples were collected from the end of June till the middle of August.

Individual assignment methods and mixture analyses were utilized to assign the fishery samples to one of the 12 regional groups. Accuracy and efficiency of the approaches for mixture analysis and individual assignment were evaluated using a variety of simulations and known origin samples. Accuracy is defined as the proportion of the mixture or individuals which are correctly assigned, and efficiency as the proportion of individuals which assign with greater than 0.70 probability.

Mixture analysis of all fishery samples revealed significant differences among regions in terms of contributions to the fishery. The proportion of the fishery mixture allocated to central Labrador represented the majority of the mixture estimated at 96.0% ± 0.7%. When the entire Labrador region is taken as a whole (southern including some lower north shore of Quebec, central Labrador, and northern Labrador / Ungava), the total contribution to the fishery overall is 97%. Both mixture and assignment analyses indicated similar relative contributions in the fishery samples with Labrador sources dominating. Taken together, the contribution of all possible non-Labrador sources to the fishery is estimated as <3%.

Individual assignment was used to explore geographic distribution of possible non-local interceptions in the fishery. Assignments to central Labrador dominated the catch and were widespread across the region. The only regional group assigned to the Lake Melville area (SFA 1B) was central Labrador. In contrast, assignments to southern Labrador / Québec (n=7), Newfoundland (n=4), Southern Gulf (n=3), all showed clusters of assignments in the southern region near the limit of the fishery, and often no assignments elsewhere. Only four individuals were assigned to the USA reporting group over all years sampled and they all occurred from northern Labrador catches.

Considerations and future initiatives

Genetic stock identification techniques indicate that the Labrador subsistence fisheries harvest salmon from several regions in eastern North America but the majority (> 96%) of salmon sampled were of Labrador central origin, distributed throughout the fishery areas (SFAs 1A, 1B, 2) and periods (Fig. 4). The results are consistent with tagging studies suggesting 94% Newfoundland and Labrador salmon in the harvest during the 1970's and 1980's (Pippy 1982). Only the Labrador central group was identified in the Lake Melville fishery samples (SFA 1B).

Rare assignments to non-local Canadian stocks (South Labrador / lower north shore, Newfoundland, and Southern Gulf of St. Lawrence / New Brunswick) in the fishery samples occur in the southern portion (SFA 2) of the fishery area, near the Strait of Belle Isle. Total annual harvests in this area have ranged from 3,400-5,500 small salmon and 1,000-2,000 large salmon in the recent 10 years. Rare assignments of USA origin salmon occurred in the northern area of the fishery (SFA 1A).

Estimation of total number of salmon from each regional group harvested in the fishery requires further work. Points to consider for this include sampling intensity and distribution, harvest reports, and size group (sea age) of salmon in the fisheries and the fishery samples to ensure representativeness of the sampling program.

There is an interest to attempt to differentiate the origin to finer spatial scale regional groups than those reported here. However, it should be clear that it will not be possible to assign a fish to an individual river even for the 189 river systems in the baseline. Further work is ongoing to refine the regional groups and involves lowering the criterion for probability of correct assignment (may produce more groups), or by using pre-established groups and validating probability of assignment.

Alternatively, new techniques are being considered. Single Nucleotide Polymorphisms (SNPs) markers widely distributed across the Atlantic salmon genome were examined for 26 populations (Bourret et al. 2013). To date, the neutral genetic structure supported by SNP markers is similar to the structure interpreted from microsatellite markers with a regional organization identical to the one reported in Dionne et al. (2008).

Sampling of the fisheries continued in 2012 and 2013, and is anticipated to continue for 2014. Funding has been secured to process these samples and to continue exploration of new technologies (SNPs) to further refine regional groups. Information such as this is essential in enhancing management approaches to reduce the impact of the subsistent fisheries on non-local salmon stocks migrating through these areas.

Acknowledgements

All fishery samples were collected with the assistance of the NunatuKavut Community Council, the Nunatsiavut Government, and Fisheries and Oceans staff. Funding for baseline sample collection in Newfoundland and fishery sample analysis was provided by the Atlantic Salmon Federation and by the Genomics Research and Development Initiative of Fisheries and Oceans Canada. Funding was also provided by a strategic project grant from the Natural Sciences and Engineering Research Council of Canada (NSERC) led by L. Bernatchez, as well as the Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs et des Ressources Aquatiques Québec.

Literature cited

Bourret, V., Kent, M.P., Primmer, C.R., Vasemägi, A., Karlsson, S., Hindar, K., McGinnity, P., Verspoor, E., Bernatchez, L., and Lien, S. 2013b. SNP-array reveals genome-wide patterns of geographical and potential adaptive divergence across the natural range of Atlantic salmon (***Salmo salar***). Mol. Ecol. 22(3): 532-551.

Bradbury, I.R., Hamilton, L.C., Robertson, M.J., Bourgeois, C.E., Mansour, A., and Dempson, J.B. 2014. Landscape structure and climatic variation determine Atlantic salmon genetic connectivity in the northwest Atlantic. Can. J. Fish. Aquat. Sci. 71(2): 246-258.

Dionne, M., Caron, F., Dodson, J.J., and Bernatchez, L. 2008. Landscape genetics and hierarchical genetic structure in Atlantic salmon: the interaction of gene flow and local adaptation. Mol. Ecol. 17(10): 2382-2396.

ICES. 2013. Report of the Working Group on North Atlantic Salmon (WGNAS), 3–12 April 2012, Copenhagen, Denmark. ICES CM.

Pippy, J. 1982. Report of the working group on the interception of mainland salmon in Newfoundland. In Can. Manuscr. Rep. Fish. Aquat. Sci. Fisheries and Oceans Canada, St. John's, Nfld. p. 196.

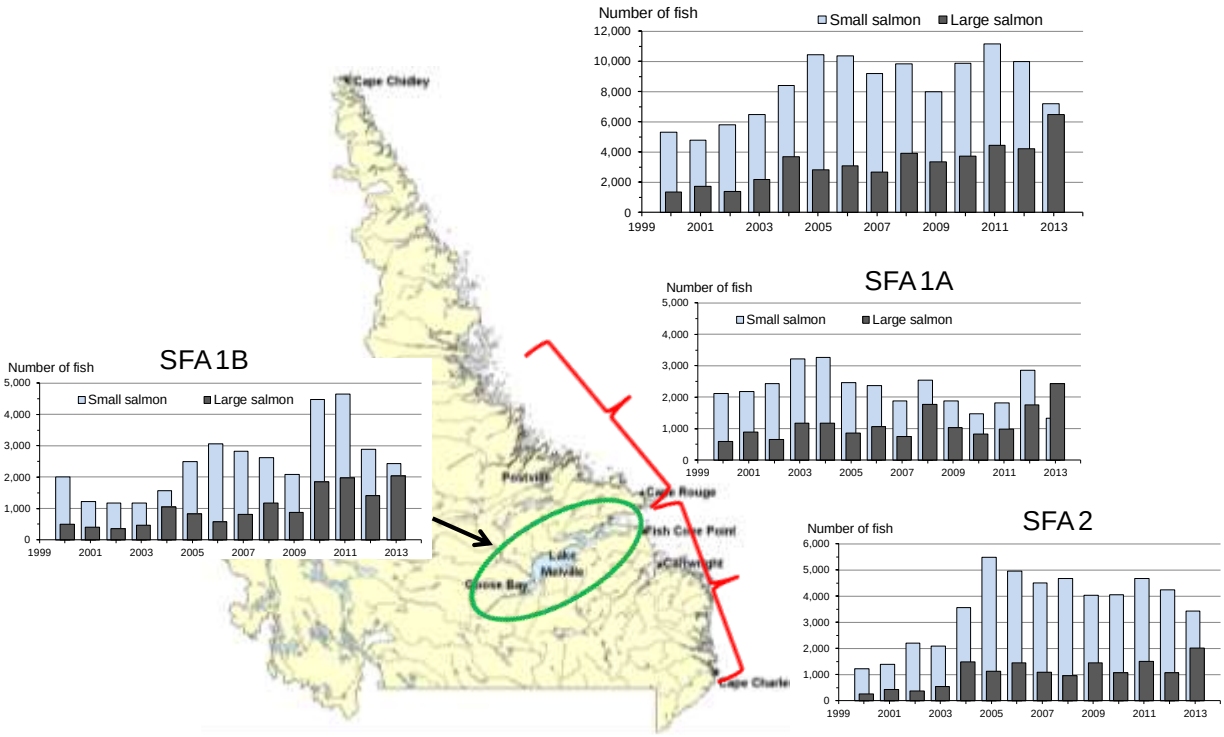

Figure 1. Reported harvest numbers of small salmon and large salmon by Salmon Fishing Area (SFA) and overall in the subsistence fisheries of Labrador, 2000 to 2013.

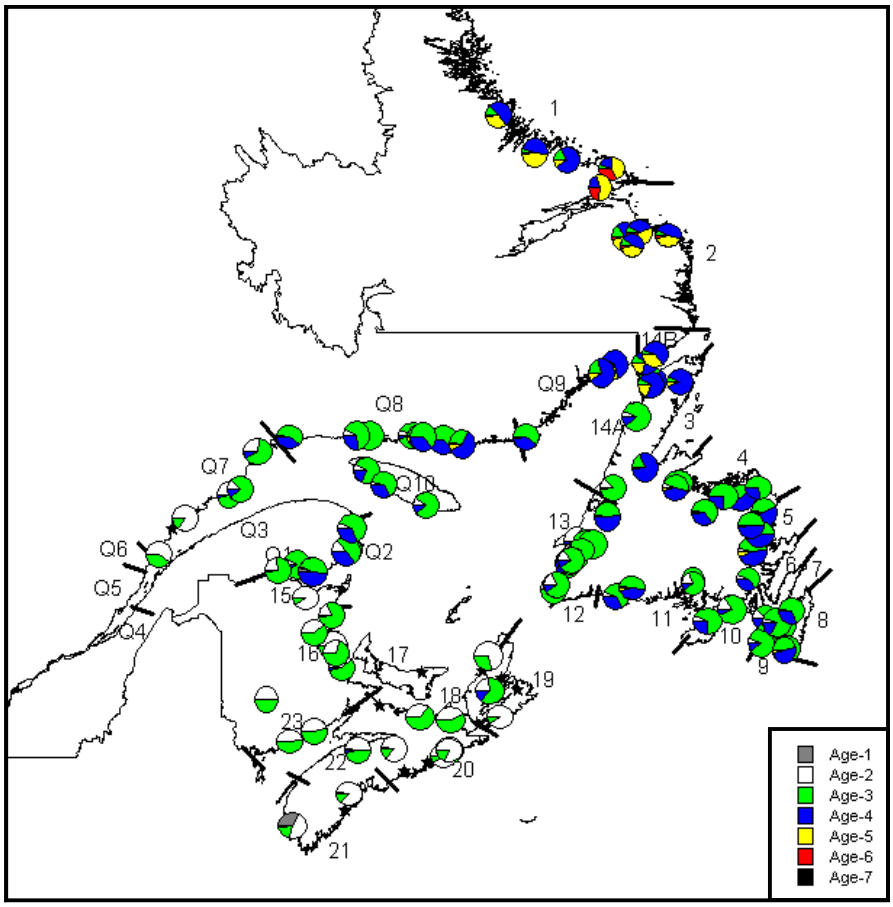

Figure 2. Proportions by freshwater age of Atlantic salmon from rivers of eastern Canada.

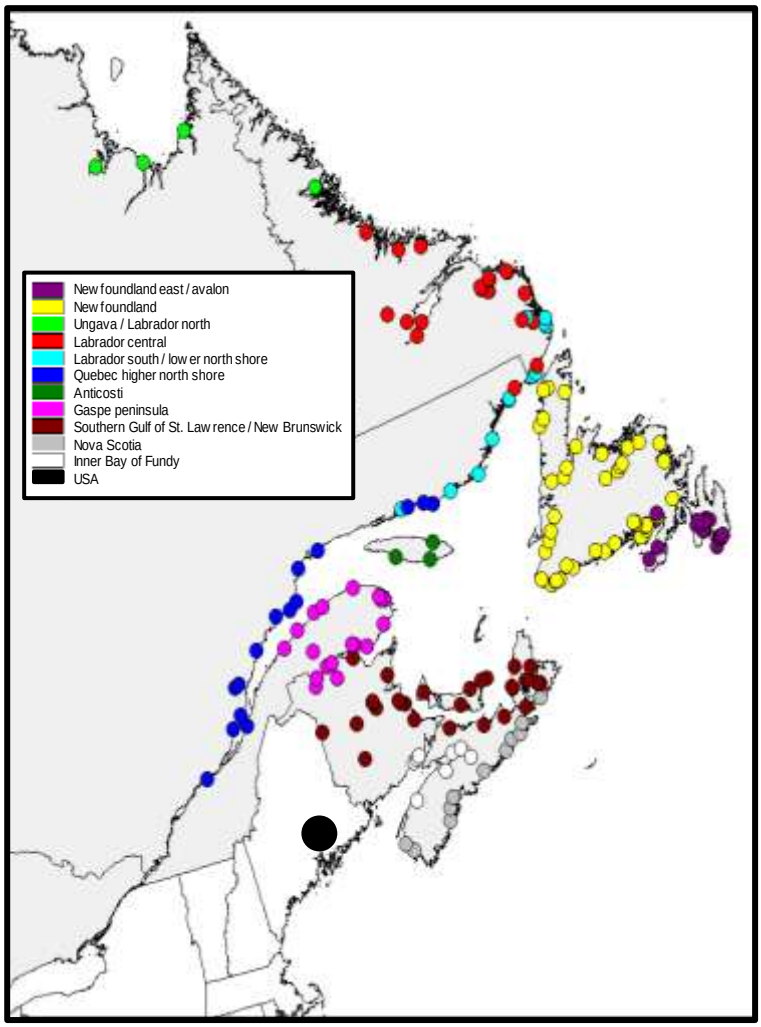

Figure 3. Regional groups based on 15 microsatellite markers for salmon populations of eastern North America.

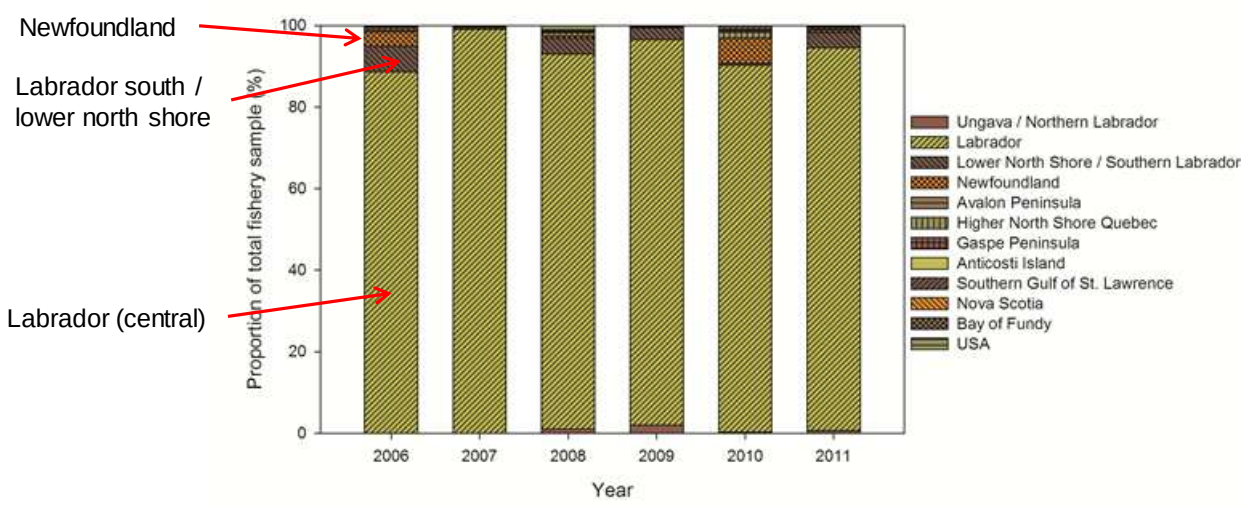

Figure 4. Temporal variation in fishery composition of samples from the Labrador Atlantic salmon subsistence harvest over the period 2006-2011, estimated by Bayesian mixture analysis.