Fine-scale genetic population structure of chum salmon in the Iwate coast, northern Japan

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Backgrounds & Objectives

- Chum salmon catch has been decreasing for nearly two decades in the coast of Iwate Prefecture or the Sanriku-region, northern Japan.
- Two salmon homing peaks in Iwate
  - Early-run：Sep. to end of Oct.
  - Late-run ：Nov. to the end of homing (Feb.)
- Two rivers, which have abundant homing salmon.
  - Tsugaruishi River (TGI, predominantly late-run)
  - Akka River (AKA, predominantly early-run)
- For conservation and fisheries management of chum salmon in Iwate, the temporal fine-scale genetic population structure were examined using fish collected through the entire homing season.

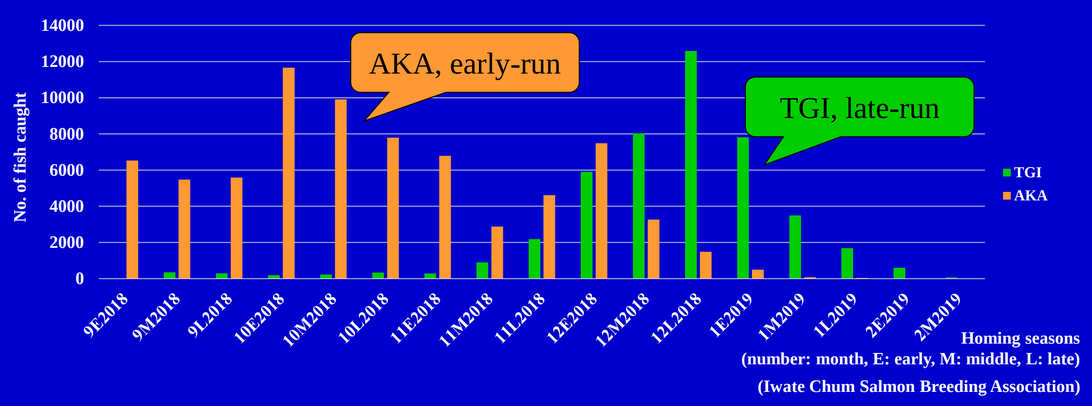
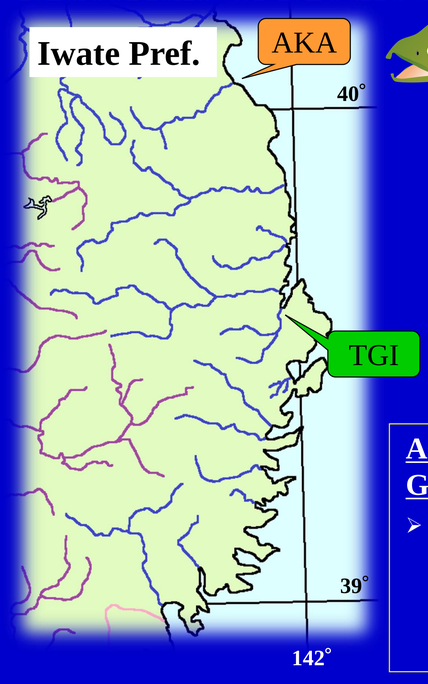
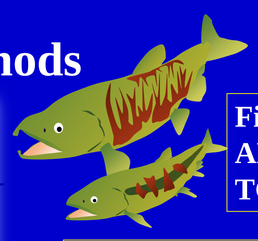


Fig.1 The numbers of fine-scale salmon homing through the season in TGI and AKA

Materials & Methods





Fish used
AKA 12 collections 1187 individuals
TGI 10 collections 902 individuals

DNA extraction from fin

microsatellite (ms) DNA analyses with 14 loci
(locus: referring to Tsukagoshi et al. 2015*, partially unpublished
*Conservation Genet Resour 7: 173-175, 2015)

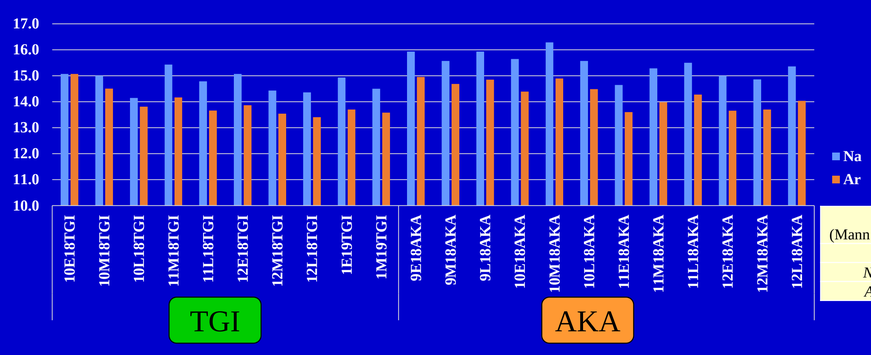
Analyses 1: Genetic variability
- Calculating
  - Number of alleles (*Na*)
  - Allelic richness (*Ar*)
  - expected heterozygosity (*He*)
  - observed heterozygosity (*Ho*)

Analyses 2: Genetic population structure
- Estimation of genetic differentiation by F_{ST}
- Structure analysis
- Molecular phylogenetic NJ tree
- Principal Component Analysis
- Hierarchical analysis (AMOVA)

Fig. 2 The location of TGI and AKA

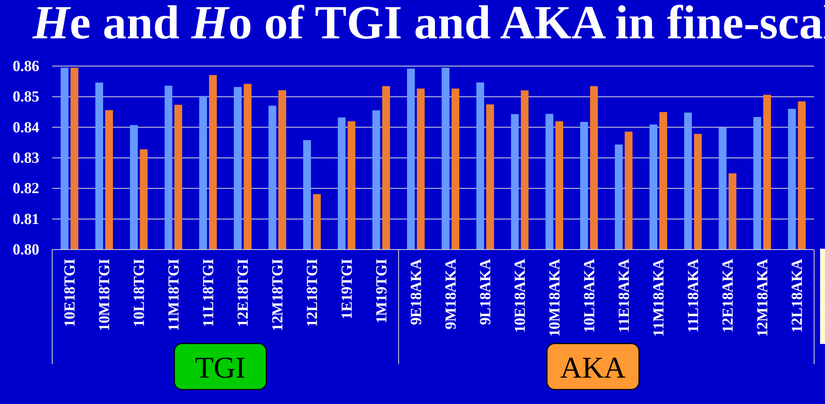
Results 1

Na and *Ar* of TGI and AKA in fine-scales



Early-run vs Late-run (Mann Whitney test with Bonferroni correction)	TGI	AKA
Na	$P>0.05$	$P<0.01$
Ar	$0.05<P<0.10$	$P<0.01$

He and *Ho* of TGI and AKA in fine-scales



*No significant departure from Hardy-Weinberg equilibrium at all the examined loci in each collection.

Early-run vs Late-run (Mann Whitney test with Bonferroni correction)	TGI	AKA
He	$P>0.10$	$0.05<P<0.10$
Ho	$P>0.10$	$0.02<P<0.05$

Variation seems large in AKA.

Results 2-1 Pairwise F_{ST} estimates with Bonferroni corrections ($P<0.01$)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	10E2018TGI	0																					
2	10M2018TGI	0.00189	0																				
3	10L2018TGI	0.00690	0.00224	0																			
4	11M2018TGI	0.00822	0.00401	0.00174	0																		
5	11L2018TGI	0.01570	0.00921	0.00641	0.00033	0																	
6	12E2018TGI	0.01662	0.00969	0.00595	0.00090	−0.00020	0																
7	12M2018TGI	0.01532	0.00907	0.00569	0.00060	0.00064	−0.00030	0															
8	12L2018TGI	0.01908	0.01256	0.00835	0.00219	−0.00024	0.00055	0.00005	0														
9	1E2019TGI	0.01721	0.01060	0.00672	0.00169	0.00035	0.00008	−0.00006	−0.00027	0													
10	1M2019TGI	0.01823	0.01278	0.00880	0.00428	0.00123	0.00043	0.00220	0.00099	0.00025	0												
11	9E2018AKA	0.00186	0.00431	0.00870	0.01254	0.01933	0.02018	0.01830	0.02294	0.02013	0.02191	0											
12	9M2018AKA	0.00183	0.00506	0.00810	0.01135	0.01806	0.01947	0.01793	0.02110	0.01911	0.02066	−0.00079	0										
13	9L2018AKA	0.00175	0.00151	0.00350	0.00516	0.01076	0.01249	0.01115	0.01398	0.01175	0.01377	0.00191	0.00079	0									
14	10E2018AKA	0.00139	0.00104	0.00163	0.00553	0.01106	0.01190	0.01165	0.01424	0.01274	0.01392	0.00505	0.00497	0.00100	0								
15	10M2018AKA	0.00466	0.00137	0.00048	0.00310	0.00924	0.00936	0.00953	0.01150	0.01126	0.01256	0.00689	0.00702	0.00171	0.00099	0							
16	10L2018AKA	0.00867	0.00367	0.00094	0.00229	0.00705	0.00645	0.00787	0.00909	0.00849	0.01069	0.01106	0.01127	0.00445	0.00428	−0.00028	0						
17	11E2018AKA	0.01334	0.00878	0.00302	0.00291	0.00579	0.00582	0.00619	0.00729	0.00654	0.00878	0.01686	0.01741	0.00782	0.00762	0.00297	0.00105	0					
18	11M2018AKA	0.01166	0.00567	0.00261	0.00099	0.00373	0.00346	0.00298	0.00450	0.00453	0.00650	0.01615	0.01489	0.00644	0.00746	0.00270	0.00086	−0.00054	0				
19	11L2018AKA	0.01435	0.00756	0.00416	0.00127	0.00163	0.00189	0.00187	0.00173	0.00268	0.00438	0.01868	0.01815	0.00948	0.00948	0.00578	0.00311	0.00225	0.00011	0			
20	12E2018AKA	0.01838	0.01082	0.00599	0.00107	0.00090	−0.00018	−0.00009	0.00141	0.00012	0.00254	0.02157	0.02156	0.01344	0.01296	0.00964	0.00648	0.00515	0.00345	0.00123	0		
21	12M2018AKA	0.01769	0.01059	0.00617	0.00128	0.00049	0.00038	0.00088	−0.00068	0.00046	0.00192	0.02052	0.01930	0.01137	0.01245	0.00924	0.00624	0.00500	0.00321	0.00143	0.00112	0	
22	12L2018AKA	0.01579	0.01007	0.00555	0.00036	−0.00015	0.00065	−0.00067	−0.00075	−0.00079	0.00054	0.01948	0.01806	0.01117	0.01157	0.00939	0.00734	0.00536	0.00287	0.00109	0.00094	−0.00089	0

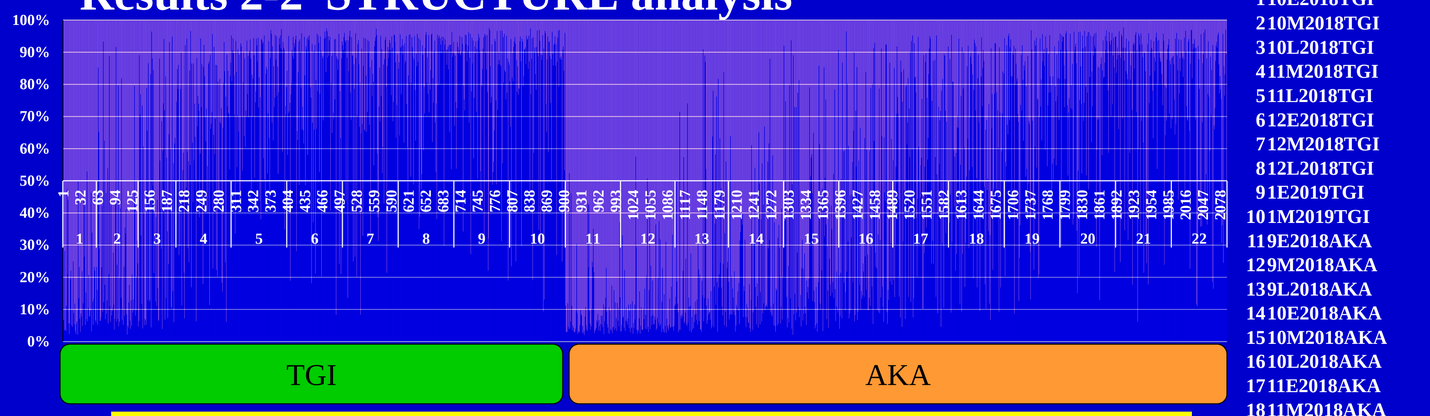
TGI vs TGI — Significance between early and late collections

TGI vs AKA — Significance between TGI early and AKA late; Significance between AKA early and TGI late

AKA vs AKA — Significance between early and late collections

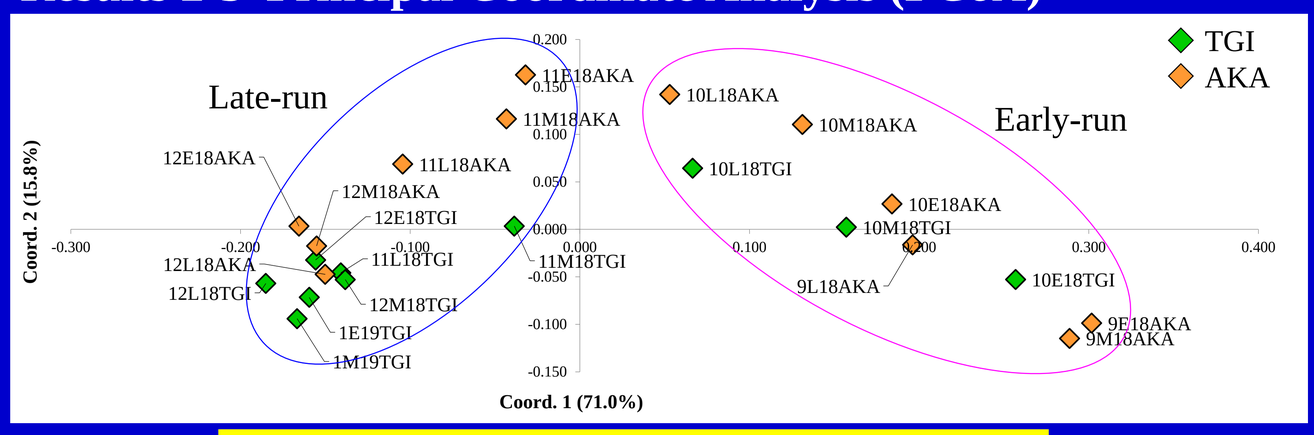
●Differentiation between early-run and late-run collections (F_{ST} and AMOVA, $P<0.001$)
●Moderate gene flow inferred within rivers reflecting past anthropogenic activity?

Results 2-2 STRUCTURE analysis



●ΔK (K=2) suggests distinct genetic differentiation between early- and late-run collections in both TGI and AKA.

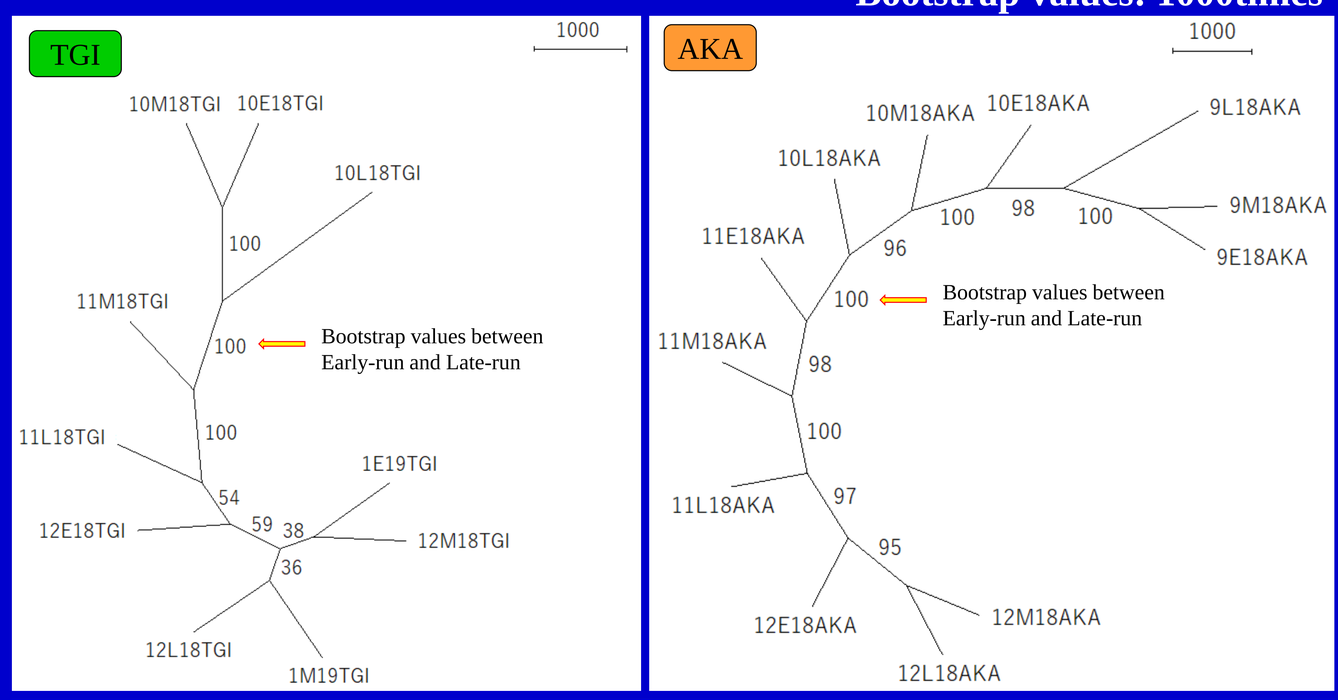
Results 2-3 Principal Coordinate Analysis (PCoA)



●Variance is bigger in early-run collections.

Results 2-4 TGI and AKA NJ trees, with CSE genetic distance

Bootstrap values: 1000times



●Almost all collections genetically distinct with high bootstrap values
●Early-run and Late-run (monophyly)
●Closely related neighboring collections

Conclusions

The present findings suggest:
- **A distinct temporal reproductive isolation between the early- and late-run of chum salmon in TGI and AKA**
- **Moderate gene flow inferred within temporal homing groups in each river suggesting past anthropogenic activity**
- **A usefulness of temporal fine-scale analysis through the entire season for unraveling complex salmon homing dynamics**

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Shimo-Akka Salmon Hatchery, Shimo-Akka Fisheries Cooperative Association, Iwate, Japan