

Genetic differences and possible origins of maturing and immature chum salmon (*Oncorhynchus keta*) in autumn collections near the southern Kuril Islands

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Abstract

This investigation examines allelic frequencies of polymorphic proteins in collection of mature and immature chum salmon caught in the waters off the southern Kuril Islands in the fall of 1975 and 1976. Significant differences were found between mature and immature fish in both years. The allelic frequencies of isocitrate dehydrogenase (IDH) of mature fish corresponded with those of chum salmon populations of Japanese rivers, and tag recoveries from these same groups of mature fish were made from the coastal fishery of Hokkaido. Comparisons of daily fluctuations of allelic frequencies among these mature fish with known variations occurring among Hokkaido populations permitted estimates of change in the structure of these populations during their spawning migration.

Allelic frequencies of immature fish corresponded better with known frequencies of populations of the Amur River area in the U. S. S. R.. These data and the recovery of one individual at the mouth of the Amur River in 1977 that was tagged in 1976 independently support the hypothesis that immature fish of these marine collections originate from the Amur River area.

Introduction

Marine aggregations of chum salmon consist of mixtures of individuals representing diverse geographic origins and differing states of maturity. Method that have been used in efforts to identify component populations of these mixtures have included analyses of data from tagging, scale patterns, age composition and change of CPUE (NEAVE *et al.*, 1976; KOBAYASHI, 1961). Data from scale patterns and age composition are limited by the significant overlap occurring among populations, while CPUE analyses are restricted through the finite number of test samplings which do not cover the whole distributing area of chum salmon. Data from tag recoveries are valuable and have yielded much useful information concerning the distribution and migration of chum salmon. Tag recoveries are very difficult in the area like the U. S. S. R. however because of the predominance of natural reproduction.

Biochemical genetic methods have provided valuable and unique insights concerning the structures of salmonid populations through the identification of distinguishing frequencies of

Received September 27, 1979. Contribution No. 203 from the Far Seas Fisheries Research Laboratory.

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allelic variants of protein in different populations (UTTER *et al.*, 1974; NUMACHI 1974; ALLENDORF and UTTER, 1978; UTTER *et al.*, 1979). The purely genetic aspects of this variation complement the predominantly environment reflection of traditional procedures used for defining structures of individual population and estimating proportions of mixed populations. The biochemical methodology has an added advantage of relative permanence of allelic frequencies in a population both among year classes (where overlap occurs) and between generations (UTTER *et al.*, 1979); thus baseline data are cumulative rather than requiring fresh sets of data for each generation.

This report examines biochemical genetic data of mature and immature chum salmon captured at sea relative to baseline data collected from parent populations that are known to migrate to these areas of capture. The composition of these marine stocks is estimated on the basis of both allelic frequency and tag recovery data.

Materials and Methods

Samples of liver and muscle were taken from chum salmon collected on research cruises of the research vessel Hokko-maru of the Japanese Fisheries Agency operating off the southern Kuril Islands between September 25th and October 7th, 1975 and October 13th through October 27th, 1976 (Figs. 1 and 2). Research gear of both cruises were gillnets and longlines. The gillnets consisted of research and commercial nets. Research nets consisted of 10 different mesh sizes from 48 to 157 mm which eliminated the fishing selectivity of gillnets of

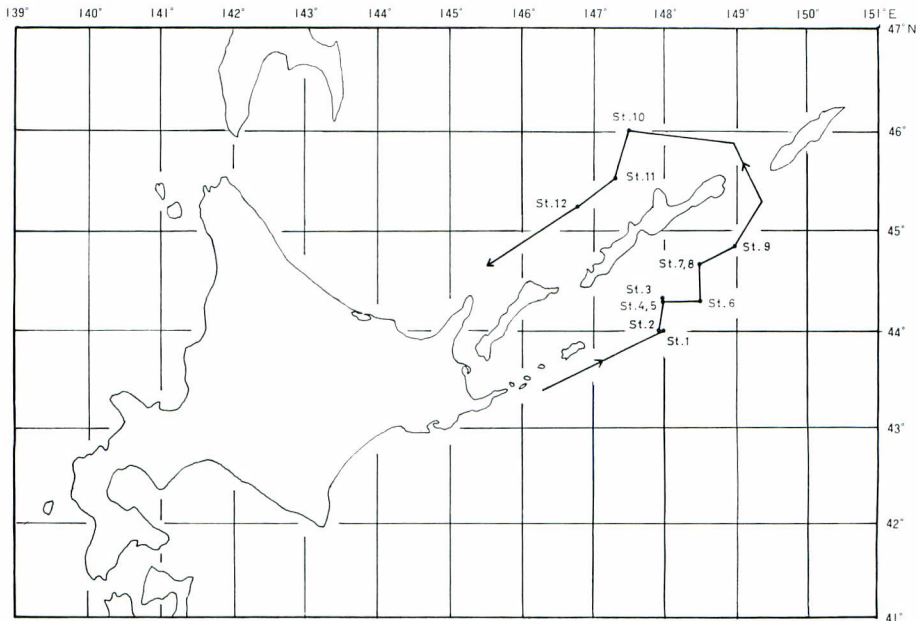


Fig. 1. Operation positions by the Hokko-maru in late September and early October, 1975.

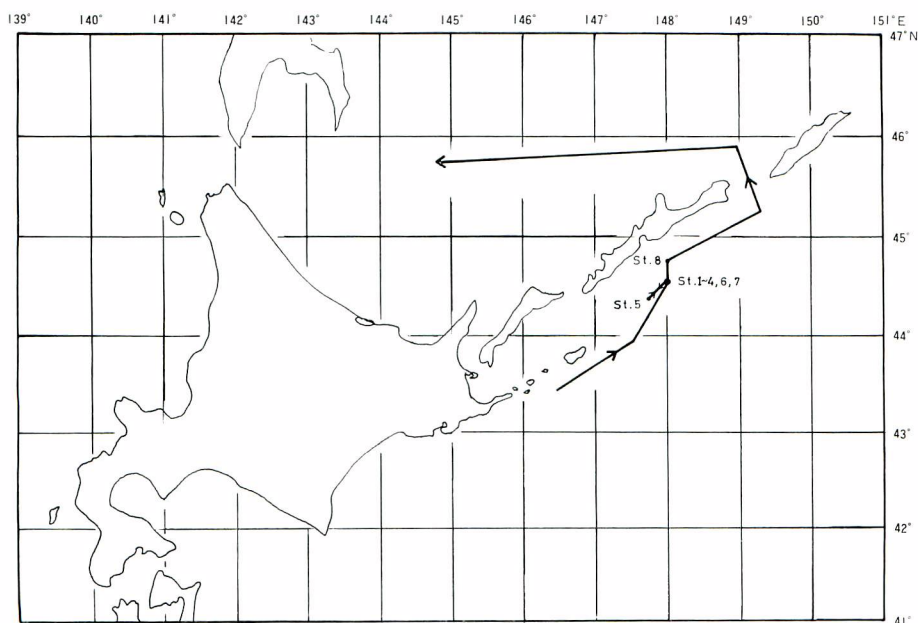


Fig. 2. Operation positions by the Hokko-maru in middle and late October, 1976.

constant mesh size. The same number of tans (a gillnets unit of 50 m length) of each mesh size were joined to one another (TAKAGI, 1972). Commercial nets consisted of a string of 28–30 tans of 121 mm mesh net. Longlines were used for tagging operations; all healthy salmon were tagged and released. Catch and tagging data for these cruises are given in Tables 1 and 2.

Samples of liver and heart were collected to obtain baseline genetic data for populations of specific areas. Nine rivers from Hokkaido were sampled in 1977 (Fig. 3). Tissues were taken at hatcheries during artificial spawning and the sampling period coincided with the peak of the run at each river, i.e. middle October for rivers east of Erimo and in the Japan Sea area, and late November and early December in the Okhotsk and Nemuro areas. Collections along the coast of the Okhotsk Sea in the U.S.S.R. (Fig. 4) were made by the re-

Table 1. Catch data of chum salmon by the Hokko-maru in the waters off Etorofu Island in autumn, 1975.

St. No.	1	2	3	4	5	6	7	8	9	10	11	12
Date	9.25	9.26	9.27	9.28	9.29	9.30	10.1	10.2	10.3	10.5	10.6	10.7
Location	44– 00N 148– 00E	44– 00N 147– 58E	44– 22N 148– 04E	44– 20N 148– 00E	44– 20N 148– 00E	44– 19N 148– 31E	44– 40N 148– 30E	44– 40N 148– 30E	44– 50N 148– 57E	46– 00N 147– 30E	45– 30N 147– 18E	45– 15N 146– 50E
Gear	Gill- net	Long- line	Long- line	Long- line	Gill- net	Gill- net	Long- line	Gill- net	Long- line	Gill- net	Long- line	Long- line
Catch	198	67	100	60	272	82	77	275	66	37	0	8
Tagging	—	28	41	23	—	—	36	—	33	—	—	3

Table 2. Catch data of chum salmon by the Hokko-maru in the waters south off Etorofu Island in autumn, 1976.

St. No.	1	2	3	4	5	6	7	8
Date	10.13	10.14	10.15	10.17	10.19	10.20	10.24	10.27
Location	44-33N 147-59E	44-32N 148-00E	44-34N 148-03E	44-32N 148-01E	44-23N 147-47E	44-31N 148-00E	44-31N 148-00E	44-44N 148-00E
Gear	Gillnet	Longline	Gillnet	Gillnet	Longline	Gillnet	Longline	Longline
Catch	452	120	294	81	23	134	32	16
Tagging	—	63	—	—	15	—	5	11

search vessel Oyashio-maru of Hokkaido University during the summer of 1976.

All tissues were frozen immediately following collection and remained frozen until processed for electrophoresis a few months later. Extraction of tissues and methods of electrophoresis followed procedures outlined in NUMACHI (1974). Genetic data were collected from two polymorphic systems; isocitrate dehydrogenase (IDH, 1.1.1.42) from extracts of liver, and malate dehydrogenase (MDH, 1.1.1.37) from extracts of muscle or heart.

Results

Two distinct maturity classes were apparent among fish of both sexes that were collected

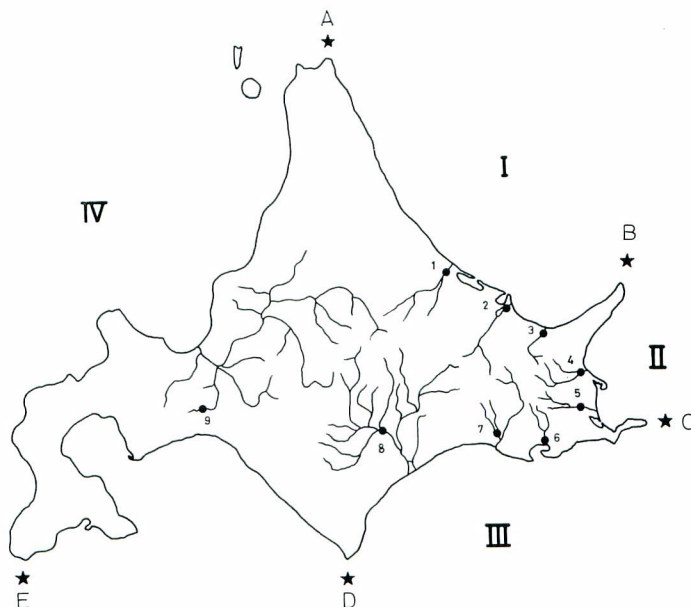


Fig. 3. Map of Hokkaido showing the rivers and hatcheries (●) from which chum salmon were sampled in the fall, 1977.

I) Okhotsk area: (1) Yubetsu River, (2) Abashiri River, (3) Shari River. II) Nemuro area: (4) Shibetsu River, (5) Nishibetsu River. III) East of Cape Erimo area: (6) Bekanbeshi River, (7) Kushiro River, (8) Tokachi River. IV) Japan Sea area: (9) Chitose River. ★ Boundary of area: A) Cape Nosappu, B) C. Shiretoko, C) C. Erimo, D) C. Shiragami, E) C. Shiragami.

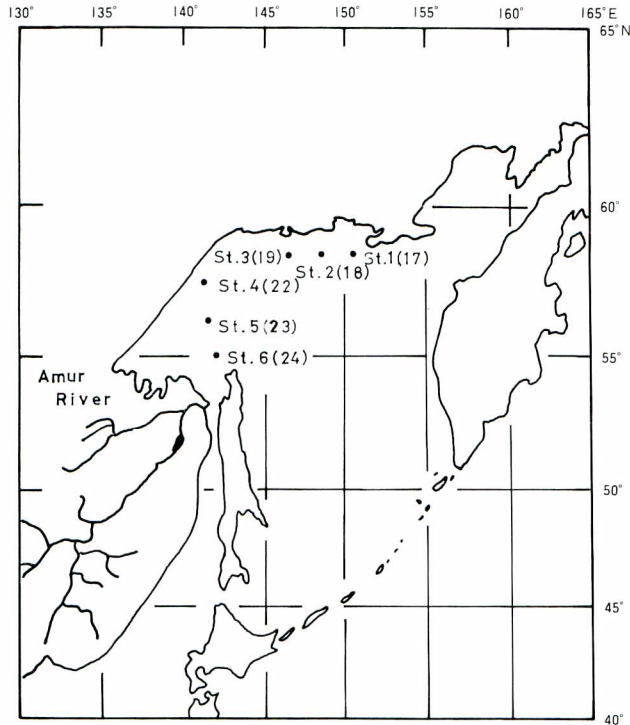


Fig. 4. Map of the area of the Okhotsk Sea showing the stations (●) from which chum salmon were sampled in August, 1976. Sampling date is given in parentheses.

in the research cruises of 1975 and 1976, and that each group consisted of plural aged individuals (Figs. 5 and 6). The fish of one group had heavier gonad weights (≥ 60 g in males, ≥ 100 g in females) and were developing obvious external characteristics of imminent spawning such as nuptial coloration and hooked snouts. Fish of the second group had much lighter gonad weights (≤ 5 g in males, ≤ 35 g in females) and were obvious not destined to

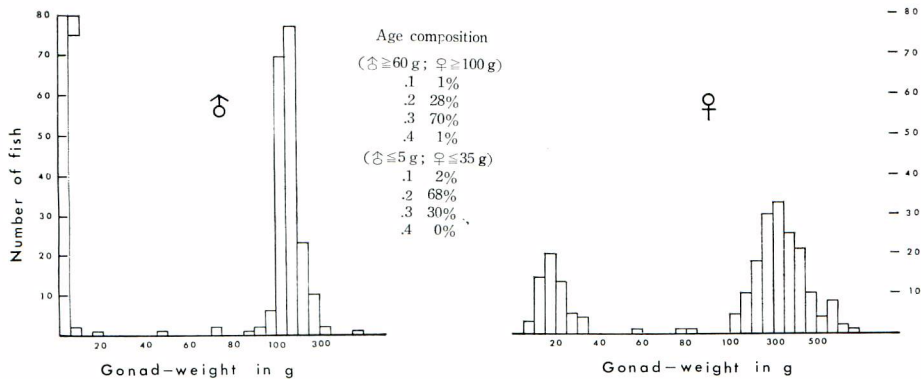


Fig. 5. Gonad weight frequency distributions and age composition of chum salmon caught in the waters off southern Kuril Islands in late September and early October, 1975.

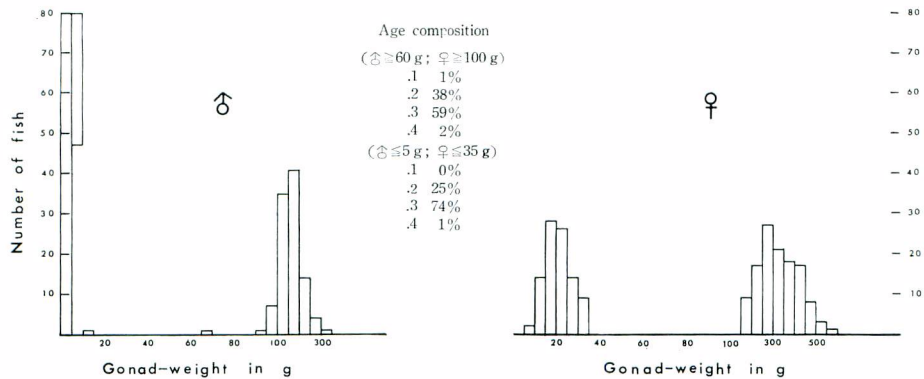


Fig. 6. Gonad weight frequency distributions and age composition of chum salmon caught in south off Etorofu Island in middle and late October, 1976.

mature and return to their natal areas during the approaching season (TAKAGI, 1961). Similar observations were made by YONEMORI *et al.* (1975) on fish collected in the same area in the fall of 1974. They proposed on the basis of these data coupled with information from tag recoveries that the group with the larger gonads was the mature population returning to Hokkaido or Honshu within the next few months, while the group with the smaller gonads would mature the subsequent years and return to rivers of the U. S. S. R. entering the Okhotsk Sea. The present study was designed to test this hypothesis through the examination of allelic frequencies of IDH and MDH in these two groups contrasted with allelic frequencies at these loci in populations of the presumed areas of destination.

Both the IDH and the MDH polymorphisms have been described in chum salmon by other workers. MAY *et al.* (1975) described two allelic forms of IDH and a four-allele polymorphism has been identified by NUMACHI *et al.* (in print); the number of IDH alleles are expanded to five through the present study. Polymorphism for MDH-B in chum salmon (the system that predominates in the skeletal muscle and is also expressed in the heart) has been described by NUMACHI *et al.* (1972), ALTUKHOV *et al.* (1975) and SEEB and GRANT (1976); three alleles have been identified for this duplicated locus.

The daily gene frequency variation for IDH and MDH in the southern Kuril Islands collections (Tables 3 and 4) indicate differences between the mature and immature groups for both years. The most striking features of both years included the occurrence of the *Mdh-b'* allele exclusively in the mature group and the reversal of frequency of the *Idh-c* and *Idh-d* alleles in the two groups. These differences were significant for the MDH locus in 1975 ($\chi^2=11.45$, $P<.005$) and for the IDH locus in 1976 ($\chi^2=31.52$, $P<.0001$) and support the hypothesis of the distinctness of these two groups.

The allelic frequencies of MDH and IDH in each of the nine collections from Hokkaido rivers (Table 5) conform to Hardy-Weinberg expectations and the distribution of alleles varies among the different populations. The *Idh-d* allele occurs at a much higher frequency in the Bekanbeshi and Kushiro river collections, and the frequency of the *Idh-a* allele ranges

from .606 in the Chitose River to .439 in the Shari River. The *Idh-e* allele occurred exclusively in the five rivers of the Okhotsk and Nemuro areas. Although the distribution of the MDH alleles does not vary significantly among collections, it is pertinent that the distribution of the *Mdh-b*' allele coincides with that of the *Idh-e* allele and presumably reflects gene flow within this area of distribution. The allelic frequencies of the Bekanbeshi and Kushiro rivers were not significant ($\chi^2=7.51$, $P>.5$) however a significant difference did exist between the frequencies of these rivers and those of the adjacent Tokachi River ($\chi^2=20.48$, 39.09 ; $P<.0005$) suggesting a restriction of gene flow to and from the Tokachi River; nevertheless, the present data generally support an earlier observation of similarities of allelic frequencies—presumably a reflection of gene flow—among proximal populations of Hokkaido chum salmon returning at the same time (the timing of peak run is late September—late October in East of Cape Erimo and Japan Sea areas, mid-November—early December in Nemuro area, late November—mid-December in Okhotsk area; OKAZAKI, 1978). A common feature of all Hokkaido populations was the higher frequency of the *Idh-d* allele relative to that of the *Idh-c* allele.

The fish taken in the Okhotsk Sea collections, like those of the southern Kuril Islands, could be segregated into two groups according to gonad weight (Fig. 7). Most of the fish taken in the southern collections (Fig. 4 Sts. 4, 5 and 6) showed high maturity and presum-

Table 3. Gene frequencies at IDH and MDH loci in populations of chum salmon caught in the waters off southern Kuril Islands in late September and early October, 1975.

Collected date			9.29	9.30	10.2	Total
Number of specimens			37	4	28	69
Mature	IDH	<i>a</i>	.554	(.750)	.500	.543
		<i>b</i>	.297	(.250)	.429	.348
		<i>c</i>	.027		.000	.014
		<i>d</i>	.122		.071	.094
		<i>e</i>	.000		.000	.000
	MDH	<i>b</i>	.962	(1.000)	.964	.965
		<i>b'</i>	.038		.036	.035
		<i>b''</i>	.000		.000	.000
Number of specimens			28	19	5	52
Immature	IDH	<i>a</i>	.536	(.579)	(.700)	.567
		<i>b</i>	.339	(.368)	(.300)	.346
		<i>c</i>	.107			.058
		<i>d</i>	.018	(.053)		.029
		<i>e</i>	.000			.000
	MDH	<i>b</i>	.991	(.987)	(.950)	.986
		<i>b'</i>	.000			.000
		<i>b''</i>	.009	(.013)	(.050)	.014

The gene frequency of the collection less than twenty is given in parentheses.

Table 4. Gene frequencies at IDH and MDH loci in populations of chum salmon caught in the waters off southern Kuril Islands in middle and late October, 1976.

Collected date		10.13	10.14	10.15	10.17	10.19	10.20	10.24	10.25	10.27	Total	
Mature	Number of specimens		65	22	66	42	6	74	5	5	3	288
	IDH	<i>a</i>	.515	.455	.432	.417	(.583)	.419	(.800)	(.700)	(.333)	.460
		<i>b</i>	.369	.386	.470	.417	(.333)	.459	(.200)	(.300)	(.333)	.418
		<i>c</i>	.054	.023	.023	.012	(.083)	.054			(.167)	.038
		<i>d</i>	.062	.136	.076	.155		.068			(.167)	.083
		<i>e</i>	.000	.000	.000	.000		.000				.000
	MDH	<i>b</i>	.981	1.000	.971	.976	(.958)	.980	(1.000)	(1.000)	(.833)	.978
		<i>b'</i>	.019	.000	.026	.018	(.042)	.017				.018
		<i>b''</i>	.000	.000	.004	.006		.003			(.017)	.004
	Immature	Number of specimens		65	35	51	25	2	19	1	6	1
IDH		<i>a</i>	.477	.514	.529	.520	(.500)	(.474)		(.667)	(.500)	.505
		<i>b</i>	.300	.343	.245	.360		(.421)	(1.000)	(.167)	(.500)	.312
		<i>c</i>	.131	.086	.167	.080	(.250)	(.079)		(.083)		.120
		<i>d</i>	.092	.057	.059	.040	(.250)	(.026)		(.083)		.063
		<i>e</i>	.000	.000	.000	.000						.000
MDH		<i>b</i>	1.000	1.000	1.000	1.000	(1.000)	(.1000)	(1.000)	(1.000)	(1.000)	1.000
		<i>b'</i>	.000	.000	.000	.000						.000
		<i>b''</i>	.000	.000	.000	.000						.000

The gene frequency of the collection less than twenty is given in parentheses.

Table 5. Gene frequencies at IDH and MDH loci in each river population of chum salmon sampled in the fall, 1977. Theoretical allelic frequencies of Hokkaido chum salmon were calculated by weighted method, taking annual contributing ratio—average escapement from 1970 to 1974—of each river to the total escapement of Hokkaido into consideration.

	River name	Collected date	Number of specimens	IDH					MDH		
				<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>b</i>	<i>b'</i>	<i>b''</i>
East of Cape Erimo area	Tokachi R.	Oct. 12th	100	.530	.435	.010	.025	.000	.973	.028	.000
	Kushiro R.	Oct. 13th	100	.515	.318	.020	.146	.000	.968	.033	.000
	Bekanbeshi R.	Oct. 14th	100	.510	.272	.000	.218	.000	.960	.040	.000
Japan Sea area	Chitose R.	Oct. 15th	100	.606	.328	.010	.056	.000	1.000	.000	.000
Okhotsk area	Yubetsu R.	Nov. 25th	100	.480	.395	.025	.080	.020	.980	.013	.008
	Shari R.	Nov. 26th	100	.439	.408	.061	.082	.010	.970	.028	.003
	Abashiri R.	Nov. 27th	100	.490	.381	.046	.062	.021	.975	.023	.003
Nemuro area	Shibetsu R.	Nov. 29th	100	.505	.414	.020	.056	.005	.983	.008	.010
	Nishibetsu R.	Dec. 1st	99	.469	.388	.026	.102	.015	.977	.020	.003
Hokkaido				.503	.392	.024	.072	.008	.973	.024	.003

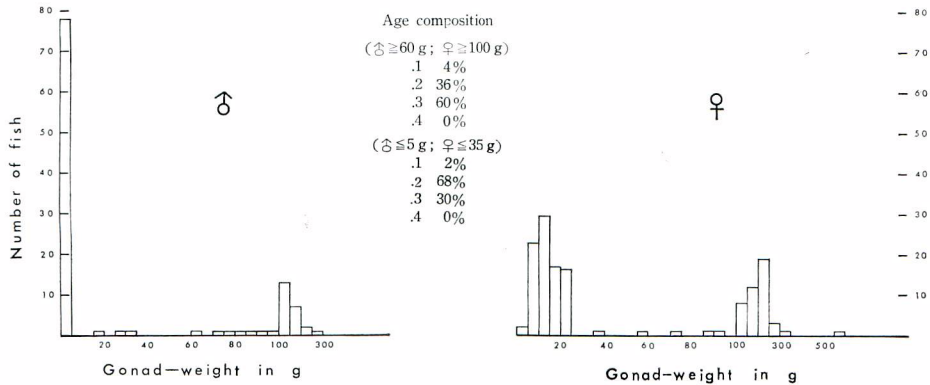


Fig. 7. Gonad weight frequency distributions and age composition of chum salmon caught in the northern and western area of Okhotsk Sea in middle and late August, 1976.

ably primarily destined for imminent spawning in the Amur River because their capture coincided both in time and location with the peak run of this region that enters the Amur River. And that it was known that the chum stocks in the Amur River dominates in this region (SANO, 1966 and 1967). The more northern collections from the Okhotsk Sea (Sts. 1, 2 and 3) were predominantly immature fish which were apparently a year away from spawning.

The allelic frequencies of the Okhotsk Sea collections (Table 6) differed from those of the Hokkaido collections in both the mature and the immature groups. MDH variation was lower than that observed in most Hokkaido populations, particularly the *Mdh-b'* allele. The relative frequencies of the *Idh-c* and *Idh-d* allele were reversed with the *Idh-c* allele consistently the most frequent.

Table 6. Gene frequencies at IDH and MDH loci in populations of chum salmon caught in the northern and western area of Okhotsk Sea in middle and late August, 1976.

Population	Collected date	Number of specimens	IDH					MDH		
			<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>b</i>	<i>b'</i>	<i>b''</i>
Mature	Aug.									
	22, 23 and 24th	51	.480	.333	.118	.069	.000	.990	.000	.010
Immature	Aug.									
west of 144°E	22, 23 and 24th	35	.531	.313	.093	.063	.000	.993	.000	.007
east of 144°E	17, 18 and 19th	78	.404	.481	.083	.032	.000	.997	.003	.000

The immature samples were further divided according to their capture east or west of 144°E. longitude because it has been established that immature chum salmon migrate northward in the Okhotsk Sea in the summer months over a broad range (MISHIMA, 1970). The western segment of immature samples were statistically indistinguishable from the mature samples ($\chi^2 = .48, P > .75$) suggesting that these fish originated in the Amur River area. The eastern segment of immature fish differed from both the Amur River fish and any known

Hokkaido population, having a frequency of the *Idh-b* allele that was greater than that of the *Idh-a* allele. The area of capture as well as the allelic frequencies indicate that these fish were probably not of Japanese origin (NEAVE *et al.*, 1976) but more likely from populations of the northern Okhotsk Sea or western Kamchatka Peninsula.

Two lines of evidence independently suggest that the mature fish captured off the southern Kuril Islands in 1975 and 1976 originated in streams of Hokkaido Island. Firstly, the allelic frequencies of these fish and the Hokkaido collections were statistically very similar ($\chi^2 = 2.44-8.52$; $P > .6-.05$). Secondly, fish of this group that were tagged were recovered only within 6 to 28 days along the coast of Hokkaido (Figs. 8 and 9, Table 7). This evidence is consistent with conclusions drawn from mature fish captured in this area in 1974 (YONEMORI *et al.*, 1975).

Daily fluctuations of the allelic frequencies among these mature fish correlated with known frequencies of some Hokkaido populations. In the 1975 collection, the *Mdh-b*' allele that is characteristic of Hokkaido populations of the Okhotsk or Nemuro areas was absent while a high frequency was observed of the *Idh-d* allele that is characteristic of the Kushiro or Benkanbeshi rivers. It is therefore postulated that these mature fish captured in 1975 originated predominantly in rivers east of Cape Erimo. This conclusion is supported by the tag recoveries of 1975 which occurred predominantly east Cape Erimo within 10 days following tagging. Also, the peak of timing of these runs coincides with the timing of these tag recoveries

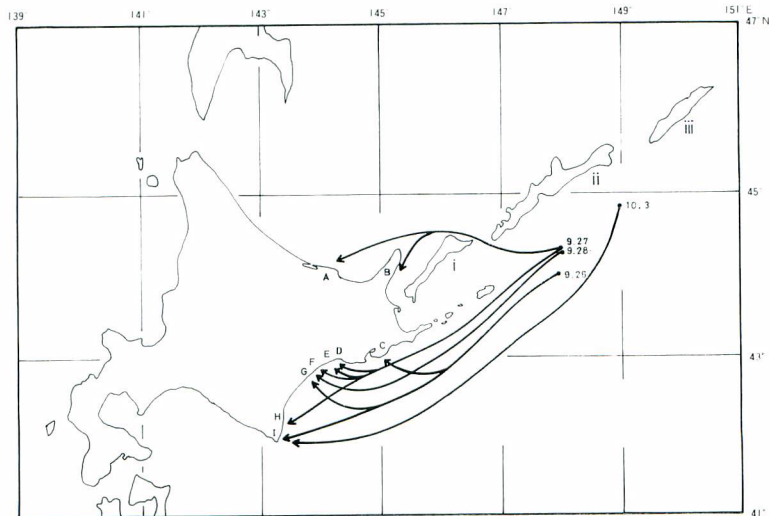


Fig. 8. Tag recoveries and their assumed migratory route from the tagging south off Etorofu Island in late September and early October, 1975.

i: Kunashiri I., ii: Etorofu I., iii: Uruppu I.

A: Tokoro, B: Rausu, C: Hamanaka, D: Kushiro, E: Shiranuka, F: Uraboro, G: Toyokoro, H: Hiroo, I: Erimo.

Numerals indicate date of tagging.

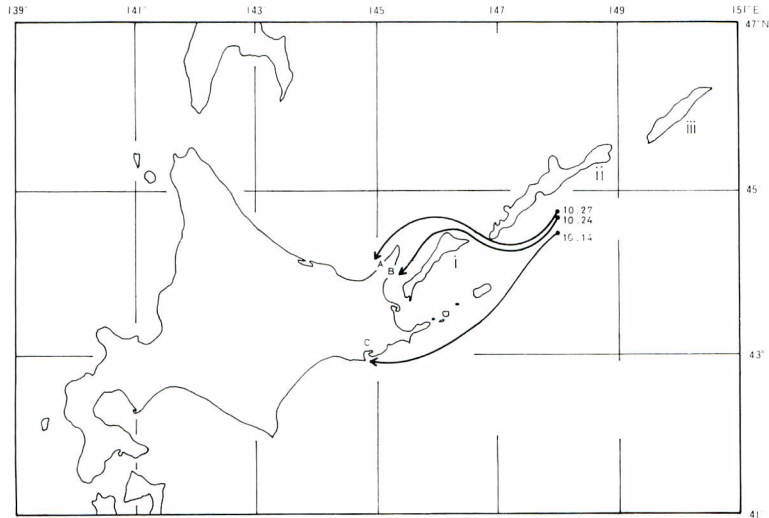


Fig. 9. Tag recoveries and their assumed migratory route from the tagging south off Etorofu Island in October, 1976.

i: Kunashiri I., ii: Etorofu I., iii: Uruppu I.
 A: Utoro, B: Rausu, C: Akkeshi.
 Numerals indicate the date of tagging.

Table 7. Tag recoveries of chum salmon from tagging experiment off southern Kuril Islands in the fall, 1975 and 1976.

Liberation		Recovery	
Date	Location	Date	Location
75. 9. 26	44-00N, 147-58E	75. 10. 2	Hamanaka, Hokkaido
75. 9. 26	44-00N, 147-58E	75. 10. 7	Toyokoro, "
75. 9. 26	44-00N, 147-58E	75. 10. 5	Erimo, "
75. 9. 27	44-22N, 148-04E	75. 10. 12	Tokoro, "
75. 9. 27	44-22N, 148-04E	75. 10. 6	Uraboro, "
75. 9. 27	44-22N, 148-04E	75. 10. 3	Kushiro "
75. 9. 27	44-22N, 148-04E	75. 10. 7	Hiroo, "
75. 9. 27	44-22N, 148-04E	75. 10. 7	Shiranuka, "
75. 9. 27	44-22N, 148-04E	75. 10. 25	Rausu, "
75. 9. 28	44-20N, 148-00E	75. 10. 5	Uraboro, "
75. 10. 3	44-50N, 148-57E	75. 10. 11	Erimo, "
76. 10. 14	44-32N, 148-00E	76. 10. 30	Akkeshi, Hokkaido
76. 10. 24	44-31N, 148-00E	76. 11. 20	Rausu, "
76. 10. 27	44-44N, 148-00E	76. 11. 10	Utoro, "
76. 10. 14	44-32N, 148-00E	77. 7. 25	mouth, Amur River, U.S.S.R.

while runs to the Okhotsk or Nemuro areas return later (from mid-November to mid-December); however it is important to recognize that these tag recoveries occurred in trap net fisheries along the coast, and that these fish were not necessarily destined to return to the proximate rivers of their recovery.

The timing of the 1976 research cruise was about three weeks later than that of 1975. A decrease of the frequency of the *Idh-a* and an increase in the frequency of the *Idh-b* alleles was noted following the first day's collection. In addition, the *Mdh-b''* allele (which was absent in these collections of 1975) began to appear towards the middle of the collections. These shifts in allelic frequency coupled with the later timing of the collections suggests that salmon of the Okhotsk or Nemuro areas were entering the research area.

The minimal tagging data of 1976 also tend to support these conclusions. The allelic frequencies of longline catches of October 14th indicate a high frequency of the *Idh-d* allele, which typifies populations of the Kushiro and Bekanbeshi rivers. One of the fish tagged that day was recovered on the shore of Akkeshi near the mouth of these rivers. Another tag recovery occurred at Utoro on the coast of Okhotsk from a fish tagged on October 27th; the electrophoretic data of this date indicate the presence of the *Mdh-b''* allele which typifies this area. These data suggest a synchrony at specific days of salmon in their spawning migration that move rapidly through the research area towards their specific rivers of origin.

Both the electrophoretic and the tagging data of immature fish captured in the research area suggested that these fish originated in the Amur River area. Allelic frequencies of both years were correlated with those of fish taken in this area ($\chi^2 = .24-4.54$; $P > .9-.2$). The only tag recovery of immaturity tagged fish occurred in 1977 at the mouth of the Amur River involving a fish tagged in the research area in 1976.

Discussion

Chum salmon returning to Japan and the coastal area of the Okhotsk Sea in the U. S. S. R. are divided into two groups on the basis of their time of return. An early group (returning in July and August) includes fish returning to the Okhotsk Sea, while the later group (with peaks from September through February) contains fish originating in Japan, southern Sakhalin and the southern Kuril Islands; previous tag recovery data have indicated that the late returning group is distributed mainly in the central and eastern areas of the North Pacific Ocean (NEAVE *et al.*, 1976).

The distribution of the early group is restricted to the western area of the North Pacific Ocean. Migration routes of some populations occur along the eastern coast of northern Japan in May or June; these fish subsequently move northward towards the Amur River or the northern coast of the Okhotsk Sea (HIRANO, 1953). The immature chum are broadly distributed in the Okhotsk Sea during the summer and begin moving southeastward in September as the surface waters begin to cool (MISHIMA, 1970). It is presumed that the immature population of the research fish taken off the southern Kuril Islands contained fish involved in this mi-

gration, and that some of them would be distributed off the east coast of northern Japan through late spring or early summer.

In addition to the early run, a second, somewhat later, run also returns to the Amur River in early and mid-September. This later run returns to the upper and middle sections of the river in contrast to the return of the early run to the lower sections, and the later run involves a greater number of fish (SANO, 1966 and 1967). The mature collections of the western Okhotsk Sea in August, 1976 represent the later run while those fish taken at the mouth of the Amur River in late July included the peak of the early run. Although no gene frequency data exist which directly contrast these two runs, the results suggest that both have similar allelic frequencies for the two loci, and that their distribution off the southern Kuril Islands is similar. It has been proposed (KONDO *et al.*, 1965) that the early run returns along the eastern coast of Sakhalin while the late run returns counter clockwise around the Okhotsk Sea (Fig. 10). Supporting details for this hypothesis remain obscure and further data, including additional gene frequency information are needed for confirmation or modification.

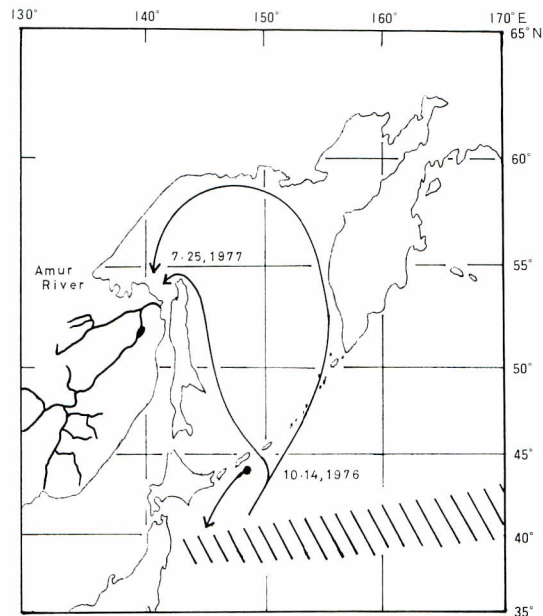



Fig. 10. Tag recovery from the tagging south off Etorofu Island in October, 1976 and its assumed migratory route. Numerals indicate the date of tagging or recovery.  : showing assumed area where chum salmon, originating from northern coastal area of the Okhotsk Sea, pass the winter.

The geographic proximity and synchrony of timing of Japanese runs and those returning to south Sakhalin and the southern Kuril Islands suggest an intermingling of these fish during their oceanic distribution. Although no tag recoveries have been made during the tagging activities of this report, recoveries supporting this hypothesis have been made in earlier studies (HIRANO, 1953). Limited allelic frequency data also suggest a similarity of these popu-

Table 8. Daily catch ratio of mature and immature chum salmon by the Hokko-maru in the waters off Etorofu Island in the fall, 1975 and 1976. (The catch of research nets are used exclusively for the gillnet operation.)

St. No.		1	2	3	4	5	6	7	8	9	10	12	
1975	Date	9.25	9.26	9.27	9.28	9.29	9.30	10.1	10.2	10.3	10.5	10.7	
	Gear	Gillnet	Longline	Longline	Longline	Gillnet	Gillnet	Longline	Gillnet	Longline	Gillnet	Longline	
	Catch	Mature	44(83%)	19(63%)	29(97%)	30(100%)	49(64%)	3(16%)	20(67%)	43(80%)	20(69%)	30(100%)	5(100%)
		Immature	9(17%)	11(37%)	1(3%)	0(0%)	27(36%)	16(84%)	10(33%)	11(20%)	9(31%)	0(0%)	0(0%)
St. No.		1	2	3	4	5	6	7	8				
1976	Date	10.13	10.14	10.15	10.17	10.19	10.20	10.24	10.27				
	Gear	Gillnet	Longline	Gillnet	Gillnet	Longline	Gillnet	Longline	Longline				
	Catch	Mature	31(43%)	22(39%)	35(59%)	11(61%)	6(75%)	30(86%)	10(59%)	3(75%)			
		Immature	41(57%)	35(61%)	24(41%)	7(39%)	2(25%)	5(14%)	7(41%)	1(25%)			

lations. ALTUKHOV (1975) reported the presence of the *Mdh-b'* and *Mdh-b''* alleles in populations of Etorofu Island and southern Sakhalin that were similar to those of Japanese populations. Although no data are available, it is presumed that the IDH frequencies are also similar because of common geographic and temporal factors which would enhance gene flow among these populations.

A great change was observed in the daily mixing ratio of mature and immature chum salmon between 1975 and 1976 (Table 8), although a simple comparison is complicated through the use of different fishing gears. The mature population predominated in 1975, and mature fish were taken exclusively at two stations near the northern Etorofu Island. In contrast, an increase of the mature population occurred as sampling progressed in 1976, presumably reflecting a rapid change from immature to mature populations during the sampling period; just the opposite was reported in a preceding study of this area (YONEMORI *et al.*, 1975). Although limited data preclude a definitive statement, it appears that such exchanges during short periods are common in this area during the fall.

The daily fluctuations of CPUE and of allelic frequencies of mature populations indicate that several mature sub-populations that rapidly replace one another are moving through this area. It is presumed that these sub-populations are discrete because of the genetic and tagging correlations between research samples and areas of destination that were observed. Rapid movement is further supported by ultrasonic tagging data (ICHIHARA *et al.*, 1975) which indicated an average movement of 106.9 km per day of chum salmon during spawning migrations off the southern Kuril Islands. These investigations have provided some new insights into the structure of chum salmon populations during their marine life history. Nevertheless, the overall picture remains sketchy. The complete picture will only gradually emerge with the accumulation of similar data through both the spawning and feeding migrations in the North Pacific Ocean.

Acknowledgments

The author wishes to express thanks to Dr. Tetsuo KOBAYASHI and Mr. Shin-ichi ABE of Hokkaido Salmon Hatchery, crew of the Hokko-maru and Oyashio-maru for their kind help in providing specimens. The author is also indebted to Dr. Ken-ichi NUMACHI, Ocean Research Institute, associate professor of Tokyo University, for his permission to use the laboratory for analysing some samples. And thanks are due to Messrs Osamu SANO and Kenji TAKAGI, Far Seas Fisheries Research Laboratory, for their enthusiasm and support. Grateful acknowledgment is to Dr. Fred UTTER, Northwest and Alaska Fisheries Center, National Oceanic and Atmospheric Administration in USA, for his critical proofreading of the manuscript and valuable advice.

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秋季に南千島水域に分布する遺伝的に異なる2つのサケ (*Oncorhynchus keta*)

集団——成熟・未成熟——とその起源について

岡崎 登志夫

摘 要

1975, 76 の両年にわたり, 秋季に南千島エトロフ島沖合水域に混在する成熟・未成熟の各サケ集団についてその遺伝的特性を検討した結果, イソクエン酸脱水素酵素に関与する遺伝子頻度に著しい差異が認められた。このうち成熟魚群のもつ遺伝子頻度は日本の河川にそ上するサケがもつものと大きな相関を示し, 同時に行なわれた標識放流からも多くの再捕結果が北海道沿岸から報告された。これらの標識放流を行なった日に漁獲された魚群のもつ遺伝的内容とその再捕された地域にそ上するサケ集団がもつ遺伝的内容には関連がみられ, 採集日ごとによる遺伝子頻度の変動と合わせて接岸期におけるサケ親魚の魚群構造に関していくつかの知見を得た。

一方, 未成熟魚群の遺伝的内容にはソ連邦のアムール川地方にそ上するサケのものとの間に大きな相関がみられた。1976年に南千島水域から標識放流したものの一尾が翌1977年にアムール河口で再捕され, この2つの事実によって秋季にこの水域に分布する未成熟のサケはアムール川地方をその起源としていることが確認された。