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1987年および1988年夏期のベーリング海における さけ・ます流網時間帯別調査結果概要

Outline of salmon gillnet survey at different time zones in the Bering Sea during the summer of 1987 and 1988

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1987年および1988年夏期のベーリング海における さけ・ます流網時間帯別調査結果概要

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【要　　約】

1. ベニザケの時間帯別漁獲傾向は明瞭でなかったが，夜間における漁獲は昼間よりやや少なかった。
2. シロザケの漁獲のピークはほぼ深夜にみられ，また漁獲量の昼夜比較では夜間に明らかに多かった。
3. カラフトマスの漁獲のピークは日没時にみられたが，漁獲量の昼夜比較では明瞭な差は認められなかった。

【目　　的】

さけ・ます類の日周期活動を明らかにする目的で，1987年および1988年夏期，ベーリング海において24時間調査を実施した。

【方　　法】

調査は1987年に4回，1988年に3回行なった。本報告では調査点番号をその実施順序にしたがって＃1から＃7までとする。1988年の＃5，＃6，＃7は1987年の＃1，＃2，＃3とそれぞれ同じ位置であり，調査月日もほぼ同じである。調査の日付，位置，日出・没時刻，水温，風速および天候をTable 1に示した。またFig.1には調査点を図示した。調査では24時間内に，8つの短い時間帯と2つの長い時間帯とを設定し（Fig.2），それぞれの時間帯に流網操業を実施した（Table 2）。Fig. 2には投網開始時刻から揚網開始時刻までを図示した。Table 2にはそれぞれの調査日別に，時間帯別操業の投網開始時刻と揚網終了時刻およびその時間間隔を網の海中浮設時間（Soaking time）として示した。使用した反数は各操業で毎回40反である。投網方向はすべて70°－160°とした。

【結　　果】

調査結果を調査別，操業別，魚種別にTable 3に要約した。この表の左側部分(I)には40反当りの漁獲尾数を，中央(II)には海中浮設時間を短時間操業では2 hrs. 長時間操業では12 hrs. に標

準化した場合の比例換算尾数を，右側(III)にはその標準化尾数を魚種ごとに，短時間操業および長時間操業の各小合計（Sub-total）尾数を100とした場合の相対値として示した。Fig．3には各調査番号別に短時間操業における流網40反当りの時間帯別標準化漁獲尾数を示した。

なお，本報告では加重平均法を用いてまとめた結果からも時間帯別漁獲傾向を検討した。加重平均（Mw）はSnedecor（1956）に従い，つぎの式により求めた。

$$Mw = \frac{w_1 \times p_1 + w_2 \times p_2 + w_3 \times p_3 + \cdots}{w_1 + w_2 + w_3 + \cdots}$$

w_NはN番目の標本数，p_NはN番目の標本の相対値を表わす。すなわちMwは各標準化尾数の相対値にそれぞれ標準化尾数を乗じたものを加算し，それを標準化尾数の合計で除したものである。ここではその値をさらに相対値化して示した。以下ではこのようにして求めた加重平均相対値を単に平均値と呼ぶ。

短時間操業の平均値からは，日出・没時を含む夜間に実施した3回の操業結果および昼間に実施した5回の操業結果をそれぞれ平均し，昼夜における漁獲の違いも比較検討した（Table 5）。

また2つの長時間操業における加重平均からも，つぎのような関係式を用いて漁獲量の昼夜比を検討した（Table 5）。

$$\{ rx + (1 - r) y \} : y = a : b$$

rはA操業の平均海中浮設時間に占めるNighttimeの比率で$r = 0.44$であった。xは夜間の単位時間当りの平均漁獲尾数，yは昼間の単位時間当り平均漁獲尾数，a，bはそれぞれA操業，B操業における漁獲の平均値を表す。これから，xとyの比を求め，夜間と昼間の単位時間当りの漁獲を比較した。

以下に漁獲尾数の少なかったマスノスケを除くベニザケ，シロザケおよびカラフトマスについて検討した。

1. ベ ニ ザ ケ

7回の調査を通して時間帯別の漁獲傾向として明瞭な特徴は見出せなかった（Fig．3）。平均値でみると時間帯間で大きな違いはみられなかったが，夜間における漁獲は少ない傾向がみられた（Table 4，Fig．4）。夜・昼の平均標準化漁獲尾数（%）は短時間操業の合計漁獲尾数を100とすると，それぞれ10.4，13.8で（Table 5），昼の方がやや多く漁獲されたが有意な差ではなかった。

また2つの長時間操業における漁獲の平均値では，$a : b = 35.5 : 64.5$であり（Table 4，Fig．5），昼間における漁獲が多いことが推察され，短時間操業の結果とも一致した。ただしこの結果から上記の式でxとyの比を計算したが，$x / y < 0$となり解が得られなかった。これは短時間操業の結果（Fig．4）からも推測されるように，同じ昼間でも漁獲尾数がA網操業中の昼間の時間帯とB網操業中とで異なり，前者が後者より少なかったことが起因してると思われる。

2. シ ロ ザ ケ

＃1～7のすべての調査において照度の低い日出時間帯と日没時間帯を含む夜間に漁獲が多かった（Fig. 3）。その傾向は平均値でみるとより明白に示された（Table 4, Fig. 4）。夜・昼の平均標準化漁獲尾数（%）はそれぞれ17.8, 9.3（Table 5），夜間の方が有意に多く漁獲された。

長時間操業における漁獲の平均値では，a：b＝53.9：46.1であり（Table 4, Fig. 5），これから求めたxとyの比は1.4：1であった（Table 5）。

3. カラフトマス

時間帯別漁獲傾向としては＃2および＃7で明らかに日没時間帯に漁獲のピークがみられ，またその＃2と＃7以外の調査では7:00～9:00（日本時間）に漁獲の増加がみられた（Fig. 3）。平均値でみると日没時に漁獲が最大となり，7:00～9:00にも増加することが確認された（Table 4, Fig. 4）。なお調査＃1の結果は漁獲尾数が極端に少なく，信頼性に欠けると判断し平均値の計算からは除外した。夜・昼の平均標準化漁獲尾数（%）はそれぞれ13.9, 11.6で（Table 5），夜間の方がやや大きな値を示したが有意な差ではなかった。

長時間操業では平均値でみると，a：b＝47.8：52.2であり（Table 4, Fig. 5），aとbの比はほぼ等しかった。なお，x：y＝0.8：1であった（Table 5）。

【考　　察】

本研究結果をまとめると以下のようになる。①ベニザケでは時間帯別漁獲傾向は明瞭でなかったが，夜・昼の漁獲比較では短時間操業，長時間操業で類似した結果が得られ，夜間における漁獲はやや少ないことが予想された。②シロザケでは短時間操業の結果から漁獲のピークはMidnightに近い時間帯にみられ，また夜間と昼間の比較でも夜間に多く漁獲されることが，短時間操業および長時間操業のどちらからも明らかとなった。③カラフトマスでは短時間操業の結果から日没時に漁獲のピークが認められた。夜・昼の比較では短時間操業からは夜間の方が，長時間操業からは昼間の方がそれぞれ多く漁獲されやすいという結果が得られたが，いずれも差は不明瞭であった。

この結果から異なる時間帯間で漁獲尾数に差が大きい順に魚種別に並べると，シロザケ，カラフトマス，ベニザケの順になる。またその時間帯別漁獲傾向として，シロザケとカラフトマスとは夜間に漁獲のピークをもつという点で類似する。ただしシロザケでは夜間の漁獲は高いレベルを維持するが，カラフトマスでは日没時のみに高い値を示す。ベニザケはシロザケ，カラフトマスとは明らかに異なり，夜間にはむしろ漁獲が少ないことが予測された。

このような魚種による漁獲傾向の違いは，基本的には種固有の日周期特性，すなわち①鉛直移動に伴う遊泳層の変化，②移動方向の変化，および③移動速度の変化を反映した結果と考えられる。つまりシロザケ，カラフトマス，ベニザケという順にみられた漁獲尾数の時間的変動差の違

いは，日周期特性の変化の度合いの大小をある程度反映したものと考えることができる。

Mishima・Shimazaki（1969）はオホーツク海において調査した結果，ベニザケでは昼間に漁獲が多く，シロザケでは時間帯間の漁獲差が不明瞭であり，カラフトマスでは日没後と日出前に漁獲が多く深夜に減少すると報告している。本結果と比較すると，ベニザケではよく一致し，カラフトマスでは今回の調査で日出前には漁獲の増加はみられなかったもののほぼ似た傾向であったが，シロザケにおいては時間帯間の漁獲差が大きくみられた今回の結果とは一致しなかった。また高木（1971）は北西太平洋で朝・昼・夕・夜の4つの時刻帯における短時間操業調査を行ない，昼間におけるさけ・ます漁獲効率が低下することを報告している。一方，待鳥（1966）は北西太平洋でさけ・ます類の垂直分布を夜間と昼間に調査し，水深別にみた漁獲分布型ではベニザケは昼夜によって相違があるが，シロザケには相違がないと報告しており，またManzer（1964）はアラスカ湾における調査で，ベニザケ，シロザケともに夜間は表層に，昼間は夜間より深い層に存在していると述べている。これらの結果は本報告から推測される遊泳層の変化特性とは必ずしも一致しなかったが，これは調査海域が異なることに伴う魚の生息環境の違いが少なからず関与したためと考えられる。すなわち時間帯別漁獲傾向の違いには，上記のような種固有の日周期特性のほかに，そこに存在する餌生物の種類や量，その時間帯別移動特性，水温，塩分分布などの環境因子が複雑に関与していることが考えられる。

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Table 1 Date, location and other conditons on surveys.

survey number	Date Y. M. D.	Location Latitude	Longitude	Time* of Sunrise	Sunset	Water temp. (°C)	Wind velocity (m/sec.)	Weather
#1	1987.6.16~17	56°30'N	178°30'E	0:14	17:59	4.6~5.1	1.6~ 8.0	O
#2	1987.6.23~24	56°30'N	179°30'W	0:07	17:53	5.6~6.2	1.6~ 5.5	O
#3	1987.7.07~08	59°30'N	175°30'W	23:37	17:57	7.2~8.2	0.0~ 3.4	O
#4	1987.7.11~12	59°30'N	177°30'W	23:51	18:01	7.7~8.1	3.4~13.9	O→F
#5	1988.6.15~16	56°30'N	178°30'E	0:15	17:59	3.5~4.1	3.4~10.8	O
#6	1988.6.22~23	56°30'N	179°30'W	0:06	17:55	6.0~6.8	0.3~ 5.5	C
#7	1988.7.09~10	59°30'N	175°30'W	23:41	17:53	6.6~7.6	1.6~ 5.5	C

*: Japanese Standard Time. Wether notations are as follows; O: overcast, F: fog, C: clouds.

Table 2 Time zones of gill-net operations in each survey

	#1			#2			#3			#4		
Operation No.	SS	EH	TS	SS	EH	TS	SS	EH	TS	SS	EH	TS
1	14:59	17:40	2^h41^m	15:04	17:51	2^h47^m	15:05	17:53	2^h48^m	15:09	17:55	2^h46^m
2	16:52	20:02	3^h10^m	17:01	20:03	3^h02^m	17:01	19:55	2^h54^m	16:53	19:37	2^h44^m
3	19:03	21:40	2^h37^m	19:06	21:39	2^h33^m	19:14	21:32	2^h28^m	18:55	21:39	2^h44^m
4	23:02	1:54	2^h52^m	23:01	1:51	2^h50^m	22:59	1:43	2^h44^m	23:08	1:51	2^h43^m
5	0:58	3:39	2^h41^m	1:01	3:48	2^h47^m	1:02	4:04	3^h02^m	1:01	3:40	2^h39^m
6	2:41	6:06	3^h25^m	3:00	6:08	3^h08^m	2:56	6:14	3^h18^m	2:49	6:57	4^h06^m
7	6:57	9:19	2^h22^m	6:52	9:20	2^h28^m	7:01	9:33	2^h32^m	7:09	10:02	2^h53^m
8	10:54	13:23	2^h29^m	10:58	13:18	2^h19^m	11:01	13:23	2^h22^m	10:54	13:40	2^h46^m
A	15:09	4:30	13^h21^m	15:05	4:39	13^h34^m	14:56	5:18	14^h22^m	14:56	5:37	14^h41^m
B	4:59	15:27	10^h28^m	5:16	15:18	10^h02^m	5:28	15:42	10^h14^m	6:05	15:34	9^h29^m

	#5			#6			#7		
Operation No.	SS	EH	TS	SS	EH	TS	SS	EH	TS
1	15:00	17:29	2^h29^m	15:01	17:38	2^h37^m	15:00	17:37	2^h37^m
2	16:46	19:37	2^h51^m	16:52	19:37	2^h42^m	16:53	19:57	3^h04^m
3	18:48	21:42	2^h54^m	18:52	21:43	2^h51^m	18:53	21:36	2^h43^m
4	23:00	1:30	2^h30^m	23:00	1:27	2^h27^m	23:00	1:45	2^h45^m
5	0:49	3:31	2^h42^m	0:50	3:39	2^h49^m	0:52	3:33	2^h41^m
6	2:47	5:55	3^h08^m	2:50	7:02	4^h12^m	2:48	6:06	3^h18^m
7	6:59	9:19	2^h20^m	7:20	9:47	2^h27^m	6:58	9:22	2^h24^m
8	11:01	13:20	2^h19^m	11:00	13:28	2^h28^m	11:00	13:22	2^h22^m
A	15:17	4:18	13^h01^m	15:16	4:34	13^h18^m	15:12	4:23	13^h11^m
B	4:58	15:31	10^h33^m	5:56	15:52	9^h56^m	5:11	15:42	10^h31^m

SS: Start of setting, EH: End of hauling, TS: time span between SS and EH. SS and EH are shown in Japanese Standard Time.

Table 3 The number of fish caught (I), the number of fish allocated proportionally when soaking time ('TS' in Table 2) in operations from No.1 to No.8 are standardized to 2 hrs. and those in A and B are to 12hrs.(II), and the relative number of fish in each species in II (III).

	I					II					III				
	S	C	P	K	T	S	C	P	K	T	S	C	P	K	T
# 1															
1	5	5	0	1	11	3.7	3.7	0.0	0.7	8.2	18.9	13.4	0.0	49.4	15.2
2	2	16	0	0	18	1.3	10.1	0.0	0.0	11.4	6.4	36.3	0.0	0.0	21.1
3	4	1	3	1	9	3.1	0.8	2.3	0.8	6.9	15.5	2.7	47.9	50.6	12.8
4	2	3	0	0	5	1.4	2.1	0.0	0.0	3.5	7.1	7.5	0.0	0.0	6.5
5	5	2	0	0	7	3.7	1.5	0.0	0.0	5.2	18.9	5.4	0.0	0.0	9.7
6	7	5	0	0	12	4.1	2.9	0.0	0.0	7.0	20.8	10.5	0.0	0.0	13.0
7	1	7	2	0	10	0.8	5.9	1.7	0.0	8.5	4.3	21.3	35.3	0.0	15.7
8	2	1	1	0	4	1.6	0.8	0.8	0.0	3.2	8.2	2.9	16.8	0.0	6.0
S.T.	28	40	6	2	76	19.7	27.8	4.8	1.5	53.8	100.0	100.0	100.0	100.0	100.0
A	14	35	3	11	63	12.6	31.5	2.7	9.9	56.6	49.9	60.4	70.2	100.0	62.2
B	11	18	1	0	30	12.6	20.6	1.1	0.0	34.4	50.1	39.6	29.8	0.0	37.8
S.T.	25	53	4	11	93	25.2	52.1	3.8	9.9	91.0	100.0	100.0	100.0	100.0	100.0
T.	53	93	10	13	169	44.9	79.9	8.6	11.4	144.9					
# 2															
1	4	1	15	0	20	2.9	0.7	10.8	0.0	14.4	18.5	1.0	11.8	0.0	7.8
2	1	44	53	0	98	0.7	29.0	34.9	0.0	64.6	4.2	38.8	38.1	0.0	35.2
3	5	22	15	2	44	3.9	17.3	11.8	1.6	34.5	25.3	23.1	12.8	100.0	18.8
4	3	17	20	0	40	2.1	12.0	14.1	0.0	28.2	13.6	16.1	15.4	0.0	15.4
5	5	13	14	0	32	3.6	9.3	10.1	0.0	23.0	23.1	12.5	11.0	0.0	12.5
6	1	1	4	0	6	0.6	0.6	2.6	0.0	3.8	4.1	0.9	2.8	0.0	2.1
7	0	5	6	0	11	0.0	4.1	4.9	0.0	8.9	0.0	5.4	5.3	0.0	4.9
8	2	2	3	0	7	1.7	1.7	2.6	0.0	6.0	11.1	2.3	2.8	0.0	3.3
S.T.	21	105	130	2	258	15.5	74.7	91.7	1.6	183.5	100.0	100.0	100.0	100.0	100.0
A	14	78	75	3	170	12.4	69.0	66.3	2.7	150.4	91.2	73.3	86.0	52.6	79.2
B	1	21	9	2	33	1.2	25.1	10.8	2.4	39.5	8.8	26.7	14.0	47.4	20.8
S.T.	15	99	84	5	203	13.6	94.1	77.1	5.0	189.8	100.0	100.0	100.0	100.0	100.0
T.	36	204	214	7	461	29.1	168.9	168.8	6.6	373.4					
# 3															
1	8	40	38	5	91	5.7	28.6	27.1	3.6	65.0	32.3	17.6	20.5	40.0	20.2
2	1	36	23	0	60	0.7	24.8	15.9	0.0	41.4	3.9	15.3	12.0	0.0	12.9
3	0	48	11	1	60	0.0	38.9	8.9	0.8	48.6	0.0	23.9	6.7	9.1	15.1
4	1	33	36	1	71	0.7	24.1	26.3	0.7	52.0	4.1	14.9	19.9	8.2	16.2
5	6	4	8	0	18	4.0	2.6	5.3	0.0	11.9	22.3	1.6	4.0	0.0	3.7
6	3	24	16	1	44	1.8	14.5	9.7	0.6	26.7	10.3	8.9	7.3	6.8	8.3
7	5	27	26	3	61	3.9	21.3	20.5	2.4	48.2	22.3	13.1	15.5	26.5	15.0
8	1	9	22	1	33	0.8	7.6	18.6	0.8	27.9	4.8	4.7	14.0	9.5	8.7
S.T.	25	221	180	12	438	17.7	162.6	132.4	8.9	321.6	100.0	100.0	100.0	100.0	100.0
A	14	245	109	5	374	11.7	204.6	91.0	5.0	312.4	45.4	60.9	39.9	29.9	51.5
B	12	112	117	10	251	14.1	131.3	137.2	11.7	294.3	54.6	39.1	60.1	70.1	48.5
S.T.	26	357	226	16	625	25.8	336.0	228.2	16.7	606.7	100.0	100.0	100.0	100.0	100.0
T.	51	578	406	28	1063	43.5	498.5	360.6	25.7	928.3					
# 4															
1	3	44	28	0	75	2.2	31.8	20.2	0.0	54.2	21.9	8.7	8.5	0.0	8.8
2	2	53	38	1	94	1.5	38.8	27.8	0.7	68.8	14.8	10.6	11.7	12.3	11.1
3	1	48	36	1	86	0.7	35.1	26.3	0.7	62.9	7.4	9.6	11.0	12.3	10.2
4	3	141	21	1	166	2.2	103.8	15.5	0.7	122.2	22.3	28.4	6.5	12.4	19.7
5	0	75	51	0	126	0.0	56.6	38.5	0.0	95.1	0.0	15.5	16.1	0.0	15.3
6	4	103	79	2	188	2.0	50.2	38.5	1.0	91.7	19.7	13.8	16.2	16.4	14.8
7	2	37	70	4	113	1.4	25.7	48.6	2.8	78.4	14.0	7.0	20.4	46.6	12.7
8	0	32	32	0	64	0.0	23.1	23.1	0.0	46.3	0.0	6.3	9.7	0.0	7.5
S.T.	15	533	355	9	912	9.9	365.2	238.6	5.9	619.6	100.0	100.0	100.0	100.0	100.0
A	8	391	155	2	556	6.5	319.5	126.7	1.6	454.4	63.3	62.1	37.3	17.7	52.0
B	3	154	168	6	331	3.8	194.9	212.6	7.6	418.8	36.7	37.9	62.7	82.3	48.0
S.T.	11	545	323	8	887	10.3	514.4	339.3	9.2	873.2	100.0	100.0	100.0	100.0	100.0
T.	26	1078	678	17	1799	20.2	879.6	577.8	15.2	1492.8					

Table 3 (continued.)

		I					II					III				
		S	C	P	K	T	S	C	P	K	T	S	C	P	K	T
# 5																
	1	5	3	7	0	15	4.0	2.4	5.8	0.0	12.3	11.6	7.6	28.3		14.0
	2	6	20	5	0	31	4.2	14.0	3.8	0.0	22.1	12.1	43.9	18.5		25.2
	3	5	10	5	0	20	3.4	6.9	3.4	0.0	13.8	9.9	21.6	16.7		15.8
	4	3	2	3	0	8	2.4	1.6	2.6	0.0	6.6	6.9	5.0	12.6		7.6
	5	3	6	0	0	9	2.2	4.4	0.0	0.0	6.7	6.4	13.9	0.0		7.6
	6	2	0	1	0	3	1.3	0.0	0.6	0.0	1.9	3.7	0.0	3.1		2.2
	7	11	2	3	0	16	9.4	1.7	2.6	0.0	13.7	27.1	5.4	12.5		15.7
	8	9	1	2	0	12	7.8	0.9	1.7	0.0	10.4	22.3	2.7	8.4		11.9
	S.T.	44	44	26	0	114	34.8	32.0	20.6	0.0	87.4	100.0	100.0	100.0	0.0	100.0
	A	10	30	41	0	81	9.2	27.7	38.4	0.0	75.3	13.5	82.9	91.8	0.0	51.6
	B	52	5	3	2	62	59.1	5.7	3.4	2.3	70.5	86.5	17.1	8.2	100.0	48.4
	S.T.	62	35	44	2	143	68.4	33.3	41.8	2.3	145.8	100.0	100.0	100.0	100.0	100.0
	T.	106	79	70	2	257	103.1	65.3	62.5	2.3	233.2					
# 6																
	1	28	54	12	8	102	21.4	41.3	9.9	6.1	78.7	17.5	11.1	12.4	21.5	13.1
	2	21	54	16	4	95	15.6	40.0	12.9	3.0	71.4	12.7	10.8	16.1	10.4	11.9
	3	13	136	10	1	160	9.1	95.4	7.3	0.7	112.6	7.5	25.8	9.2	2.5	18.7
	4	16	34	14	2	66	13.1	27.8	11.4	1.6	53.9	10.7	7.5	14.3	5.7	9.0
	5	18	38	13	8	77	12.8	27.0	9.5	5.7	55.0	10.4	7.3	11.9	20.0	9.1
	6	29	92	16	5	142	13.8	43.8	8.1	2.4	68.1	11.3	11.8	10.2	8.4	11.3
	7	18	47	15	6	86	14.7	38.4	13.3	4.9	71.3	12.0	10.4	16.7	17.2	11.9
	8	27	70	9	5	111	21.9	56.8	7.3	4.1	90.0	17.9	15.3	9.1	14.3	15.0
	S.T.	170	525	105	39	839	122.3	370.4	79.8	28.4	600.9	100.0	100.0	100.0	100.0	100.0
	A	49	356	59	14	478	44.2	321.2	54.0	12.6	432.1	23.4	66.8	50.4	42.8	53.6
	B	120	132	44	14	310	145.0	159.5	53.2	16.9	374.5	76.6	33.2	49.6	57.2	46.4
	S.T.	169	488	103	28	788	189.2	480.7	107.2	29.5	806.6	100.0	100.0	100.0	100.0	100.0
	T.	339	1013	208	67	1627	311.5	851.0	187.0	58.0	1407.5					
# 7																
	1	1	79	1	0	81	0.8	60.4	0.8	0.0	61.9	5.2	11.7	3.3	0.0	11.1
	2	4	126	9	1	140	2.6	82.2	6.9	0.7	92.3	17.8	15.9	30.0	43.6	16.6
	3	4	186	8	0	198	2.9	136.9	6.7	0.0	146.6	20.0	26.5	29.0	0.0	26.3
	4	1	100	4	0	105	0.7	72.7	2.9	0.0	76.4	4.9	14.0	12.6	0.0	13.7
	5	3	49	3	0	55	2.2	36.5	2.2	0.0	41.0	15.2	7.1	9.7	0.0	7.4
	6	2	67	3	0	72	1.2	40.6	1.8	0.0	43.6	8.2	7.8	7.9	0.0	7.8
	7	2	34	0	0	36	1.7	28.3	0.0	0.0	30.0	11.3	5.5	0.0	0.0	5.4
	8	3	71	2	1	77	2.5	60.0	1.7	0.8	65.1	17.3	11.6	7.3	56.4	11.7
	S.T.	20	712	30	2	764	14.7	517.7	23.0	1.5	556.9	100.0	100.0	100.0	100.0	100.0
	A	8	344	5	0	357	7.3	313.1	4.6	0.0	325.0	56.1	36.8	34.1		37.1
	B	5	471	8	0	484	5.7	537.4	9.0	0.0	552.1	43.9	63.2	65.9		62.9
	S.T.	13	815	13	0	841	13.0	850.6	13.6	0.0	877.2	100.0	100.0	100.0	0.0	100.0
	T.	33	1527	43	2	1605	27.7	1368.2	36.6	1.5	1434.1					

S: Sockeye salmon, C: Chum salmon, P: Pink salmon, K: King salmon, T: Total of all species of a genus 'Oncorhynchus' caught.

Table 4 The fish number calculated by the weighted-average-method using data from #1 to #7 at 8 different short time zones and 2 different long time zones in Sockeye, Chum and Pink, respectively (the left side), and the relative number of them (the right side).

	{Σ(Ⅱ×Ⅲ)} ／ΣⅡ			%		
	S	C	P	S	C	P
1	19.2	11.9	15.3	16.1	10.1	12.7
2	12.5	19.4	22.8	10.5	16.5	18.9
3	13.5	23.8	12.7	11.3	20.3	10.6
4	11.1	19.5	14.8	9.3	16.6	12.2
5	14.9	11.0	13.5	12.5	9.4	11.2
6	12.7	11.1	13.0	10.7	9.4	10.8
7	17.6	9.3	17.7	14.8	7.9	14.7
8	17.7	11.6	10.7	14.9	9.9	8.8
S.T.	119.1	117.7	120.5	100.0	100.0	100.0
A	41.1	57.9	53.7	35.5	53.9	47.8
B	74.6	49.6	58.6	64.5	46.1	52.2
S.T.	115.7	107.6	112.3	100.0	100.0	100.0

'Ⅱ' and 'Ⅲ' show the number standardized and the relative one, respectively, and are as same as ones in Table 3.

Table 5 Means ($\bar{X}$) and standard deviations (S.D.) of the relative number of fish caught during nighttime and daytime calculated by the weighted averages in short time operations, the ratios (R) between the two means, the percentages of fish caught in two long time operations calculated by the wighted averages in their operations, and the ratios (R=x/y) calculated by the formula noted in the text in Sockeye, Chum and Pink, respectively.

Operation No.	Sockeye		Chum		Pink	
	$\bar{X}$ ± S.D.	R	$\bar{X}$ ± S.D.	R	$\bar{X}$ ± S.D.	R
2,3,4	10.4 ± 1.00	0.8	17.8 ± 2.17	1.9	13.9 ± 4.40	1.2
1,5,6,7,8	13.8 ± 2.17		9.3 ± 0.86		11.6 ± 2.21	
A	35.5	–	53.9	1.4	47.8	0.8
B	64.5		46.1		52.2	

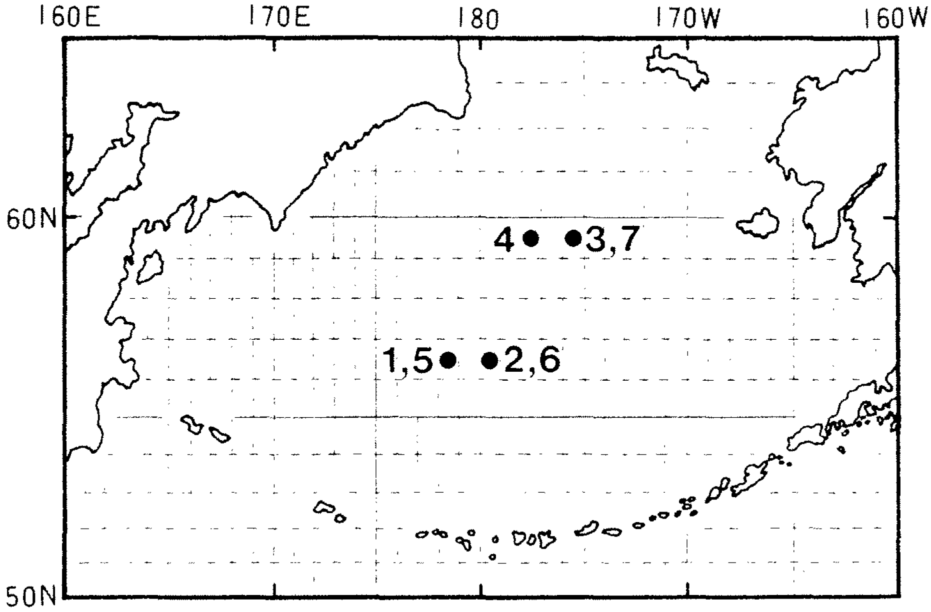

Fig. 1 Stations where gill-net surveys were held. Each number shows the survey number; #1 to #4 are conducted in 1987 and #5 to #7 are in 1988.

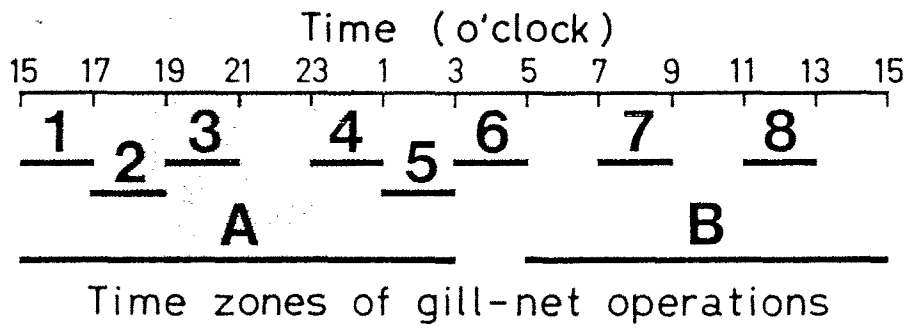

Fig. 2 Time zones of gill-net operations in each survey which is composed of 8 short time operations and 2 long time ones indecated by thick bars during 24 hrs. Time is indicated in Japanese Standard Time. Shadowed zone shows night time.

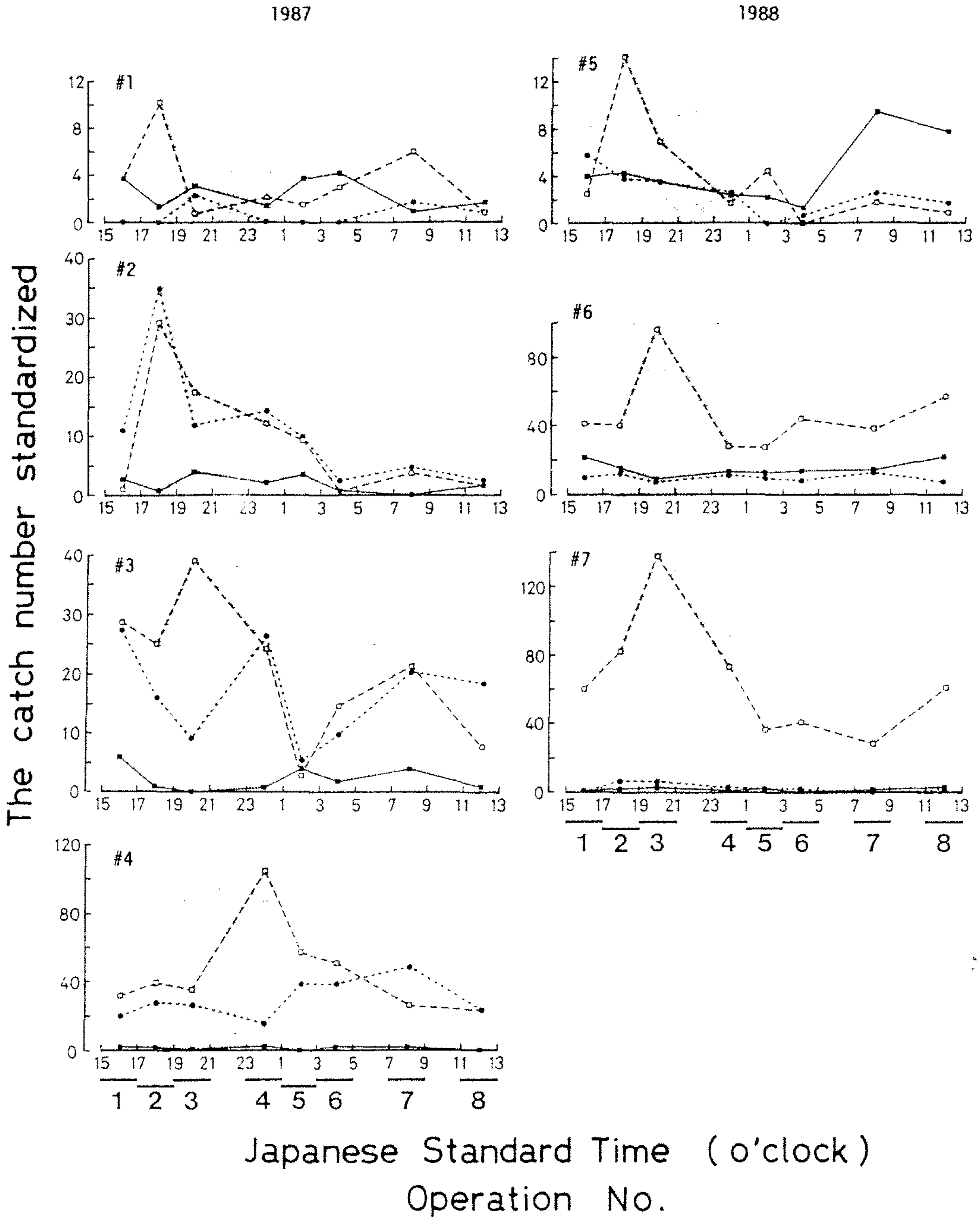

Fig. 3 Diagrams showing the catch number allocated proportionally when the soaking time (TS) of every operation is assumed to be 2 hrs. at each time zone. Abscissa: time (Japanese Standard Time) and operation number at the bottom. Ordinate: the catch number standardized. Shadowed zones show night time. ■ and solid line: Sockeye, □ and broken line: Chum, ● and dotted line: Pink.

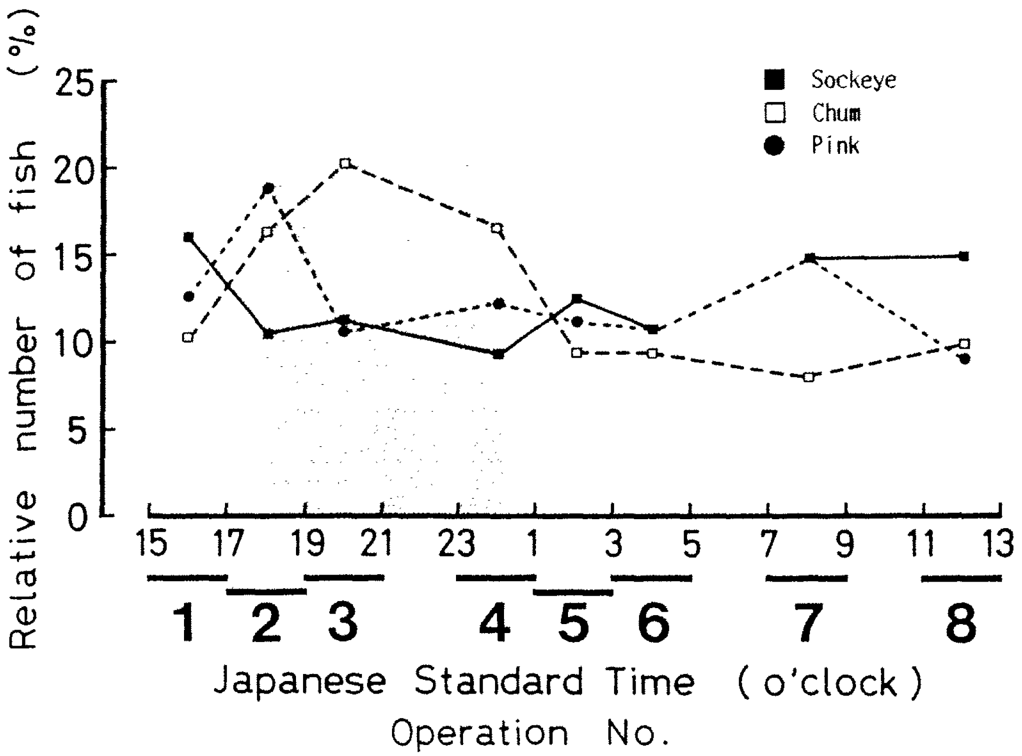

Fig. 4 The relative catch number of fish calculated by the weighted-average-method at 8 different time zones in Sockeye, Chum and Pink, respectively. In the case of Pink the data in #1 are omitted because of smaller sample size. Abscissa: time(Japanese Standard Time) and operation number, Ordinate: relative number of fish indicated in percentage. Other symbols are as same as ones in Fig. 3.

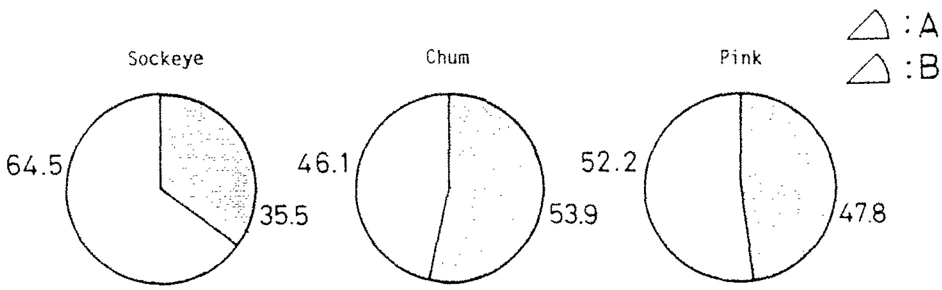

Fig. 5 Comparison of relative number of fish calculated by the weighted-average-method at 2 different long time zones (A and B). In Pink the data in #1 are omitted because of smaller sample size.

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TRANSLATION

OUTLINE OF SALMON GILLNET SURVEY AT DIFFERENT TIME ZONES IN THE BERING SEA DURING THE SUMMER OF 1987 AND 1988

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Summary

1. Although no catch trend of sockeye by time zone was apparent, the catch at nighttime was slightly lower than at daytime.

2. The peak catch of chum salmon was observed at midnight, and in comparing the catch during nighttime and daytime, the catch was clearly higher at nighttime.

3. The peak catch of pink salmon was observed at sunset, and in comparing the catch during nighttime and daytime, no significant difference was recognized.

Purpose

Twenty four-hour surveys were conducted in the Bering Sea during the summer of 1987 and 1988 for the purpose of studying the diurnal movement of salmon.

Method

The surveys were conducted 4 times in 1987 and 3 times in 1988. In this report, survey stations were numbered from #1 to #7, in the order in which they were conducted. The location of #5, #6 and #7 of 1988 was the same as #1, #2 and #3 of 1987, respectively, and the survey dates were almost the same. The survey date, location, time of sunrise and sunset, water temperature, wind velocity and weather are shown in Table 1. In addition, Fig. 1 shows the location of the survey station. In the surveys, 8 short time zones and 2 long time zones were established (Fig. 2) and gill-net operations were conducted in each time zone (Table 2). Time between start of net setting and start of net hauling is illustrated in Fig. 2. Starting time of net setting, ending time of net hauling and the time span of operation as net soaking time by time zone and by survey day were shown in Table 2. Number of tans used was 40 for each operation. The direction of net setting was all 70° - 160°.

Results

Survey results were summarized by survey, by operation and by species in Table 3. The left column of this table (I) is the number of fish caught, middle column (II) is the number of fish allocated proportionally when soaking time of operations is standardized to 2 hrs. for short time operations and to 12 hrs. for long time operations, and the right column (III) is relative value of standardized number of fish by species when each sub-total number of fish of short time operations and long time operations are set at 100. The standardized number caught during short time operations per 40 tan by survey number and by time zone is shown in Fig. 3.

Furthermore, catch trends by time zone were also examined by the results of a weighted average method. Weighted mean (Mw) was obtained from the following formula according to Snedecor (1956):

$$Mw = \frac{W_1 \times P_1 + W_2 \times P_2 + W_3 \times P_3 + \ldots}{W_1 + W_2 + W_3 + \ldots}$$

where Wn is a number of samples of Nth and Pn is a relative value of Nth sample. That is, this value was obtained by the following: relative value of each standardized number of fish was multiplied by respective standardized number of fish and each product was added and then this sum was divided by a total of standardized number of fish. The value was further changed to a relative number and is presented here. In the following text, the relative weighted average value obtained by this method is called simply "mean value."

Using mean value of short time operations, results for three nighttime operations including sunrise and sunset and five daytime operations were averaged respectively, and the difference of catch between daytime and nighttime was also compared (Table 5).

In addition, from weighted average values of two long time operations, the catch difference between daytime and nighttime was also compared by using the following formula (Table 5):

$$[rx + (1-r)y] : y = a:b$$

where r is a ratio of nighttime to an average soaking time of operation A and r = 0.44, x is an average number of fish caught per unit time during nighttime, y is an average number of fish caught per unit time during the daytime, and a and b are mean catch of operations A and operation B, respectively. The ratio of x and y was calculated by this formula and then daytime catch per unit time and that for nighttime catch were compared.

In the following text, comparisons were made among sockeye, chum and pink salmon, but chinook salmon was excluded because only a small number were caught.

1. Sockeye salmon

Any distinctive feature of catch trend by time zone was not detected through 7 surveys (Fig. 3). From the point of mean value, although no big difference among time zones was observed, the catch in nighttime tended to be less (Table 4, Fig. 4). The mean standardized number of fish caught (%) in nighttime and daytime was 10.4 and 13.8 respectively, when the total number of catch by short time operation was converted to 100 (Table 5). Catch was slightly higher in daytime, however, there was no significant difference between them.

The mean value of catch by the two long time operations was a:b = 35.5:64.5 (Table 4, Fig. 5). This suggested that the catch was higher in daytime and was consistent with the result of short time operations. However, although the ratio of x to y was calculated from this result using the above formula, the result came as $x/y < 0$ and the answer was not obtained. As expected from the results of the short time operations (Fig. 4), even in the same daytime, the number of fish caught by net A operation during the daytime zone differed from that by net B operation and the former was less than the latter. This difference is considered to be the reason of the result of the above ratio calculation.

2. Chum salmon

In all survey stations (#1 to 7) the catch was high at nighttime including sunrise and sunset time zones when light intensity is low (Fig. 3). The mean value revealed this trend clearly (Table 4, Fig. 4). The mean standardized number of fish caught (%) during nighttime and daytime was 17.8 and 9.3, respectively (Table 5), and significantly more chum salmon were caught during nighttime.

The mean values of catch of long time operations were a:b = 53.9:46.1 (Table 4, Fig. 5), and the ration of x and y obtained from these values was 1.4:1 (Table 5).

3. Pink salmon

For the catch trend by time zone, the peak catch was observed clearly at sunset time zone in #2 and #7 and in survey stations other than #2 and #7, an increase of catch was observed at 0700 - 0900 (Japanese standard time) (Fig. 3). Examining the mean value, catch was the largest at sunset and it also increased in 0700 - 0900 (Table 4, Fig. 4). The result of surveys at station #1 was judged to be unreliable due to its extremely small number caught and was excluded from the calculation of the mean value. The mean standardized number of fish caught (%) during nighttime and daytime was 13.9 and 11.6, respectively (Table 5), and the value was slightly higher during nighttime but there was no significant difference.

In the long time operation, the mean value was a:b = 47.8:52.2 (Table 4, Fig. 5) and the ratio of a and b was almost equal. In addition, the ratio of x and y was x:y = 0.8:1 (Table 5).

Discussion

The results of this study were summarized as follows: 1) for sockeye salmon, although no catch trend by time zone was apparent, similar results were obtained from short time operation and long time operation in the comparison of catch during nighttime and daytime and catch at night was estimated to be slightly lower; 2) for chum salmon, the peak catch was observed at the time zone near midnight from the result of short time operations, and in the comparison of catch during nighttime and daytime, it was clear that chum salmon was caught more often during the nighttime from the results of short time operation and long time operation, 3) for pink salmon, the peak catch was observed at sunset from the result of short time operation. In the comparison of catch during nighttime and daytime, short time operations showed a greater catch during nighttime and long time operations indicated a greater catch during daytime, however the differences were unclear in each case.

In ordering species by larger difference in catch number by time zones using these results, the order was chum, pink and sockeye salmon. In addition, for catch trends by time zone, chum and pink salmon had a trend similar to that of their peak catch during nighttime. However, although a high catch level was maintained during nighttime for chum salmon, the high value only appeared at sunset for pink salmon.

Sockeye salmon was clearly different from chum and pink salmon and it was estimated that the catch was low during nighttime.

The difference of catch trends by species is basically considered to be due to their particular diurnal characteristics such as 1) change of swimming layer in accordance with vertical movement, 2) change in direction of movement and 3) change in velocity of movement. In other words, the ordering of changes in catch by time which was observed for chum, pink and sockeye salmon is considered to conform to some extent to the magnitude of change of diurnal characteristics.

Based on the survey in the Okhotsk Sea Mishima and Shimazaki (1969) reported that many catches were taken during daytime for sockeye salmon, the catch difference among time zones was unclear for chum salmon and a higher catch occurred after sunset and before sunrise and a reduced catch at midnight for pink salmon. Comparing their results to mine, both results were consistent with that for sockeye salmon. For pink salmon, although no catch increase was observed before sunrise in our survey, both results showed similar tendencies. For chum salmon, the results obtained by Mishima and Shimazaki did not agree with our results in which the large difference in catch among time zones was observed. In addition, Takagi (1971) conducted a survey of short time operations of 4 time zones in the northwest Pacific: morning, noon, evening and night and reported that the fishing efficiency for salmon during daytime tended to decrease. On the other hand, Machidori (1966) surveyed vertical distribution of salmon during nighttime and daytime in the northwest Pacific and reported that the catch distribution pattern by depth and by night and day was different in sockeye salmon but was not different in chum salmon. Moreover, based on the survey in the Gulf of Alaska, Manzer (1964) reported that both sockeye and chum salmon inhabited the surface layer during nighttime and during daytime, and that they inhabited a deeper layer than that in nighttime. However, these two reports were not always consistent with the characteristics of the change of the swimming layer estimated from our results. This difference was considered to be caused by the effects of difference in the habitat of fish in the different survey areas. In other words, not only the particular diurnal characteristics but also the environmental factors such as the kind and amount of existing prey organisms, their characteristics of movement by time zone and the distribution of water temperature and salinity are considered to affect the difference of catch trends by time zone.

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Tables 1 to 5 and Fig. 1 to 5 are in English in the Japanese document.