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SURFACE TEMPERATURES AND DISTRIBUTION OF STEELHEAD TROUT (*Salmo* spp.) RELATIVE TO THE BOUNDARIES OF THE JAPANESE DRIFT GILLNET FISHERY FOR FLYING SQUID (*Ommastrephes bartrami*)

by

Robert V. Walker and Robert L. Burgner

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Fisheries Research Institute
College of Ocean and Fishery Sciences
University of Washington
Seattle, Washington 98195

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INTRODUCTION

Burgner and Meyer (1983) presented information on surface temperatures and salmon distribution relative to the monthly northern boundaries of the Japanese drift gillnet fishery for flying squid. This information refined that presented by Burgner et al. (1982), and indicated that salmon may be encountered in low densities along the northern border of the squid fishery zone in June and July, that they are unlikely to be encountered in August, and that there is the potential for significant incidental catches in September.

Steelhead trout distribution with respect to ocean temperature was not addressed by Burgner and Meyer (1983), because steelhead catch data were not included on the Japanese salmon research vessel catch records that they analyzed. The 1972-83 Japanese research vessel catch records were recently corrected and augmented with steelhead catch data, which permitted the preparation of this document as a supplement to Burgner and Meyer (1983).

Because North American steelhead (*Salmo gairdneri*) and a closely related Asian anadromous trout (*Salmo mykiss*) are not distinguished in high seas research operations and are thought to intermingle in the study area covered by this paper, our use of the word "steelhead" applies to both species.

METHODS AND DATA SOURCES

Data on steelhead catches and surface temperature measurements by Japanese salmon research vessels for 1972-83 were analyzed. The number of research vessel daily operations, operations where steelhead were caught, total catch of steelhead and catch per tan in the drift gillnets of commercial-size mesh were summarized by month, stratified by 1°C intervals of recorded sea surface temperature. The catch per tan was calculated as total catch of steelhead (in commercial-size mesh) across all years, divided by total effort (tans of commercial-size mesh deployed). The data were obtained from the annual catch data records provided by the Japan Fisheries Agency.

The catch per tan for the various month and temperature strata were compared to monthly means and extremes of the position of the 12°C and 15°C sea surface temperature isotherms for 1972-80 as presented by Burgner and Meyer (1983, Figs. 1-14).

RESULTS AND DISCUSSION

Appendix Tables 1-6 show the monthly values of Japanese research vessel gillnet steelhead catches per tan by 1°C temperature intervals for sampling conducted in the North Pacific. The data were separated by the western boundary of the squid fishery area (170°E) into two areas, 157°E to 170°E south of 54°N, and east of 170°E south of 52°N, for the months April through September. A table for the limited sampling in March is not included, as no steelhead were caught in that month. The number of operations in September was also very limited, but the catch per unit effort (CPUE) of steelhead was

relatively high. Sampling effort for the other months, April-August, was much more extensive. Steelhead were more abundant east of 170°E, both in absolute catch numbers and measures of density (catch per tan). The driftnet squid fishery operates in the region east of 170°E, south of a monthly-adjusted boundary.

Total catches of steelhead and CPUE are both low compared with salmon species, and this should be kept in mind while interpreting the data. Since the numbers are small, slight changes in catch figures or in the method of calculating CPUE (i.e., weighted or unweighted means across years) can yield changes of several degrees in the temperature at which maximum CPUE occurs. Also, research vessel sampling effort was less extensive at ocean temperatures where salmon and steelhead are less abundant. Consequently, the CPUE indices may not reflect as accurately the abundance of steelhead to be expected at higher temperatures.

Temperatures at which highest catches per tan were made in each month west and east of 170°E are summarized in Table 1. Our figures show no indication of a seasonal trend, as highest CPUE occurred at temperatures varying widely between months. Similarly, there is little evidence of a seasonal trend in the maximum temperature at which steelhead were caught (Table 2). During the months June-September, when the squid fishery is open, steelhead were encountered in waters from 10°C to 14°C, east of 170°E. Because our figures showed no seasonal trends, we computed total steelhead catches and overall CPUEs by 1°C temperature intervals for the months March through September (Appendix Table 7).

The likelihood of steelhead presence in the northern part of the squid fishery zone can be estimated by comparison of the maximum temperatures of occurrence (Table 2) with monthly 15°C and 12°C isotherms relative to the fishery boundary. The monthly 15°C and 12°C temperature mean and range positions with respect to the monthly northern boundaries of the squid fishery were plotted by Burgner and Meyer (1983, Figs. 1-14). Comparison of these figures with results in Table 2 indicates that steelhead are unlikely to be encountered in the squid fishery area in June and August. In July the 15°C isotherm overlaps the northern fishery boundary in about half the years, while temperatures as low as 12°C do not occur within the fishery area. As steelhead occur in waters as warm as 13-14°C in July, they may be encountered in the fishery area in very low numbers in some years. CPUE indices (Appendix Table 4) suggest that catches would probably be less than 0.01 fish per tan at the northern boundary.

In September the 15°C isotherm falls consistently within the squid fishery zone and the 12°C isotherm often extends into the zone west of 160°W. Data on steelhead distribution in September are very limited, but CPUEs are relatively high and the maximum temperature of catches is 12-13°C. Hence there may be moderate incidental catches of steelhead, particularly west of 160°W.

Steelhead distribution data are lacking for the months October-December when the fishery continues to operate. Temperature data show the 15°C isotherm falling consistently within the squid fishery zone in all three months and the 12°C isotherm extending into the zone in all three months in cooler years. Although we lack steelhead catch and temperature data for these

SUMMARY

Our analysis of steelhead distribution with respect to temperature, supplements the information on salmon provided by Burgner and Meyer (1983). The data indicate steelhead are unlikely to be encountered along the northern border of the squid fishery zone in June and August, that they may be encountered in very low densities in July, and that there is the potential for more significant incidental catches in September. October-December temperatures do not preclude the presence of steelhead in the squid fishery area, but the distribution of steelhead relative to temperatures is unknown for these months. These results are quite similar to those for the five species of salmon, with the exception of Burgner and Meyer's (1983) conclusion that there is potential for incidental catches of chum, pink, and coho in June.

LITERATURE CITED

Burgner, R. L., R. W. Mercer, and R. L. Major. 1982. Surface temperatures and salmon distribution relative to the Japanese driftnet fishery for flying squid (Ommastrephes bartrami). (Document submitted to annual meeting of the INPFC, Tokyo, Japan, November 1982.) 22 pp. Fish. Res. Inst., Univ. of Washington, Seattle.

Burgner, R. L. and W. G. Meyer. 1983. Surface temperatures and salmon distribution relative to the boundaries of the Japanese drift gillnet fishery for flying squid (Ommastrephes bartrami). (Document submitted to annual meeting of the INPFC, Anchorage, U.S.A., November 1983.) 35 pp. Fish. Res. Inst., FRI-UW-8317, Univ. of Washington, Seattle.

Table 1. Temperatures (^{o}C) at which highest steelhead catches per tan were made by Japanese research vessels fishing west and east of 170^{o}E. (Lower temperature boundary inclusive.)

Month	W of 170^{o}E	E of 170^{o}E
March	--	--
April	4-5*	11-12
May	11-12	8-9
June	8-9	7-8
July	6-7	12-13
August	12-13	8-9
September	--	11-12

*Only temperature interval at which steelhead were caught.

Table 2. Maximum temperatures (^{o}C) at which catches of steelhead were made by Japanese research vessels fishing gillnets west and east of 170^{o}E longitude. (Lower temperature boundary inclusive.)

Month	W of 170^{o}E	E of 170^{o}E
March	--	--
April	4-5*	11-12
May	11-12	8-9
June	9-10	10-11
July	10-11	13-14
August	12-13	11-12
September	--	12-13

*Only temperature interval at which steelhead were caught.

APPENDIX

Appendix Table 1. Total catches of steelhead and catches per tan in gillnets fished by Japanese research vessels for operations in the month of April, 1972-1983, stratified by recorded sea surface temperature; catch data are for commercial-type gear (A).

SURFACE TEMP.	157E TO 170E, SOUTH OF 54N				EAST OF 170E, SOUTH OF 52N			
	NO. OPERATIONS		NO.		NO. OPERATIONS		NO.	
	TOT.	W/STHD.	STHD.	CPUE	TOT.	W/STHD.	STHD.	CPUE
.0 - .9	2	0	0	.0000	0	0	0	.0000
1.0 - 1.9	25	0	0	.0000	0	0	0	.0000
2.0 - 2.9	63	0	0	.0000	17	0	0	.0000
3.0 - 3.9	35	0	0	.0000	36	0	0	.0000
4.0 - 4.9	26	1	2	.0004	46	0	0	.0000
5.0 - 5.9	25	0	0	.0000	27	2	9	.0015
6.0 - 6.9	10	0	0	.0000	19	1	1	.0003
7.0 - 7.9	7	0	0	.0000	21	1	4	.0009
8.0 - 8.9	11	0	0	.0000	25	1	1	.0002
9.0 - 9.9	7	0	0	.0000	18	1	1	.0003
10.0 - 10.9	11	0	0	.0000	17	0	0	.0000
11.0 - 11.9	10	0	0	.0000	11	2	3	.0017
12.0 - 12.9	8	0	0	.0000	2	0	0	.0000
13.0 - 13.9	1	0	0	.0000	0	0	0	.0000
14.0 - 14.9	2	0	0	.0000	0	0	0	.0000
15.0 - 15.9	0	0	0	.0000	0	0	0	.0000
16.0 - 16.9	0	0	0	.0000	0	0	0	.0000
17.0 - 17.9	0	0	0	.0000	0	0	0	.0000
18.0 - 18.9	0	0	0	.0000	0	0	0	.0000
19.0 - 19.9	0	0	0	.0000	0	0	0	.0000
20.0 - 20.9	0	0	0	.0000	0	0	0	.0000

Appendix Table 2. Total catches of steelhead and catches per tan in gillnets fished by Japanese research vessels for operations in the month of May, 1972-1983, stratified by recorded sea surface temperature; catch data are for commercial-type gear (A).

SURFACE TEMP.	157E TO 170E, SOUTH OF 54N				EAST OF 170E, SOUTH OF 52N			
	NO. OPERATIONS		NO.		NO. OPERATIONS		NO.	
	TOT.	W/STHD.	STHD.	CPUE	TOT.	W/STHD.	STHD.	CPUE
.0 - .9	1	0	0	.0000	0	0	0	.0000
1.0 - 1.9	20	0	0	.0000	0	0	0	.0000
2.0 - 2.9	84	0	0	.0000	12	0	0	.0000
3.0 - 3.9	186	0	0	.0000	111	0	0	.0000
4.0 - 4.9	205	0	0	.0000	108	3	3	.0002
5.0 - 5.9	100	2	3	.0001	75	21	54	.0053
6.0 - 6.9	47	4	4	.0005	40	13	65	.0130
7.0 - 7.9	20	0	0	.0000	29	10	50	.0131
8.0 - 8.9	5	0	0	.0000	14	5	47	.0262
9.0 - 9.9	0	0	0	.0000	12	0	0	.0000
10.0 - 10.9	0	0	0	.0000	15	0	0	.0000
11.0 - 11.9	8	1	2	.0036	1	0	0	.0000
12.0 - 12.9	3	0	0	.0000	2	0	0	.0000
13.0 - 13.9	1	0	0	.0000	0	0	0	.0000
14.0 - 14.9	0	0	0	.0000	0	0	0	.0000
15.0 - 15.9	0	0	0	.0000	0	0	0	.0000
16.0 - 16.9	0	0	0	.0000	0	0	0	.0000
17.0 - 17.9	0	0	0	.0000	0	0	0	.0000
18.0 - 18.9	0	0	0	.0000	0	0	0	.0000
19.0 - 19.9	0	0	0	.0000	0	0	0	.0000
20.0 - 20.9	0	0	0	.0000	0	0	0	.0000

Appendix Table 3. Total catches of steelhead and catches per tan in gillnets fished by Japanese research vessels for operations in the month of June, 1972-1983, stratified by recorded sea surface temperature; catch data are for commercial-type gear (A).

SURFACE TEMP.	157E TO 170E, SOUTH OF 54N				EAST OF 170E, SOUTH OF 52N			
	NO. OPERATIONS		NO.		NO. OPERATIONS		NO.	
	TOT.	W/STHD.	STHD.	CPUE	TOT.	W/STHD.	STHD.	CPUE
.0 - .9	0	0	0	.0000	0	0	0	.0000
1.0 - 1.9	0	0	0	.0000	0	0	0	.0000
2.0 - 2.9	7	0	0	.0000	0	0	0	.0000
3.0 - 3.9	77	0	0	.0000	8	0	0	.0000
4.0 - 4.9	165	1	1	.00003	74	2	3	.0003
5.0 - 5.9	144	2	3	.0001	132	5	20	.0008
6.0 - 6.9	124	8	36	.0016	96	7	35	.0024
7.0 - 7.9	80	6	8	.0006	69	14	106	.0104
8.0 - 8.9	61	10	21	.0024	68	9	73	.0064
9.0 - 9.9	39	1	3	.0005	43	5	24	.0033
10.0 - 10.9	11	0	0	.0000	11	2	4	.0044
11.0 - 11.9	9	0	0	.0000	6	0	0	.0000
12.0 - 12.9	3	0	0	.0000	2	0	0	.0000
13.0 - 13.9	1	0	0	.0000	6	0	0	.0000
14.0 - 14.9	1	0	0	.0000	3	0	0	.0000
15.0 - 15.9	0	0	0	.0000	1	0	0	.0000
16.0 - 16.9	0	0	0	.0000	2	0	0	.0000
17.0 - 17.9	0	0	0	.0000	1	0	0	.0000
18.0 - 18.9	0	0	0	.0000	0	0	0	.0000
19.0 - 19.9	0	0	0	.0000	0	0	0	.0000
20.0 - 20.9	0	0	0	.0000	0	0	0	.0000

Appendix Table 4. Total catches of steelhead and catches per tan in gillnets fished by Japanese research vessels for operations in the month of July, 1972-1983, stratified by recorded sea surface temperature; catch data are for commercial-type gear (A).

SURFACE TEMP.	157E TO 170E, SOUTH OF 54N				EAST OF 170E, SOUTH OF 52N			
	NO. OPERATIONS		NO.		NO. OPERATIONS		NO.	
	TOT.	W/STHD.	STHD.	CPUE	TOT.	W/STHD.	STHD.	CPUE
.0 - .9	0	0	0	.0000	0	0	0	.0000
1.0 - 1.9	0	0	0	.0000	0	0	0	.0000
2.0 - 2.9	0	0	0	.0000	0	0	0	.0000
3.0 - 3.9	0	0	0	.0000	0	0	0	.0000
4.0 - 4.9	0	0	0	.0000	0	0	0	.0000
5.0 - 5.9	6	1	1	.0013	6	0	0	.0000
6.0 - 6.9	76	14	58	.0047	31	8	16	.0046
7.0 - 7.9	143	7	32	.0011	129	16	103	.0043
8.0 - 8.9	185	13	40	.0012	152	23	120	.0049
9.0 - 9.9	123	6	10	.0005	105	29	149	.0107
10.0 - 10.9	62	3	3	.0004	54	11	34	.0055
11.0 - 11.9	17	0	0	.0000	30	1	7	.0024
12.0 - 12.9	9	0	0	.0000	15	4	21	.0146
13.0 - 13.9	7	0	0	.0000	7	2	6	.0105
14.0 - 14.9	6	0	0	.0000	6	0	0	.0000
15.0 - 15.9	7	0	0	.0000	6	0	0	.0000
16.0 - 16.9	1	0	0	.0000	6	0	0	.0000
17.0 - 17.9	1	0	0	.0000	3	0	0	.0000
18.0 - 18.9	1	0	0	.0000	4	0	0	.0000
19.0 - 19.9	0	0	0	.0000	3	0	0	.0000
20.0 - 20.9	0	0	0	.0000	6	0	0	.0000

Appendix Table 5. Total catches of steelhead and catches per tan in gillnets fished by Japanese research vessels for operations in the month of August, 1972-1983, stratified by recorded sea surface temperature; catch data are for commercial-type gear (A).

SURFACE TEMP.	157E TO 170E, SOUTH OF 54N				EAST OF 170E, SOUTH OF 52N			
	NO. OPERATIONS		NO.		NO. OPERATIONS		NO.	
	TOT.	W/STHD.	STHD.	CPUE	TOT.	W/STHD.	STHD.	CPUE
.0 - .9	0	0	0	.0000	0	0	0	.0000
1.0 - 1.9	0	0	0	.0000	0	0	0	.0000
2.0 - 2.9	0	0	0	.0000	0	0	0	.0000
3.0 - 3.9	0	0	0	.0000	0	0	0	.0000
4.0 - 4.9	0	0	0	.0000	0	0	0	.0000
5.0 - 5.9	0	0	0	.0000	0	0	0	.0000
6.0 - 6.9	0	0	0	.0000	0	0	0	.0000
7.0 - 7.9	1	0	0	.0000	2	0	0	.0000
8.0 - 8.9	7	1	1	.0010	5	4	25	.0551
9.0 - 9.9	20	2	3	.0014	7	1	1	.0016
10.0 - 10.9	31	1	1	.0002	17	7	20	.0155
11.0 - 11.9	20	4	5	.0023	20	4	9	.0092
12.0 - 12.9	12	2	3	.0027	8	0	0	.0000
13.0 - 13.9	4	0	0	.0000	2	0	0	.0000
14.0 - 14.9	5	0	0	.0000	1	0	0	.0000
15.0 - 15.9	1	0	0	.0000	2	0	0	.0000
16.0 - 16.9	2	0	0	.0000	2	0	0	.0000
17.0 - 17.9	0	0	0	.0000	0	0	0	.0000
18.0 - 18.9	0	0	0	.0000	1	0	0	.0000
19.0 - 19.9	0	0	0	.0000	2	0	0	.0000
20.0 - 20.9	0	0	0	.0000	2	0	0	.0000

Appendix Table 6. Total catches of steelhead and catches per tan in gillnets fished by Japanese research vessels for operations in the month of September, 1972-1983, stratified by recorded sea surface temperature; catch data are for commercial-type gear (A).

SURFACE TEMP.	157E TO 170E, SOUTH OF 54N				EAST OF 170E, SOUTH OF 52N			
	NO. OPERATIONS		NO.		NO. OPERATIONS		NO.	
	TOT.	W/STHD.	STHD.	CPUE	TOT.	W/STHD.	STHD.	CPUE
.0 - .9	0	0	0	.0000	0	0	0	.0000
1.0 - 1.9	0	0	0	.0000	0	0	0	.0000
2.0 - 2.9	0	0	0	.0000	0	0	0	.0000
3.0 - 3.9	0	0	0	.0000	0	0	0	.0000
4.0 - 4.9	0	0	0	.0000	0	0	0	.0000
5.0 - 5.9	1	0	0	.0000	0	0	0	.0000
6.0 - 6.9	0	0	0	.0000	0	0	0	.0000
7.0 - 7.9	0	0	0	.0000	0	0	0	.0000
8.0 - 8.9	0	0	0	.0000	1	0	0	.0000
9.0 - 9.9	1	0	0	.0000	1	1	1	.0125
10.0 - 10.9	4	0	0	.0000	1	1	3	.0375
11.0 - 11.9	5	0	0	.0000	1	1	4	.1000
12.0 - 12.9	1	0	0	.0000	4	1	11	.0688
13.0 - 13.9	0	0	0	.0000	1	0	0	.0000
14.0 - 14.9	0	0	0	.0000	0	0	0	.0000
15.0 - 15.9	0	0	0	.0000	0	0	0	.0000
16.0 - 16.9	0	0	0	.0000	0	0	0	.0000
17.0 - 17.9	0	0	0	.0000	0	0	0	.0000
18.0 - 18.9	0	0	0	.0000	0	0	0	.0000
19.0 - 19.9	0	0	0	.0000	0	0	0	.0000
20.0 - 20.9	0	0	0	.0000	0	0	0	.0000

Appendix Table 7. Total catches of steelhead and catches per tan in gillnets fished by Japanese research vessels for operations in the months March through September, 1972-1983, stratified by recorded sea surface temperature; catch data are for commercial-type gear (A).

SURFACE TEMP.	157E TO 170E, SOUTH OF 54N				EAST OF 170E, SOUTH OF 52N			
	NO. OPERATIONS		NO.		NO. OPERATIONS		NO.	
	TOT.	W/STHD.	STHD.	CPUE	TOT.	W/STHD.	STHD.	CPUE
.0 - .9	3	0	0	.0000	0	0	0	.0000
1.0 - 1.9	45	0	0	.0000	0	0	0	.0000
2.0 - 2.9	158	0	0	.0000	29	0	0	.0000
3.0 - 3.9	312	0	0	.0000	159	0	0	.0000
4.0 - 4.9	407	2	3	.00004	230	5	6	.0001
5.0 - 5.9	279	5	7	.0001	240	28	83	.0020
6.0 - 6.9	257	26	98	.0022	186	29	117	.0044
7.0 - 7.9	251	13	40	.0008	250	41	263	.0062
8.0 - 8.9	269	24	62	.0013	265	42	266	.0062
9.0 - 9.9	190	9	16	.0006	186	37	176	.0066
10.0 - 10.9	119	4	4	.0002	115	21	61	.0047
11.0 - 11.9	69	5	7	.0010	69	8	23	.0036
12.0 - 12.9	36	2	3	.0007	33	5	32	.0123
13.0 - 13.9	14	0	0	.0000	16	2	6	.0050
14.0 - 14.9	14	0	0	.0000	10	0	0	.0000
15.0 - 15.9	8	0	0	.0000	9	0	0	.0000
16.0 - 16.9	3	0	0	.0000	10	0	0	.0000
17.0 - 17.9	1	0	0	.0000	4	0	0	.0000
18.0 - 18.9	1	0	0	.0000	5	0	0	.0000
19.0 - 19.9	0	0	0	.0000	5	0	0	.0000
20.0 - 20.9	0	0	0	.0000	8	0	0	.0000

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ERRATA

On the bottom of page 2 the last part of the last sentence before the SUMMARY was dropped. The last sentence should read:

> Although we lack steelhead catch and temperature data for these months, the temperature maximums for preceeding months indicate it is quite possible that steelhead may be encountered.