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A PRELIMINARY STUDY OF THE EFFECTS OF PIER LIGHTING ON FISHES

by

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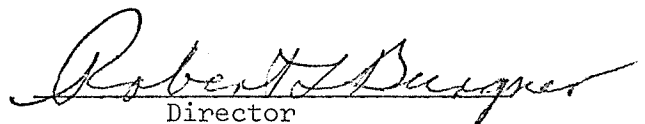
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A PRELIMINARY STUDY OF THE EFFECTS OF PIER LIGHTING ON FISHES

INTRODUCTION

Seven large docking facilities are planned for the 4 miles of shoreline of Hood Canal in the United States Navy's Bangor Annex near Keyport, Washington (Figs. 1 and 2). These concrete piers will extend up to 400 m from shore and will cover or enclose approximately 30 hectares of water. The proposed lighting will provide constant illumination underneath and outside the piers.

From February to July, the major portion of chum salmon (*Oncorhynchus keta*) outmigrant populations from Hood Canal spawning grounds passes along this shoreline¹. The effect of the proposed lighting on these migrants, other salmonids, and resident fishes is unknown². This study was carried out in July 1976 to determine if lighting similar to that proposed would attract and hold fish. Further work investigated the effect of different colors of lights on fish. Feasibility of identification and enumeration of fishes present in the experimental area was investigated.

MATERIALS AND METHODS

Experimental Design

Laboratory investigations of responses of fishes to light are very difficult to apply to the field². Therefore, lighting similar to that proposed for the piers was produced by placing 26 temporary lights on the south trestle of the Explosives Handling Wharf No. 1 (EHW) presently under construction at Bangor Annex. Rows of support pilings divided the wharf's 440-ft-south trestle in twenty-two 6-m sections. These were numbered from the shore outward (Fig. 3). Wall-mounted fixtures with 35-W low pressure sodium (SOX) lamps suspended .7 m from the top of the pier railing (Fig. 4) at Sections 2, 6, 10, 14, 18, and 22 illuminated the outboard area south of the pier. Twenty 75-W PAR 130-V floodlights were suspended under the south edge of the trestle at Sections 2 through 21 (Fig. 5).

The fishes' response to this lighting was determined by observing from the pier the number of fish present under the SOX lights at Sections 6, 14, and 22 and under the floodlights at Sections 5 and 15 during three pairs of

¹Schreiner, James U., Aloysius J. Didier, Jr., Ernest O. Salo, and Bruce P. Snyder. 1975. Salmonid outmigrations in Hood Canal, Progress Report March 1975 to July 1975. Fish. Res. Inst., Univ. Wash., 26 pp.

²Salo, Matthew E. 1976. Annotated bibliography on the effects of light on salmonids with reference to Bangor Annex area. Special Report to Dept. of the Navy, Contract No. N68248-76-C-0011. Fish. Res. Inst., Univ. Wash., 89 pp.

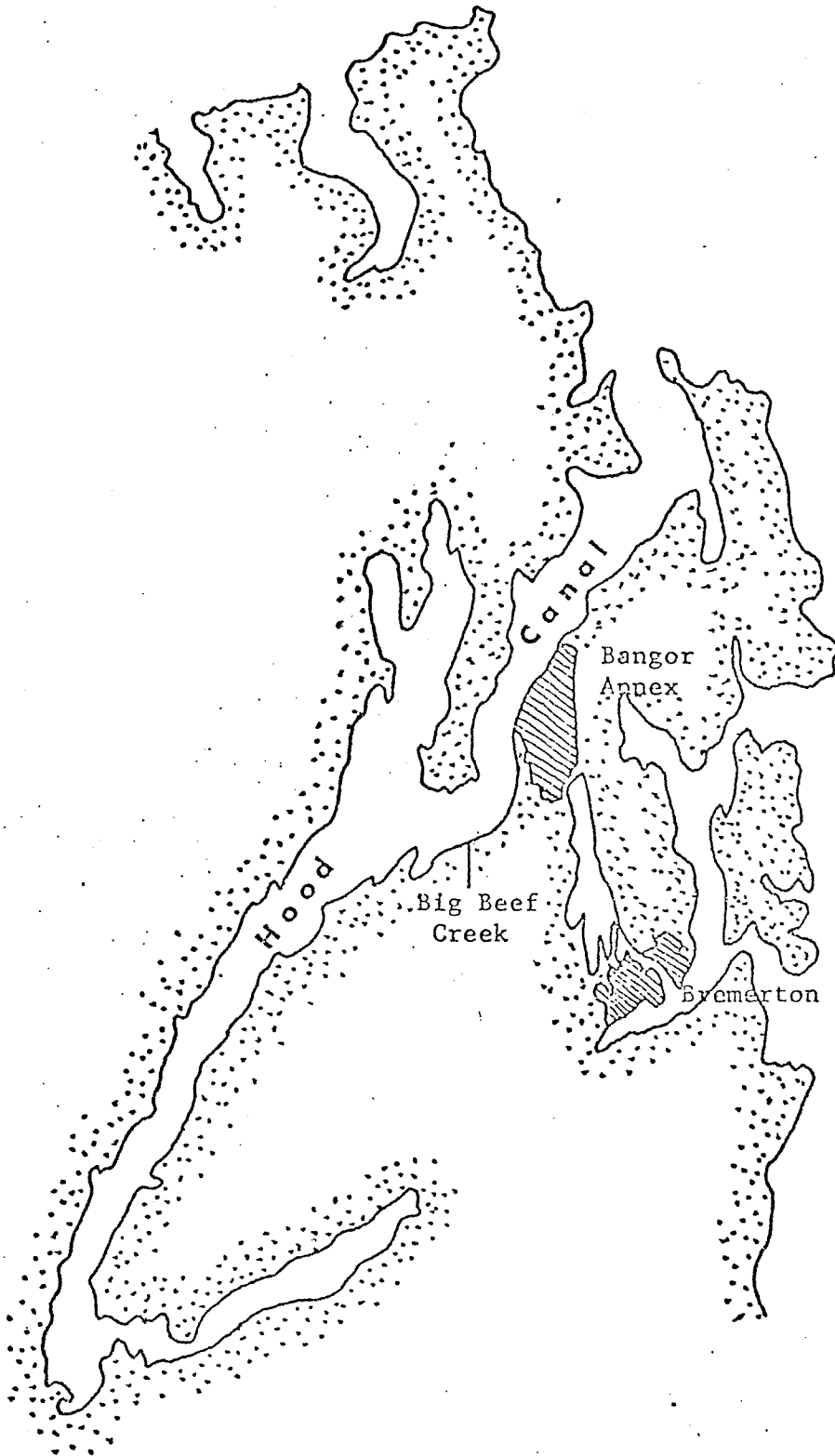


Fig. 1. Location of the Bangor Annex (Trident site) on Hood Canal, Washington.

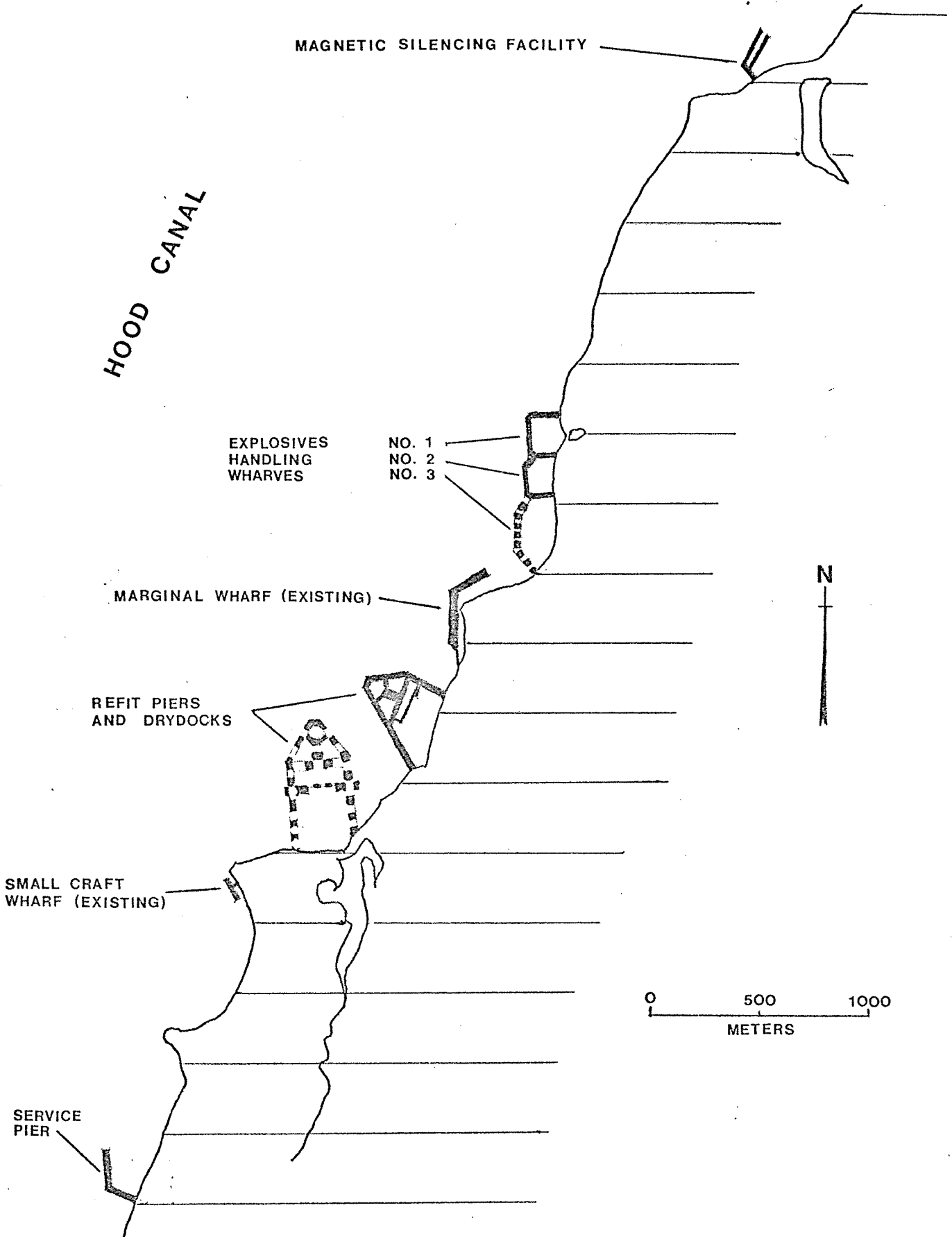


FIG. 2. Existing and Proposed Docking Facilities
Bangor Annex, Hood Canal, WA, 1976

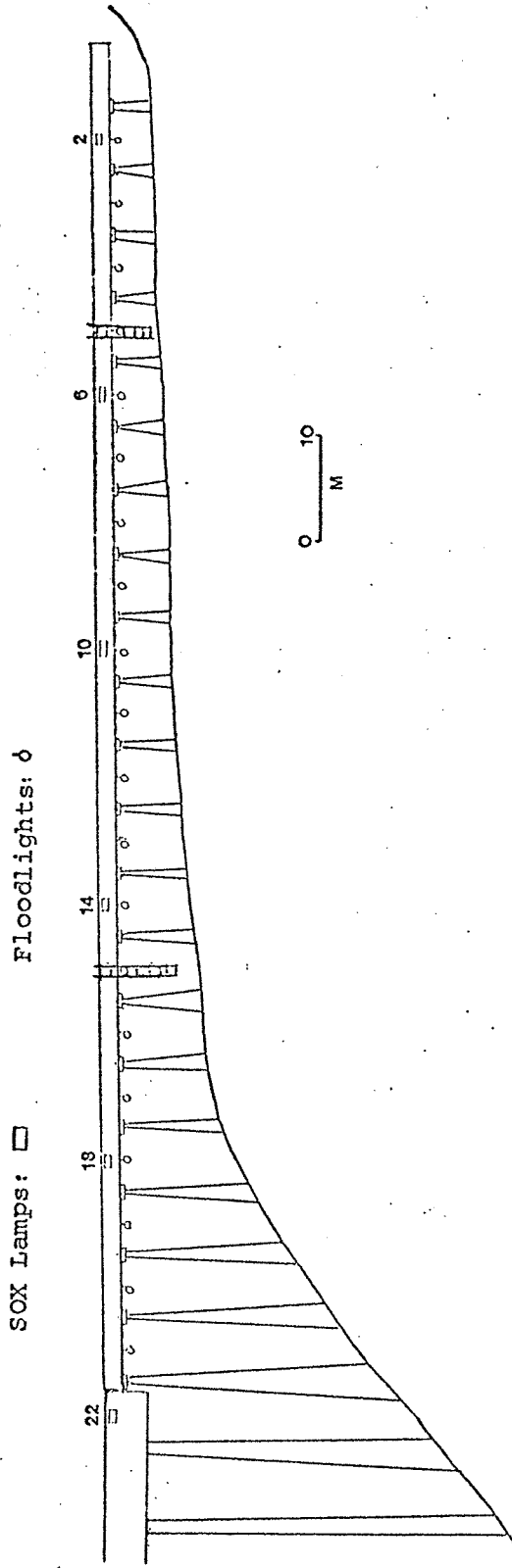


FIG. 3. South Trestle of EHW No. 1 - side view

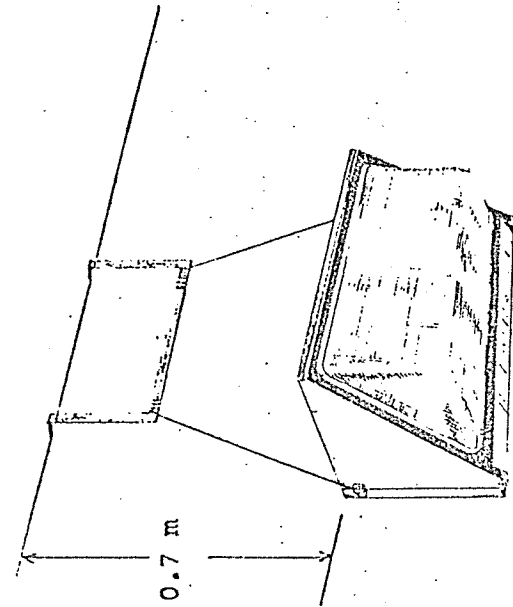


FIG. 4. SOX Lamp

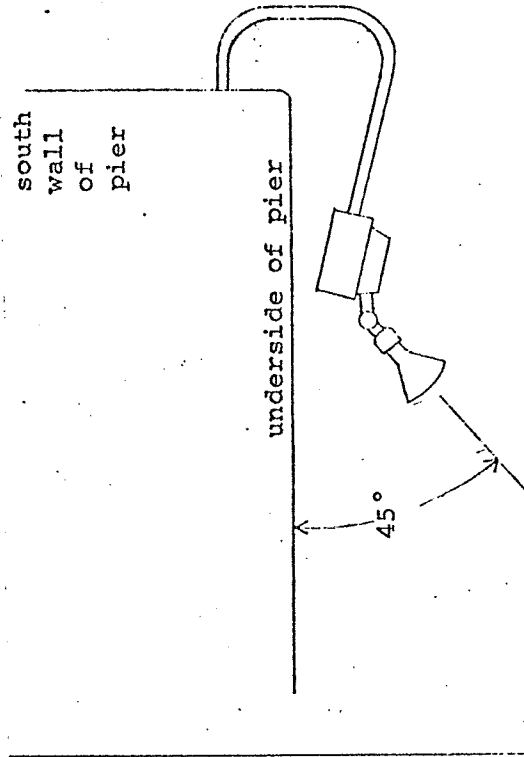


FIG. 5. Floodlight

nights. Each pair consisted of one night with the lights on (light night) and one night with the lights off (dark night). Observations were made each hour from 2200 to 0400. A hand-held spotlight was used on the dark nights. The lights were turned on at 2000 and off at 0430 during the light nights. After a pair of nights, the observer made a qualitative judgment whether the lighting attracted and held the fish. Two observers were used, one observing two pairs of nights, 7/14-15/76-Light (L) and 7/15-16/76-Dark (D); 7/19-20/76-L, 7/20-21/76-D, and the second observing one pair, 7/22-23/76-D, 7/23-24/76-L. No quantitative data were collected on the species composition.

Concurrent with the qualitative observations, counts were made of the number of fish in each of five sample areas located under the lights at the above sections. These sample areas were defined by momentarily shining a spotlight beam on the surface. The number of fish visible to the observer within the spot the moment it was turned on was the datum.

On July 26, the white 75-W floodlamps were replaced by 100-W yellow floods. Observation methods were identical to those made during two previous pairs of nights (7/26-27/76-L, 7/27-28/76-D; 7/28-29/76-L, 7/29-30/76-D).

During the nights of July 23-24, 24-25, and 25-26, modified echosounding equipment was used to quantify the fish present under the SOX lamp at Section 18. A transducer producing a 22° full-angle cone was set on the bottom and faced upward. Fish present in the cone were recorded on a chart recorder and oscilloscope, and the characteristics of the sound reflected from the fish were recorded on magnetic tape. A computer program is used to analyze the tape, showing relative biomass by depth by time. Thorne et al. (1972) give a full description of the equipment.

The equipment was tested during the first night. The lights were turned on and off in various sequences and the fishes' responses recorded. On the following two nights, the reaction of fishes to different colored floodlights was tested. Yellow, red, blue, green, and amber 100-W and white 150-W PAR 130-V floodlights were used to illuminate the surface above the transducer. Each night the regular lighting system was turned on for 1 hr at 2200 to attract fish to the area. On 7/24-25/76, the yellow, red, white, blue, green, and amber floodlights were successively turned on for 1/2-hr each. The acoustic equipment recorded the relative density of the fish present. Between each 1/2-hr exposure, light intensity was monitored and the equipment calibrated. During the following night the lighting order was changed to amber, green, red, blue, white, and yellow.

Light Intensity Measurements

Light intensities produced by the lighting system were measured with a Li-Cor LI-212S underwater photometric sensor with a LI-185 meter, both from Lambda Instruments Corp., Lincoln, Nebraska.

Enumeration and Identification Methods

Various methods of enumeration and identification of fishes present around the pier when the lights were on were tested during 2 weeks prior to the experiments. The effectiveness of diver observation and observation from various positions along the pier and in boats was compared. Beach seines (30 m), tow nets (3 m x 6 m and 1.2-m x 1.2-m), dip nets and a cast net were tried. Enumeration capabilities of standard echo sounding gear aboard a 38-ft boat was evaluated. Electrofishing was attempted using two 2-m electrodes attached to a 40-volt, 200-amp welder.

RESULTS

Light Intensities

During light nights, light intensity on and under the water surface varied with tide stage and turbidity of the water. Ambient light intensity during the nights, from 0 to 0.01 lux, had a negligible effect. Maximum intensity of variable lighting from a nearby pier and lightning tower was recorded as 0.01 lux. Intensities on the water surface under the lighted SOX lamps varied from 61 to 24 lux at high and low tides respectively. The light from the SOX lamps penetrated to the bottom at Station 18 during all the tide stages. Fig. 6 shows the intensity depth relation during a representative observation period. Dark night surface and under-water readings were consistently 0 lux.

Enumeration and Identification

Observation from the pier was the most effective and convenient of the methods tested. Dip nets and the cast net did not catch fish. The catch of the beach seines and tow nets seemed to be selective, generally catching only a few salmonids after being pulled through schooling perch. The echo sounding gear could not record fishes in the relatively shallow water. Slight gyrations in smaller fishes were produced by the electrodes but fish were not stunned or killed. Divers could rarely approach fishes for accurate identification.

Attraction Responses to Pier Lighting

White 75-W Floodlights

Qualitative observations. During the first three pairs of light-dark nights, many more fish were observed in the experimental field during the light nights than the dark. Typical comments by the observers were: "large numbers (5,000 +) of juvenile herring were gathered directly under the SOX lamps from 2300 to 0100 on the lighted night. No such gathering occurred on the dark night." "There were many more fish (present during

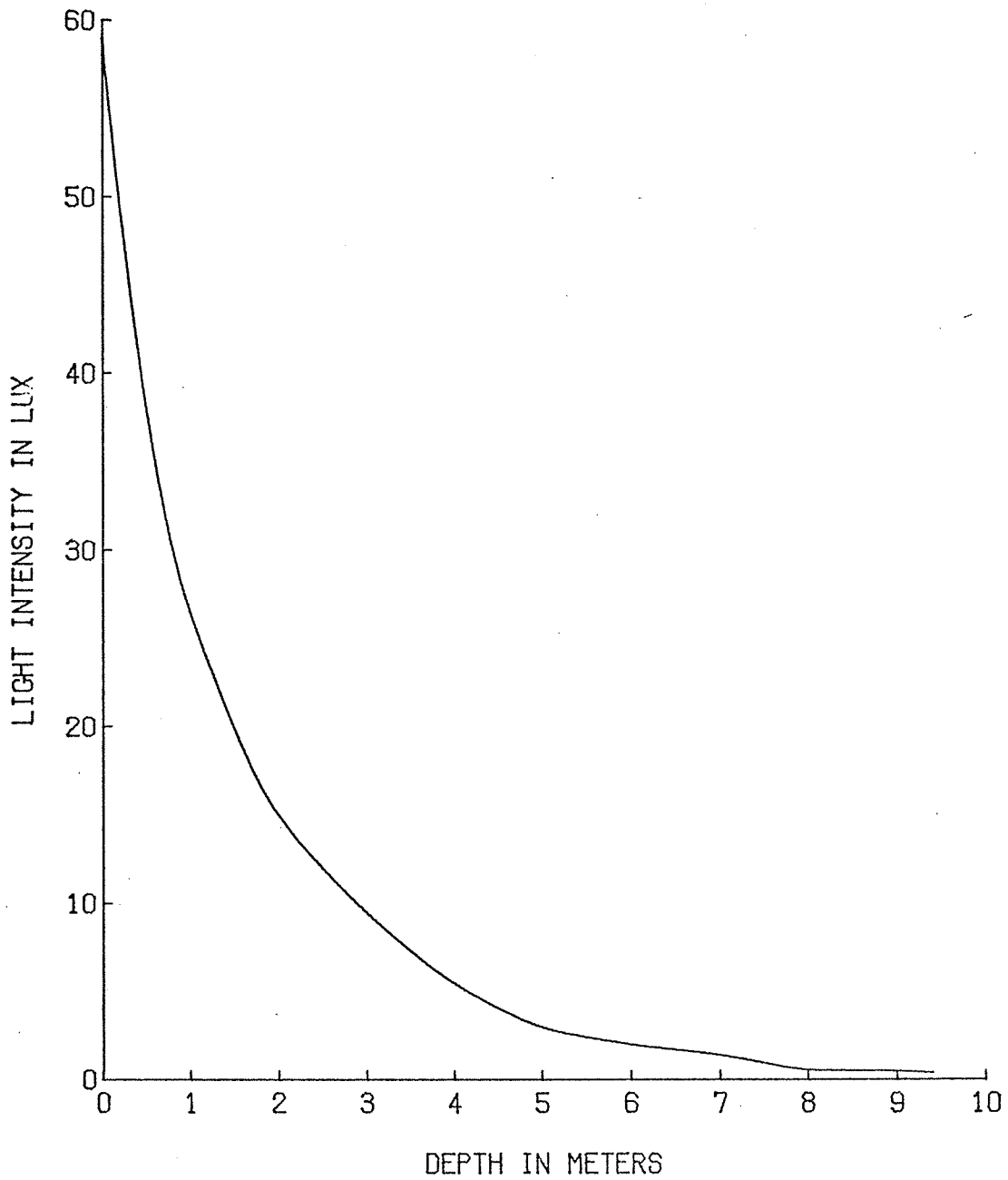


FIG. 6 LIGHT INTENSITY-DEPTH RELATIONSHIP
STATION 18, 23*21 HRS, 7/19/76, BANGOR ANNEX, HOOD CANAL, WA.

the light night) than last night (the dark night)". Fish were observed under the lighted lamps at 2200. At times, numbers increased until 0100. At other times, numbers remained constant from 2300 to 0400. Fish were seen all along and under the pier, and were heard splashing out to 100 m south of the trestle. Few fish were seen or heard north of the trestle. More fish were observed in deeper water than in shallow. On the lighted nights, the fish were densest and schooling directly underneath the SOX and floodlamps. On the dark nights the fish observed were evenly dispersed and ungrouped in the experimental field. It was obvious to the observers that the lights did attract fish. Following are some of the fishes recorded in the lighted area by surface and diver observers:

<u>Fishes</u>	<u>Approximate length (cm)</u>
Herring, juveniles	5
Herring, sub-adults	15
Salmonids	
Chum salmon	10-15
Chinook and/or steelhead	50-75
Chinook and/or coho	10
Cutthroat trout	20-30
Sculpins	10
Perch	5-20
Dogfish	40-80
Starry flounder	25-40

Count data. Table 1 lists the number of fish counted in the spotlight during the first three pairs of nights when the 75-W white bulb was used. When blanks in the data are compensated for by eliminating the corresponding data in the other member of the light-dark pair, the sum of the fish counted during three light nights is 998, and the sum of the dark nights 29 fish.

Table 2 lists the sum of the fishes counted at each station during the light nights after correction for blanks in the data.

Table 2. Sum of fishes counted at each station during the light nights (white 75-W), Bangor Annex, Hood Canal, Washington

Station	5	6	14	15	22
Σ	7	16	229	237	484

Table 1. Numbers of fish observed in spotlight, Bangor Annex, Hood Canal, WA.

Light-7/14-15/76

Time	Station				
	5	6	14	15	22
2200	0	0	-	-	2
0000	0	0	5	4	50
0200	0	0	4	8	10
0400	0	0	1	3	30

Dark-7/15-16/76

Time	Station				
	5	6	14	15	22
2200	0	0	4	0	0
0000	0	1	10	0	1
0200	0	0	1	0	0
0400	-	0	0	1	0

Light-7/19-20/76

Time	5	6	14	15	22
2200	1	0	22	0	50
2300	2	3	6	3	30
0000	1	1	30	10	30
0100	1	1	0	15	25
0200	1	-	-	-	-
0300	0	4	15	1	25
0400	-	0	2	30	35

Dark-7/20-21/76

Time	5	6	14	15	22
2200	0	0	0	0	0
2300	1	1	1	0	0
0000	1	0	0	0	0
0100	1	0	0	0	0
0200	1	0	0	0	0
0300	-	-	-	-	-
0400	0	0	0	0	0

Light-7/22-23/76

Time	5	6	14	15	22
2200	0	0	25	0	4
2300	0	5	20	0	50
0000	0	0	25	60	25
0100	2	0	50	30	100
0200	0	0	25	100	25
0300	0	2	0	1	10
0400	0	0	1	2	20

Dark-7/21-22/76

Time	5	6	14	15	22
2200	0	0	1	0	0
2300	0	0	0	0	0
0000	0	0	1	0	0
0100	0	1	3	0	0
0200	0	0	0	0	0
0300	0	1	0	0	0
0400	2	0	0	0	0

Chi square analysis shows an unequal distribution at the 5% level along the length of the pier, confirming the observation that more fish were gathered under the lights over deeper water than over shallow water.

Acoustic data. Interesting results were obtained on July 23-24 when the acoustic equipment was tested. Fig. 7 illustrates the dispersal of fish the moment the lights were turned off, preceded by a 96-min exposure. Fig. 8 illustrates the gathering of fish after the lights were turned back on. Six minutes elapsed between the end of the chart in Fig. 7 and the start in Fig. 8. Similar gathering and dispersal was obtained during two other trials that night. The acoustic gear also revealed large numbers of fishes present below the observable depth.

Yellow 100-W Floodlights

Qualitative observations. About the same number and kinds of fishes were observed during the two pairs of nights when yellow floods were used as when the white floods were in place. It was again obvious to the observers that the lights attracted fishes.

Count data. Table 3 lists the number of fish counted in the spotlight during the yellow-light nights. The sum of the fish counted during the two light nights is 1,387; that of the dark nights, 12. Table 4 lists the sum of the fishes counted at each station during the yellow-light nights after correction for blank data. Chi-square analysis again shows an unequal distribution at the 5% level along the length of the pier, with more fish gathered under the lights over deeper water.

Table 4. Sum of fishes counted at each station during the light nights (yellow 100-W), Bangor Annex, Hood Canal, Washington

Station	5	6	14	15	22
Σ	1	3	380	359	614

Responses to colored lights. Figs. 9 and 10 show the fish present at Station 18 during the last 5 min of each colored light run for July 24-25 and July 25-26.

TABLE 3
 Numbers of fish observed in spotlight (yellow 100-W)
 Bangor Annex, Hood Canal, WA

Light-7/26-27/76

Time	Station				
	5	6	14	15	22
2200	0	0	2	0	0
2300	0	0	0	0	6
0000	0	0	0	0	15
0100	0	0	3	4	1
0200	1	0	1	0	7
0300	0	3	0	0	25
0400	0	0	0	0	0

Dark-7/27-28/76

Time	Station				
	5	6	14	15	22
2200	0	0	1	0	0
2300	0	0	0	0	0
0000	0	2	0	0	0
0100	0	0	0	1	0
0200	0	0	0	0	0
0300	0	0	0	0	0
0400	0	1	1	0	1

Light-7/28-29/76

Time	Station				
	5	6	14	15	22
2200	0	0	20	0	10
2300	0	0	50	50	100
0000	0	0	100	50	100
0100	0	0	2	100	100
0200	0	0	100	100	50
0300	0	0	2	5	100
0400	0	0	100	50	100

Dark-7/29-30/76

Time	Station				
	5	6	14	15	22
2200	0	0	2	0	0
2300	0	0	0	0	0
0000	0	0	0	0	0
0100	0	0	0	0	0
0200	0	0	0	1	0
0300	0	0	2	0	0
0400	0	0	0	0	0

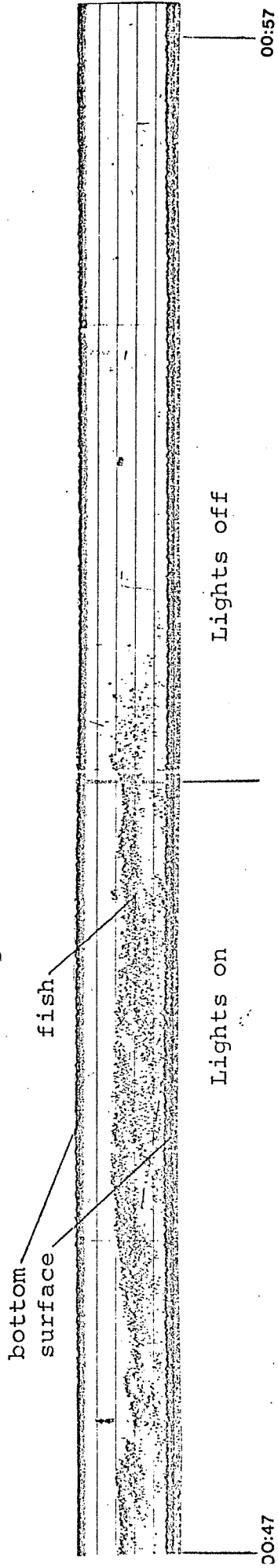


FIG. 7. Chart from acoustic equipment showing fish present at section 18
0047 to 0057, July 24, 1976, Bangor Annex, Hood Canal, WA

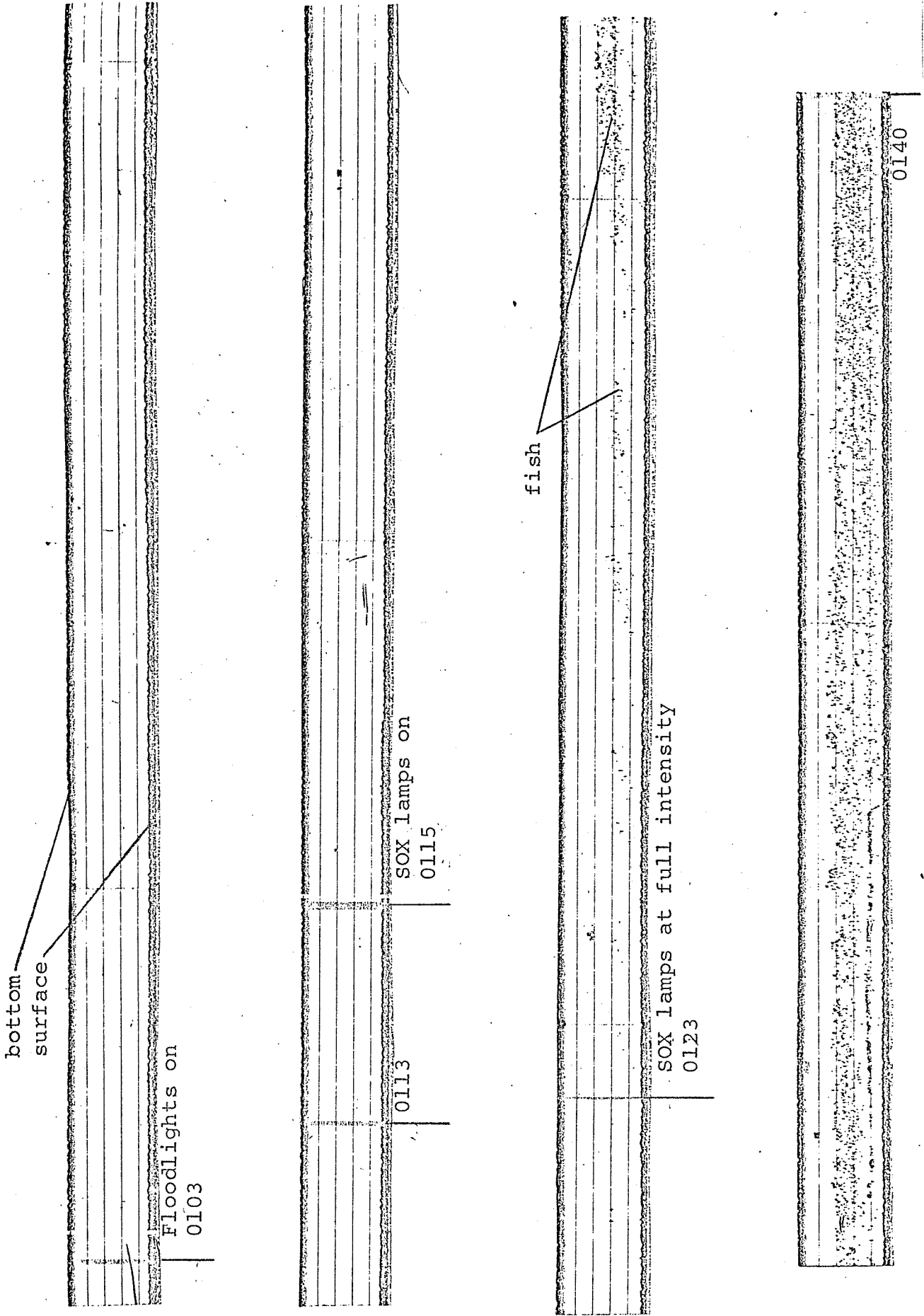


FIG. 8. Chart from acoustic equipment showing fish present at section 18
0103 to 0140 July 24, 1976, Bangor Annex, Hood Canal, WA

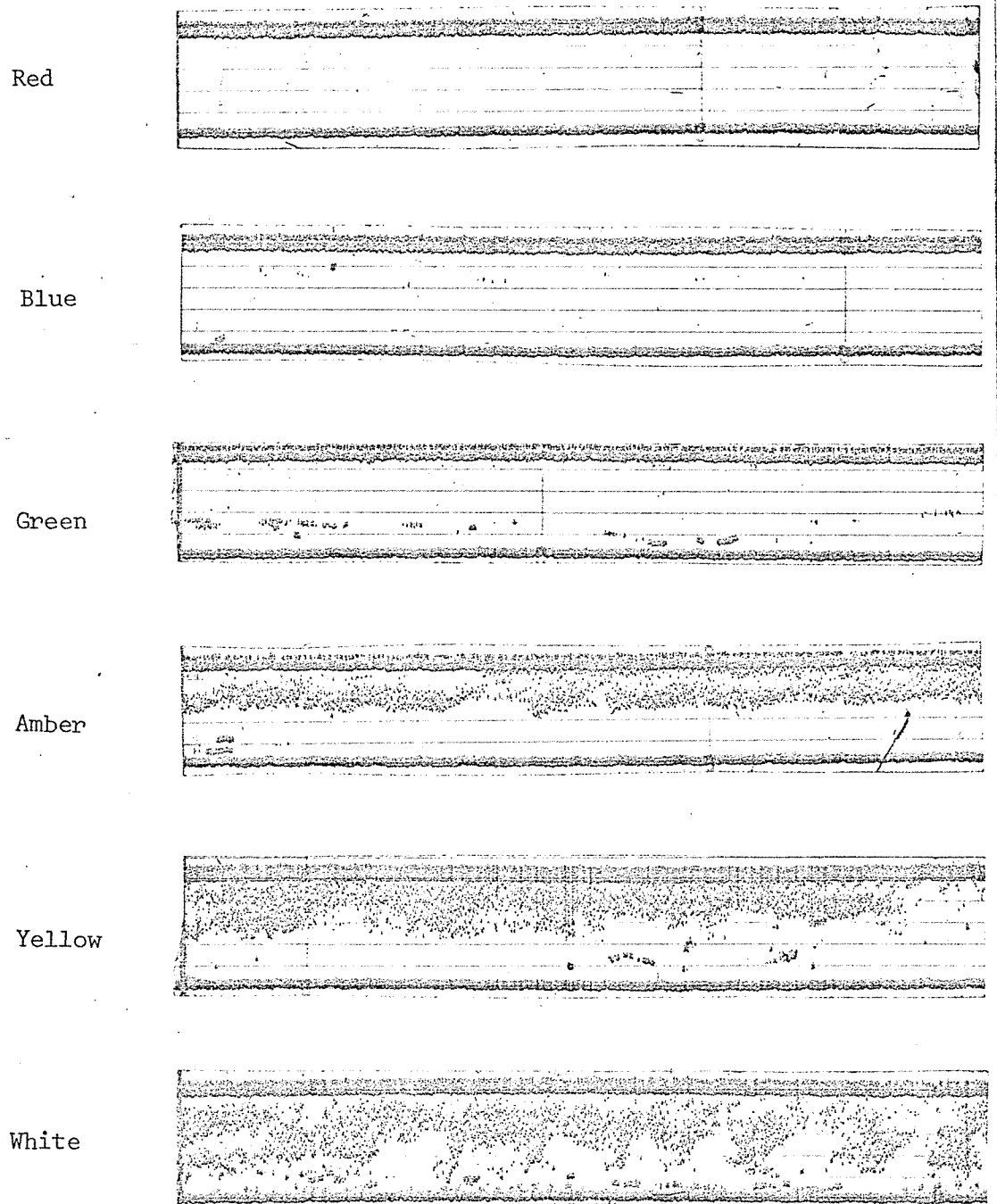


FIG. 9. July 24-25, Station 18. Chart recordings showing fish present in transducer cone during last 5 minutes of each half-hour colored-light run, Bangor Annex, Hood Canal, WA

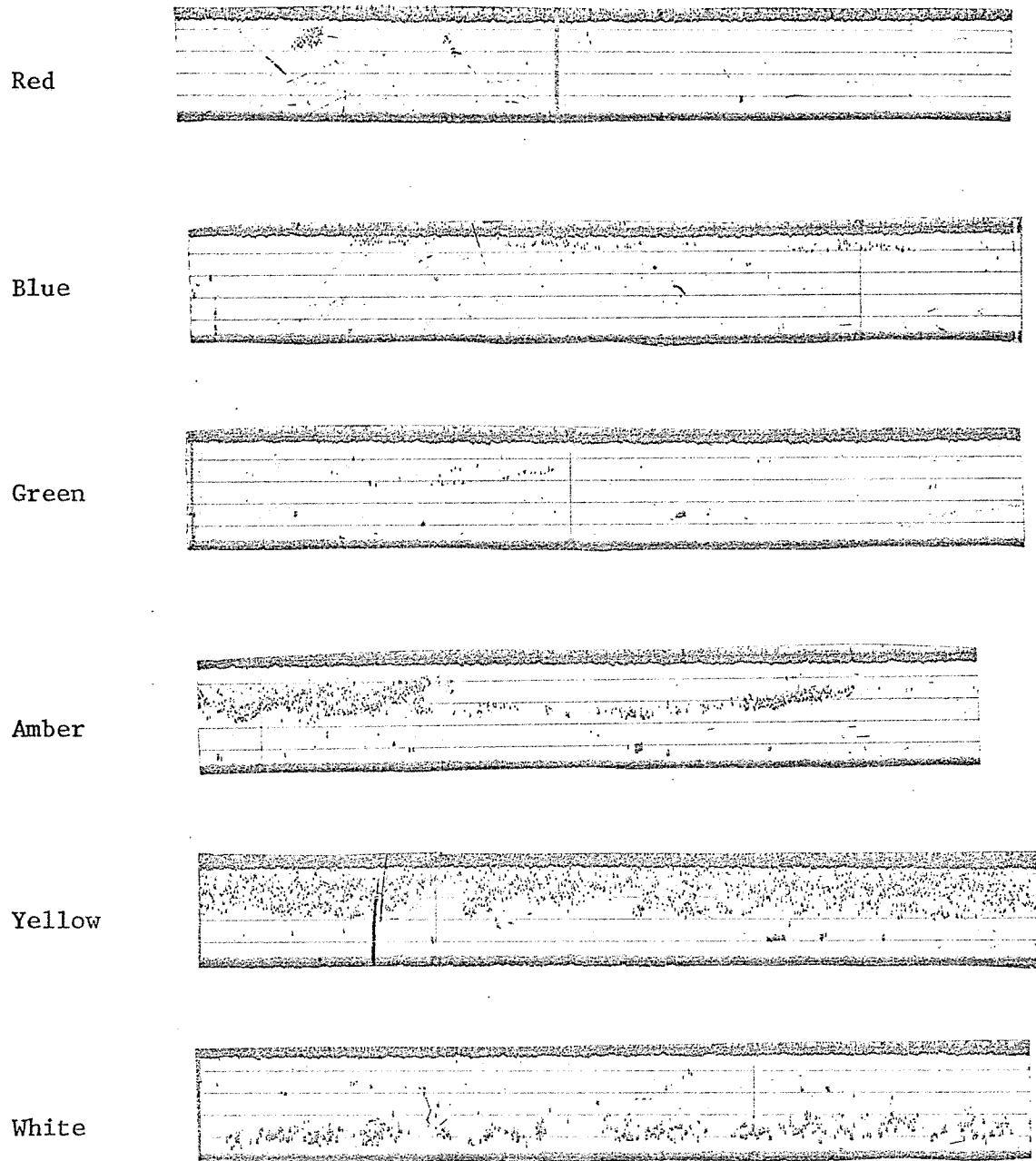


FIG. 10. July 25-26, Station 18. Chart recordings showing fish present in transducer cone during last 5 minutes of each half-hour colored-light run, Bangor Annex, WA.

DISCUSSION

Attraction Responses to Pier Lighting

The clarity of the count data, qualitative judgments of the observers, and results obtained with the acoustic gear allow us to conclude that fishes were attracted to lighting similar to that proposed for the completed EHW under site conditions from July 1 to 30, 1976. Replacing the white 75-W floodlights with yellow 100-W lights did not decrease the attraction response. No quantitative data on species composition were collected, but migrant salmonids were seen grouped under the lights. Many more herring and perch were observed than salmonids, but it should be noted that the salmonid outmigrations were declining and nearly over.

Responses to Colored Lights

The colored floodlights of the same wattage and voltage produced different light intensities. Therefore, the differences in attraction response to the colored lights cannot be attributed solely to the different wave lengths. However, a rough qualitative judgment can be made that the white 150-W-PAR 130-V and the yellow 100-W-PAR 130-V floodlights attracted more fish than the red, blue, or green 100-W PAR 130-V floodlights.

RECOMMENDATIONS

Objectives

This study revealed some fishes were attracted to lighting. Further study should concentrate on the effects of lighting on outmigrating salmonids, especially chum salmon.

Distinction should be made between determining the response of salmonids to lighting and the effect of this response. Future studies may determine that salmonids are attracted to lighted piers, but the effect of this attraction would need consideration. The objectives of any further study should be clearly defined.

Methods

Because light responses in the laboratory may differ from field responses, work was carried out in the field. The location of the temporary lighting system on the EHW No. 1 enabled on-site study. Use of the R/V Kumtucks for living facilities and office and shop space with easy access to the EHW was convenient.

No problems were experienced with the temporary lighting system. Lighting similar to that proposed for the completed pier was obtained.

Further field work must involve an accurate method of identification and enumeration of fishes present in the study area. The modified acoustical gear worked well to quantify the number of fishes present in a sample area, but identification was impossible. Identification by surface observation was limited to the first 2 meters and was not very accurate or precise. Divers disturbed the fishes and could rarely come close enough for accurate identification. Photographic methods with visible or infrared flash should be investigated. If nets are used to gather a sample, quick action is needed for non-biased results during dark and lighted nights. Salt-water electrofishing is possible and should be looked into. Acoustical television would be excellent for both enumeration and identification but is cost prohibitive.

If work is done with colored lights, it should be realized that different colored lamps of the same wattage produce different levels of light intensity.

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