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by

A. W. H. NEEDLER, Director

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of the University of British Columbia, in an effort to describe their normal appearance, which would facilitate the detection and diagnosis of diseases and parasites. Emphasis was placed on the descriptive anatomy (including measurements and color) of the visceral organs.

Oceanography. In August, 1955, Canada, through the Pacific Oceanographic Group, took part in a synoptic survey (NORPAC) of the Pacific north of the Tropic of Cancer. The Canadian vessel, the frigate H.M.C.S. Ste. Therese, covered the area between Latitudes 46° and 55° N, and from the Canadian coast to Longitude 176° W, occupying 85 stations and sailing 7,160 miles. Data will be exchanged with the Japanese and United States agencies concerned. This survey, perhaps the greatest cooperative oceanographic operation yet carried out, has improved our basis for understanding the distribution of salmon on the high seas as well as the oceanographic influences on our fisheries generally. Similar operations will be especially valuable if they can be carried out in connection with the more extensive fishing to sample salmon stocks which is part of the INPFC research program for 1956. Findings in 1955 already suggest that the 14° C. isotherm marks the approximate southern boundary of salmon and northern of tuna. The NORPAC operation is described in greater detail in the report of the Joint Committee on Oceanography.

SALMON MANAGEMENT IN THE SKEENA AREA.

In October, 1954, the Chief Supervisor of Fisheries and the Director of this Station were appointed as a committee responsible for the management of the Skeena River salmon fisheries, thus bringing the resources of administration and research into particularly close cooperation to that end. The Station's program of research in the Skeena area was expanded in 1955 and additional projects are planned for 1956. Attention has been concentrated to date on sockeye salmon but additional research to assist in the management of the large pink salmon resources of the area is under consideration. The committee has made use of earlier research by the Station (as well as of the current investigations) as a basis for decisions regarding regulation of the fishery but a number of gaps in our knowledge remain to be filled. The actual management activities of the committee have been reported elsewhere and only the research carried out by the Station for the committee is summarized here.

Skeena sockeye catch. The Skeena sockeye catch in 1955 (only 157,358 fish) was exceptionally low and the escapement (101,976) was also very poor indeed (see below). The catch of pink salmon, on the other hand, was exceptionally large and the escapements apparently good. Catches and escapements of spring, coho and chum were moderate. The slide which damaged the runs to the Babine area in 1951 and 1952 affected the 4-year-old sockeye returning in 1955 but not the 5-year-olds or the pinks. The average ratio of 4_2 sockeye (4-year-old with almost two years in fresh water) to 5_2 sockeye is 45:43 in the Skeena area. In 1955 the composition of the catch (as indicated by a sample of 604 fish) was 15% 4_2, 59% 5_2, 14% 5_3 and 11% 6_3, showing the relative scarcity of the 4_2 fish. Even when the effects of the slide are taken into account the run seems to have been below expectation, as were many sockeye runs from the Fraser to Alaska.

Fishing and tagging in the estuary. In 277 standard gill-net sets or "drifts" between May 26 and September 28, just above the up-river boundary of the commercial fishery, 6,483 salmon were caught (1,267 sockeye, 780 spring, 3,688 pink, 126 chum and 622 coho). It is hoped that, by relating such catches to escapements, an almost immediate index of the numbers of salmon getting through the fishery will be developed in a few years as an aid to regulation of the fishery to provide optimum escapements. Starting July 17, gill-nets of ten panels of different meshes from 3½ to 8-inch stretched measure were used, reducing selectivity and providing reasonably good sampling of all sizes. A promising indication that this fishing is indicative of escapement was given by variations of the catch in accordance with weekly closures of the commercial fishery.

Tags totalling 2,964 were placed on salmon taken by this fishing (823 on sockeye, 375 on springs, 1,488 on pinks, 45 on chums and 233 on cohos). To date, 333 have been recovered, about two-thirds from the commercial fishery and one-third from up-river areas. The proportion of the total recovered was 11%, of sockeye 22% and of pinks 3%. The purpose of the tagging is to discover when runs to various areas pass through the fishery.

Spawning runs, egg deposition and smolt production in the Babine area. The adult salmon spawning escapement to the Babine Lake area has been enumerated at a counting fence each year since 1946, as shown in the following table:

Year	Sockeye	Percentage of "jack" sockeye	Spring	Pink	Coho	Chum
1946	475,705	12.2	10,528	28,161	12,489	18
1947	522,561	50.0	15,614	55,421	10,252	7
1948	560,000[x]					
1949	509,132	9.4	7,433	13,663	11,938	5
1950	543,658	33.0	6,838	38,728	11,654	7
1951[xx]	152,457	7.2	2,778	50	2,122	0
1952[xx]	376,947	7.4	5,915	2,706	10,554	1
1953	714,614	3.9	8,353	1,108	7,648	17
1954	503,422	1.9	5,925	4,604	3,094	66
1955	101,976	30.0	3,528	2,151	8,947	3

[x]Estimated from comparison with stream survey and fence counts of previous years.

[xx]The runs of 1951 and 1952 were blocked by the Babine River rock slide. The effective spawning in 1952 was less than the number of adults indicates, many fish being so damaged or delayed as to prevent spawning.

The runs of sockeye salmon have shown considerable variation in magnitude and composition, being influenced by the rock slide which partially blocked the 1951 and 1952 runs, and by restrictive measures applied to the commercial fishery in 1953. In order to obtain the full picture of the potential egg deposition, the proportion of females, and their size, are studied each season. Female fish formed about 37% of the 1955 run, large males 33% and "jacks" (precocious 3-year-old males) 30%. This low proportion of females in an already small run, combined with a low egg content, gave a potential egg deposition slightly in excess of 100 million, the lowest recorded since the investigation commenced in 1946.

Since 1951, estimates of the size of sockeye smolt runs from Babine Lake have been made by marking portions of the run captured at Fort Babine and recovering marked individuals at the outlet of Nilkitkwa Lake among counted samples. Since the number of eggs carried into the Babine watershed is known from counts and examination of spawners, the survival from egg to smolt can be derived for any brood year. Furthermore, smolt production from spawning escapements of different known sizes throws light on the optimum size of escapement to the Babine area, the largest sockeye producer in the Skeena system.

The remarkable smolt run of 1955 can be compared with those of other years:

Eggs deposited in	1949	1950	1951	1952	1953
Potential deposition	869×10^6	583×10^6	198×10^6	x411×10^6	$1,254 \times 10^6$
Smolts resulting	4.2×10^6	4.5×10^6	3.1×10^6	2.8×10^6	31×10^6
% Survival	0.48	0.77	1.57	0.68	2.47

xProbably two-thirds of these eggs were not actually available because of the effect of the Babine Slide on the 1952 spawners, making the survival 2%.

The 1955 smolt run of over 30 million came from much the largest egg deposition recorded since smolt estimates were begun. The tendency for the smolts to be small in size when runs are large has been noted previously and was still true in 1955, but the tendency for survival rates from larger egg depositions to be low did not hold. There are indications from sampling of young sockeye at Babine Lake this summer (see below) that they do not use the food resources throughout the whole lake in the same way every year because of limited dispersion of fry from the spawning areas. Better utilization of the lake resources by the young sockeye in 1954, coupled with favourable conditions for incubation and winter survival, may account for the sudden production of a smolt run of a new order of magnitude.

STUDIES OF THE SOCKEYE SALMON FISHERIES.

The age composition of sockeye catches. The catches of sockeye from the Nass River, Skeena River, Rivers Inlet and Smith Inlet gill-net fisheries are sampled each year to determine the age, sex and size composition. The age data indicate the brood years from which the sockeye in the catches originated. For 1954 and 1955 catches the percentages of the major age-groups in the samples were:

Area		1954	1955	40-year average[x]
Nass River	4_2	35	12	19
	5_2	20	15	11
	5_3	40	70	62
Skeena River	4_2	48	15	45
	5_2	43	59	42
Rivers Inlet	4_2	60	45	50
	5_2	39	54	48
Smith Inlet	4_2	61	42	35
	5_2	38	58	64

[x]Except for Smith Inlet, which is based on only 10 years.

If to the foregoing figures we could add those of the escapement, the age and sex composition of the returning stock could be computed and a better idea of the factors affecting the return of the sockeye would result. Limited sampling of the Rivers Inlet sockeye escapement during the past five years has indicated that the selectivity of the fishery may result in the age and sex composition of the escapement being somewhat different from that of the catch. This would have significance if, as seems to occur in that area, 4-year-old sockeye produce a return in four years and 5-year-old fish produce a return in five years.

Comparative study of Skeena River and Rivers Inlet sockeye catches. The age composition of catch samples which have been collected for the past 40-odd years has been used to compare sockeye catches at Rivers Inlet and Skeena River, with the intention of determining causes of fluctuations in abundance in the two stocks.

Comparisons between numbers of parent and offspring, and between fish of the same brood-year stocks that matured in different years, confirm the existence of hereditary factors in determining age at maturity. The influence of environmental conditions upon age at maturity could not be disproven, but it must be less important.

Catches at both rivers showed marked annual variability, but with definite indications of 5- and 4-year "cycles" of abundance among the 5- and 4-year fish, respectively. Peaks and lows in the two areas seldom occurred simultaneously, but Skeena River was usually one year ahead of Rivers Inlet.

In both rivers there was a preponderance of age 5_2 fish in earlier years, followed by a period (1925-1941) in which 4_2 fish were usually in excess, and more recently a return to the dominance by 5_2 fish.

In both rivers the average sizes of 5_2 fish have remained relatively constant or have increased slightly, but the average size of 4_2 fish has decreased by about 1/2 pound.

It is concluded that among sockeye salmon populations the principal factors responsible for variations in adult production are the number and the age composition of the spawning stock. In each age-class, levels of abundance tend to be proportional to the numbers of the parents of the same age-class, and these levels tend to be perpetuated. Variations in environment frequently destroy this condition of stability.

SOCKEYE SMOLT PRODUCTION AT PORT JOHN.

The propagation of a small sockeye population has been studied at the Port John field station for the past seven years in association with similar studies on other species. The run of 1,470 in 1954 was within the range of runs counted in earlier years; the run of 2,566 in 1955 was the largest yet recorded. The timing of the runs has been similar in all years. A fairly constant loss of between 25 and 30% occurs between entrance from the sea into Hooknose Creek and entrance of spawning brooks from the lake.

In 1955, 76,700 fry resulted from an egg deposition of about 745,000 - a survival of 9.7%. The survival in the seven years has varied from 1.8% to 25%. In 1955, 43,000 fry were released directly into the sea and all smolts are being marked in 1955 and 1956 to distinguish them from the returns from this experiment. In 1955, 14,866 smolts migrated to sea. Smolt production has varied between 11,000 and 20,000 from egg depositions of 300,000 to 2,000,000.

FACTORS LIMITING FRESH-WATER PRODUCTION OF SOCKEYE.

The factors that limit the production of young sockeye to the stage at which they migrate to sea as smolts have been studied in order to understand changes in sockeye abundance and devise means of increasing it. A thorough knowledge of how these factors operate is essential both to regulation of the fishery to best advantage and to development of positive measures to increase sockeye production by improving the conditions in fresh water. At Lakelse Lake, commencing in 1949, the relations between the number of eggs deposited, the number of fry produced and the number of yearlings migrating to sea have been determined and the effects of various environmental factors on the survival and growth of the young sockeye have been studied.

During the past four years enumeration techniques have been developed and intensive studies on survival in the streams and on predation during the lake residence of the sockeye have been completed. Attention is now being focussed on the interrelation between sockeye in the lake and their zooplankton food. Methods for capturing the young sockeye at all stages in their lake residence and for evaluating the zooplankton supply have been developed. Work in this phase of the investigation has been extended to other areas in the Skeena drainage, notably Babine, Nilkitkwa and Kitsumgallum Lakes.

Adult sockeye runs to Lakelse Lake. From 1944 to 1951 the numbers of adult fish spawning in the Lakelse area were estimated by tagging and by partial fence counts. Since 1952, absolute counts have been made of almost all the Lakelse spawners. The methods used to estimate the early runs have been carefully checked, indicating that estimates based on tagging tended to be too high, while those based on partial fence counts were too low. Approximate corrections have been applied and the revised data show that during the past twelve years the adult run to Lakelse has averaged 14,500 (varying from 3,700 to about 25,000).

There has been a general decline in the escapement, the runs in the past four years amounting on the average to only about 1/2 to 2/3 of those from 1944 to 1948. Tagging has shown that the Lakelse run moves through the fishery in mid-June. From 1944 to 1948 the fishing season opened, on the average, on June 29; since 1949 the average opening date has been a week earlier (June 22). The resulting increased exploitation of the Lakelse sockeye run may explain the recent drop in the escapement, at least partially.

Survival to the fry stage. For the past two years, estimates have been made of the numbers of fry entering Lakelse Lake in the early spring. At Williams Creek (where over 90% of the Lakelse sockeye spawn) the survival rate from egg to fry (17.7%) was over twice that estimated in 1954 (7.8%). The increase was, in part, attributable to a stream improvement program carried out on the creek by the Department of Fisheries. Through blockage of a diversion channel in 1953, flow conditions in the creek were better in 1954 (the brood-year of the 1955 fry run) than in 1953. As a result, next year's smolt run is expected to be better than those of the past three years despite the fact that the 1954 egg deposition was one of the lowest on record.

Studies on fry survival at Scully Creek (used by about 7% of the Lakelse spawners) were concluded in 1955 after six years of fence counts of both adults and fry. The survival from egg to fry has been fairly constant (9.3 to 13.8%) despite a wide variation in the numbers of spawners (121 to 507 females). It was found that on the average 15% of the eggs deposited fail to be fertilized, and between 60 and 80% of the remainder die in the gravel, leaving about 20 to 30% of the original number to hatch and emerge from the gravel. Of these, from 20 to 70% fall to predators in the stream, leaving on the average about 10% of the original number of eggs by the time the fry reach the lake. A larger proportion of the fry are taken by predators when the fry run is small than when it is large.

Research has been conducted on the behaviour mechanism underlying the downstream migration of sockeye fry. The results suggest that the downstream movement starts as the light intensity falls to zero and ends abruptly at the approach of day. Artificial light almost completely prevents the movements of fry under conditions otherwise simulating those in nature. In general, it is felt that displacement by the current, resulting from a failure of visual processes at low light intensities, plays a large part in the downstream movement.

Survival to the smolt stage in Lakelse Lake. The survival rate from egg to smolt has averaged 1.4% (range 1.0 to 4.9%); in five of the seven years for which records are available, the survival was between 1.0 and 1.8%. There has been no obvious relationship between the number of eggs laid and the number of smolts produced, nor any evidence of a lower growth rate in years of high than in years of low smolt populations. These facts suggest that neither competition for spawning area among adults nor competition among young fish in the lake for food is limiting production of sockeye in the area, i.e., neither the capacity of the spawning area nor that of the nursery grounds is now being taxed.

The first direct measurement of survival from fry to smolt was obtained in 1955. Of an estimated 1,500,000 fry entering the lake in the spring of 1954, 312,000 (21%) emigrated as smolts in 1955.

Estimates of the numbers of predators and studies on their diets and movements indicate that predation is the major cause of sockeye mortality between the fry and the smolt stage. These studies were completed this year and analyses are now being conducted to gain detailed information on the relations between the size of predators and prey, on the effects of changes in distribution of predators and prey, and on the timing of predation. This will be useful for assessing the importance of predation in other areas and for discovering methods of controlling it.

Tow-net hauls and small-mesh gill-net sets in the offshore waters, where young sockeye feed, have failed to take juvenile stages of other species. This suggests that direct competition with these species is not an important factor limiting sockeye production at Lakelse.

Collections of young fish and plankton show that the distribution of the sockeye in the lake is related to the distribution of the zooplankton, which in turn is determined mainly by light and currents. The rate of growth of the young sockeye is influenced both by temperatures and the availability of their zooplankton food. Preliminary measurements suggest that the content of nutrient chemicals in the lake water indirectly limits zooplankton production at Lakelse.

It was originally planned to carry out fertilization or predator control in an attempt to increase the production of sockeye. However, the adult escapements in the last three years have been so low that it is doubtful whether a significant increase in the annual yield of smolts could be achieved. To do this it would probably be necessary first to increase the output of fry from the creeks, either by providing larger adult escapements or by artificial propagation in the creeks. Neither of these alternatives appears to be feasible in 1956.

Smolts in other Skeena lakes. Periodic collections at Kitsumgallum Lake indicate that the quantities of zooplankton and temperatures were much lower than at Lakelse. The young sockeye population of the lake was composed of individuals in both their first and second years (unlike Lakelse and Babine Lakes, where very few second-year fish have been observed) and that they had a much slower rate of growth than at Lakelse.

Collections of young sockeye at Babine Lake and Nilkitkwa Lake (an enlargement of the Babine River) showed that the distribution of young sockeye was related to the distribution of the parent spawning population and that 70% were concentrated in 12% of the total available nursery area. Extreme low rates of growth in the areas of concentration indicate overcrowding. Sockeye taken in the more sparsely populated regions of Babine Lake show a rate of growth comparable to that in Lakelse Lake, and temperatures and quantities of zooplankton also appeared to be comparable. Work in the Babine area will be expanded next year to follow up these findings which are very significant to management of the important Babine sockeye run.

Preliminary visits were made to Bear and Morice Lakes during the spring smolt runs. Samples were collected for comparison with smolts from other areas and samples of zooplankton were also obtained. The data have yet to be analyzed.

SPRING AND COHO SALMON.

Over the last four years spring and coho salmon have together contributed 22% by weight and 28% by value of the commercial salmon landings of British Columbia. Approximately two-thirds of each species is caught by troll and the remainder by gill-net. A rapidly expanding ocean sport fishery also operates in the Strait of Georgia. The international nature of the ocean migrations, especially by Columbia River "chinook" (spring) salmon, has led to close cooperation with the United States biologists through the Pacific Marine Fisheries Commission. After the record low catch on the Columbia River in 1954 they expressed grave concern regarding the sharp decline in the fall chinook salmon stocks in recent years and restrictive measures were advocated for trolling along the entire coast. Trollers in British Columbia are also concerned about the condition of the stocks which they fish.

Information has been obtained in recent years on ocean migrations (by tagging and marking experiments), on growth, food and maturity (by sampling) and on the mortality of releasing small fish (by field experiments). Present results suggest that minimum size limits are not good conservation measures because when small fish are caught and released the mortalities are too high for any gain to result from the increase in growth of the survivors. In 1955, sampling of the troll catch for marked fish was continued at Prince Rupert and Vancouver but no new field work was undertaken. Instead a detailed appraisal of the spring salmon fishery is being prepared.

<u>The troll catch in 1955</u>. The catch of red spring salmon was late

and similar in size to the small catch in 1954. For outside waters this was associated with another poor fall chinook run to the Columbia River. The white spring catch was below the high catches of the last three years. The total catch will probably be the lowest spring salmon catch in the last five years. The coho salmon catch was also late, the peak being in August instead of in July. The September catch was low and the final total will be lower than that in the cycle year, 1952, and will probably be the second lowest catch in the last five years. This year for the first time, fishing licences were restricted to commercial fishermen only, giving more accurate information on the commercial trolling effort.

Sampling the troll catch for marked salmon. By examining 86,000 spring salmon and 68,000 coho salmon, 210 marked fish were found. As in previous years most of the fish marked in United States streams were recovered off the west coast of Vancouver Island. This sampling will probably terminate in 1956.

This season the $2\frac{1}{2}$-pound minimum size limit was relaxed for coho salmon ("bluebacks") caught in the Strait of Georgia, pending a change of the opening date in 1956 from June 1 to June 16. As a result, more small fish were captured. Sampling indicates that for June, 24% of the fish caught were less than the minimum $2\frac{1}{2}$ pounds in weight compared to 11% in 1954, 2% in 1953 and 4% in 1952. However, fish caught off the west coast of Vancouver Island were also small, especially in August, which suggests poor ocean growth for this year's stock.

History of spring salmon fisheries. Up to ten years ago the gill-netters caught at least half of the spring salmon catch of British Columbia. Since then the gill-net catch has remained at about the same level but the trolling effort and catch has increased greatly, especially off the southern part of the Province, until now the trollers are taking two-thirds of the total catch. Although past records are not too accurate, it would appear that the catches of the last decade are the highest in the history of the fishery. The proportion of white spring salmon also appears to have increased, until in 1953 and 1954 it constituted about one-quarter of the troll catch and one-half of the gill-net catch. Catch and escapement records suggest that the white spring salmon spawn mainly in certain large coastal rivers of British Columbia, especially the Fraser River, while the Columbia River stocks are composed of red spring salmon.

In the last twenty-five years the gill-net catch in the Columbia River has decreased by 75% but the offshore troll catch has been maintained by the increase in effort. Tag returns and the time of fishing indicate that our outside trollers have always fished the fall "chinook" run of the Columbia River more heavily than the earlier runs. Tagging also indicates that about 1930 the Columbia River stocks contributed over one-half of our outside troll catch but that by 1950 they probably accounted for less than one-quarter. Thus the decline in the spring and summer Columbia stocks some years ago affected our fishery to some degree early in the season, but the recent decline in the fall Columbia stocks (50% in the last five years) is affecting our outside troll catches more seriously at the seasonal peak of the fishing.

The concern of our trollers in recent years may well arise from high effort and operating costs causing a smaller individual return, without any decrease in fish production other than the effect of the recent decline in the fall chinook stocks of the Columbia River.

PINK AND CHUM SALMON FRY PRODUCED BY VARIOUS NUMBERS OF SPAWNERS.

At the Port John field station a study has been in progress for a number of years on the relation between numbers of spawners and the numbers of fry produced in pink and chum salmon. Using a weir which catches both adults and fry, the spawners entering Hooknose Creek each autumn and the fry leaving each spring are recorded. In general it has been shown that larger numbers of spawners (of both species combined) produce larger numbers of fry up to a certain point after which the numbers of fry no longer increase, and perhaps even fall off. The point at which more spawners produce no more fry is very important to management: it seems to be at a density of the order of one female to one and a half square yards of suitable gravel.

The adult pink salmon entering in 1954 numbered 31,402 producing the greatest egg deposition since the investigation started (28,000,000); the chums numbered 3,336, a moderate run. The pinks showed a return from the sea of 2.59% of the fry which left the creek in 1953. In 1955 the numbers of adults of both species were small (1,319 pinks and 1,301 chums). The figures for pink salmon to date are summarized in the following table:

Year of spawning	Spawning stock	Fry produced	Returning adults	Percentage returning
1947	5,576	33,000	1,173	5.2
1948	1,160	64,000	1,857	3.1
1949	1,173	54,000	1,670	3.2
1950	1,857	234,000	8,685	3.7
1951	1,670	243,000	1,599	0.7
1952	8,685	1,227,000	31,402	2.6
1953	1,599	204,000	1,319	0.6

Ocean survival cannot readily be determined for chum salmon since they return as mature fish at different ages.

CONDITIONS FOR SURVIVAL AND DEVELOPMENT OF SALMON EGGS.

Investigation of the conditions affecting survival and development from spawning to emergence of fry has been continued both in the field and in the laboratory. A knowledge of these conditions is essential to the development of measures to increase salmon production by improving them. Recent advances in this knowledge suggest that the production of fry under improved and controlled conditions might be made to pay, especially in the case of those species which go immediately to sea and, consequently, are not affected by the limited capacity of fresh waters to rear them over long periods. Knowledge of the conditions for optimum survival from egg to fry also have significance in regulation to provide adequate spawning escapement and no more.

The equipment and techniques used to measure rate of flow of water past salmon eggs, mentioned last year, has been improved, in cooperation with the Pacific Oceanographic Group, and better adapted to measure high velocities in loose gravel.

Survival of eggs in natural gravels. From November, 1954, to February, 1955, 130 salmon redds were sampled and velocity of flow and oxygen content measured. Pink, chum and coho eggs were recovered and their survival compared with the conditions observed. This field work indicates a minimum oxygen level for survival of five parts per million in contrast with a minimum level of about two parts per million in the laboratory with faster flows. It is suggested that the difference is due to accumulation of waste products at the velocities encountered in nature. The minimum suitable velocity appears to be about ten centimetres per hour.

Minimum oxygen requirements for developing chum eggs. The study of the effects of low oxygen on the survival and development of chum salmon eggs has been continued in greater detail and at a new level of temperature (10° C.). Experiments indicate changing oxygen requirements in various stages of development. There may be immediate lethal effects from low oxygen or delayed effects which prevent hatching or produce monsters.

In the earliest stages tested, twelve to nineteen days after fertilization, the eggs survived oxygen concentrations as low as 0.2 parts per million (only 1.8% saturation) but development was arrested and abnormalities resulted. No ill effects were apparent above 0.6 parts per million. This remarkable tolerance to low oxygen was replaced during subsequent development by a higher demand resulting in a final minimum level of about 1.8 to 1.9 parts per million for successful development and hatching. These results at 10° C. showed little difference from those at 5° C., indicating a relative independence of temperature in this range.

Fry production in a gravel bed with controlled flow. In the autumn of 1954 about three million pink salmon eggs from the Lakelse River were planted in an artificial spawning bed at Jones Creek on the lower Fraser River. The planting had two purposes: (1) It was an experiment in the establishment of a run of pink salmon by the introduction of stock from another river system; there is no run of pink salmon in Jones Creek in the even-numbered years. (2) It was an experiment in the use of controlled conditions for the production of pink salmon fry. Both these aims have great potential for increasing pink salmon production. It is too early to assess the results fully.

About 1,100,000 fry were produced. The survival from egg to fry was 37%, considerably higher than the survivals of from 1% to 23% which have been observed in British Columbia streams under natural conditions. The results will be compared with those of spawning by pink salmon in 1955, in which choice of spawning sites by the fish and other environmental factors have been under observation.

Similar numbers of migrant fry have produced many thousands of returning adults under natural conditions in smaller rivers (see the results at Port John above). If none return in 1956, more studies and experiments will be required; if there is a substantial return, important progress will have been made towards increasing pink salmon production.

BEHAVIOUR OF MIGRATING PINK AND CHUM SALMON FRY.

Dr. W.S. Hoar of the University of British Columbia continued his studies on this subject in 1955 at the Port John field station where migrating fry and facilities for experiments were available. His findings improved our understanding of the migration of the fry by bringing out clearly the change in behaviour which takes place when they first school.

Pink salmon which have never schooled are negatively phototactic, prefer a cover of stones and do not emerge into bright light. Pink salmon fry which have schooled show a strong cover reaction when exposed to a rapid increase in light intensity but do not seek cover unless the change is abrupt. In general they remain in bright light after they have schooled. This change in behaviour occurs rapidly (15 minutes or less) when the fry school for the first time. Chum salmon fry establish a definite direction of swimming in the quiet water of a circular channel or basin. The established direction is stable and not permanently disturbed by light or darkness, by water currents, by strong avoiding reactions, by changing the location or by excluding direct skylight. The direction may be initially established in relation to water currents.

These results have an important bearing on any attempts which may be made to increase salmon production by producing fry under controlled conditions. The fry must be released in a manner which will take account of their migratory behaviour and the way in which it changes when schooling takes place.

LOW LETHAL TEMPERATURES IN YOUNG SALMON.

In conjunction with the planting and culturing of chum salmon for introduction to Hudson Bay, laboratory tests on the tolerance of chum salmon fry and sockeye yearlings to low temperatures in salt water have been conducted. For each species, samples of fish were first acclimated to two levels of temperature, 2.5° C. and 5.0° C., and exposed for a period of one month or more to a salinity of 27.28‰. Subsequently, tolerance tests were performed at three levels of temperature, -0.5, -1.0, -1.5° C., and at approximately the same salinity. None of the young salmon withstood the test temperatures for more than three days. It appears that survival during winter in Hudson Bay would depend on refuge in brackish or fresh water, or migration out of the Bay to warmer waters.

GUIDANCE OF MIGRANT YOUNG SALMON PAST OBSTRUCTIONS.

The rapid development of British Columbia brings a demand for water for power, irrigation and other uses. This demand presents a growing threat to the fishing industry which depends on the reproduction of salmon in fresh waters which are both accessible and close to their natural condition. There is no prospect in view of preventing altogether the damage caused by dams on salmon rivers, and the work reported here must not be interpreted as making such dams possible without serious loss to the fisheries. It seems important, however, to explore every possible means of maintaining salmon production in rivers with obstructions to the passage of salmon. The most difficult problem is to guide young salmon past obstructions to their downstream migration. There appear to be two principal aspects to this problem - the guidance of the fish to a by-pass and the design of an opening which they will enter.

Guiding sockeye and coho smolts. Two lines of research have shown promise, one based on the reaction of the salmon to visual stimuli and the other on their reaction to electric fields. The Station's work at the Lakelse River counting fence follows the former approach. It is hoped that a combined study of both can be arranged in 1956.

A new deflector, based on earlier experiments, was tested in 1955. It consisted of a moving curtain of ¼-inch cables suspended vertically in the water and travelling on a continuous belt which turned back at the opening into which the salmon were to be guided. The deflector was so placed as to guide smolts away from one opening in the Lakelse River fence, which is preferred, towards another, and the effectiveness of the deflector was assessed by comparing the route taken by the young salmon with that taken normally. The effectiveness of different intervals between cables (4, 6, 8 and 10 inches) and various rates of travel (4, 8 and 12 inches per second) were tested by day and by night, with and without illumination.

There appears to be both a critical rate and a critical interval for most effective operation, but in general the higher the rate and the smaller the interval, the greater the deflection. Experiments at critical rates of operation (8 and 12 inches per second) and critical intervals (4 to 6 inches) resulted in an average deflection of 89% of the sockeye (range 86% to 96%) and 58% of the coho (range 36% to 81%). Bright lighting at night provided better deflection than no lighting, or the full light of day-time. Repeated experiences by the same fish along the deflector reduce its effectiveness.

Designing a by-pass which young salmon will enter. Experience has shown that successful guidance is finally dependent on a by-pass which the fish will enter, thus eliminating any accumulation of migrants along the deflector and permitting a continuous downstream movement of the fish. An experimental by-pass built in the Lakelse fence to receive the deflected smolts incorporated a series of cross-reflecting mirrors lining a plywood shoot. It was designed to minimize all visual or otherwise sensible cues which might influence the fish (e.g., points of turbulence) while at the same time accelerating the in-coming water to exceed their swimming speed. With the exception of the approach to the by-pass, which inclined upwards and appeared brighter because of a fill of fresh gravel, schools of sockeye readily moved down the shoot and were swept into the trap. Dim light at the entrance was more effective than bright or no lighting, when the deflector was floodlit. Coho, which usually swam at a lower level in the water than sockeye, did not enter as readily. Future designs might be modified to meet these limitations. The general principles applied in this first effort proved to be valuable and contributed to the deflection achieved.

Enough is now known to make an applied test of deflector and by-pass desirable. Although the same degree of success has not attended the guiding of coho smolts, an extension of the same techniques would appear to hold good promise. A cautionary note must be interjected, however, since the few experiments on guiding fry, as distinct from the larger smolts, have been relatively unsuccessful.

Sight in young salmon. The above experiments use visual orientation in smolts but have been conducted with little knowledge of the vision of the fish. Basic studies of this nature have been started. The relation of rods and cones, and the masking effects of the heavily pigmented retinal epithelial cells, are under investigation both histologically and experimentally. The histological techniques of staining and sectioning the eye have reached a stage where ready cytological examination is possible. Two pertinent findings have resulted to date. Young salmon require about thirty to forty minutes to adapt their vision to darkness and this stage is reached about half way through the evening seaward migration of Lakelse sockeye. This means, for instance, that colour vision, as far as it occurs in fish, would be eliminated with at that stage and that a change in spectral sensitivity occurs during migration.

Adult salmon repellent. In cooperation with the Pacific Fisheries Experimental Station, continued efforts are being made to isolate the ingredient in mammalian skin which acts as a repellent to migrating adult salmon in fresh water, with a threshold dilution of 1 part in 80,000,000,000.

Its characteristics are now sufficiently well defined to permit testing of possible synthetics. One (an amino acid) has shown limited effectiveness. It is desirable to obtain an active synthetic since the concentration of the repellent from natural sources is laborious and would reduce its practical value.

HERRING.

In autumn and winter, on their pre-spawning migration, herring concentrate in inshore waters where they are fished mainly by an efficient purse-seine fleet. To avoid the danger of leaving too few spawners to maintain the population, the fishery is regulated by restrictions on the catch, season and gear. The purpose of the Station's investigations of herring is to provide the scientific basis for regulation to ensure that maximum use, without endangering future yield, is made of the resource and to aid industrial efficiency by prediction of abundance. The manner in which natural factors and the fishery affect the recruitment, abundance and distribution of herring must be understood. While the former cannot be controlled, the latter can, but should be only to the extent necessary to maintain long-term yield.

Information bearing on these objectives is obtained from five sources: (1) A tagging and tag-recovery program. (2) The collection of catch statistics to provide information on the catch and fishing effort on each major fishing ground. (3) Sampling of the catch to show the age composition and average lengths and weights of fish in different areas. (4) Observation of the amount and intensity of spawn deposition in all areas. (5) The assessment in certain areas of the abundance and distribution of young herring in their first year. The tagging program permits the definition of the limits of the various populations and the assessment of the extent of intermingling between them. Information from catch statistics, age composition and amount of spawn deposi-