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EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1958

BIOLOGICAL EFFECTS OF THE RIPPLE ROCK EXPLOSION

Ripple Rock was long a serious hazard to navigation in Seymour Narrows, part of the island waterway on the coast of British Columbia. Its twin peaks that rose to within 20 feet of the surface caused numerous accidents in the past. Removal of the twin peaks was undertaken by the Canadian Department of Public Works, and consisted of driving a 2500-foot tunnel from Maud Island, under the narrows, to terminate in a series of passages within the peaks. These passages were filled with 2,750,000 lb. of explosive (duPont Nitramex 2-H). The charge, designed to clear the waterway to a depth of 40 feet below sea level, was detonated at 9.31 a.m. P.S.T. on April 6th, 1958 (Fig. 1). The blast was timed to take advantage of low water and maximum tidal velocity, the former to decrease the over-burden on the explosive, and the latter to sweep broken rock away from the blast site.

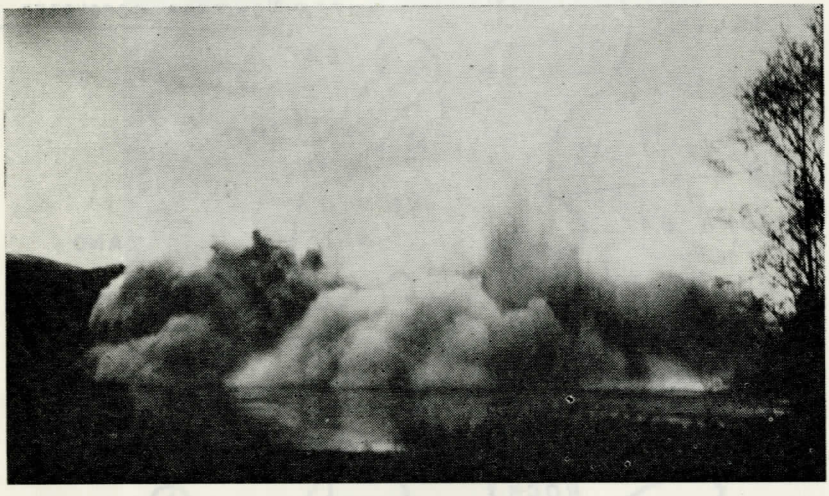


FIG. 1.—Explosion of Ripple Rock, from a mile away.

Through the co-operation of the Department of Public Works, the Fisheries Research Board of Canada and Department of Fisheries were able to conduct a study of the effects of the blast on the fish populations in Seymour Narrows. This study had two aspects: (1) to survey the area for surface kill immediately after the blast, and (2) to study the effects on fish placed in cages at various distances from the blast site (Fig. 2).

PREPARATIONS

For the study of caged fish, use was made of commercial crab traps (Fig. 3) and floating live ponds. Boat traffic and the tidal currents in Seymour Narrows precluded the use of surface floats and buoy lines to each crab trap. They were, therefore, set in strings of three to nine traps from shore anchors, or tied to surface lines stretched across the mouths of bays. The floating live ponds also were tied to these surface lines, or lashed to wharf pilings.

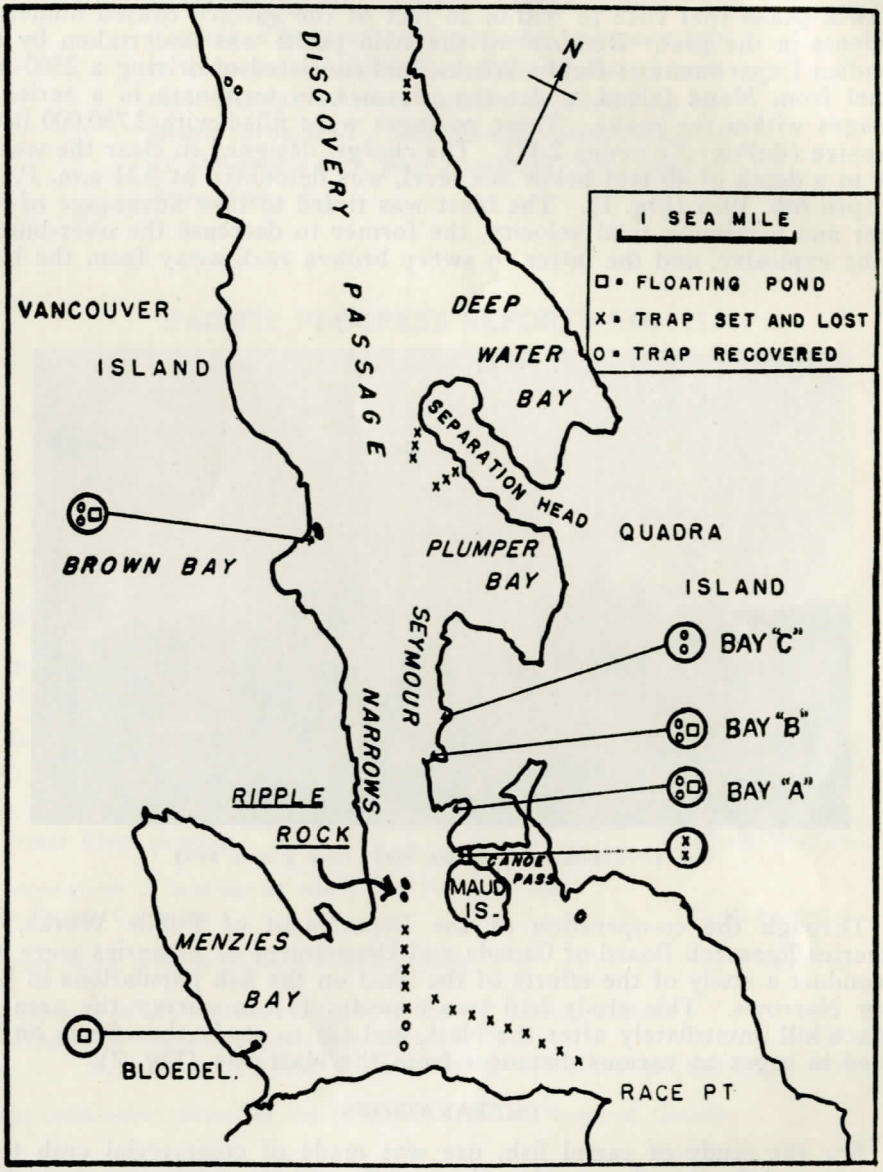


FIG. 2.—Ripple Rock blast area.

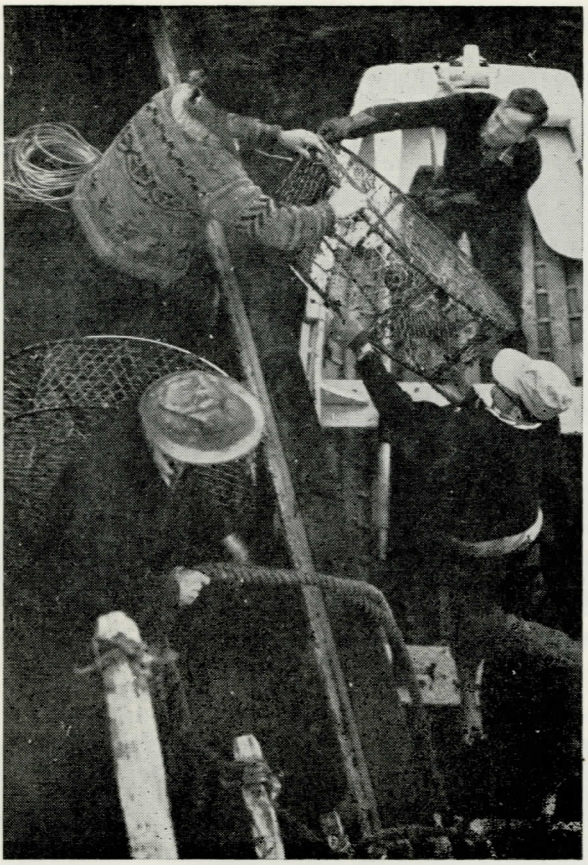


FIG. 3.—Retrieving cages after the blast.

The location of the traps and ponds was dictated largely by the topography of the area and the need to find suitable shore anchorages where the tidal action was relatively weak. Despite these limitations, however, it was possible to place six traps within ½ mile of the blast site (Fig. 2). Thirteen traps were placed from ½ to 1 mile away, seven between 1 and 2 miles, six between 2 and 3 miles, and four were anchored approximately 4½ miles north of the rock. The live ponds were set over the same area: one within ½ mile, one at ¾ mile, one at 1¼ miles, and a fourth at 2 miles distance from the rock.

The lingcod (*Ophiodon elongatus*) was chosen as the main experimental species for two reasons. Firstly, there is a commercial fishery for lingcod in the area, and secondly, these fish are known to survive well in confinement. Two lingcod were placed in each of the 35 traps except in Menzies Bay where four traps were stocked with one lingcod and one lemon sole (*Parophrys vetulus*) in each. The live ponds were stocked with lemon sole predominantly. A few other fish were included with these in some of the ponds. They included small lingcod, grey cod (*Gadus macrocephalus*), blackcod (*Anoplopoma fimbria*), ratfish (*Hydrolagus colliei*), and rock sole (*Lepidopsetta bilineata*).



FIG. 4.—Some of the rockfish found floating in the surface water immediately after the blast.

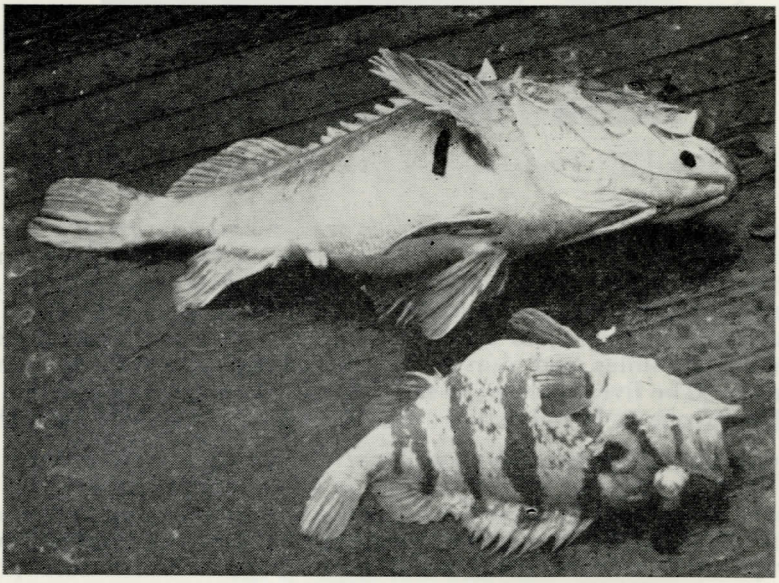


FIG. 5.—A red snapper (top) and a banded rockfish killed by the blast.

Traps located to the north of Ripple Rock were set out 2 days before the blast, while those to the south, in Menzies Bay, were set the day before. All the fish had been caught by the chartered trawler *Phyllis Carlyle* during the week prior to the blast, and had been kept in live ponds and canvas tanks until required. Of necessity they were subjected to frequent handling during this period, but care was taken to make sure that fish in poor condition were not included in the experiment.

RESULTS

Surface Observations

Immediately after the blast, five vessels of the Department of Fisheries and the Fisheries Research Board, assisted by small auxiliary craft, commenced a search of the area. Approximately 100 rockfish (*Sebastodes*) were seen, and most of these were collected. All were found to the north of the blast and within a distance of 3 miles (the northward ebb of the tide could account for this one-sided distribution). No other fish were seen.

Four species of rockfish were represented in the collection, as shown in Fig. 4. They were mostly banded rockfish (*S. nigrocinctus*) and red snappers (*S. ruberrimus*). There were a few orange-spotted rockfish (*S. maliger*) and two copper rockfish (*S. caurinus*).

Post-mortem examinations were made of some of these fish. About 50% showed only minor damage — protruding eyeballs and distended belly, but with intact viscera and no rupture of blood vessels (Fig. 5). The rest showed more severe signs of damage — frayed gills, ruptured air bladders and blood clots about the heart, liver, and kidney. Four specimens had the air bladder broken inwards, indicating compression, while in two fish it was blown outwards, indicating a decrease in pressure. The latter could have been due to the rarefaction wave of expansion that follows a compression wave, or may simply have been a side effect of the explosion, namely, decompression resulting from the fish being forced to the surface by the turbulent action of the water.

Recoveries from Traps and Ponds

Recovery of traps and ponds was not started until the day after the blast. Great difficulty was experienced in the recovery of traps because of the rugged nature of the bottom, and the wearing action of the tides on the anchor ropes. Only 12 traps were retrieved.

Traps. The two traps in bay "A" (Fig. 2) had broken from their mooring and were reported awash on the shore after the blast. The next day they were found and all fish (four lingcod) were alive and in good condition. In bay "B" all lingcod were alive. The traps in bay "C" held three live lingcod and one dead one. The dead individual had a large portion of the belly missing and the edges of the wound were frayed as though bitten. The cause of death was not determined. All lingcod in traps in Brown Bay and further north were alive. In the two traps recovered from Menzies Bay, the first held a lingcod and a lemon sole, both alive. The second trap, 600 feet nearer the rock, contained a live lingcod and a dead lemon sole. The lemon sole showed signs of injury by the trap, but there was no internal damage. It is presumed to have died from causes associated with confinement and handling.

Ponds. The live pond in bay "A" had been smashed by the blast and all the fish had escaped. One dead rock sole was found in the bottom of the pond. This fish had died from a blow on the head, presumably from a piece of flying rock. The live pond in bay "B" was intact. It contained some lemon soles, a greycod, a blackcod, and a lingcod, all alive. Two lemon soles, a ratfish and a rock sole were dead. Post-mortem examinations of the soles failed to reveal any damage attributable to the blast. These fish had been bruised by the netting of the pond and hence it is presumed that they died from the effects of handling and confinement. The live pond in Brown Bay held lemon soles and lingcod. Two dead lemon soles were found. These fish were examined and again showed no effects which could be attributed to the blast. The live pond at Bloedel, about 1½ miles from the blast, held ten lemon soles and two lingcod alive, and in good condition. Three lemon soles were dead and post-mortem examinations again suggested that these fish had died from causes relating to confinement rather than the blast.

Observations on Other Species

Five killer whales, a school of porpoises, two sea lions, and one fur seal were observed within 3 miles of the blast site just prior to the explosion. Various observers reported seeing these animals swimming in the area after the blast. Two dead diving birds were recovered immediately after the blast. Live molluscs (chitons) were collected from the intertidal zone of Maud Island (¼ mile from the blast) the day after the explosion. On that day over a hundred sea urchins were observed floating in Menzies Bay. These had presumably been killed by the blast and carried into the bay by the flood tide. Samples of herring spawn were collected before and after the blast from Salt Water Lagoon about a mile east of Ripple Rock, behind Maud Island. There was no difference in the number of dead eggs in each sample.

CONCLUSIONS

The recoveries from the cages indicate that fish mortality due to the Ripple Rock blast was confined to an area less than half a mile in radius from the rock. Even though dead rockfish were recovered off Separation Head (2½ miles distant), these fish were presumably killed closer to the rock and swept northward by the tide. Considering that lingcod placed in traps half a mile from the blast survived in spite of confinement and previous handling, and that observed mortality directly attributable to the blast was confined to rockfish, it is concluded that damage to the fish population of Discovery Passage was negligible.

Biological Station, Nanaimo, B.C. J. A. Thomson

THE MAGNITUDE OF HERRING SPAWN LOSSES DUE TO BIRD PREDATION ON THE WEST COAST OF VANCOUVER ISLAND

During the spring months, schools of mature Pacific herring (*Clupea pallasi*) appear in numerous bays and inlets along the British Columbia coastline to deposit their adhesive eggs on vegetation growing in shallow water above and below the zero tide mark.

A heavy mortality is known to take place amongst herring eggs during the approximately 15-day incubation period. Preliminary studies undertaken from 1947 to 1950 on the various causes of spawn mortality suggested that the principal source of egg mortality was bird predation (Fig. 1). The large concentrations of gulls and ducks which congregate on the spawning areas appeared to be responsible for over 50% of the total mortality. In order to determine whether annual changes in the magnitude of bird predation on spawn affects the abundance of the resulting year-class of herring, more detailed studies were carried out from 1951 to 1953 on five spawning grounds on the west coast of Vancouver Island to ascertain, quantitatively, the extent to which bird predation reduces spawn abundance.

Sampling

Paired areas of uniform spawn-laden vegetation (each 5 feet square) were selected on each of the spawning grounds studied. One area (control plot) was covered with netting to prevent birds from feeding there while an adjacent area (exposed plot) was left unprotected.

In 1951, eight random samples each comprising 25 square inches of spawn-laden eel grass were removed at 3-day intervals from each of the control and exposed areas of two pairs of plots at Toquart Bay. In 1952 and 1953, three pairs of experimental plots were sampled at Nuchatlitz Village, two pairs each at Macoah Passage and Toquart Bay, and one pair



Fig. 1.—A large concentration of gulls feeding on herring spawn deposited on inter-tidal vegetation at Toquart Bay during March, 1951.

Table I. The percentage loss of eggs due to bird predation as derived from the average weights of herring spawn found in control and exposed plots at the beginning and end of the incubation period on selected west coast of Vancouver Island spawning grounds, 1951, 1952 and 1953.

Place and year	No. of samples* taken from paired plots	Exposed plot: Average weight† of eggs in sample: Beginning of incubation period	Exposed plot: Average weight† of eggs in sample: End of incubation period	Exposed plot: Percent decrease in av. weight	Control plot: Average weight† of eggs in sample: Beginning of incubation period	Control plot: Average weight† of eggs in sample: End of incubation period	Control plot: Percent decrease in av. weight	Spawn loss due to bird predation (percent exposed decrease minus percent control decrease)
Toquart Bay, 1951	160	6.0	0.9	85	6.8	3.4	50	35
Macoah Passage, 1952	64	12.4	0.1	99	11.6	6.5	44	55
Toquart Bay, 1952	64	13.9	1.9	84	12.6	6.3	50	34
Cypress Bay, 1952	32	8.7	3.4	60	8.9	6.9	22	38
Nuchatlitz Village, 1952	96	29.1	7.3	75	37.0	25.0	32	43
Matilda Inlet, 1953	32	3.3	1.4	56	3.4	2.5	26	30
Average spawn loss found on eel grass during the period of the study				76			37	39

* Equal numbers of samples were taken from exposed and control plots.

† Weight in grams; 1 gram=approximately 1/28 ounce.

each at Cypress Bay and Matilda Inlet. From these spawning grounds eight random samples, each consisting of 16 square inches of spawn-covered eel grass were taken from the control and exposed plots at the beginning and end of the incubation period only (Table I). Sampling was terminated on all spawning grounds on the twelfth day so that losses in spawn abundance due to bird predation would not be confused with reductions resulting from hatching. A comparison of the amount of spawn in each type of plot at the end of the incubation period provided an estimate of the spawn loss due to bird predation.

In 1949, 21 seagulls were shot on the Queen's Cove spawning ground and their stomach contents analysed, as an alternative method of estimating the extent of spawn predation by gulls.

The laboratory analysis of all spawn samples involved the separation of the adhesive eggs from the vegetation and the determination of the total number of eggs in each sample from the relation between the total weight of the sample and the average weight of sub-samples of known number of eggs. The spawn in the gull stomachs was treated in a similar manner; however, in most cases the eggs were badly macerated.

Results

In the experimental plots it was assumed that spawn abundance in both the control and exposed areas was simultaneously and proportionally reduced by all mortality factors except bird predation. The results obtained during the 3-year study are shown in Table I. The percentage spawn loss occurring on each bird predation plot was estimated by subtracting the percentage decrease in spawn abundance in the control plot from the percentage decrease in spawn abundance in the exposed plot (Fig. 2). The spawn loss in the exposed plots, resulting from the operation of all spawn mortality factors, was found to be quite severe, ranging from 56 to 99%. The decrease in egg numbers attributed to bird predation alone ranged from 30 to 55%, averaging 39% for the period of the study.

The nature of the decline in spawn abundance as observed in the 1951 experimental plots at Toquart Bay is shown in Table II. Sharp reductions in spawn abundance occurred during the early part of the incubation period in the exposed plots. During the first 3 days, 66% of the total spawn loss had taken place, and by the sixth day 78% loss had occurred. The decrease in the control plots (attributed to several factors including desiccation, lack of fertilization, tide and wave action, etc.) was, however, light in the first 3 days, but increased somewhat in subsequent periods. The heavy, initial decline in spawn abundance in the exposed plots is related to the feeding habits of the birds. The occurrence of a herring spawning attracts large numbers of sea birds which congregate on the beaches to feed first on the spawning fish and then on the plentiful supply of eggs. In time, as the eggs become scarcer and more difficult to pick up, the birds gradually disperse. Thus, immediately after a spawn deposition takes place, there are not only more birds present than at any other time during the incubation period, but also more eggs per unit area for the birds to consume. This results in a heavy, early loss of eggs.

Glaucous-winged and herring gulls were found to be responsible for most of the predation on herring spawn on the west coast of Vancouver Island. The stomach contents of the gulls shot at Queen's Cove in 1949 consisted

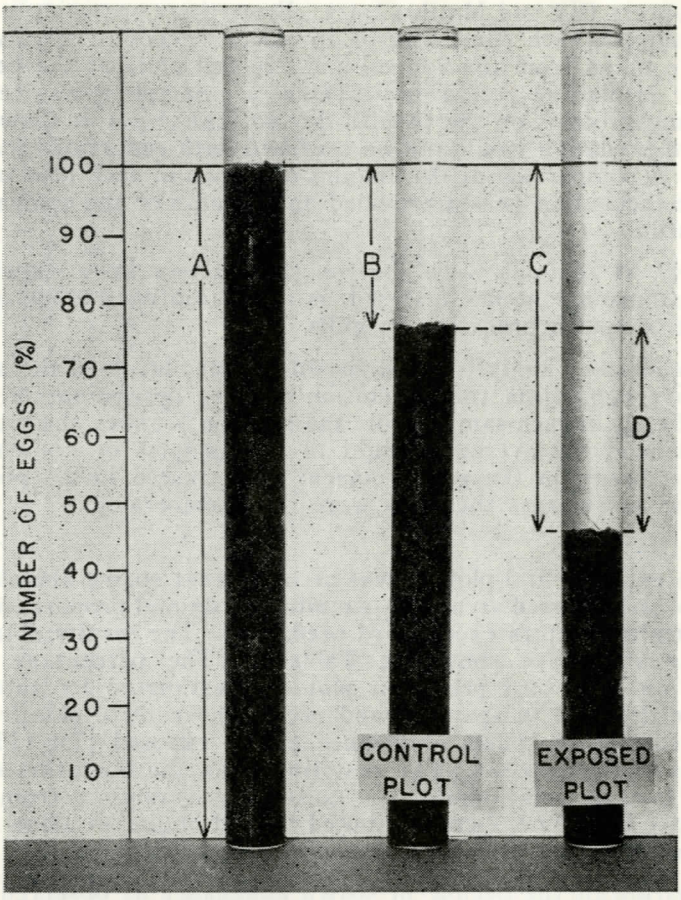


FIG. 2.—Extent of spawn losses in bird predation plots at Matilda Inlet in March, 1953. **A** represents the amount of spawn (100%) present at the beginning of the incubation period. **B** is the amount of spawn lost (26%) from the control plot at the end of the incubation period. **C** is the total amount of spawn (56%) removed from the exposed plot by the end of the incubation period. **D** represents the amount of spawn consumed by birds, 56 – 26=30%.

Table II. A comparison of the percentage decreases at 3-day intervals in the average weight of herring eggs found on exposed and control plots at Toquart Bay in 1951.

	Exposed plot		Control plot	
Days after spawning	Av. weight (in gm.) of eggs remaining	Percent decrease	Av. weight (in gm.) of eggs remaining	Percent decrease
0	6.0	...	6.8	...
3	2.0	66	6.3	7
6	1.3	78	5.2	23
9	1.1	82	4.0	41
12	0.9	85	3.4	50

Table III. Comparative average weights (in grams) of the amount of herring eggs and vegetation found in the stomachs of two species of gulls shot on the Queen's Cove spawning ground on the west coast of Vancouver Island in 1949.

Species of gull	No. of birds examined	Av. weight of eggs ingested	Av. weight of vegetation ingested	Ratio of weight of eggs to weight of vegetation	Estimated average number of eggs in stomach
Herring	9	9.1	13.2	0.7	8,500
Glaucous-winged	12	14.5	3.1	4.7	13,800

almost exclusively of herring eggs and vegetation. The glaucous-winged gull appeared to feed primarily on eggs whereas herring gulls consumed greater proportions of vegetation along with the spawn (Table III). The ratio of amount of spawn to amount of vegetation ingested was over six times greater for glaucous-winged gulls than for herring gulls. It would seem that glaucous-winged gulls are more selective feeders and tend to pick the eggs off the vegetation.

Quantitative assessment of spawn losses by the analysis of bird stomachs proved to be impractical since partial or complete digestion of the eggs made it impossible to obtain accurate egg counts.

Discussion

Although storms, frosts, and desiccation may also cause the destruction of herring spawn, the greatest and most consistent factor responsible for spawn losses was found to be sea-bird predation. During the period of the study it was estimated that on the average about 39% of the spawn deposited along the west coast of Vancouver Island was consumed by birds, the rate of decrease being greatest during the first 3 days of the incubation period.

Considerable variation was found in the amount of bird predation between spawning grounds in the same year. As would be expected, this variation appeared to be related to the number of birds present. Extensive spawning grounds usually attract a proportionally greater number of birds than small, isolated spawnings.

It was not possible to determine from this study whether significant differences occurred in the extent of bird predation from year to year. If such differences occur they are probably not great, since no obvious variation was noted in the total number of birds present during the period of the study.

Information derived from annual surveys carried out by officers of the Federal Department of Fisheries on the west coast of Vancouver Island indicated that year-class abundance is not related to the amount of spawn from which the year-class is derived. However, there is presumably a critical level of spawn deposition (not yet reached) below which the number of eggs hatched will limit population abundance. If the herring stocks of British Columbia should ever be reduced to this level, the effect of bird predation may become serious and measures may have to be applied to protect the spawn.

Biological Station, Nanaimo, B.C. D. N. Outram

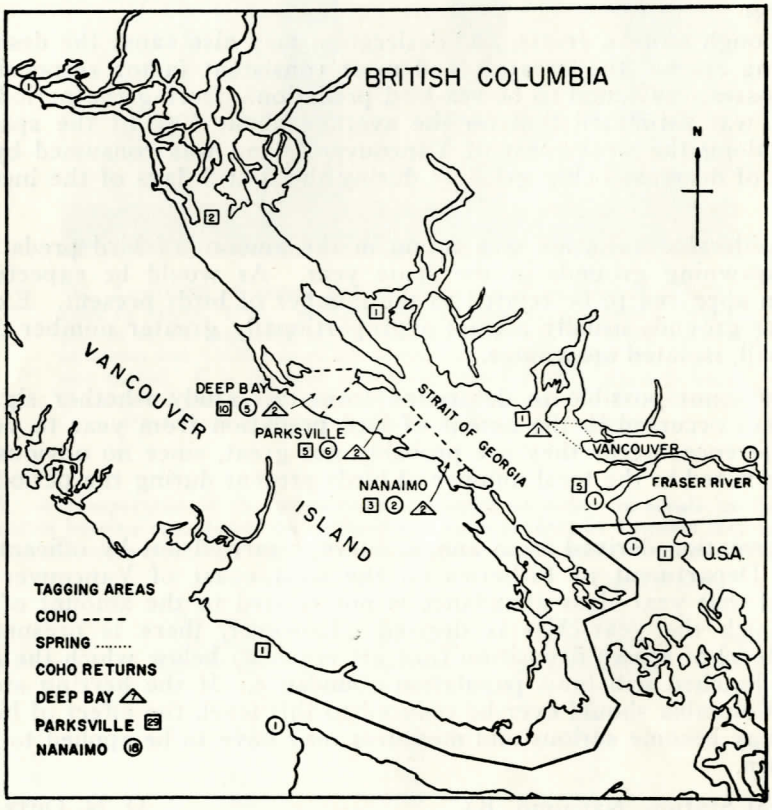
THE TAGGING OF SPRING AND COHO SALMON IN THE STRAIT OF GEORGIA IN 1956

Throughout the year many small spring and coho salmon*, commonly called "grilse", are caught in the Strait of Georgia by sportsmen. In the same waters, the commercial trollers also catch small spring salmon throughout most of the year and small coho salmon after the season opens on June 15. The cohos caught by trollers are commonly called "bluebacks" and are smaller than those caught off the west coast of Vancouver Island (this series of Progress Reports, No. 85, 1950). Earlier tagging experiments, conducted in the Strait of Georgia in 1927 and 1928, suggest that some spring and coho salmon spend their entire ocean life in inside waters.

In 1956 the Fisheries Research Board vessel *Alta* was used to catch and tag, by various methods, small spring and coho salmon during their feeding migrations in the Strait of Georgia. The objective was to obtain further information on the seasonal movements and the extent of the fishing drain on these inside fish.

From May 9 to June 22, trolling was carried out along the east coast of Vancouver Island from Nanaimo to Deep Bay (see accompanying Figure).

* Spring and coho salmon can be most readily distinguished by the fact that the teeth are set in black-coloured gums in springs (also called "blackmouths") and in silver-coloured gums in cohos (also called "silvers").



Distribution of recaptured coho salmon tagged in the Strait of Georgia in 1956.

The catch was mainly small coho salmon varying in length from 16 to 24 in. (tip of nose to fork of tail). They were caught at all depths from the surface to the deepest lure (about 20 fath.) while fishing in waters from 30 to 100 fath. deep. All the coho salmon were starting their second year in the ocean after spending one year in fresh water. They were actively feeding, chiefly on the numerous small crustaceans that were available.

From December 12 to 20 the fishing took place near Vancouver off the mouth of the Fraser River (see Figure). The catch in this area was mainly small spring salmon varying in length from 10 to 27 in. They were caught from the surface to the deepest lure (about 15 fath.) in waters from 20 to 60 fath. deep, but most were taken on the deeper lures. More than half of the fish were small spring salmon (average length 12 in.) in their first year in the ocean. The remainder were all in their second ocean year (average length 21 in.) except for one fish (27 in.) in its third year. Most of the fish were feeding, chiefly on small herring.

In order to reduce the mortality involved in catching the fish, the barbs were removed from the hooks (size No. 5) and the fish were handled with care from the time they were caught. To obtain only the most viable fish for release after tagging, the fish were retained in a live box on the boat for at least one hour after they were caught and tagged. Following this procedure 17.6% (51 out of 289) of the coho salmon, and 19.8% (18 out of 91) of the spring salmon were unsuitable for tagging purposes. These percentages are much lower than the comparable mortality of 33% that was obtained for small coho salmon in 1954 when barbed hooks were used (Progress Reports No. 106, 1956).

Comparative Efficiency of Different Types of Lures

All fishing was carried out by trolling with four similarly weighted lines, each bearing from four to eight lures spaced 4 fath. apart. During most of the coho salmon tagging in May and June, two different colours of two common trolling spoons were used with one type on each line. A comparison of the efficiency of each type of spoon is presented in Table I.

Table I. Number of coho salmon (bluebacks) caught by four types of trolling spoons.

Type and color of spoon	Number of fish caught	Percentage
Gibbs Egg Wobbler No. 1—brass	105	39.3
" " " " —painted red	74	27.7
Super Diamond No. 5—brass	50	18.8
" " " —silver	38	14.2
Total:	267	100.0

The common brass Egg Wobbler caught more small coho salmon than the same spoon painted red or the Super Diamond spoon made of either brass or silver. A study of the stomach contents of 47 fish revealed no marked differences in the feeding habits of the fish that were caught by each of the four types of lures.

In December during the tagging of spring salmon, both brass and silver Super Diamond spoons were used, mainly as the shallower lures, and

chrome-plated Kelp-Kutters were used, mainly as the deepest lures. The Kelp-Kutters caught about twice as many fish-per-lure as the Super Diamond spoons (with more fish being taken by the brass than the silver type). The Kelp-Kutters also caught larger fish (average 19 in.) at various depths, than the spoons (average 13 in.). Stomach contents from six small fish and 48 larger fish (caught by commercial trollers) showed that both size groups were feeding almost entirely on small herring of various sizes.

Comparison of Two Types of Tags

For certain groups of fish, two different types of plastic tags were used in rotation. The Peterson disk or button type of tag (used in recent troll tagging experiments) was attached through the back of the fish by means of a stainless steel pin. The spaghetti type of tube tag (used in recent net tagging experiments) was inserted through the back of the fish with the aid of a hypodermic needle and tied with a square knot. A comparison of the number of fish tagged and returned with each type of tag is given in Table II.

Table II. Number of spring and coho salmon tagged in rotation with either the Peterson disk or the spaghetti tube tag and the returns from each.

	Type of tag	
	Peterson disk	Spaghetti tube
Coho salmon:		
Number of fish tagged	57	40
Number returned	17 (29.6%)	3 (7.5%)
Spring salmon:		
Number of fish tagged (over 16 in. long)	10	12
Number returned	3 (30%)	2 (17%)
Number of fish tagged (under 16 in. long)	9	7
Number returned	0	0

In both coho and the larger spring salmon more fish with disk tags were returned than those with tube tags. No recoveries were made from tagging small spring salmon with either type of tag. The difference in recovery rate of almost four times as many disk tags as tube tags is most significant in coho salmon. This suggests that many of the tube tags were lost from the fish, probably because the simple square knots became untied.

Coho Salmon Tag Returns

The total number of coho salmon tagged is given in Table III. The distribution of the 54 coho salmon recoveries is shown in the Figure. Since 37 (68%) were recaptured in the general tagging area, the majority probably spend the summer months feeding near the east coast of Vancouver Island. However, the average time between capture and recapture was 74 days. Thus it appears that following tagging, during late June and July, the fish must move off to feed in areas that are not heavily fished. Most of those tagged off Nanaimo and Parksville were later recaptured to the northwest while

Table III. Number of coho salmon (bluebacks) tagged in each area and returned by each type of gear.

Area of tagging	Number tagged	Number returned			
		Troll	Sport	Gill net	Total
Nanaimo	82	11	4	3	18
Parksville	120	15	8	6	29
Deep Bay	32	3	3	1	7
Total	234	29	15	10	54
Fish with disk tags	189	26	15	10	51

those from Deep Bay were recaptured to the southeast. During the summer, three were recovered at the northern end of the Strait of Georgia, three along the mainland coast of British Columbia, two at the southern end of the Strait of Georgia in United States waters and two had migrated to outside waters around the southern end of Vancouver Island. In the fall, seven were recaptured as they entered the Fraser River to spawn after being out an average of 118 days.

Because the disk tag has been shown to provide more returns than the tube tag, only the 189 fish tagged with disk tags will be used to indicate the percentage returns by various fisheries. The return of 51 tags (27%) is higher than that obtained in past troll tagging experiments. However, if the same number escape to spawn there is still a loss of about 45% due to tagging and natural mortality or the lack of return of recaptured tags. Twenty-six (51.0%) were returned by trollers; 15 (29.4%) by sportsmen; 9 (17.7%) by commercial gill netters and one fish (1.9%) was taken by the Indian food fishery in the Fraser River. This would imply that sportsmen catch less than one third of the fish that feed in the tagging area. However, when the large number of small "grilse" that are caught by the smaller sport lures are considered, it is apparent that much more than one third of the coho salmon in this area are caught by sport gear.

Spring Salmon Tag Returns

A total of 70 spring salmon were tagged but only eleven recoveries were made. Because of the poor return from tagging small fish, little can be concluded from these few returns.

From 51 fish tagged in December off Vancouver, only seven (7.3%) were recovered. Five fish in their third year were caught, during the following summer and fall, along the east coast of Vancouver Island from Nanaimo to the northern end of the Strait of Georgia, after being out an average of 252 days. One was recaptured near the tagging area (272 days out) and one as it entered the Fraser River 268 days after tagging.

From the 20 larger fish tagged in May and June, between Nanaimo and Deep Bay, four (20%) were recovered. One was secured in the tagging area 49 days later; one while entering the Fraser River after 109 days out, and two during the following summer in their fourth year of life. One of the latter was taken at the northern end of the Strait of Georgia (355 days out) and the other off the southwestern part of Vancouver Island (411 days

out). Apparently some spring salmon spend all of their life in the Strait of Georgia while others go out to sea before returning to spawn.

SUMMARY

Small spring and coho salmon feeding in the Strait of Georgia are most efficiently caught by commercial trolling gear using brass Egg Wobbler spoons for coho salmon and Kelp-Kutter flashers for spring salmon. The use of barbless hooks reduces the catching and releasing mortality to about one half of that obtained when barbed hooks are used. Peterson disk tags provide larger returns (about 25% of those tagged) than spaghetti tube tags when tied with a square knot. In order to successfully tag smaller fish (below 16 in. fork length) another method of capture and tagging will have to be devised to obtain a sufficient number of recoveries. Some fish of both species spend their entire ocean life feeding in certain inside areas but during some periods they are apparently not available for capture by the present intensive sport and commercial fisheries.

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D. J. MILNE
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ADULT RETURNS OF PINK SALMON FROM THE 1954 FRASER RIVER PLANTING

In an earlier paper (this series of Progress Reports, No. 103, pp. 14–15, 1955), the experimental transplantation in 1954 of pink salmon eggs to Jones Creek, tributary to the lower Fraser River, was described. The output of 1,100,000 fry was of moderate size and of the order that, in other streams, has produced many thousands of returning adults. In the even-numbered years there are almost no pink salmon in the Fraser River system. An interesting point of the experiment was to see how many fish could return to a small tributary, a hundred miles inland, when there were no other members of their species from other tributaries to help keep down their losses to predators.

The number of returning adults that reached the Fraser River in the fall of 1956 was approximately 4,500. Between 2,581 and 3,024 spawned in Jones Creek; approximately 300 were taken in the Indian fishery and some 1,500 in the Fraser River gill-net fishery. Possibly four to five thousand were taken by more distant fisheries.

A high degree of homing was shown by the fish. Nine out of twelve pinks tagged by the Department of Fisheries in the Fraser River 11 miles upstream from Jones Creek subsequently appeared in the latter. Eight of them were recorded as dead spawned-out fish. The other tagged fish was seen in the stream below the controlled flow channel. Since the fish-wheel used to capture fish for this tagging program takes only a small percentage of the fish in the area it is likely that many more of the returning pinks missed Jones Creek, went up the river, milled around, and then moved down

until they found their home streams. This is quite remarkable as there was only 10 cu. ft./sec. flow from Jones Creek running into the many tens of thousands of cubic feet of flow in the main river. Other streams and the area around the power house downstream were checked but no evidence of wandering was found. The study was made easier because there were no other pink salmon populations present.

The sex ratio on the spawning ground was roughly two females per male. From the size of the fish on the spawning ground and the large average weight of the fish in the Fraser gill-net fishery, it is quite possible that the large males were selected by the spring salmon gill nets in use at that time in the Fraser.

The timing of the run was different from that of the native "on year" runs. The first fish was in the channel August 17, which is at least two weeks early. By September 12, which is about the time the "on year" runs start, half the spawners were in the channel. The time of the last half of the run closely paralleled that of the "on year" runs.

The returning number of spawners was low — 0.3% of the outgoing fry. The fish that came back were strongly conditioned to find the incubating stream. Large numbers that did not come back may have failed to find the proper part of the coastline. Evidence from other studies, though, supports the idea that a million fry in a river system the size of the Fraser is an extremely small number and can be expected to suffer high losses from predation. It is very encouraging that after passing through a fishery, two-thirds the number of eggs taken on the Skeena River were available to start the next generation. With no fishery, the original number of spawners and eggs would have been available and possibly considerably exceeded.

The survival of the 1955 "on year" spawning population makes an interesting comparison. Approximately 400 pink salmon spawned in the controlled flow channel. The egg deposition was estimated between 380,000 and 428,000. In the spring of 1956, altogether 157,933 migrating fry were counted, representing a survival of 37 to 40%, which is the same as the survival of the eggs planted in 1954. In 1957, whereas 1056 pinks spawned above the counting fence, 400 spawned below it. This is 0.9% of the migrating fry.

The increase of the spawning population from 1955 to 1957 appears to be the result of the high survival from the egg to fry stage and not to excessive survival from fry to adults. The small 1955 population seems to have benefited from the presence of other populations in the system.

A question posed in the earlier article cited was whether the population of each spawning stream can be treated as a separate problem or whether a certain minimum population must be maintained for the whole watershed. The answer from this single experiment is that there is a minimum population for the watershed but that the number may well be within man's ability to establish.

The collection of 3,000,000 eggs was presumably a base minimum with which to attempt the experiment and 5,000,000 a more reasonable minimum number. More experiments with larger numbers of eggs are required to assess the problem fully.

Biological Station, Nanaimo, B.C. W. PERCY WICKETT

THE RECENT RISE IN LANDINGS OF WHOLE FISH FOR MINK FEED IN BRITISH COLUMBIA

In recent years a remarkable growth has occurred in the trawl fishery for scrapfish to meet the demand of an expanded fur-farm (mink) industry on the west coast. Fur farms have increased in size and many have been re-established in this area from the prairie provinces and other areas because of diminishing reserves and rising cost of such protein sources as horse meat and freshwater fish.

For many years the supply of waste material from the filleting operations on trawl landings of flatfish and cod was sufficient to meet the fur-farm demand. Only small quantities of whole fish were landed specifically for that market. Between 1945 and 1950, the average annual landing of such fish was little more than 50,000 pounds. Since 1951, however, the demand has increased greatly and more attention has been directed to fishing exclusively for scrapfish. As shown in Table I the landing of whole fish for mink feed rose from 414,000 pounds in 1951 to more than 11,000,000 pounds in 1956.

Table I. Otter-trawl landings of whole fish for mink feed in British Columbia.

Year	Pounds
1951	414,000
1952	1,392,000
1953	2,298,000
1954	2,843,000
1955	6,242,000
1956	11,024,000

Table II. Percentage composition of species contributing to otter-trawl landings of mink feed.

Species	1951	1952	1953	1954	1955	1956
Turbot (arrow-toothed sole)	71.0	71.3	53.8	56.4	65.5	57.5
Whiting (bigeye)	19.3	20.7	17.8	16.5	20.2	22.5
Hake	4.2	2.6	1.1	2.4	0.6	*
Skate	0.5	0.5	0.5	2.4	0.7	1.1
Starry flounder	*	0.5	0.3	0.5	0.5	4.8
Lemon sole	*	0.4	6.6	5.6	0.4	*
Misc. sole	*	0.1	6.2	3.9	1.6	1.9
Grey cod	*	0.1	4.0	3.6	2.0	1.7
Butter sole	*	*	7.9	1.9	5.3	7.7
Rockfish	*	*	1.7	6.2	2.5	2.6
Other species	5.0	3.8	0.1	0.6	0.7	0.2
Total:	100	100	100	100	100	100

* Negligible quantities landed.

Table III. Percentage composition of landings of mink feed from various areas of the British Columbia coast in 1956.

Species	Hecate St. and Queen Charlotte Sound	West Coast Vancouver Island	Strait of Georgia
Turbot (arrow-toothed sole)	73.3	84.8	3.3
Whiting (bigeye)	1.1	3.3	76.3
Butter sole	17.3	0.3	0.0
Other sole	0.7	4.4	1.0
Grey cod	2.7	0.5	1.5
Rockfish	2.0	5.0	0.7
Starry flounder	0.6	negligible	16.5
Other species	2.3	1.7	0.7
Total:	100	100	100
Total landing (pounds)	4,890,000	3,060,000	3,060,000

Table II shows the composition of these landings. Species which previously had found no place in the British Columbia trawl fishery for food fish (human consumption) now play a prominent role in the animal feed fishery. The turbot or arrow-toothed sole (*Atheresthes stomias*) and the whiting or bigeye (*Theragra chalcogramma*) have attracted particular attention because they exist in dense concentrations within close reach of market centres. They have accounted for 70 to 90% of the annual production between 1951 and 1956. Species useful as food for human consumption have not been used extensively as mink feed because as a rule they command higher prices on the food fish market.

The composition of the landings of scrapfish is not the same in all areas, and only certain grounds within these areas appear to be sufficiently productive for commercial operation. As shown in Table III, the Hecate Strait and Queen Charlotte Sound area yielded close to 5 million pounds of scrapfish in 1956. The important contributors were the turbot (which were taken mainly during the summer months on the Mexicana grounds near Cape Scott) and the butter sole (*Isopsetta isolepis*) (taken mainly during the winter months in Skidegate Inlet, Queen Charlotte Islands).

Off the west coast of Vancouver Island the turbot accounted for the bulk of the catch and this originated mainly on the Swiftsure Bank during the summer months.

In the Strait of Georgia, where the trawl fishery is confined mainly to the winter months, the main species are the whiting, or bigeye, and the starry flounder (*Platichthys stellatus*). The bulk of the whiting catch came from the Gulf Islands area — Swanson Channel and Active Pass — and the starry flounder came from grounds off the mouth of the Fraser River.

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CANADIAN OCEAN DRIFT BOTTLE RECOVERED IN HAWAII

Oceanographers of the Pacific Oceanographic Group at Nanaimo, B.C., are very pleased with the recovery of one of their drift bottles on the Hawaiian Islands. Mr. Salvador Gemeno, Jr., found it March 23, 1958, on the beach at Kaneohe Bay, which is on the island of Oahu, north of the city of Honolulu. He receives the one dollar reward offered by the Fisheries Research Board for the return of the information card contained inside the bottle.

This is the first reported recovery on the Hawaiian Islands of these Canadian drift bottles. It is also the first recovery from this particular release of of 1,000 drift bottles on August 26, 1956, at the position of latitude 44° 49′ N. and longitude 148° 56′ W. The oceanographers have been awaiting with great interest the report of a recovery from this release, because another lot of 1000 bottles had been released a day earlier at ocean weather station PAPA, 350 miles to the northeast. First recoveries from the earlier release were reported in March 1957, and since then over 100 bottles have been recovered, generally on the west coast of Vancouver Island and the coasts of Washington and Oregon.

The recovery from the Hawaiian Islands of a bottle from this August 26th release would indicate that it was caught in the main stream of the southward-flowing California current which gradually turns at about latitude 30°N. to form the North Equatorial Current flowing westward across the Pacific Ocean. The direct hypothetical drift path is estimated to be 2,400 miles long, but it is most probable that the bottle meandered over a considerably longer distance, perhaps even back-tracking on itself.

Nineteen months elapsed from the time of release to recovery. It is reasonable to assume that the bottle was probably picked up soon (within a month) after it landed at Kaneohe Bay becuase this is a well-travelled beach. The net speed of drift along the most direct path would be 4 miles per day. It is recorded on various sailing charts prepared from many years of shipping records that the average speed of surface drift in the California and North Equatorial Currents is 10 to 20 miles per day. So it is quite possible that this particular bottle actually travelled as much as 4500 miles before beaching on Oahu Island.

Since the inception of the project in August 1956, a total of 25,000 drift bottles have been released at several locations in the Northeast Pacific Ocean by the Pacific Oceanographic Group. To April 1, 1958, a total of 800 bottles have been recovered from locations ranging all the way from the outer Aleutian Islands to Cape Blanco in Oregon. It is expected that further recoveries from the August 26, 1956, release will be made in the region of the Hawaiian Islands.

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A COMPARISON OF THE NUTRITIVE VALUE OF CONDENSED HERRING SOLUBLES PREPARED BY ACID AND ENZYME TREATMENTS

Herring solubles are widely used as supplements in animal rations, particularly in diets for poultry. Solubles are prepared from herring stickwater by condensation of the latter to a product containing approximately 50% solids. If no further treatment than evaporation were involved in the production of solubles from stickwater, a product would result which would be too viscous and would contain too much oil to be suitable for commerce. This unsatisfactory viscosity and oil content results from the presence of suspended and dissolved protein in the original stickwater. Two principal methods have been devised to overcome the effects of this protein. In one method the protein is coagulated by acid and removed by centrifugation; in the other it is converted to smaller molecules by treatment with proteolytic enzymes.

There are no published data available on the relative nutritional value of solubles prepared by the two methods of treatment of stickwater. This study was designed to supply this information.

Preparation of Solubles

Stickwater was prepared from fresh whole herring by the following procedure. Herring mixed with half its weight of water was cooked by

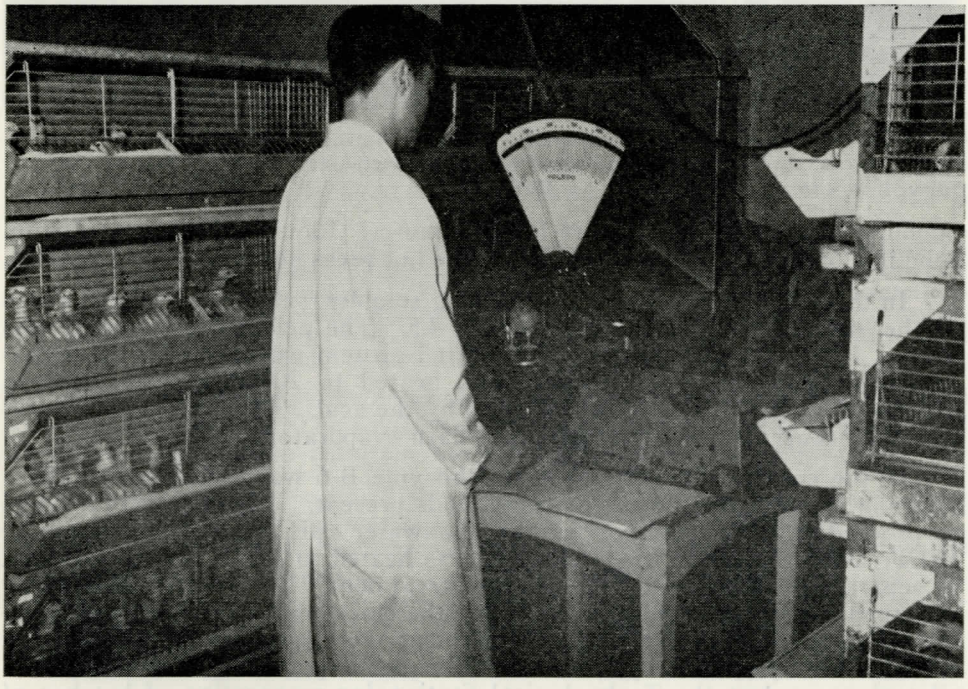


Fig. 1.—Chicks being weighed to determine their growth response to fish-soluble supplemented diets, at the Department of Poultry Science, University of British Columbia.

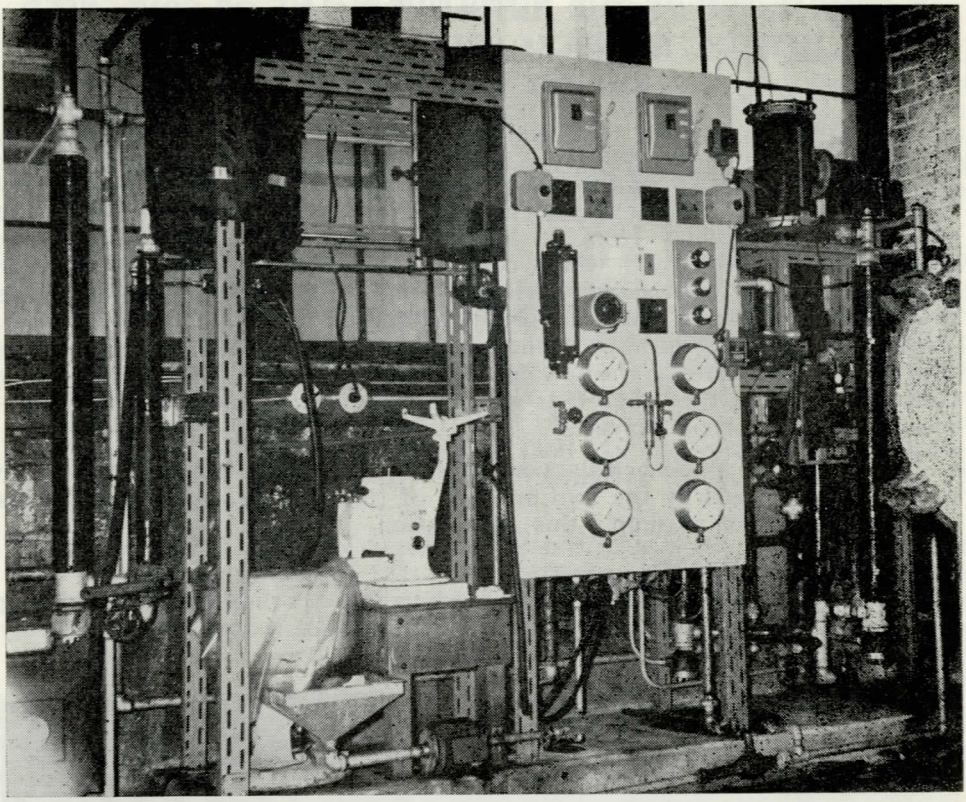


FIG. 2.—Pilot plant for the conversion of fish stickwater to solubles, located at the Technological Station in Vancouver.

bubbling steam into the mixture for 20 minutes. Liquid was separated from solid in a press. Oil was removed from the hot press liquor by centrifugation.

In the acidulation method of preparing solubles, sulphuric acid was added to the stickwater until the pH became 4.5. The acidified stickwater was held at 170°F. for 30 minutes. Coagulated protein was removed by centrifugation. The supernatant liquid was heated to 200°F. and centrifuged using a disc bowl to remove oil released by the acid. The treated stickwater was then concentrated to solubles in a flash evaporator.

In the enzyme digestion process Rhozyme B-6 was added to the stickwater in amount of 0.5% of the total solids present. Digestion was allowed to proceed at the natural pH of the stickwater (pH 6–6.5) for 2 hours at 140°F. After digestion the stickwater was heated to 200°F. and centrifuged to separate oil released by the enzyme treatment. The treated stickwater was then concentrated to solubles. For the chick nutrition studies (Fig. 1) the solubles prepared by enzyme treatment were adjusted to pH 4.5, the same as that produced by the acidulation technique. Figure 2 shows the pilot plant used at the Technological Station for preparation of batches of solubles by the above two methods.

Table I. Analyses of solubles (wet weight basis) prepared by acid and enzyme treatment of stickwater.

Constituent	Acid-treated solubles	Enzyme-digested solubles
	%	%
Water	50.00	50.00
Total solids*	50.00	50.00
Insoluble solids	5.03	4.92
Protein	39.90	40.80
Oil	0.97	0.58
Ash	10.07	9.55
Total for water +protein+ash+oil	100.94	100.93

* Although it was technically impossible to prepare solubles containing exactly 50% solids, the analyses obtained were recalculated to this basis to enable comparison of the two products to be made more readily.

A comparison of analyses of solubles prepared by the two methods is given in Table I.

NUTRITION STUDIES

The following experiments were conducted to determine if there were any differences in the nutritive value of herring solubles prepared by the acid and by the enzyme digestion procedures. A sample of herring stickwater was processed in the laboratory by both methods. A sample of condensed solubles (acid-treated) produced commercially from the same lot of stickwater was obtained, as well as a sample of the presscake.

In Test 1 two laboratory preparations made by the acid and enzyme methods respectively from the same sample of stickwater were used. A sample of herring presscake and a commercially prepared acid-treated sample of solubles were included in the test. The four preparations were compared when fed at levels of 2, 4 and 6% as supplements to the following diet:

> Ground yellow corn 60.27, soybean oil meal 35.73, bonemeal 2.0, limestone 1.0, iodized salt 0.5, *dl*-methionine 0.1, choline chloride (25%) 0.4, manganese sulphate 0.025 *lb. per 100 lb.;* vitamin B_{12} 0.0009, riboflavin 0.16, niacin 0.8, calcium pantothenate 0.5, thiamin hydrochloride 0.16, biotin 0.0045, folic acid 0.035, inositol 1.0, *p*-aminobenzoic acid 0.1, ascorbic acid 10.0, α-tocopherol acetate 0.5, menadione 0.018 *gm. per 100 lb.;* vitamin A 2,000, vitamin D_3 150 *units per 100 lb.*

It will be noted that the basal diet was well supplemented with vitamins and with methionine. The solubles were added with adjustment in the level of soybean oil meal to maintain the same protein level throughout.

Table II. Average weights of chicks in Test 1 at 4 weeks of age.

Supplement, fed at level:	0	2%	4%	6%
	grams	*grams*	*grams*	*grams*
None	328			
Commercial acid-treated solubles		338	319	338
Laboratory acid-treated solubles		318	332	334
Laboratory enzyme-treated solubles		322	316	325
Presscake		320	342	322

Each diet was fed to duplicate lots of 15 female chicks which in this and subsequent experiments were from New Hampshires hens. They were fed a diet supplemented with vitamin B_{12} but containing no dehydrated green feed or fish meal.

The average weights of the chicks are given in Table II. In no instance was there a response to the addition of the condensed solubles or presscake.

In Test 2 a corn–soya type of basal diet of the following composition was used:

> Ground yellow corn 55.25, soybean oil meal 40.0, dehydrated cereal grass 1.0, iodized salt 0.5, limestone 1.0, bonemeal 2.0, feeding oil 0.25, *lb. per 100 lb.*; manganese sulphate 6.0, riboflavin 0.16, niacin 0.8, calcium pantothenate 0.5 *gm. per 100 lb.*

The two laboratory preparations of solubles were tested when added to the basal diet at levels of 0.5, 1.0 and 2.0%. Since the basal diet contained no source of vitamin B_{12} the effect on growth rate of supplementing the basal diet with vitamin B_{12} was determined.

Each diet was fed to duplicate lots of 15 female chicks. The average weights of the chicks at 25 days of age are given in Table III.

Table III. Average weights of chicks in Test 2 at 25 days of age.

Supplement, fed at level:	0	0.5%	1.0%	2.0%
	grams	*grams*	*grams*	*grams*
None	240			
Acid-treated solubles		248	255	274
Enzyme-treated solubles		247	252	264
Vitamin B_{12}, in amounts of 0.5, 1.0, and 2.0 μg/kg. respectively		242	240	242

The chicks fed the solubles grew more rapidly than those fed the basal diet but there was no difference in the response to the acid- and the enzyme-treated preparations at the levels fed. The growth stimulus was not due to the vitamin B_{12} content of the solubles because there was no response to the pure vitamin at any of the levels at which it was added to the basal diet.

Test 3 was conducted to compare the effect of the laboratory-prepared acid- and enzyme-treated solubles with those of folic acid and methionine when added to a basal diet of similar composition to that employed in Test 2. Supplementation with solubles was at the 1 and 2% levels. When folic acid was used in the diets it was added at the rate of 0.25 mg. per lb. *dl*-Methionine was used as a supplement at the 0.1% level.

Duplicate lots of 20 male chicks were fed each of the experimental diets.

The average weights of the chicks at 3 weeks of age are shown in Table IV. From the response obtained with the solubles it appears that part of the response obtained to herring solubles in a corn–soya ration is due to the folic acid content of the solubles if special attention is not given to fortification of the diet with this vitamin. Methionine did not stimulate growth significantly when added to the basal diet. The chicks fed the diets containing condensed herring solubles did not respond to the addition of folic acid or methionine to the diet.

Table IV. Average weights of chicks in Test 3 at 3 weeks of age.

Supplement	None	Folic acid	Methionine
	grams	*grams*	*grams*
None	225	242	238
1% acid-treated solubles	262	–	–
2% acid-treated solubles	258	258	–
1% enzyme-treated solubles	242	–	–
2% enzyme-treated solubles	258	251	254

Test 4 was designed to compare the laboratory preparation of condensed herring solubles specifically on the basis of their value as protein supplements. The percentage composition of the diet was as follows:

> Ground yellow corn 32.1, ground wheat 32.1, soybean oil meal 20.0, cerelose 5.0, dehydrated green feed 2.5, fishmeal (70% protein) 2.5, iodized salt 0.5, limestone 1.0, bonemeal 2.0, feeding oil (2250A–300D) 0.3, dried corn fermentation solubles 2.0 *lb. per 100 lb.;* manganese sulphate 6.0 *gm. per 100 lb.*

In the diets supplemented with acid-treated solubles, 5 and 10 lb. of the preparation were substituted for 2.5 and 5.0 lb. respectively of cerelose. The total weights of the rations supplemented were thus greater than 100 lb. in order to allow for the water content of the solubles. The amounts used of the enzyme-treated solubles were slightly lower than for the acid-treated solubles in order that similar amounts of protein should be contributed by the corresponding levels of the two preparations. A mixture of 1.72 lb. of isolated soybean protein, 0.50 lb. *dl*-methionine and 0.25 lb. glycine per 100 lb. was added to the basal diet to serve as a reference standard for the 5% level of the condensed solubles and twice these amounts as a standard for the 10% level.

Each diet was fed to 25 male chicks for 3 weeks. The average weights are shown in Table V and indicate that there were no differences in nutritive value of the different types of solubles in so far as the effect on growth was concerned.

Nitrogen balance studies were carried out to evaluate more critically the relative protein quality of the preparations. The results of these determinations are also shown in Table V. Each of the values represents the average nitrogen retention found in three separate series of determinations.

Table V. Average weights of chicks and nitrogen retention in Test 4 at 3 weeks of age.

Supplement to basal diet	Weight	Nitrogen retention
	grams	%
None	259	51.0
5% acid-treated solubles	273	50.4
10% acid-treated solubles	268	46.3
5% enzyme-treated solubles	269	50.4
7.5% enzyme-treated solubles	264	44.8
Reference protein,* level 1	267	50.4
Reference protein,* level 2	265	49.7

* Isolated soybean protein supplemented with methionine and glycine.

Each series in turn comprised the nitrogen retention over 3-day periods on the 7–9, 13–15 and 19–21 days of the experiments.

At the 5% level of supplementation the nitrogen retention was the same with both samples of condensed solubles as for the purified protein supplement. When the level of supplementation was raised to 10%, nitrogen retention was lowered only slightly with the purified protein supplement, but more markedly in the case of the chicks fed either sample of solubles. When used at a practical level to supplement the basal diet the two types of herring solubles appeared to be of good and of similar protein nutritive quality and to be similar in value as supplements to the diet in question.

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(*Issues No. 1 to 20 were called Industrial Memoranda*)

No. 21. Measurement of the viscosity of herring solubles. By W. A. B. Thomson, R. E. E. Jonas, R. A. MacLeod and D. R. Idler. (April 1958, 5 pp., free.)

No. 22. (A list with abstracts of) Selected publications concerning smoked fish. (May 1958, 5 pp., free.)