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THE TAGGING OF HERRING (Clupea Pallasii) IN BRITISH COLUMBIA: APPARATUS, INSERTIONS, AND RECOVERIES DURING 1938-39

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INTRODUCTION.

In the autumn of 1936 an experiment in herring tagging and recovery was begun in southern British Columbia. This experiment, involving the use of internal iron tags and their recovery with a specially designed induction detector, gave results which indicated the suitability of the method for studying herring populations under the conditions current in southern British Columbia. Consequently a programme involving these techniques was developed: (1) To investigate the integrity of so-called local populations as determined by racial studies (Tester, 1937); (2) to determine the nature and extent of herring migrations; (3) to give some information on the intensity of fishing; and (4) to help interpret other features of the herring-fishery.

Published reports on the work in previous years (Hart and Tester, 1937; 1938) have demonstrated, among other things, the movement of fish from the Strait of Juan de Fuca to the fishing-grounds on the south-east coast of Vancouver Island; the fact that there is a certain amount of migration from one fishing area to another, although there is a definite tendency for fish to return to the same area; and have given indications that on the east coast in 1937 a minimal estimate of the intensity of the fishing was 21 per cent.

The present report adds further data to those already obtained and records the extension of the work into the area north of Vancouver Island. Additions to equipment and changes

in technique are described in some detail. Tags recovered during the 1938–39 season are recorded and discussed, and a list is presented of the tags used since the preparation of the last report.

TAGGING METHODS.

Tagging Equipment.

Knives and guns used for tagging were of the same design as those used in previous years (Hart and Tester, 1938).

The floating pound already described (loc. cit.) was again used for retaining herring from commercial nets for tagging. This proved difficult to handle during the bad weather prevalent during the early part of the herring season. At the end of the season a successful trial was made using the 36-foot live-well boat " Virago Point " for this purpose. Later the 34-foot salmon-troller " Whiff " (Fig. 1) was used most satisfactorily for tagging. Her hold

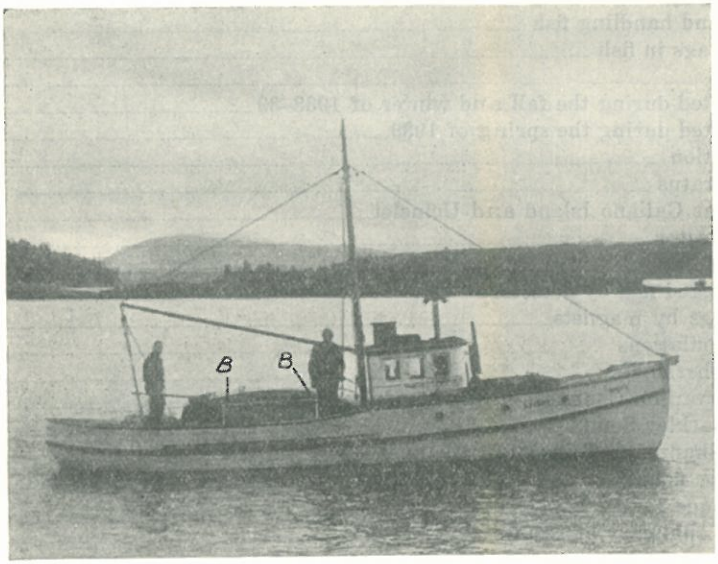


Fig. 1. Boat fitted with bait-tank as used in tagging herring.
(B) Bait-tank.

was fitted with a bait-tank 5 feet long, 3 feet wide, and 4½ feet deep, supplied with salt water by a pump operated by the main engine at a speed sufficient to fill the tank in 25 minutes. This arrangement had all the advantages of a live-well boat and the additional one of greater seaworthiness.

To retain fish for tagging bait-boxes were used similar to those commonly employed for holding live ling-cod bait. One of these boxes made out of 3½-inch slats set about ¾ inch apart was 6 feet long, 4 feet wide, and 3 feet deep. Two smaller boxes made from 2¾-inch slats set about ¾ inch apart were 5 feet long, 2½ feet wide, and a little more than 2 feet deep.

Catching and Handling Fish.

All the fish used for tagging during the fishing season were caught in commercial purse-seines. They were either tagged directly from the seines or transferred to one of the retainers described above for tagging as soon as was convenient.

All the other herring tagged were captured in beach- or purse-seines, or with a dip-net. One lot was seined in the heart of a salmon-trap; some were tagged directly from the partly dried-up seine while the boats drifted, whereas others were transferred to bait-box, bait-tank, or live-well for retention until they could be tagged. In all handling care was taken to avoid rough treatment such as would knock off scales, and to avoid overcrowding which might lead to smothering.

Inserting Tags in Fish.

All of the tags used during the fishing season were inserted with the tagging-gun as described in Hart and Tester (1938). In the spring tagging an effort was made to estimate the relative efficiency of the tagging-gun by tagging some fish from each lot with the gun and some with the knife. Three different methods of using the knife were employed. On the west coast of Vancouver Island the fish were held with one hand and tagged with the other, as described and figured in Hart and Tester (1937). In the Strait of Georgia one tagger held the head and tail ends of the fish in his two hands, exposing part of its side to the other tagger who made the incision and inserted the tag. The method used in central and northern British Columbia was similar, except that the first tagger held the fish against a board. During most of the tagging cotton gloves were worn on the hands coming in contact with the fish.

TAGGING.

A summary of information on the tagging of fish from which tags were returned during the 1938–39 season and of all the tagging done during 1938–39 is given in Table I., with the identification code for concise reference. The detailed data on tagging technique are being withheld until such time as it will be possible to discuss the results and conclusions of the experiments.

In Table VI. is given a complete list of the identification numbers of the tags inserted during 1938–39, together with certain other details of tagging. General tagging localities may be determined by using the code to refer to Table I. Similar information for previous years has been published in former reports and is not repeated.

TABLE I.—A SUMMARY OF THE TAGGING DATA FOR RETURNS MADE DURING THE 1938–39 FISHING SEASON AND FOR TAGS INSERTED DURING THE 1938–39 FISHING SEASON AND THE 1939 SPAWNING SEASON.

Tagging Code.	Date.	No. of Tags inserted.	Place of Tagging.
1A	Oct. 6, 7, 8, 1936	2,392	Swanson Channel.
1C	Oct. 17, 19, 20, 1936	2,398	Swanson Channel.
1E	Mar. 4, 1937	700	Horswell Point, near Nanaimo.
1I	Mar. 17, 1937	1,000	Blind Entrance, Kyuquot Sound.
1K	Mar. 19, 1937	798	Head of Ewin Creek, Nootka Sound.
1L	April 25, 1937	1,198	Head of Tod Inlet, Saanich Inlet.
2A	Sept. 25, 1937	499	Off Sooke.
2B	Oct. 9, 1937	700	Off Sooke.
2C	Oct. 18, 22, 23, 1937	1,257	Swanson Channel.
2D	Nov. 9, 10, 12, 1937	2,829	Swanson Channel.
2E	Nov. 18, 25, 1937	700	Rainy Bay, Barkley Sound.
2F	Nov. 21, 23, 28, 1937	1,298	Effingham Inlet, Barkley Sound.
2G	Nov. 23, Dec. 1, 4, 1937	800	Imperial Eagle Channel (Middle Channel), Barkley Sound.
2H	Mar. 7, 8, 1938	2,299	Macoah Passage, Barkley Sound.
2I	Mar. 9, 1938	899	Calm Creek, Clayoquot Sound.
2J	Mar. 11, 1938	1,293	Queens Cove, Esperanza Inlet.
2K	Mar. 12, 1938	995	Plumper Harbour, Nootka Sound.
2L	Mar. 21, 1938	1,198	Winter Harbour, Quatsino Sound.
2M	Mar. 25, 1938	1,395	Bella Bella, Milbanke Sound.
2O	Mar. 7, 8, 1938	791	Horswell Point, near Nanaimo.
2P	Mar. 15, 1938	497	False Narrows, S.E. side.
2Q	Mar. 16, 17, 1938	799	False Narrows, N.W. side.
2R	Mar. 23, 1938	500	Departure Bay, near Nanaimo.
2S	April 2, 3, 1938	1,196	Union Bay, Baynes Sound.
2T	April 22, 1938	797	Birch Bay, near Blaine, U.S.A.
3A	Oct. 1, 1938	1,454	Off Sooke.
3B	Oct. 11, 13, 1938	1,078	Swanson Channel.
3C	Nov. 25, 1938	99	Vernon Bay, Barkley Sound.
3D	Dec. 5, 7, 9, 10, 1938	447	Trincomali Channel, off Porlier Pass, Reid Island; and Stuart Channel, off Fraser Point.
3E	Dec. 16, 1938	1,000	Swanson Channel.
3F	Jan. 11, 1939	197	Boat Pass, Nootka Sound.
3G	Jan. 12, 1939	798	S.E. Arm, Quatsino Sound.
3H	Jan. 12, 13, 14, 1939	755	Tuck Inlet, near Prince Rupert.
3I	Jan. 15, 16, 17, 19, 20, 1939	1,195	Kwakshua Pass, Calvert Island.
3J	Mar. 6, 7, 1939	1,299	Laredo Inlet.
3K	Mar. 2, 5, 1939	945	Departure Bay, near Nanaimo.
3L	Mar. 8, 1939	1,000	Off north end of Qualicum Beach.
3M	Mar. 9, 1939	997	Kuleet Bay, near Ladysmith.
3N	Mar. 20, 1939	1,000	Gap, Nanaimo Harbour.
3O	Mar. 26, 1939	999	Pender Harbour.
3P	Mar. 29, 1939	997	Dodd Narrows, near Boat Harbour.
3Q	Mar. 11, 1939	1,297	Rivers Inlet Cannery.
3R	Mar. 19, 1939	2,192	Browns Pass, near Bella Bella, Milbanke Sound.
3S	Mar. 22, 1939	1,797	Duncan Bay, near Prince Rupert.
3T	Mar. 25, 1939	899	Butler Cove, near Prince Rupert.
3U	Mar. 7, 1939	1,494	Toquart Harbour, Barkley Sound.
3V	Mar. 19, 1939	1,599	Off Markale, Kyuquot Sound.
3W	Mar. 21, 22, 1939	1,491	Kendrick Arm, Nootka Sound.
3X	Mar. 28, 1939	681	Matilda Creek, Clayoquot Sound.
3Y	Mar. 29, 1939	682	Sydney Inlet.
3Z	Mar. 28, 1939	497	Holmes Harbour, north end of Puget Sound.
3AA	April 15, 1939	152	Gorge, Victoria.

TAGS INSERTED DURING THE FALL AND WINTER OF 1938–39.

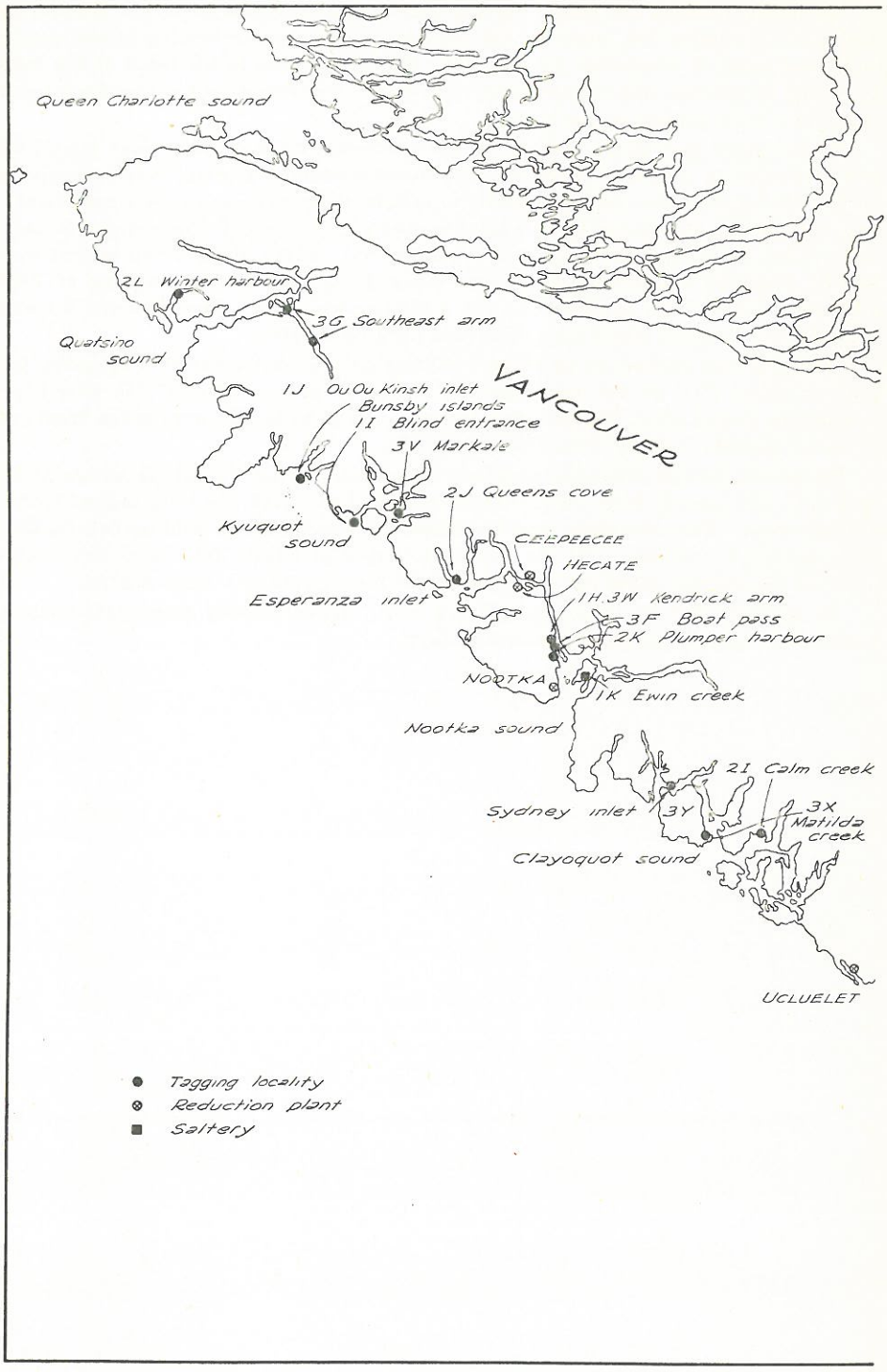
As in the previous two years, herring were tagged at Sooke from the salmon-traps. This was done on October 1st, prior to the opening of the regular herring-fishing season on the south-east coast of Vancouver Island. The fish were seined in the heart of the trap, tagged as quickly as possible, and released near the traps. One thousand four hundred and fifty-four tags (3A) were applied in one day.

In the early part of the fishery off the south-east coast of Vancouver Island the fishing was carried on in Swanson Channel. The floating pound was used there to apply 1,078 tags for the 3B taggings, but proved difficult to handle under adverse weather conditions. Its use was, accordingly, abandoned for the later taggings at Trincomali Channel and Stuart Channel (3D), when the fishery extended into other waters. There, the 447 fish tagged were dipped directly from the seines while they were being dried up. The last tagging of 1,000 fish at Swanson Channel (3E) involved the use of the live-well boat. The fish were dipped from the seine into the live-well where they were held pending tagging.

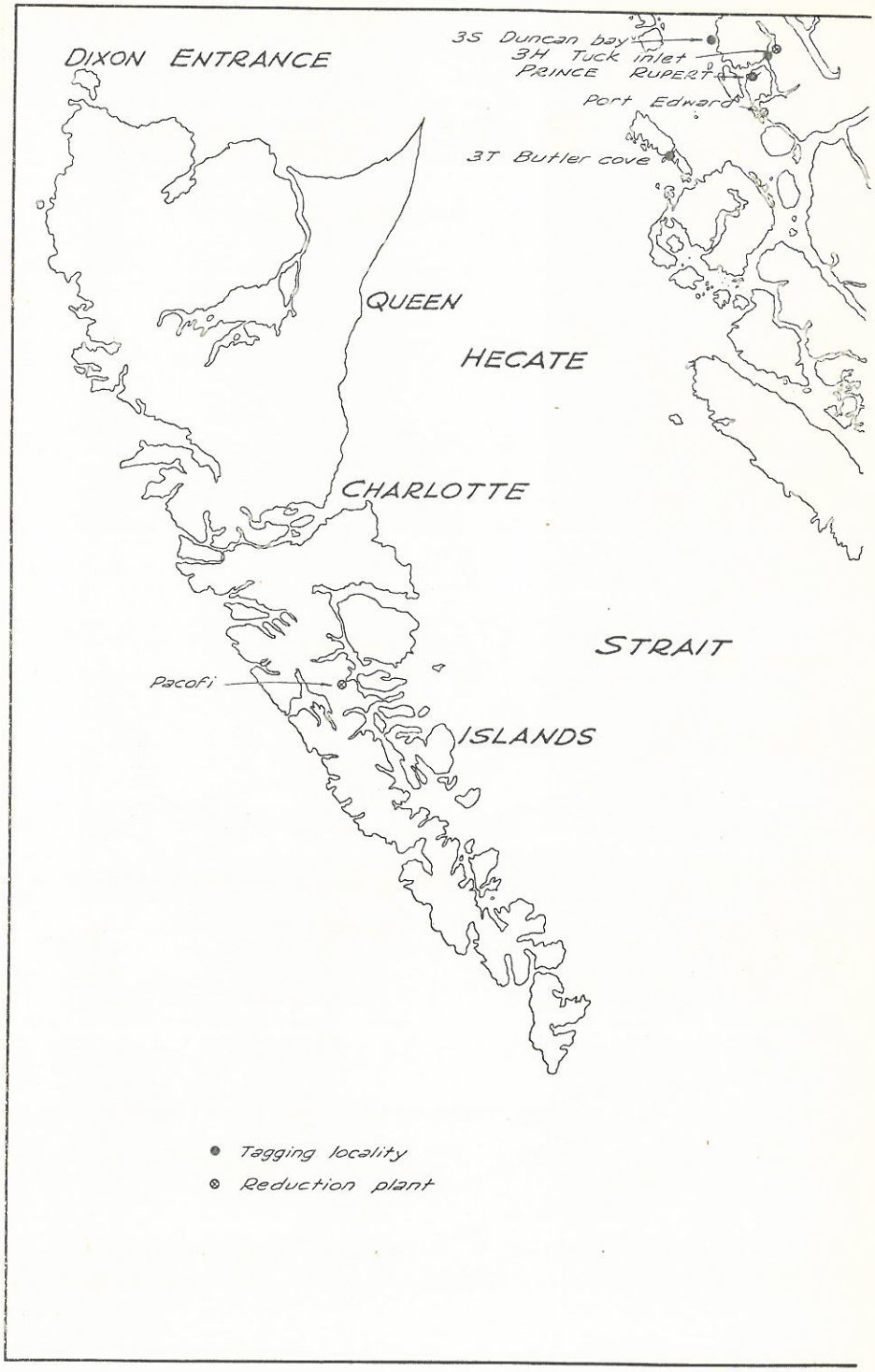
Tagging was carried on in three localities on the west coast of Vancouver Island. In Barkley Sound (3C) 99 fish were tagged; in Nootka Sound (3F) 197 fish were tagged; and in Quatsino Sound (3G) 798 fish were tagged. All of these fish were taken from commercial seines by taggers working from the seine-skiffs.

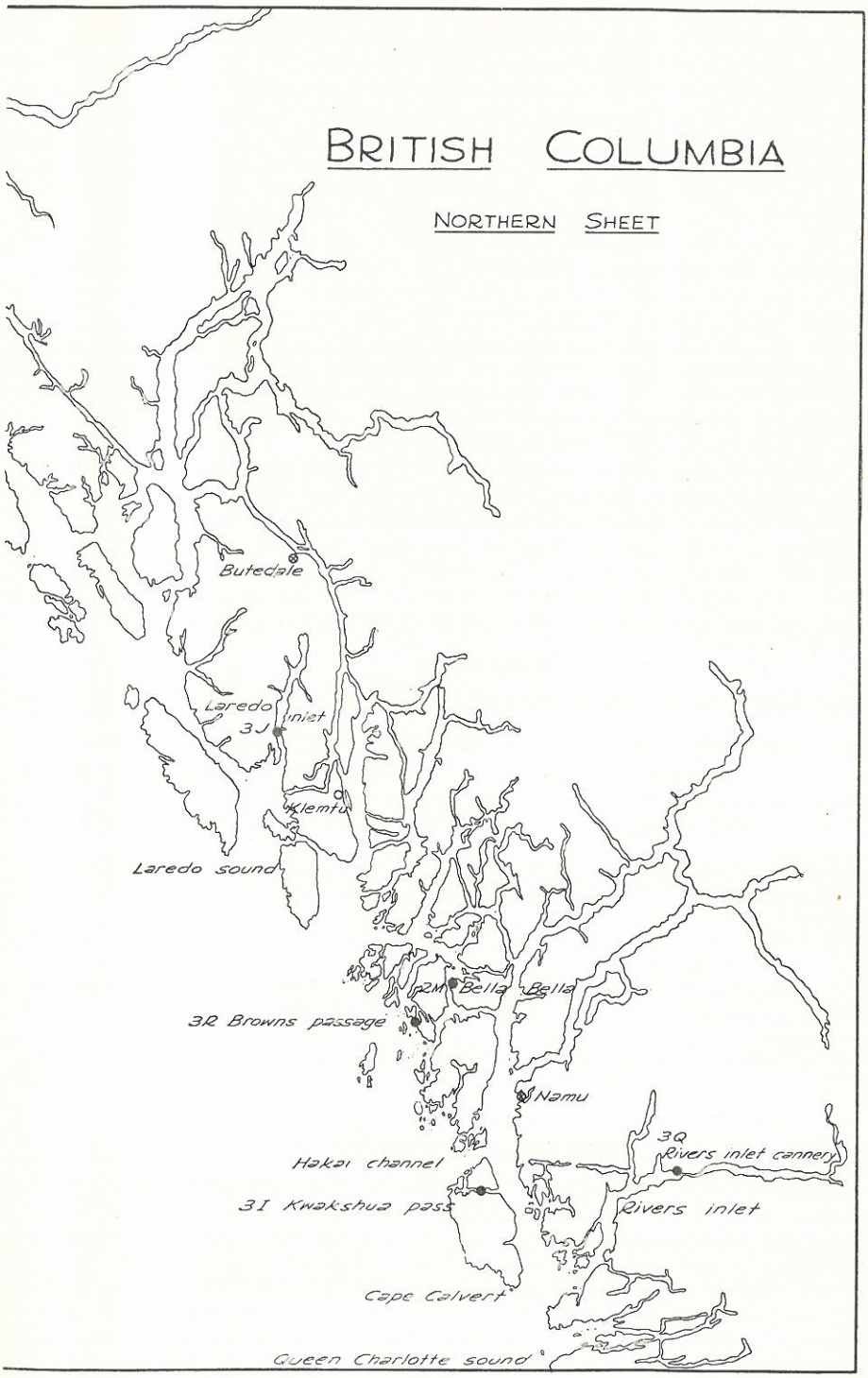
In central British Columbia taggings were made during the fishing season at Kwakshua Pass (3I) and Laredo Inlet (3J). At Kwakshua Pass 1,195 fish were tagged from the commercial seine. This operation was facilitated by the fishermen holding fish partly dried-up while waiting for tenders. Of the 1,299 fish tagged at Laredo Inlet some were tagged direct from the commercial seines and some were held for tagging in a large dip-net.

In northern British Columbia 755 fish were tagged directly from commercial seines at Tuck Inlet (3H) during three successive days.


Queen Charlotte sound
2L Winter harbour
3G Southeast arm
Quatsino sound
VANCOUVER
1J Ou Ou Kinsh inlet
Bunsby islands
1I Blind entrance
3V Markale
2J Queens cove
Kyuquot sound
CEEPEECEE
HECATE
Esperanza inlet
1H 3W Kendrick arm
3F Boat pass
2K Plumper harbour
NOOTKA
1K Ewin creek
Nootka sound
2I Calm creek
Sydney inlet
3Y
3X Matilda creek
Clayoquot sound
UCLUELET
Tagging locality
Reduction plant
Saltery

BRITISH COLUMBIA
SOUTHERN SHEET
STRAIT OF GEORGIA
COURTENAY
30 Pender harbour
25 Union bay
Baynes sound
3L Qualicum
1E, 2O Horswell point
2H
Macoah passage
TOQUART
2F Effingham inlet
KILDONAN
ECOOLE
2E Rainy bay
2G Middle channel
3C Vernon bay
3U Toquart harbour
Barkley sound
2R, 3K Departure bay
2N Newcastle-Protection
NANAIMO
2Q
2P False narrows
3P Dodd narrows
STEVESTON
2M Kulleet bay
3D Stuart chan
3O Trincomali chan
1D Porlier pass
Galiano island
BLAINE
2T Birch bay
Active pass
1A 1C, 2C, 2O, 3B, 3E
Swanson channel
ISLAND
1L Tod inlet
3AA Victoria gorge
2A, 2B, 3A
Sooke
VICTORIA
STRAIT OF JUAN DE FUCA
3Z Holmes harbour


DIXON ENTRANCE
3S Duncan bay
3H Tuck inlet
PRINCE RUPERT
Port Edward
3T Butler cove
QUEEN
HECATE
CHARLOTTE
STRAIT
Pacofi
ISLANDS
Tagging locality
Reduction plant


BRITISH COLUMBIA
NORTHERN SHEET
Butedale
Laredo inlet
3J
Klemtu
Laredo sound
3M
Bella Bella
3R Browns passage
Namu
3Q
Rivers inlet cannery
Hakai channel
3I Kwakshua pass
Rivers inlet
Cape Calvert
Queen Charlotte sound

Tags inserted during the Spring of 1939.

Around the Strait of Georgia six lots of tags were inserted in fish which were spawning or about to spawn. Some of these (Qualicum Beach (3L), Kuleet Bay (3M), Pender Harbour (3O), Dodd Narrows (3P), and Departure Bay (3K) in part) were captured in a beach-seine or dip-net, transferred to the bait-box or bait-tank, and tagged at once. Part of the fish (500) for the Departure Bay tagging (3K) were captured in a bait-seine and held for a day before tagging. The fish tagged in the Gap at Nanaimo Harbour (3N) were taken in a commercial bait-seine. In Holmes Harbour (3Z) 497 herring were tagged by Mr. L. Royal. These fish were taken from a weir built to catch herring for bait purposes. A small tagging of spawned-out and spawning herring was carried out in the Gorge at Victoria (3AA). These fish, taken in a large commercial beach-seine, were not in very good condition, partly owing to cuts which were presumably inflicted by jigs. In all, 6,587 tags were inserted.

On the west coast of Vancouver Island fish were tagged in five localities. At Toquart Harbour (3U) in Barkley Sound, Markale (3V) in Kyuquot Sound, and Kendrick Arm (3W) in Nootka Sound the herring were caught in a small bait-seine from which they were tagged, although part of them were transferred to the bait-box and tagged later at Toquart and Markale. At Matilda Creek (3X) and Sydney Inlet (3Y) the fish were caught in a large commercial bait-seine and were all or nearly all transferred to the bait-box for tagging. On the west coast of Vancouver Island 5,947 tags were used.

Two taggings were completed on spawning fish in central British Columbia. These two taggings, from herring caught with and tagged from the small purse-seine at Rivers Inlet Cannery (3Q) and Browns Pass (3R), accounted for 3,489 tags.

In northern British Columbia two taggings were made. At Duncan Bay (3S) fish were captured with and tagged from the small purse-seine. In Butler Cove (3T) herring were obtained from a commercial bait-seine and were held in a live-box pending tagging. In all, 2,696 tags were inserted during the spawning period in northern British Columbia.

Recapitulation.

All the tags inserted to date may be summarized according to season, locality, and number, as follows:—

Locality.	1936–37.	1937–38.	1938–39.
Fall and Winter.			
Strait of Juan de Fuca	1,500	1,199	1,454
South-east coast of Vancouver Island	7,090	4,086	2,525
West coast of Vancouver Island	.....	2,798	1,094
Central British Columbia	.....	.....	2,494
Northern British Columbia	.....	.....	755
Spring.			
Strait of Georgia (including Victoria Gorge and Puget Sound)	1,898	5,279	6,587
West coast of Vancouver Island	5,692	6,684	5,947
Central British Columbia	.....	1,395	3,489
Northern British Columbia	.....	.....	2,696
Totals	16,180	21,441	27,041

RECOVERY APPARATUS.

Two principal methods were employed for recovering tags. The first of these removes the tagged herring from a chute in the unloading conveyers at the saltery or reduction plant. It depends upon the disturbance created when the tag in a fish passing through the magnetic field of one of a pair of balanced electric coils initiates a series of electrical events which culminate in the by-passing of the tagged fish through a trap-door moved by a compressed-air piston. This apparatus, called an induction detector, has been fully described in previous reports (Hart and Tester, 1937; 1938). Tag-recovery by this equipment has the advantages that there is absolutely no doubt concerning the point of origin of the fish and the whole tagged fish is available for examination. The disadvantages lie in the expense of the installation and in the necessity that an investigator be in constant attendance.

The second principal method of tag-recovery is by the use of electromagnets placed in a short chute between the drier and grinder of a reduction plant. Installations of this type have been described and figured in Hart (1937) and the arrangements for obtaining recovered tags have been dealt with in Hart and Tester (1937). At two plants where there was insufficient space to install magnets of the type usually used, experimental magnets with curved poles were installed in the bottoms of the screw-conveyers between the driers and grinders. This type of recovery magnet did not give satisfactory results, although it was instrumental in recovering some tags. The disadvantage of magnet returns in that there is frequently an element of doubt concerning the actual point of origin of the fish has been pointed out in previous reports. This must be taken into consideration in dealing with the results. The use of magnets for tag-recovery has an advantage in the large number of recovered tags available for consideration at moderate expense.

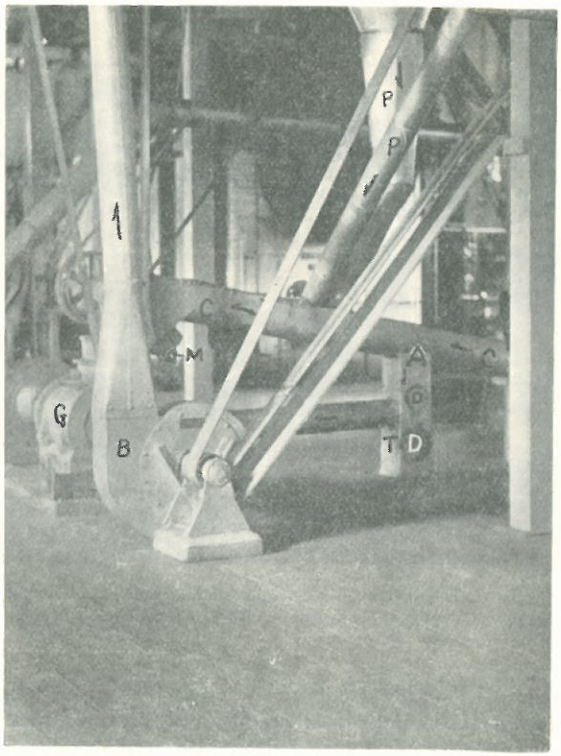


Fig. 2. Trap in which many herring-tags were recovered at Ucluelet. (CC) Case for worm-conveyer from drier; (A) by-pass; (T) trap for metal with clearing-doors (D); (B) blower to cyclone; (P) discharge from cyclone; (M) magnet; (G) grinder.

A third method by which tags were recovered at one plant is worthy of mention. A cyclone was installed in the Ucluelet plant to cool the meal before grinding. In order to save the fan-blades a trap to remove metal was installed below the place where the meal was taken from the conveyer (Fig. 2). A large proportion of the herring-tags at the Ucluelet plant were recovered by this trap, from which they were readily removed by the use of a magnetized steel bar. It is worthy of note that, owing to the greater weight of herring-tags, a much higher proportion of them were recovered by this trap than was the case for pilchard-tags (which have about half the weight).

At other plants tags were taken in varying numbers from irregularities in the conveyers. In still others the design of the plants was such that the tags failed to pass directly through the drier, with the consequence that many tags were recovered from that source.

One tag was recovered by a fisherman cutting up herring for bait.

The Detectors at Galiano Island and Ucluelet.

The induction detector at Galiano Island was operated again for the first six weeks of the fishing season. Although the set-up was essentially the same as that used the previous year and described in the reports for 1936 and 1937, one change was necessary in that the solenoid air-valve needed replacement. As larger air-hoses had to be used this led to an unknown decline in efficiency, as it proved impossible to perfect the timing with the altered equipment. Twenty-eight recoveries were made by this unit during its period of operation.

The installation at Ucluelet (Fig. 3) had two alterations from the condition described in the report for 1937. In the first place, changes made in the reduction plant conveyer system permitted the installation of a somewhat longer chute than that employed in the previous year. The chute was pivoted to facilitate timing the equipment. The second alteration consisted of the installation in the mercoid-switch circuit of a system of condensers and resistances

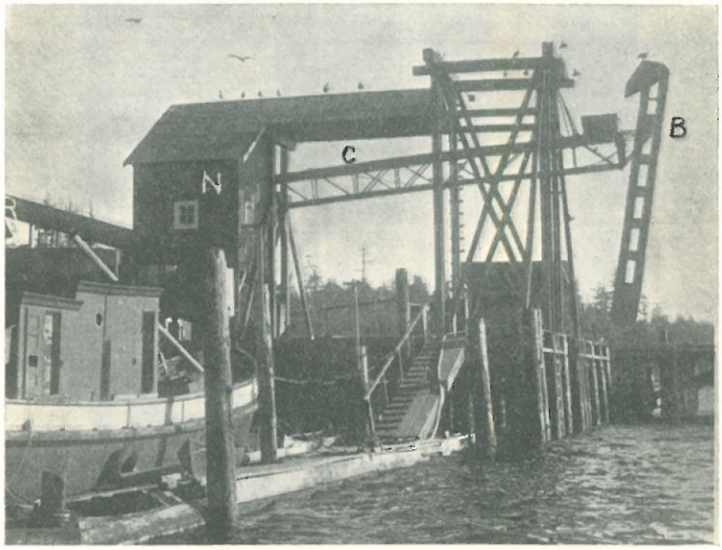


Fig. 3. The unloading machinery and control-room at Ucluelet. (B) Marine leg; (C) pivoted conveyer; (R) fixed conveyer; (N) control-room for tag-recovery equipment.

which could be adjusted to keep the circuit open for any required length of time (delayed-action relay). In spite of these improvements it proved very difficult to get satisfactory timing with the unit. Difficulty was experienced also with condensers placed in the line to remove "noise" which, instead, stored up charges induced by the operation of the conveyer and released them at frequent irregular intervals. This caused so much disturbance to the proper working of the set that it was frequently impossible to operate. Very few fish were captured after the trouble was located and removed. Only five tags were recovered by the Ucluelet detector.

The Nootka Detector.

In November the electrical apparatus and air system of the Galiano unit were transferred to the Nootka plant of the Nootka Packing Co. (1937), Ltd. There they were connected to a trap-door system which was adapted to the particular arrangements of the Nootka conveyers. This installation, while similar in principle to that in use at the other plants, differed considerably in detail. In order to obtain the necessary drop it proved necessary to bring a sloping conveyer down to dock-level and to have the unloaded fish slide down a chute fixed above the conveyer at a less steep slope. The essential features of this installation are indicated in Figs. 4, 5, and 6. Some difficulty with timing and with pick-up interference was experienced with this unit also. However, for part of the season it gave satisfactory service and it was instrumental in recovering thirty-four tags.

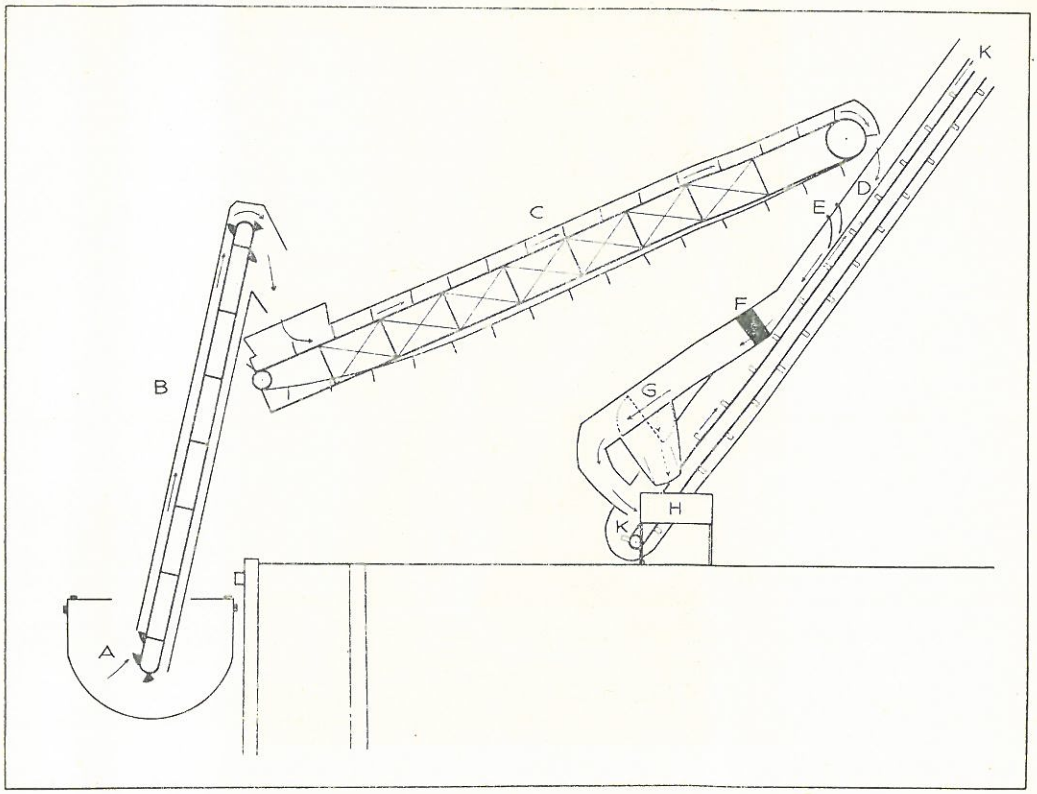


Fig. 4. Diagram of the Nootka detector installation. Herring are unloaded from the hold of the boat (A), pass up the marine leg (B) and along the pivoted conveyer (C). They then fall to the chute (D) which is placed above the slats of the elevator (K). They slide down the chute past the canvas baffles (E) which retard their speed, through the coil (F), over the trap-door (G), and drop to the elevator (K), which transports them into the plant. When a tagged fish passes through the coil (F), the trap-door (G) opens and the tagged fish, along with several others, passes through the trap-door and down a short copper chute into the bin (H).

MAGNETS.

Herring-meal was passed over four of the seven magnets which were effective last year in recovering herring-tags. The companies owning the plants, the name and location of the plants, and the number of tags recovered by each plant (on the magnet or otherwise) follow:—

British Columbia Packers, Limited, Kildonan, Barkley Sound	45
Banfield Packing Co., Ltd., Ucluelet, Barkley Sound	66
Nootka Packing Co. (1937), Ltd., Nootka, Nootka Sound	119
Nelson Bros. Fisheries, Limited, Ceepeecee, Esperanza Inlet	169

A few herring-tags were recovered during the pilchard season by plants which operated on herring in 1937–38 but not in 1938–39, as follows:—

British Columbia Packers, Limited, Ecoole, Barkley Sound	1
Nelson Bros. Fisheries, Limited, Toquart, Barkley Sound	3
British Columbia Packers, Limited, Hecate, Barkley Sound	1

Tags were also recovered by new magnets of the usual type installed at:—

British Columbia Packers, Limited, Imperial, Steveston	217
British Columbia Packers, Limited, Port Edward, Port Edward	112
Tucks Inlet Packing Co., Ltd., Tuck Inlet	88
British Columbia Packers, Limited, Pacofi, Queen Charlotte Islands	0

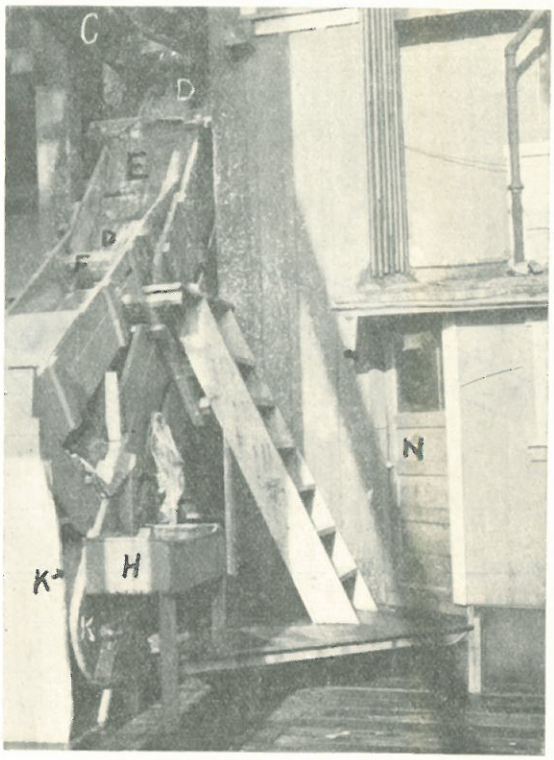


Fig. 5. Nootka installation. (C) Bottom of pivoted conveyer; (D) chute; (E) canvas baffles; (F) coil; (K) lower end of elevator; (H) bin; (N) door into room for detector equipment.

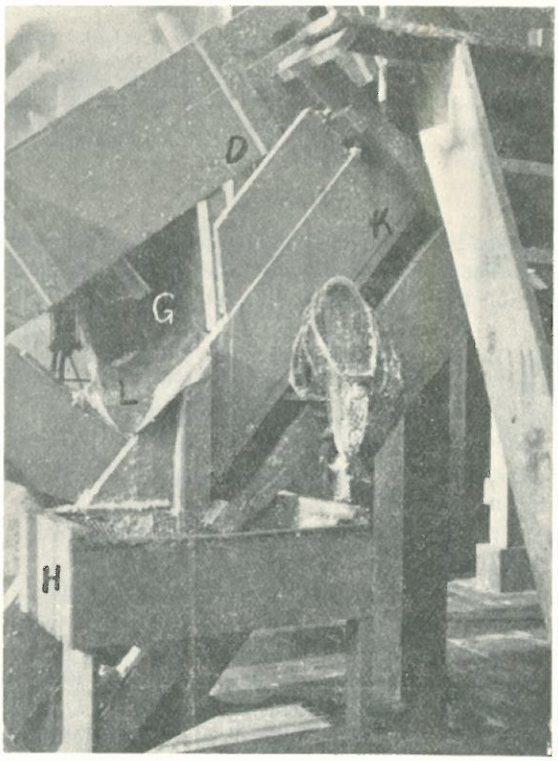


Fig. 6. Nootka installation. (D) Side of chute; (K) side of elevator; (G) end of open trap-door; (L) copper chute; (H) bin.

As the Imperial plant used alternating current a Tungar rectifier was supplied to deliver direct current to the magnet. Although the Tuck Inlet plant has two meal-lines, a recovery magnet was installed in only one of these. Many of the Port Edward tags were recovered from the drier.

A few tags were recovered by magnets with crescentic poles installed in the bottoms of meal conveyers at:—

Canadian Fishing Company, Ltd., Butedale, Princess Royal Island..... 15
British Columbia Packers, Limited, Namu, Fitzhugh Sound..... 56

Curved-pole magnets were installed in each of the two meal-lines at Namu.

In all, 892 tags were recovered by magnets.

RECOVERY OF TAGGED FISH BY DETECTORS.

Sixty-seven tagged fish were recovered by the use of induction detectors.

One return was a fish tagged in the spring of 1937. This fish, tagged at Horswell Point (1E), was recaught at the north end of Trincomali Channel on November 18th.

There were thirteen recoveries of fish tagged during the fall to spring, 1937–38. Two fish tagged at Sooke (2B) were recaptured at the north end of Trincomali Channel, and one fish captured and tagged in Swanson Channel (2D) was caught again in the same place exactly one year later (November 12th). A fish tagged off Horswell Point (2O) was taken in Swanson Channel on October 26th. A fish tagged in Barkley Sound (2G) was recaptured in Imperial Eagle Channel on December 19th. One herring tagged at Esperanza Inlet (2J) was recaptured at Scow Bay or Jewitt Cove, Nootka Sound, on January 9th. Two herring tagged in Quatsino Sound at Winter Harbour (2L) were recovered in the south-east arm and Koprino Harbour of Quatsino Sound on January 12th and December 17th. Five herring tagged at Bella Bella (2M) were returned by the induction detector. One of these came from the south-east arm of Quatsino Sound on January 12th and the remaining four came from Kwakshua Pass in Calvert Island in the latter half of January.

TABLE II.—TAGS RECOVERED BY INDUCTION DETECTORS DURING 1938–39.

Code.	Place and Month of Tagging.	Place of Capture.					Total.
		East Coast of Vancouver Is.	Barkley Sd.	Nootka Sd. and Esperanza In.	Quatsino Sd.	Kwakshua Pass.	
1E	Horswell Point, March, 1937	1	----	----	----	----	1
2B	Sooke, Oct., 1937	2	----	----	----	----	2
2D	Swanson Channel, Nov., 1937	1	----	----	----	----	1
2G	Barkley Sound, Nov.-Dec., 1937	----	1	----	----	----	1
2J	Esperanza Inlet, March, 1938	----	----	1	----	----	1
2L	Quatsino Sound, March, 1938	----	----	----	2	----	2
2M	Bella Bella, March, 1938	----	----	----	1	4	5
2O	Horswell Point, March, 1938	1	----	----	----	----	1
2T	Birch Bay, April, 1938	1*	----	----	----	----	1
3A	Sooke, Oct., 1938	12	----	----	----	----	12
3B	Swanson Channel, Oct., 1938	15	----	----	----	----	15
3F	Nootka Sound, Jan., 1939	----	----	4	----	----	4
3G	Quatsino Sound, Jan., 1939	----	----	----	10	----	10
3I	Kwakshua Pass, Jan., 1939	----	----	----	----	12	12
	Totals	33	1	5	13	16	68

* Recovered by a fisherman cutting up bait about five weeks after tagging. Fish caught off Fraser River.

Of the fish tagged during the current year fifty-three were recovered by tag detectors. Of the fish tagged at Sooke (3A) twelve were recovered, all from the fishing-grounds around the south-east coast of Vancouver Island; ten certainly, and probably eleven, came from Swanson Channel; one came from the north-west end of Trincomali Channel. Fifteen fish

tagged during the first Swanson Channel (3B) tagging were recovered. Of these thirteen were returned from Swanson Channel, the fourteenth was probably from Swanson Channel, and the fifteenth came from the north-west end of Trincomali Channel. The four fish recovered from the Nootka Sound (3F) tagging were returned from Nootka Sound immediately after. Similar situations were apparent for the Quatsino Sound (3G) taggings from which ten fish were recovered within two days from the same place. From the Kwakshua Pass (3I) taggings twelve tagged herring were recovered between January 23rd and February 8th.

One fish tagged at Birch Bay (2T) was recaptured off the mouth of the Fraser on April 22nd and the tag observed when the fish was cut up for bait. It is considered here since, as with detector recoveries, there is no reasonable doubt concerning the place of origin of the fish.

The returns of tagged fish by the three induction detectors are summarized in Table II.

RECOVERY OF TAGS BY MAGNETS.

It seems advisable to restate here the principal difficulty in the use of magnets for recovering tags. In all plants, but to varying degrees, there is a tendency for tags to get held up in the drier or conveyers so that they are not recovered while the fish in which they entered the plant are being processed. For this reason the tags are reported from the wrong load of fish and may be reported from an incorrect locality. Two examples will illustrate the difficulty. One (2G) herring-tag was recovered during the pilchard season by a plant which had processed some 1,800 tons of pilchards. There is no reasonable doubt but that the tag entered the plant toward the end of the 1937 herring season and was not dislodged from the machinery until shortly before its recovery. Another (2G) herring-tag was recovered during a run on a load of pilchards in October. This tag may have stuck in the plant all during the pilchard season (curtailed at that plant), or it may have come in with east coast herring which had been processed recently. It is really not possible to say definitely. Because of such uncertainty it seems advisable to present a full discussion of the returns with a statement of all possibilities. This is done in the following paragraphs, with the returns from each tagging discussed separately.

It should be noted that in some cases—i.e., 1I, 1K, and 2C—there is a slight possibility that some of the tags may have been returned after lying in the plants for a full year. In other cases this explanation of returns appears negligible. Aside from this remote possibility, there are no reasonable grounds for questioning the accuracy of any reported place of recovery beyond the possibilities discussed in the comments.

Swanson Channel (1A): One tag was reported from a run of cold-storage fish taken in Barkley Sound in 1937; the record is possibly correct, but the tag probably originated from east coast herring, or may possibly have come from Barkley Sound fish of 1938.

Swanson Channel (1C): One tag was returned from the east coast of Vancouver Island.

Horswell Point (1E): Two tags were returned from the east coast of Vancouver Island.

Kyuquot Sound (1I): Two tags were recovered. One returned at the beginning of the 1938 pilchard season probably originated in Kyuquot Sound herring taken in the fall of 1937. The other was returned from Kyuquot Sound herring, but may have originated from Nootka Sound or Sydney Inlet.

Nootka Sound (1K): Two tags were recovered. One, reported from Galiano Island, may have originated in Barkley Sound. The other, reported from Quatsino Sound, may have originated from the Nootka-Esperanza area or Kyuquot Sound.

Saanich Inlet (1L): Two tags were returned from the east coast of Vancouver Island.

Sooke (2A): Two tags were returned from the east coast of Vancouver Island.

Sooke (2B)?: One tag was returned from the east coast of Vancouver Island.

Swanson Channel (2C): Four tags were returned, three from the east coast. The fourth was reported from Quatsino Sound, but may have originated from the Nootka-Esperanza region or Kyuquot Sound.

Barkley Sound (2E): Two tags were returned. One was reported from a run of cold-storage fish taken in Barkley Sound in 1937, which is probably correct, although Barkley Sound 1938 and the east coast are possible places of origin. The other was reported from the east coast of Vancouver Island, but may have originated from Barkley Sound fish.

Barkley Sound (2F): Five tags were returned. Two returned during the 1938 pilchard season originated from Barkley Sound herring of the previous year. Of the other three reported from Barkley Sound, all may have been recovered from the east coast and two of these may also have originated from cold-storage fish taken in Barkley Sound in 1937.

Barkley Sound (2G): Five tags were returned. Four of these were returned during the 1938 pilchard season and must have entered the plants during the previous herring season. The remaining one was returned during a run on pilchards taken in Nasparti Inlet containing no herring, and it would seem that it probably originated from east coast herring. The possibility that it is a "hang-over" from the previous season may be considered in view of the other returns recorded here.

Barkley Sound (2H): One tag was returned from Barkley Sound but may have originated from east coast fish.

Clayoquot Sound (2I): Ten tags were recovered. Two of these were reported from the east coast, one certainly and the other probably correctly, although Barkley Sound is a possible locality of origin. Eight of the tags were reported from Barkley Sound, but any of them may have actually originated from the east coast. No doubt some, if not all, of these eight returns are correct.

Esperanza Inlet (2J): Seven tags were returned. Of two reported recoveries from fish taken on the east coast of Vancouver Island one is certainly correct and the other may have originated in Barkley Sound. One reported from Sydney Inlet may have come from Esperanza Inlet fish. One tag reported as coming from Kyuquot fish probably originated in Quatsino Sound, but may have come from the Nootka-Esperanza or Kyuquot areas. Three other tags were reported from runs of Quatsino herring, but may have originated from Nootka, Esperanza, or Kyuquot fish.

Nootka Sound (2K): Six tags were recovered. One, reported in Barkley Sound, may have originated from east coast fish. Two reported from Nootka Sound may have come from Sydney Inlet, Esperanza, or Quatsino areas. One reported from Kyuquot probably originated in Quatsino Sound but, like two originally reported from Quatsino, may have originated from Nootka, Esperanza, or Kyuquot fish.

Quatsino Sound (2L): Eight tags were recovered. Five of these were reported from Quatsino Sound, but they may have originated from Sydney Inlet, Nootka-Esperanza, or Kyuquot areas. Three of these tags were reported from Kwakshua Pass in central British Columbia; these possibly, and it is believed probably, originated in Quatsino Sound, but they may have originated in any of the regions just mentioned.

Bella Bella (2M): Fifty-eight tags were recovered. Thirty-five of these were reported as coming from Kwakshua Pass or, what amounted to the same thing during this year, "Namu area." Some of these may have had other sources of origin as follows: West coast areas, sixteen; other areas in central British Columbia, four; Tuck Inlet or Prince Rupert Harbour, four; east coast, eleven. Twenty-two are recorded from Laredo Sound. Evidence based on the condition of the tags or the reliability of the plant in producing accurate data on place of origin of the tags indicates that sixteen of these returns are probably correct. However, the numbers of these which may have had other points of origin are: Kwakshua Pass and other areas in central British Columbia, twelve; Kwakshua Pass, Tuck Inlet, or Prince Rupert Harbour, six; east coast, four. One was reported from Quatsino Sound. It may have originated from the Nootka-Esperanza area or Kyuquot.

Horswell Point (2O): Four tags were recovered. All are reported from the east coast, but two of these may have originated in Barkley Sound.

False Narrows (2P): Eight tags were recovered. Seven of these were reported from the east coast. One was reported from Barkley Sound, but possibly originated from east coast fish.

False Narrows (2Q): Thirteen tags were recovered. Twelve of these were reported from the east coast. One tag was returned during a run of Barkley Sound fish, but may have originated with east coast fish.

Departure Bay (2R): One tag was returned. It was reported from Barkley Sound, but may have come from east coast fish.

Baynes Sound (2S): Five tags were returned. Three of these came from east coast fish. The fourth was reported from Barkley Sound, but may have entered the reduction

plant with east coast fish. The fifth was reported from Kwakshua Pass. It may have originated there, in the Nootka-Esperanza area, Kyuquot area, or Quatsino Sound.

Birch Bay (2T): Two tags were recovered. One was recovered on the east coast. The other was reported from Barkley Sound, but may have originated with east coast fish.

Sooke (3A): Seventy-nine tags were returned. Seventy-two were reported from the east coast of Vancouver Island. Of these, two may have originated in Barkley Sound. Two tags were reported as coming from runs of salmon-offal, and two others from a run of pilchards including no herring taken in Nasparti Inlet. These tags, too, no doubt came from east coast herring. Three tags were recorded from Barkley Sound, but may have originated in east coast fish.

Swanson Channel (3B): Eighty-eight tags were returned. Eighty-four were reported from the east coast, but one of these may have originated in Barkley Sound. Three tags were recovered during a run of salmon-offal; they probably entered the plant with east coast herring. One tag was recorded from Barkley Sound, but probably originated on the east coast.

TABLE III.—TAGS RECOVERED BY MAGNETS DURING 1938–39.

Code.	Place and Month of Tagging.	Reported Probable Place of Capture.										Total.
		East Coast of Vancouver Is.	Barkley Sd.	Sydney In. and Clayoquot Sd.	Nootka Sd. and Esperanza In.	Kyuquot Sd.	Quatsino Sd.	Kwakshua Pass.	Laredo In.	Tuck In. and Prince Rupert	????	
1A	Swanson Channel, Oct., 1936	.....	.....	.....	.....	.....	.....	.....	.....	.....	1*	1
1C	Swanson Channel, Oct., 1936	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
1E	Horswell Point, March, 1937	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
1I	Kyuquot Sound, March, 1937	.....	.....	.....	.....	2*	.....	.....	.....	.....	.....	2
1K	Nootka Sound, March, 1937	1*	.....	.....	.....	.....	1*	.....	.....	.....	.....	2
1L	Saanich Inlet, April, 1937	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
2A	Sooke, Sept., 1937	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
2B	Sooke, Oct., 1937	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
2C	Swanson Channel, Oct., 1937	3	.....	.....	.....	.....	1*	.....	.....	.....	.....	4
2E	Barkley Sound, Nov., 1937	1*	1*	.....	.....	.....	.....	.....	.....	.....	.....	2
2F	Barkley Sound, Nov., 1937	.....	3*	.....	.....	.....	.....	.....	.....	.....	2*	5
2G	Barkley Sound, Nov., 1937	1*	.....	.....	.....	.....	.....	.....	.....	.....	4*	5
2H	Barkley Sound, March, 1938	.....	1*	.....	.....	.....	.....	.....	.....	.....	.....	1
2I	Clayoquot Sound, March, 1938	2*	8*	.....	.....	.....	.....	.....	.....	.....	.....	10
2J	Esperanza Inlet, March, 1938	2*	.....	1*	.....	1*	3*	.....	.....	.....	.....	7
2K	Nootka Sound, March, 1938	.....	1*	.....	2*	1*	2*	.....	.....	.....	.....	6
2L	Quatsino Sound, March, 1938	.....	.....	.....	.....	.....	5*	3*	.....	.....	.....	8
2M	Bella Bella, March, 1938	.....	.....	.....	.....	.....	1*	35*	22*	.....	.....	58
2O	Horswell Point, March, 1938	4*	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
2P	False Narrows, March, 1938	7	1*	.....	.....	.....	.....	.....	.....	.....	.....	8
2Q	False Narrows, March, 1938	12	1*	.....	.....	.....	.....	.....	.....	.....	.....	13
2R	Departure Bay, March, 1938	.....	1*	.....	.....	.....	.....	.....	.....	.....	.....	1
2S	Baynes Sound, April, 1938	3	1*	.....	.....	.....	.....	1*	.....	.....	.....	5
2T	Birch Bay, April, 1938	1	1*	.....	.....	.....	.....	.....	.....	.....	.....	2
3A	Sooke, Oct., 1938	72*	3*	.....	.....	.....	.....	.....	.....	.....	4*	79
3B	Swanson Channel, Oct., 1938	84*	1*	.....	.....	.....	.....	.....	.....	.....	3	88
3C	Barkley Sound, Nov., 1938	5*	1*	.....	.....	.....	.....	.....	.....	.....	.....	6
3D	Trincomali Channel, Dec., 1938	16	1*	.....	.....	.....	.....	1*	.....	.....	1*	19
3F	Nootka Sound, Jan., 1939	.....	.....	.....	.....	.....	3†	.....	.....	.....	.....	3
3G	Quatsino Sound, Jan., 1939	.....	.....	.....	.....	.....	137	52†	.....	.....	.....	189
3H	Tuck Inlet, Jan., 1939	.....	.....	.....	.....	.....	.....	1†	4†	171*	.....	176
3I	Kwakshua Pass, Jan., 1939	.....	.....	.....	.....	.....	4†	114*	19*	2†	.....	139
3J	Laredo Inlet, March, 1939	.....	.....	.....	.....	.....	.....	.....	37	.....	.....	37
??	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	3	4
	Totals	223	25	1	2	4	157	207	82	173	18	892

* Some uncertainty about the source of at least one of the tags included in the entry. Reference should be made to the text.

† Reasonable certainty that the reported source is not correct.

Barkley Sound (3C): Six tags were recovered. Five of them were reported from Barkley Sound and may have originated on the east coast. One of them was recorded from the east coast and may have originated, and no doubt did originate, in Barkley Sound.

Trincomali Channel (3D): Nineteen tags were recovered. Sixteen were reported from the east coast of Vancouver Island. One was reported from Barkley Sound, one from Kwakshua Pass, and one from a plant clean-up. All of these three may have originated, and no doubt did originate, with east coast fish.

Nootka Sound (3F): Three tags were reported from Quatsino Sound. These, no doubt, originated from Nootka Sound fish.

Quatsino Sound (3G): One hundred and eighty-nine tags were returned. One hundred and thirty-seven were returned from Quatsino Sound. Fifty-two were recorded as being taken from Kwakshua Pass. These may have originated in Quatsino Sound and such is strongly believed to be the case.

Tuck Inlet (3H): One hundred and seventy-six tags were returned. One hundred and forty-five were reported from Tuck Inlet or Prince Rupert Harbour. Twenty-six were reported from Tuck Inlet or Namu, one from Namu, and four from Laredo Sound. Probably all of these tags entered the reduction plant with Tuck Inlet or Prince Rupert Harbour fish.

Kwakshua Pass (3I): One hundred and thirty-nine tags were recovered. One hundred and three of these were recorded from Kwakshua Pass or its equivalent. Eight were recorded from Tuck Inlet or Kwakshua Pass and no doubt originated at Kwakshua. Fifteen tags were reported from Laredo Sound or Laredo Inlet, four from Hakai Channel, and three off Cape Calvert. These may represent movements of the fish, but more probably the tags originated with Kwakshua Pass fish. One return from each of Prince Rupert Harbour and Tuck Inlet and four records from Quatsino Sound may have originated at Kwakshua Pass, and probably did so.

Laredo Inlet (3J): Thirty-seven tags were recovered. All of these were reported from Laredo Inlet or its equivalent.

Four unidentifiable tags were recovered.

These returns have been summarized according to tagging place and time, and locality of recovery, in Table III.

STABILITY OF POPULATIONS.

Tester (1937) presented evidence from racial examinations of herring from many localities in British Columbia that free intermingling did not take place between populations of herring on the east coast of Vancouver Island, on the west coast, and to the north of Vancouver Island. Evidence was also presented which indicated rather stable groups within these larger areas. The records of tags which have been out for at least six months may be used as a test of the conclusions drawn from racial studies.

Considering detector and magnet returns together there are fifty-one returns of tags which have been out for six months or more, from taggings made on the east coast (including Sooke). Of these, forty-one have been returned certainly from the east coast, two have certainly been returned from other areas, and there is doubt about the remaining eight. From the data supplied with the returns there is no special reason for ascribing the returns to either the east coast or other areas. However, it would appear more reasonable to consider the uncertain returns as distributed in proportion to the tags concerning which the origin is certain. In that event an overwhelming majority of the returns (forty-nine out of fifty-one) are from east coast areas. If the doubtful tags are divided equally between the two groups the majority of east coast returns is still very substantial (forty-five out of fifty-one).

While it is demonstrated by the tagging-work that herring which are on the east coast fishing-grounds in the fall or which spawn on the east coast in the spring have a strongly marked tendency to return to east coast fishing-grounds in subsequent autumns, it is evident from the tag returns that the fishery exploits a composite population. During the course of the investigation spawning fish have been tagged on nine different occasions on the east coast of Vancouver Island (prior to 1939) at various places from Baynes Sound to Tod Inlet and Birch Bay. Recoveries have been made from every tagging with the single exception of one rather small one in Ganges Harbour. This shows that the east coast fishery is supplied by herring which spawn in many places widely separated in the Strait of Georgia.

There were fifty-two returns by detectors and magnets of tags out more than six months from west coast taggings. There is evidence, however, concerning ten of these that they were held up in reduction plant machinery and do not constitute valid returns. They are not, accordingly, considered further. Of the remaining forty-two, twenty-two were certainly returned from the west coast and two were definitely returned from fishing-grounds other than the west coast, while there is uncertainty concerning the origin of the remaining eighteen. Repetition of the calculations indicated in the foregoing paragraph indicates majorities of thirty-eight and thirty-one out of forty-two returns from west coast areas.

In all, there were sixty-three returns from Bella Bella (2M) tags. Twenty of these were definitely from the central area of British Columbia north of Vancouver Island and two were certainly from outside that area (Quatsino Sound). If the forty-one tags concerning which uncertainty exists are divided as before, the majorities of the returns from central British Columbia are fifty-seven and forty-one out of sixty-three. The fact that the element of doubt concerning thirty-one of the forty-one doubtful returns is largely academic, and that there is reasonable certainty that they originated in central British Columbia, indicates that the fifty-seven out of sixty-three majority is closer to describing the actual condition.

It is not possible to treat the individual west coast taggings by the method used above for the larger districts since consideration of the returns shows that there is no or little possibility of obtaining a return concerning the origin of which there is no doubt. However, certain general statements are in order concerning some of the taggings. Ten tags were returned from the tagging in Calm Creek, Clayoquot Sound (2I), none of them from Clayoquot Sound. All of them were returned from the east coast or Barkley Sound. The returns from the Esperanza Inlet (2J) and Nootka Sound (2K) taggings are capable of only uncertain interpretation. Three of the thirteen magnet returns were from the east coast or Barkley Sound—one certainly from the east coast. Five returns are reported from areas between Sydney Inlet and Kyuquot Sound, although some of these may have originated from Quatsino Sound fish. It is perhaps significant that the only return concerning which there is complete certainty (i.e., that made by the detector) came back from the Nootka area. Five tags from these two taggings were recorded from Quatsino Sound. Any of these may have originated in other west coast areas, but it seems unlikely that all would have done so. Seven of the ten Quatsino Sound (2L) tags were returned from Quatsino Sound and it is believed that the remaining three (reported from Kwakshua Pass) also entered the reduction plants with Quatsino Sound fish. In any case, no 2L tags were recovered by plants which operated on Kwakshua Pass herring but did not operate on Quatsino Sound fish.

In summary, it may be said that there is good evidence for the belief that the integrity of the populations of herring in the major districts is fairly well preserved. On the west coast of Vancouver Island a considerable amount of movement from one area to another is manifest, but the extent cannot yet be defined owing in part to the uncertain nature of the data obtained from magnet recoveries. It appears that the Quatsino Sound population is fairly distinct, but even it certainly receives some additions from northern areas and possibly from those to the south-east.

MOVEMENTS OF HERRING.

Sooke to Swanson Channel.—Influence of the Tides.

The two previous reports on herring-tagging have shown a movement of herring from the south end of Vancouver Island near Sooke to the fishing-grounds in the Strait of Georgia at Swanson Channel and Trincomali Channel near Porlier Pass. These results are fully confirmed by the returns for the present year in which eighty-four tags put in fish at Sooke on October 1st were reported as coming from fish captured on the east coast grounds and eighty-two of these certainly did so. The first of these was recovered on October 12th. As this represents a maximum time for the migration of the earliest fish and as the distance by the most direct route is around 50 miles, the minimum speed of migration is rather more than 4 miles a day. The recovery of several tags from east coast fish on magnets at Ucluelet and Kildonan on October 15th and days immediately following indicates that the movement at that minimum speed was general.

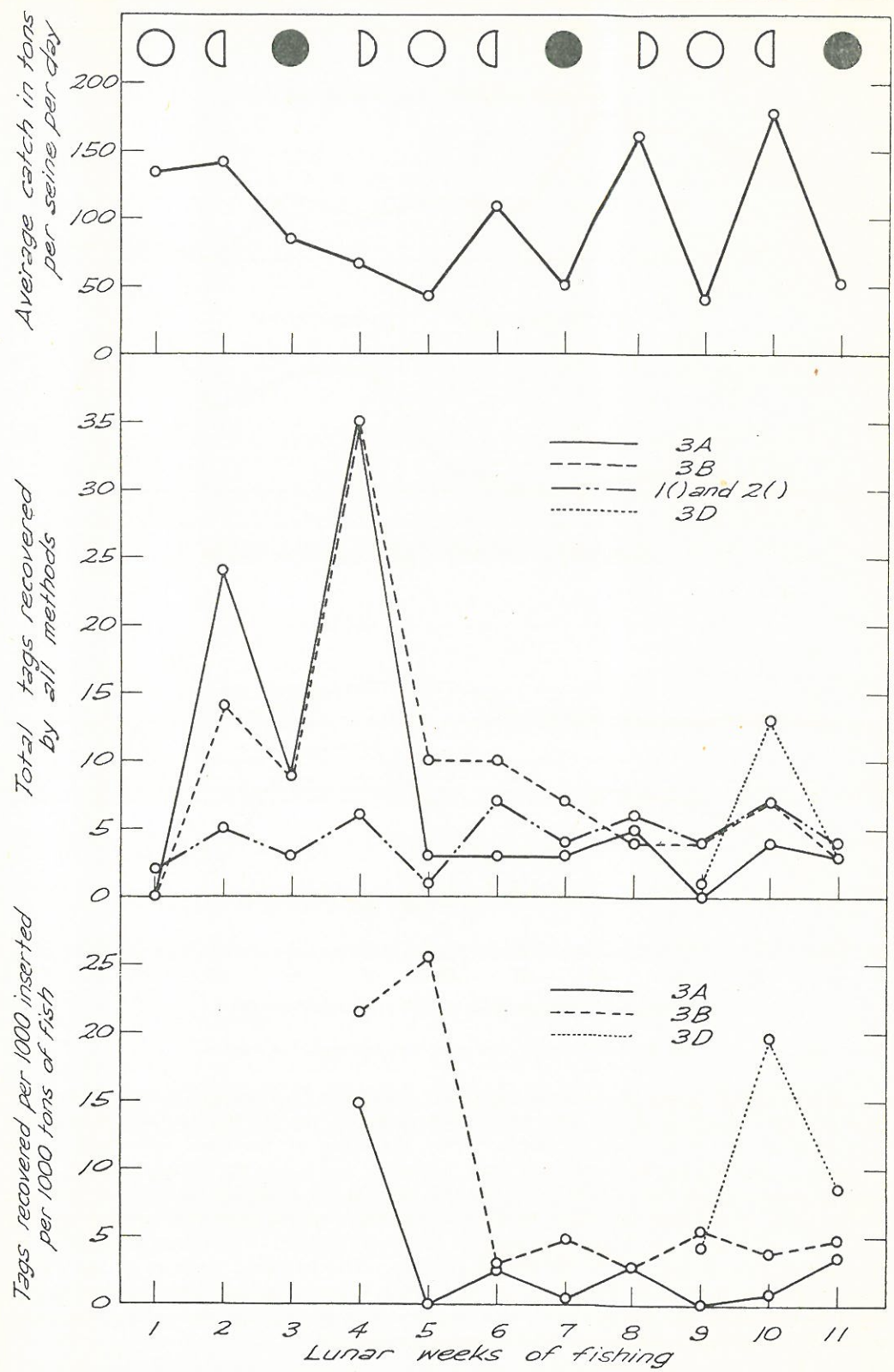


Fig. 7. The recovery of tags used on the east coast of Vancouver Island in relation to lunar weeks of the fishery and the availability of herring in Swanson Channel.

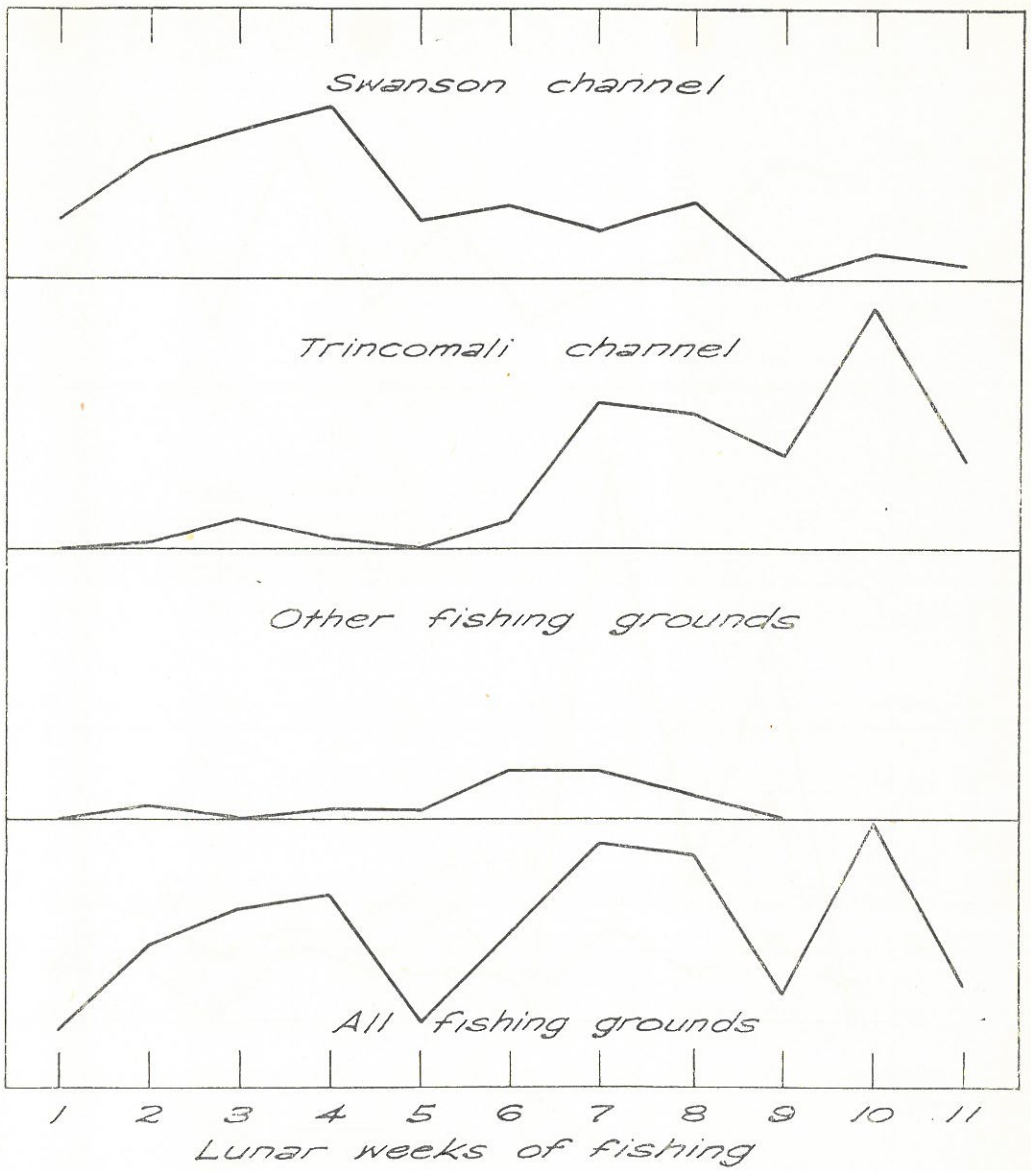


Fig. 8. Week of capture and sources of fish handled at Plant A.

Tester (1938) found that herring were more available in Swanson Channel during the first and third quarters of the moon and less available during the full and new moons, and considered as the most likely explanation that the effect of the moon was through the strength of the tides and their influence upon influxes of new fish to the fishing-grounds. The tagging results of the fall of 1937 supported the view that new fish appeared on the grounds at the times of the first and third quarters. The most recent recoveries as portrayed in Table IV. and Figs. 7 and 8 also lend support to the explanation of increased availability by the immigration of new fish to the fishing-grounds. The following features of the curves seem worthy of notice: In the top panel the weekly average catches made by unit fishing effort and corrected for weather, etc., with one exception demonstrate the regular alteration in trend of availability which might be expected by theory.

TABLE IV.—DISTRIBUTION OF MAGNET RETURNS BY LUNAR WEEKS.

(East Coast Returns lagged One Day from that reported, West Coast Returns lagged Two Days.)

Lunar Week.	Availability. Catch/Seine/Day.	TAGS RECOVERED BY MAGNETS.							
		3A.		3B.		3D.		East Coast only 1 (x) and 2 (x).	
		E.	W.	E.	W.	E.	W.	E.	W.
Oct. 6–Oct. 12	135	0	0	0	0	0	0	1	1
Oct. 13–Oct. 19	142	0	21	0	11	0	0	1	4
Oct. 20–Oct. 26	85	0	6	0	5	0	0	0	2
Oct. 27–Nov. 3	67	23	9	25	8	0	0	5	0
Nov. 4–Nov. 10	44	0	1	10	0	0	0	1	0
Nov. 11–Nov. 17	108	3	0	3	1	0	0	4	0
Nov. 18–Nov. 25	51	1	1	7	0	0	0	3	1
Nov. 26–Dec. 2	161	5	0	4	0	0	0	6	0
Dec. 3–Dec. 9	40	0	2	3	1	1	0	2	2
Dec. 10–Dec. 17	178	2	1	6	0	13	0	3	4
Dec. 18–(Dec. 21)	55	3	0	3	0	2	1	4	0
Totals		37	41	61	26	16	1	30	14
Not included		1	----	1	----	2	----	2	
Total tags recovered		79	----	88	----	19	----	46	

In the centre panel the total of 3A tags recovered shows very high return for the second and fourth weeks. The first peak is presumably the result of the first entrance of tagged fish on the grounds. The second peak probably has two explanations: Firstly, a second group of Sooke fish entering the fishery; and secondly, the commencement of effective action by the Plant A magnet and the recovery by it of tags accumulated in the drier. The subsequent parts of the curve illustrate the falling-off of returns with time after tagging, and to some extent they reflect the addition of new Sooke tags to the exploited populations. The peaks on the 3B tags will have similar explanations, except that falling off may be expected to play a more important part and migration on to the fishing-grounds will not be effective. The curve for 3D illustrates only falling off after tagging. The recorded single tag in week 9 is probably an error due to methods of handling the data. The (1) and (2) tags show no trend throughout the season, as would be expected from fish which had been tagged long enough to become thoroughly mixed. It is noteworthy that the fluctuations in returns agree perfectly with moon phase, and excellently with catch per unit fishing effort. This probably indicates that for some reason increasing amounts of fish were routed through reduction plants at times when abundance was high.

In the lower panel the 3A tags, with the exception of the final week of fishing, show a positive relation between the catch per unit of fishing effort and the number of tags recovered per thousand tags inserted per thousand tons of fish examined for tags. This agrees with the observation of the previous season and with what would be expected according to the theory of movement already outlined. The 3B tags show a reciprocal recovery distribution to that of the 3A tags. This again is in agreement with the results for the previous year (where there was one exception) and with the hypothesis under examination. As the 3B tags are put in on the fishing-grounds any additions to the supply of herring there will result in a dilution effect on the tagged fish.

SOOKE TO BARKLEY SOUND.

In the 1937–38 season, certainly one and possibly more tags put in at Sooke were recovered from Barkley Sound fish. During the 1938–39 season, plant operations were such

that there was no opportunity for obtaining indisputable records. It is worthy of note in this connection that a significantly* higher proportion of Sooke tags (3A) as compared with Swanson Channel (3B) tags was recovered by magnets in plants which operated on Barkley Sound fish than by the Plant A which did not. This might be taken as indicating that some 3A tags entered Barkley Sound reduction plants with Barkley Sound herring, but other explanations are equally plausible. For example: There is evidence in Table IV. that the magnet at Plant A was not operating efficiently during the first three weeks of the herring season during which the other plants recovered many 3A tags. Furthermore, toward the end of the season boats bound for the west coast tended to load Swanson Channel fish, whereas boats loading for Plant A took more fish from Trincomali. Such a difference as that may have been responsible for differences in the proportions recovered of the two lots of tags.

Swanson Channel to Trincomali Channel.

Some east coast herring-fishermen are of the opinion that there is no direct movement of herring between the Swanson Channel fishing-grounds and those in Trincomali Channel, and some evidence from tag returns of the two previous years seemed to support their contention. That there is movement of some sort between the two fishing-grounds is definitely shown by the returns for 1938–39. One fish tagged in Swanson Channel (3B) was recovered by the induction detector from a load of fish captured at the north end of Trincomali Channel. Three tags (3B) were recovered during a lunar week by a plant which operated only on Trincomali Channel fish, and in the following week six 3B tags were recovered during a week in which 140 tons of Swanson Channel fish were processed as compared with 1,340 tons of Trincomali Channel fish. These returns show without doubt that fish move from the Swanson Channel grounds to those in Trincomali Channel. It is still possible, however, that the fishermen are correct in their contention that no direct movement takes place, for the herring may have moved out through Active Pass up the Strait of Georgia and back through Porlier Pass or they may have moved from one ground to the other through the narrower channels among the islands.

INTENSITY OF THE FISHERY.

Tag returns may be used to make estimates of the numbers of fish on the grounds and hence of the intensity of the fishery. This may be done by making use of the following calculations: Number of fish on grounds = (catch of fish examined for tags) × (number of tags used) / (number of tags recovered); the intensity of the fishery = (total catch of fish) / (number of fish on the grounds). The figures for three reduction plants and the Galiano detector may be used in making these calculations and the results are set out in Table V. In considering the results of these calculations several points should be kept in mind. In the first place, the estimates of fish on the grounds are maximums—i.e., any error caused by (1) migration of the fish, (2) inefficiencies of recovery methods, and (3) death of the fish as a result of tagging, will increase the apparent abundance of fish on the grounds. The high estimates of abundance based on Plant A figures are probably due to the plant's low efficiency in tag recovery early in the season. The high estimates for the Galiano detector

* Statistical methods are available which make it possible to calculate the odds against an observed condition arising by chance. If the odds are as high as 20 to 1 against such an occurrence the condition is said to be significant; if the odds are more than 100 to 1 against the condition is termed very significant. However, statistics alone cannot give any information as to what the significance concerns. That can only be learned by an impartial consideration of all the factors leading to the result obtained and sometimes, as in this case, it is not possible to arrive at a definite conclusion.

In the present case it can be shown that the distribution of returns shown in the following tabulation from Table IV. could not happen by chance once in more than 100 trials if the tags from both taggings were distributed randomly over all of the east coast fishing-grounds and only there. However, as shown in the text, more than one reasonable explanation of the condition may be offered.

	3A Tags.	3B Tags.	Total.
Recovered in plants handling only east coast fish	37	41	78
Recovered in plants handling both east coast and west coast fish	61	26	87
Totals	98	67	165

are no doubt associated with the decline in its efficiency, and a detailed examination of the log for that unit shows that such an explanation is quite possible. The estimates of 120,000 tons of fish on the grounds appear to be closest to correct and even they are maximum. This figure, taken with the 25,000 tons set as a quota for the east coast fishery, gives an estimate of 21 per cent. for the fishing intensity, which agrees closely with the minimum intensity of fishing as calculated for the previous year (21 per cent.). These figures are not directly comparable because no allowance was made for the efficiency of the recovery methods. This was done for induction detector returns for the previous year.

TABLE V.—DATA AND TREATMENT FOR ESTIMATING ABUNDANCE OF FISH ON GROUNDS.

	Tags recovered.			Tons of Swanson Channel and Trincomali Channel Herring processed.		Percentage Tags returned.			Maximum Estimate of Fish on Grounds in Thousands of Tons.		
	3A.	3B.	3D.	3A and 3B.	3D.	3A.	3B.	3D.	3A.	3B.	3D.
Plant A	38	62	18	8,840	2,210	2.60	5.80	4.0	340	170	55
Plant B	27	20	0	2,360	?	1.90	1.90	----	120	120	----
Plant C	15	7	1	1,220	?	1.04	0.65	----	120	187	----
Galiano detector	11	14	----	1,990	0	0.76	1.30	----	260	150	----
Tags used	1,454	1,078	447								

The recovery from the very few fish caught in Barkley Sound of six 3C tags out of ninety-nine used indicated that not only were fish hard to catch but that there were extremely few fish in the area.

The magnets installed in the northern plants are known to have such low efficiencies that there is little advantage in making calculations of population abundance. It is perhaps noteworthy, however, that, during only the latter part of the season, 176 tags of the Tuck Inlet (3H) tagging were recovered out of 755 used. This indicates a recovery efficiency of 23 per cent. Obviously the fishing intensity must have been considerably higher.

TAGGING TECHNIQUE.

In the report for 1937–38 evidence was brought forward which indicated that crowding fish in the pound during tagging operations led to lower returns, and hence presumably a higher mortality from tagging, even although no deleterious effects were observable during the tagging operation. It was observed that the number of returns was greater in cases where the number of fish in the pound did not exceed 500. The results for this year confirm the previous ones as is shown in the tabulation:—

	Taggings of less than 1,000.	Taggings of more than 1,000.
Tags inserted	1,657	2,429
Tags recovered	5	0

Statistical tests show that this difference is highly significant as it could occur by chance only once in more than 100 times. As the fish tagged in smaller lots were more exposed to the fishery of the 1937–38 season it seems likely that the difference is actually due to differences in methods of handling the fish and, consequently, the results serve as a warning against crowding fish during tagging operations.

DISCUSSION AND SUMMARY OF RESULTS.

Considering British Columbia (excluding the Queen Charlotte Islands) as being divided into four main areas—east coast of Vancouver Island, west coast of Vancouver Island, central British Columbia, and northern British Columbia—the results of tagging experiments have shown only negligible movements from one major area to another. In the central and northern parts of the Province the work has not yet been sufficiently extensive to allow much opportunity for the detection of such intermingling. Consequently, the results for those regions are not of great significance. However, the data on the west and east coasts of Vancouver Island are full enough to indicate that the intermingling of the populations in those areas with each other or with the central and northern areas is slight.

There is little opportunity of obtaining detailed information concerning lack of movement between the smaller (fishery) areas on the west coast of Vancouver Island. Concerning some there is no doubt but that large proportions of the tags turned up in fish caught in areas other than that of tagging (e.g., Calm Creek). With others there appears to be reasonable certainty that all of the tags came back from the general vicinity of tagging (e.g., Quatsino Sound). In the case of still other taggings the returns seemed to indicate that tags were returned from both the tagging and other areas, but data concerning magnet recoveries are so uncertain that it is at present impossible to state whether there is a significant tendency for more of these tags to return from the tagging areas than from other regions.

In the returns for the current year there was ample corroboration of the movement of herring from the southern part of the Strait of Juan de Fuca at Sooke to the fishing-grounds in the Strait of Georgia. There is some evidence for belief in a movement of fish from Sooke to Barkley Sound, but it is readily interpreted in other ways.

During the 1938–39 season there was definite evidence of movements of herring from Swanson Channel to Trincomali Channel, near Porlier Pass. This is in contrast to the results of previous years, but it is not necessarily shown that the fish moved by the most direct route.

Consideration of the intensity of the fishery on the east coast of Vancouver Island and in the Prince Rupert Harbour area indicates minimum estimates of 22 and 23 per cent. These, especially the latter, are probably low, but by how much cannot at present be stated.

TABLE VI.—DETAILED LIST OF TAGS INSERTED DURING 1938–39.

Series H.	Date released.	Tagging Code.	Where released.	No. of Tags used.
36301–37500	Oct. 1, 1938	3A	Off Sooke	1,157
37501–37600	Oct. 11, 1938	3B	Swanson Channel	100
37601–37900	Jan. 12, 1939	3G	S.E. Arm, Quatsino Sound	300
37901–38100	Oct. 1, 1938	3A	Off Sooke	198
38101–38300	Jan. 12, 1939	3G	S.E. Arm, Quatsino Sound	199
38301–38400	Jan. 15, 1939	3I	Kwakshua Pass, Calvert Island	99
38401–38500	Jan. 12, 1939	3G	S.E. Arm, Quatsino Sound	99
38501–38600	Oct. 1, 1938	3A	Off Sooke	99
38601–38800	Jan. 12, 1939	3G	S.E. Arm, Quatsino Sound	200
38801–39000	Jan. 11, 1939	3F	Boat Pass, Nootka Sound	197
39001–39100	Jan. 15, 1939	3I	Kwakshua Pass, Calvert Island	100
39201–39400	Jan. 15, 1939	3I	Kwakshua Pass, Calvert Island	200
39401–39600	Jan. 19, 1939	3I	Kwakshua Pass, Calvert Island	200
39601–39700	Jan. 16, 1939	3I	Kwakshua Pass, Calvert Island	99
39701–39800	Jan. 18, 1939	3I	Kwakshua Pass, Calvert Island	100
39801–40000	Jan. 16, 1939	3I	Kwakshua Pass, Calvert Island	198
40001–40300	Oct. 11, 1938	3B	Swanson Channel	299
40301–40995	Oct. 13, 1938	3B	Swanson Channel	679
41001–41100	Nov. 25, 1938	3C	Vernon Bay, Barkley Sound	99
41101–41200	Dec. 5, 1938	3D	Stuart Channel	100
41201–41300	Dec. 7, 1938	3D	Stuart Channel	99
41301–41400	Dec. 9, 1938	3D	Trincomali Channel	100
41401–41550	Dec. 10, 1938	3D	Trincomali Channel	148
41551–41900	Dec. 16, 1938	3E	Swanson Channel	350
42001–42550	Dec. 16, 1938	3E	Swanson Channel	550
42601–42700	Dec. 16, 1938	3E	Swanson Channel	100
42701–42900	Jan. 12, 1939	3H	Tuck Inlet	188
42901–43000	Mar. 6, 1939	3J	Laredo Inlet	100
43801–43900	Mar. 7, 1939	3J	Laredo Inlet	100
44301–44400	Mar. 6, 1939	3J	Laredo Inlet	100
44401–44500	Mar. 7, 1939	3J	Laredo Inlet	100
44501–44700	Mar. 11, 1939	3Q	Rivers Inlet Cannery	200
44701–44800	Mar. 6, 1939	3J	Laredo Inlet	100
44801–44900	Mar. 7, 1939	3J	Laredo Inlet	100
44901–45000	Mar. 6, 1939	3J	Laredo Inlet	100
46001–46300	Jan. 13, 1939	3H	Tuck Inlet	294
46301–46600	Jan. 14, 1939	3H	Tuck Inlet	273
46601–47000	Mar. 2, 1939	3K	Departure Bay	400
47001–48000	Mar. 8, 1939	3L	Off Qualicum	1,000
48001–49000	Mar. 9, 1939	3M	Kuleet Bay	997
49001–49200	Jan. 20, 1939	3I	Kwakshua Pass, Calvert Island	199
49201–49300	Mar. 6, 1939	3J	Laredo Inlet	100
49301–49400	Mar. 5, 1939	3K	Departure Bay	97
49401–49500	Mar. 6, 1939	3J	Laredo Inlet	100
49551–49600	Mar. 2, 1939	3K	Departure Bay	50
49601–50000	Mar. 5, 1939	3K	Departure Bay	398
50001–50100	Mar. 6, 1939	3J	Laredo Inlet	99
50101–50400	Mar. 7, 1939	3J	Laredo Inlet	300
50401–51500	Mar. 11, 1939	3Q	Rivers Inlet Cannery	1,097
51501–53700	Mar. 19, 1939	3R	Browns Pass	2,192
53701–55500	Mar. 22, 1939	3S	Duncan Bay	1,797
55501–56400	Mar. 25, 1939	3T	Butler Cove	899
56801–57000	Apr. 15, 1939	3AA	Gorge, Victoria	152
57001–58500	Mar. 7, 1939	3U	Toquart Harbour, Barkley Sound	1,494
58501–60100	Mar. 19, 1939	3V	Off Markale, Kyuquot Sound	1,599
60101–61600	Mar. 21, 1939	3W	Kendrick Arm, Nootka Sound	1,491
61601–62300	Mar. 28, 1939	3X	Matilda Creek	681
62301–63000	Mar. 29, 1939	3Y	Sydney Inlet	682
65001–66000	Mar. 20, 1939	3N	Gap, Nanaimo Harbour	1,000
66001–67000	Mar. 29, 1939	3P	Dodd Narrows	997
67001–68000	Mar. 26, 1939	3O	Pender Harbour	999
68001–68400	Mar. 28, 1939	3Z	Holmes Harbour, Puget Sound	397
68601–68700	Mar. 28, 1939	3Z	Holmes Harbour, Puget Sound	100

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