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College of Fisheries
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THE MIGRATORY BEHAVIOR OF JUVENILE CHUM SALMON RELEASED IN 1977 FROM THE HOOD CANAL HATCHERY AT HOODSPORT, WASHINGTON

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Clifford J. Whitmus
Fisheries Research Institute

and

Scharleen Olsen
Washington State Department of Fisheries

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Approved

Roy E. Nakatani
Acting for the Director

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ABSTRACT

A mark and recapture study was conducted in 1977 by the Fisheries Research Institute and Washington State Department of Fisheries to monitor the migratory behavior of hatchery stocks of chum salmon during their first three weeks of outmigration in Hood Canal. Fluorescent pigment was used to mark 256,000 (mean length 53.7 mm) and 402,000 (mean length 57.2 mm) chum salmon which were released April 20 and June 5, 1977, respectively, from WDF Hood Canal hatchery. The smaller chums released in April migrated out of Hood Canal faster (8-10 km/day) than the larger chums released in June (5-7 km/day). Fish released in April moved offshore at a smaller size than the June release. The growth rate of the June release was monitored for 4 weeks and indicated a 5% body weight gain per day.

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INTRODUCTION

The Washington State Department of Fisheries (WDF) has selected chum salmon (Oncorhynchus keta) as the primary species and Hood Canal as one of the principal areas for enhancement. Hood Canal produces 60% of the total catch of chum salmon in Puget Sound, and in 1977 Hood Canal hatcheries released 20 million chum salmon. By 1980 the production from these hatcheries and streamside egg boxes will exceed 50 million fish.

The WDF has a hatchery on Purdy Creek, a tributary of the Skokomish River (George Adams) and one at Hoodsport (Hood Canal). The Department of the Interior, Fish and Wildlife Service (USFWS), operates a hatchery on the Quilcene River. The University of Washington has a spawning channel, hatching boxes, and an experimental hatchery at Big Beef Creek near Seabeck (Schroder 1977). Various Indian tribes are constructing small hatcheries to produce returns to their reservations.

Hood Canal also serves as a migration path and rearing area for naturally produced chum salmon from streams such as Big Beef Creek, Dewatto, and Tahuya rivers on the east side, the Skokomish River on the southwest corner, and the Duckabush, Dosewallips, and the Hamma Hamma rivers on the west side of Hood Canal. With continued intensive enhancement of wild and hatchery stocks of chum salmon a total of 100 million fish may emigrate annually in the 1980's.

It has been demonstrated that the basic food of small chum salmon in Hood Canal is epibenthic harpacticoid copepods (Kaczynski et al.

1973, Feller and Kaczynski 1975, Simenstad 1976). These copepods derive their food from detritus-based bacteria flora (Sibert et al. 1977) which are found mainly along beaches and in estuarine conditions at river mouths. This limits the very young salmon to nearshore conditions which, although extensive in Hood Canal, are finite. Thus, the migration behavior becomes important in determining the residence time, which is the length of time spent in the estuarine and nearshore feeding grounds. Mason (1974) found that chum fry resided in an estuary for up to 30 days (average 1-2 weeks). Migration behavior is also involved with the size or stage that chum fry become pelagic feeders, utilizing the potentially larger food supply of deeper waters. Previous studies on pink salmon (O. gorbuscha) in Canada (LeBrasseur 1964) indicate that a fork length of 45 to 55 mm is a critical size for offshore movement and that possibly physiological changes occur at a length of 60 to 80 mm.

Parker (1965), studying the survival of pink salmon outmigrants in the Bella Coola area, British Columbia, estimated that there was a 77% mortality during the initial 40-day period of the life in enclosed marine waters. Neave (1948 and 1953) made the assumption that pink and chum salmon approach an ecological similarity, i.e., both species are subject to the same sources of mortality at the same degree of effectiveness during similar stages of life history (Parker 1962). From this assumption Parker (1962) proposed a relatively high initial

instantaneous mortality rate, termed "coastal" followed by a relatively low "oceanic" rate.

We possess the technology for producing millions of additional fish, but we know little about either their survival subsequent to release or the absolute numbers of fish Hood Canal can support instantaneously. Chum and pink salmon spend 4-6 weeks in Hood Canal. Thus, the role of Hood Canal in the early marine survival of chum and pink salmon requires investigation. Periodic assessments of the hatchery strategies are recommended to safeguard against exacerbating mortality rates or other disruptions of the system's ecology.

Knowledge of residence time, spatial distribution, and the timing of the natural runs would assist hatchery managers to determine the optimum size, time, and number of fish to release. This in turn may lead to the goal of enhancement, that being significant increases in the catch of returning adults.

This report describes the migratory behavior of small juvenile chum salmon which were marked by flourescent pigments, and recaptured in the waters of Hood Canal. This cooperative study between the Fisheries Research Institute (FRI) of the University of Washington and WDF had two major objectives:

1) Investigate the spatial distribution and migration rates of different sizes of chum salmon.
2) Define the growth rates of marked chum salmon during their residence in Hood Canal.

METHODS AND MATERIALS

Marking

The marking of juvenile chum salmon (38-60 mm) with fluorescent pigment, as described by Jackson (1959), was selected as the most efficient and economical technique. This technique consists of forcing fluorescent pigment granules through the epidermis into the dermis of the fish by means of a small sandblasting gun and compressed air. The sandblasting gun was modified (Carr, Shurman, and Tival, in preparation) to use 0.94-liter (1-qt) polyethylene bottles instead of the standard 1-qt metal canister. The gun was fitted with a 2.4-mm (3/32-inch) siphon and blast orifice. Air was supplied with 6.9-m^3 (244-ft^3) air cylinders fitted with a double-stage oxygen regulator. The spray gun was connected to the regulator by 15.2 m (50 ft) of flexible high pressure air hose.

A marking trough (Carr et al., in preparation) that minimized the stress but maximized the numbers that could be marked was developed (Fig 1).

The pigment is a fluorescent, biologically inert polystyrene (Dayglo, Jeffrey Mill Grind [JMG] [30-350 μ], arc yellow and rocket red) which is not readily excited by normal light but will fluoresce under ultraviolet illumination. It was found that the manufacturer's grind contained particles much larger than the 350 μ granule upper size limit. These large particles, when sprayed at high pressure during

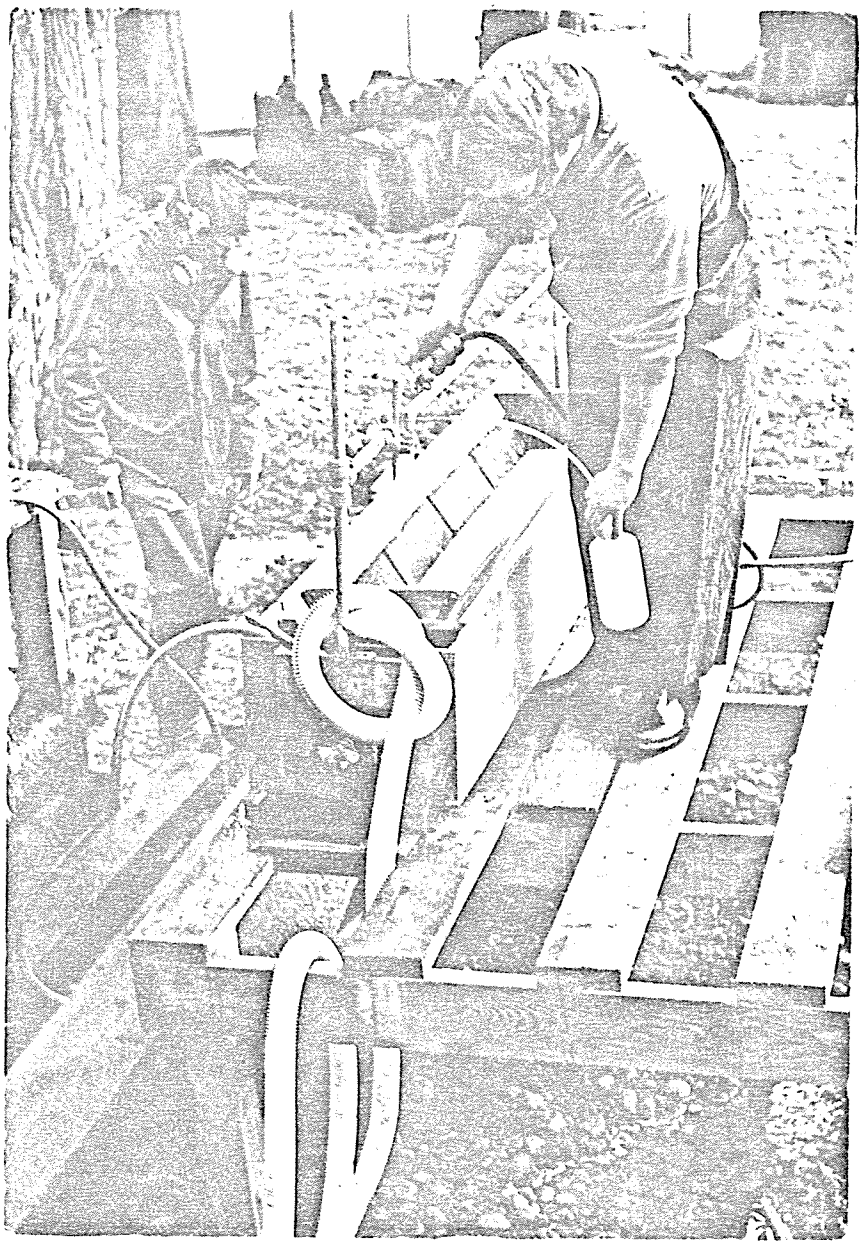


Fig. 1. Marking trough developed for the mass marking of juvenile salmonids.

preliminary studies, caused excessive mortalities, which necessitated the sieving of the pigment to 500 μ.

The fish were removed from the hatchery pond, weighed for enumeration, and transferred into a holding trough. Approximately 500-750 fish (1.0-1.4 kg) were transferred by dip net or bucket from the holding trough to the marking trough. The fish were immediately sprayed with pigment at 6.9-8.3 kg/cm^2 (100-120 PSI) at a distance of 40.6-45.7 cm (16-18 inches) for 6 sec duration, and washed from the marking trough into a recovery trough (Fig. 2). At periodic intervals the fish were released from the recovery trough into a hatchery pond.

Subsamples of marked fish were transported to Point Whitney Shellfish Laboratory where mark retention and mortality rates were monitored for up to 30 days. Fish were held in outdoor, single flow-through saltwater aquaria.

Nearshore Sampling

Nearshore sampling was conducted by the use of a floating 37-m beach seine with 18 m of 3-cm stretch mesh, and a 0.6-m x 2.4-m x 2.3-m bag of 6-mm stretch mesh (Fig. 3) (Schreiner 1977a). The net was set by boat 30 m from shore and then drawn symmetrically to the shore. At 10 m from shore the net was closed causing the catch to be funneled into the bag. This method has previously been used for salmonid outmigration studies in Hood Canal (Schreiner 1977a and 1977b). A 10-m x 2-m beach seine of

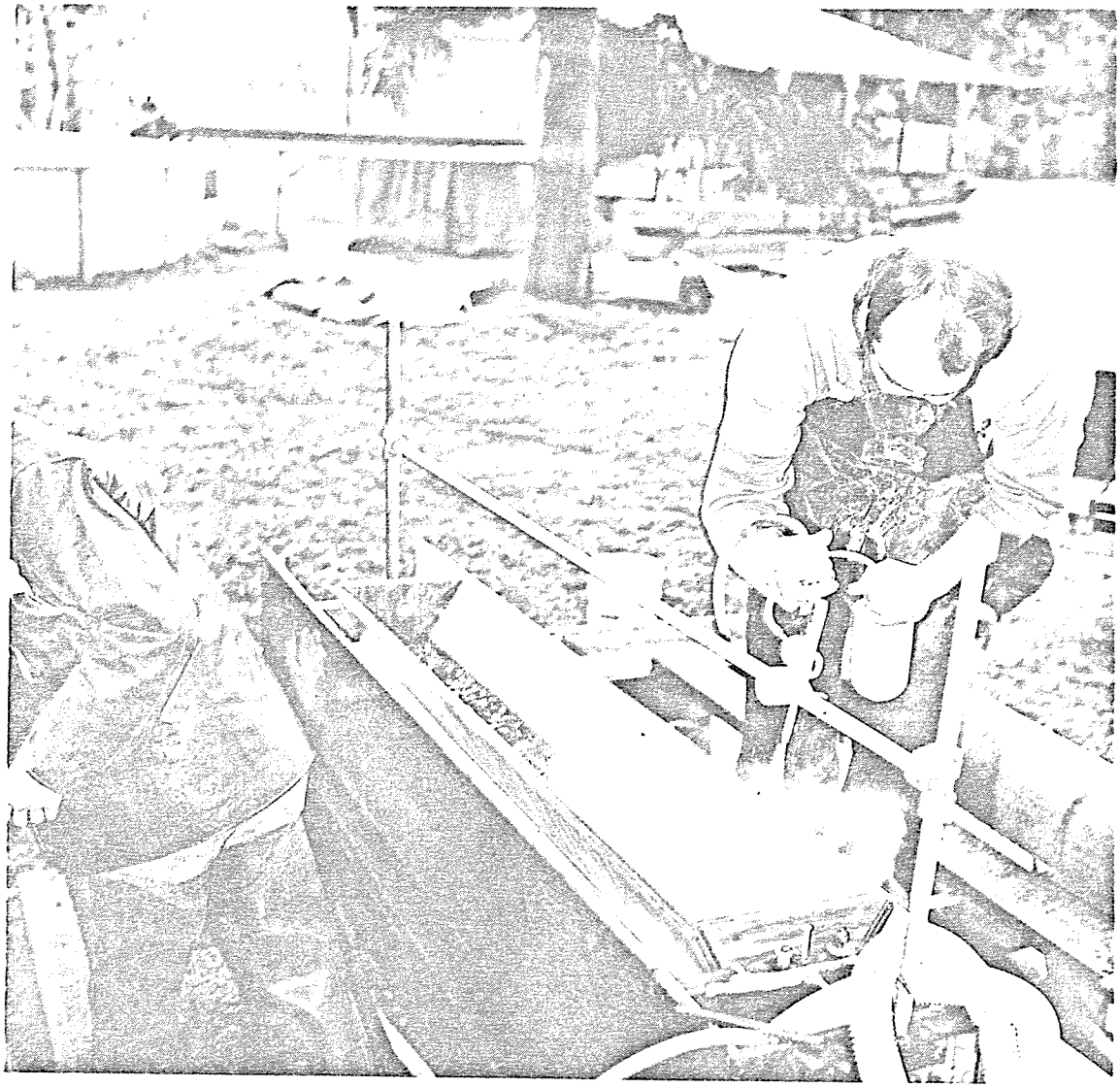
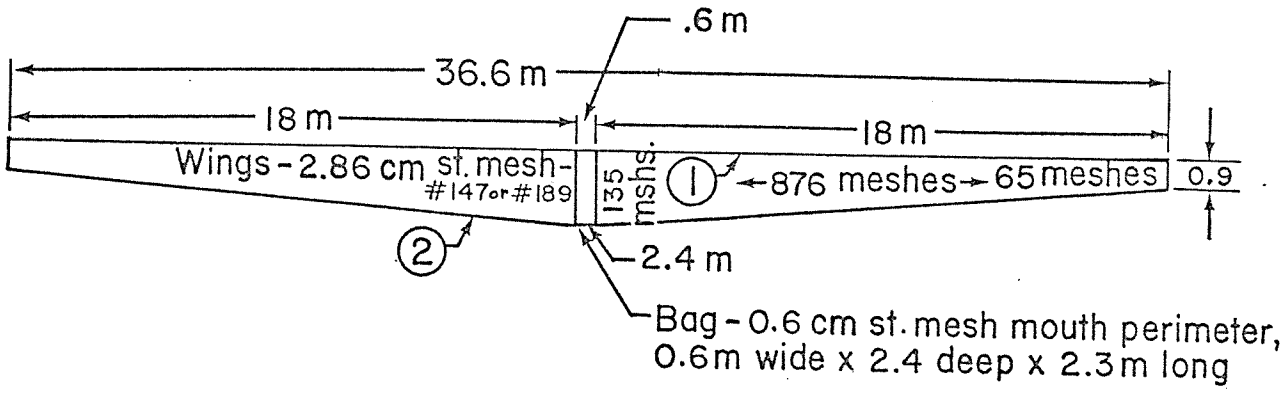


Fig. 2. Juvenile chum salmon being sprayed with fluorescent pigment.



① 3.8 cm x 6.4 cm float every 6th hanging; convert to floating seine with seven 12.7 x 27.9 cm "T" floats.

② 113.4 g lead every 2nd hanging.

Fig. 3. Convertible beach seine utilized during nearhsore surveys April through July 1977, in Hood Canal.

6-mm stretch mesh was also used periodically. The net was pulled parallel to shore by two people over a 30.5-m (100-ft) transect.

Beach seining sites were established from Ayres Point (southeast of Hoodsport) to Foulweather Bluff (north end of Hood Canal) (Fig. 4). Sites in the Bangor area were established in 1975 and 1976 for the outmigration studies (Fig. 5). Sites were sampled periodically from April 22, 1977 through July 25, 1977.

Visual observations from outboard-powered skiffs were conducted by WDF personnel in the second monitoring effort and were used to gain information related to the quantitative effectiveness of the sampling methods. These surveys were used to locate fish and to determine their accessibility to beach seining or townetting. They were also used to monitor the Dabob and Quilcene bay areas and to monitor the movement of the salmon south of Hoodsport. In conjunction with the visual surveys, 10-m beach seining was used to sample fish for marks.

Offshore Sampling

Surface townetting was conducted simultaneously with beach seining in a standard manner (Schreiner 1977a and 1977b). The net is 15 m long with a 3.1-m x 6.1-m opening with mesh sizes grading from 76 mm at the opening to 6 mm at the bag (Fig. 6). The net was towed with the tide between two boats, the 11.4-m (38-ft) R/V TENAS and the 7.8-m (26-ft) motor whaleboat, NARWHAL. The vessel speed varied from 0.9-1.1 m/sec (3.0-3.7 ft/sec) depending on weather, tide, and the amount of drag

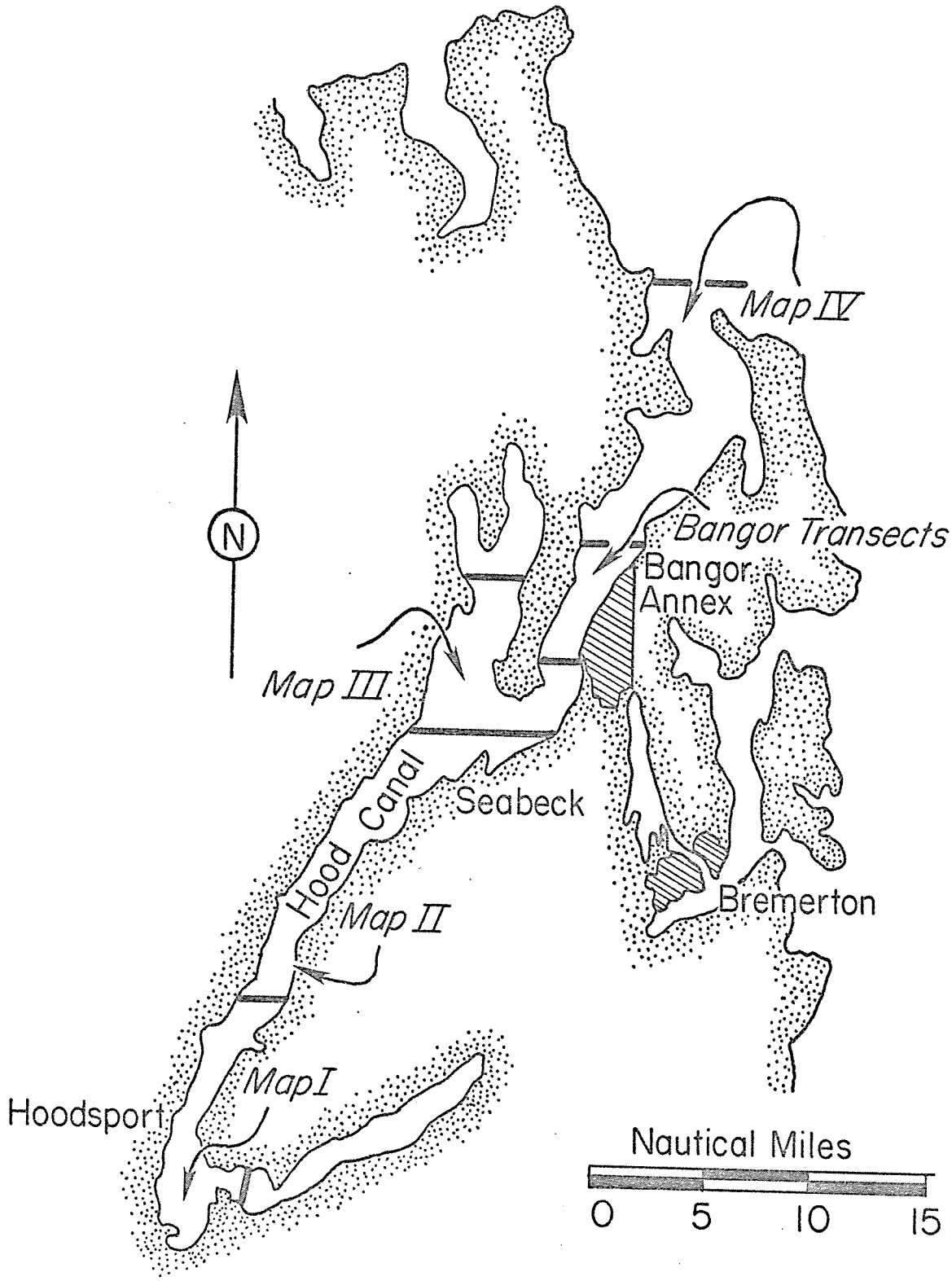


Fig. 4. Beach seining and townetting sites in Hood Canal for 1977 fluorescent marking studies. (See Appendices A and B for detailed transect maps.)

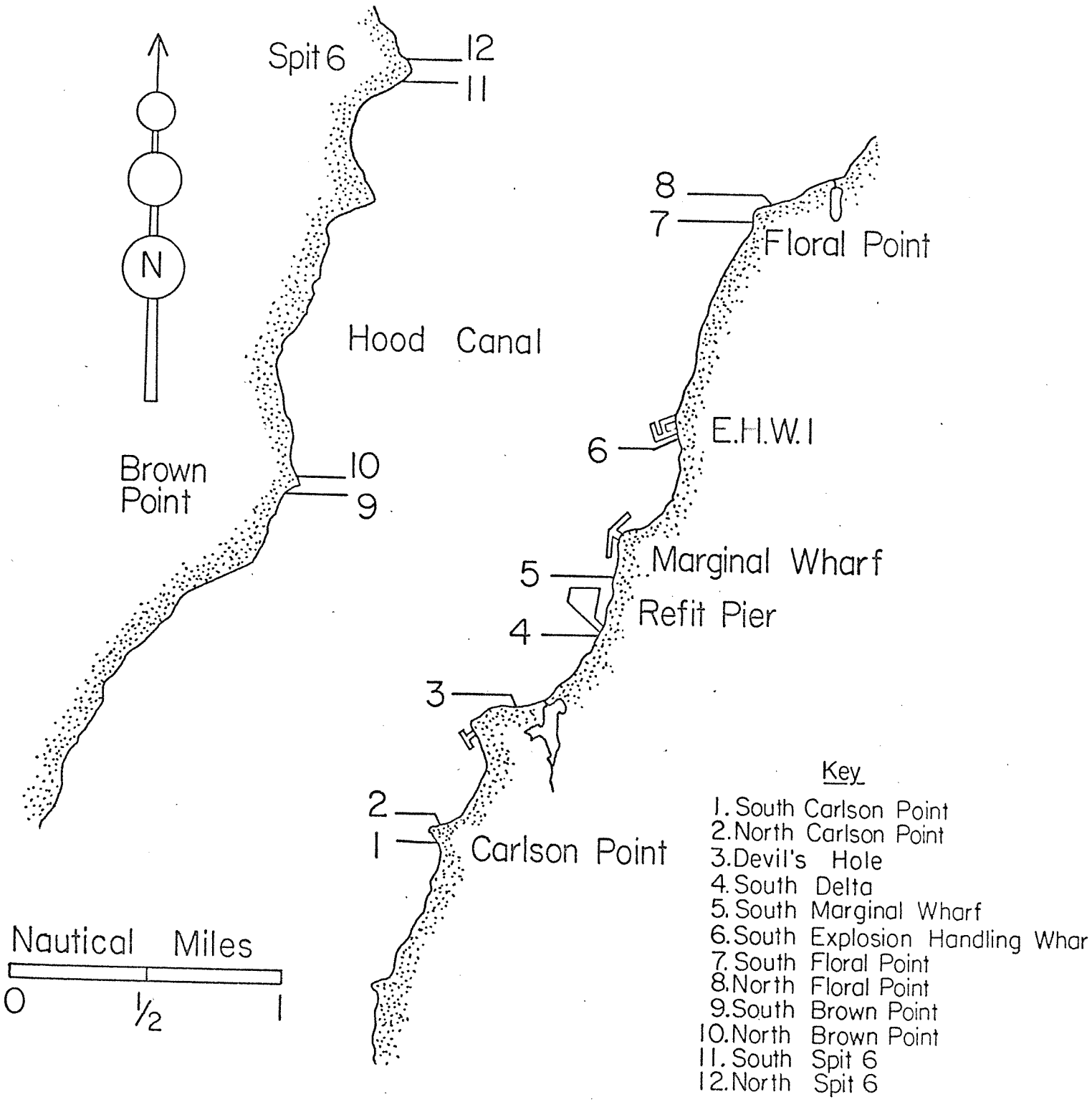
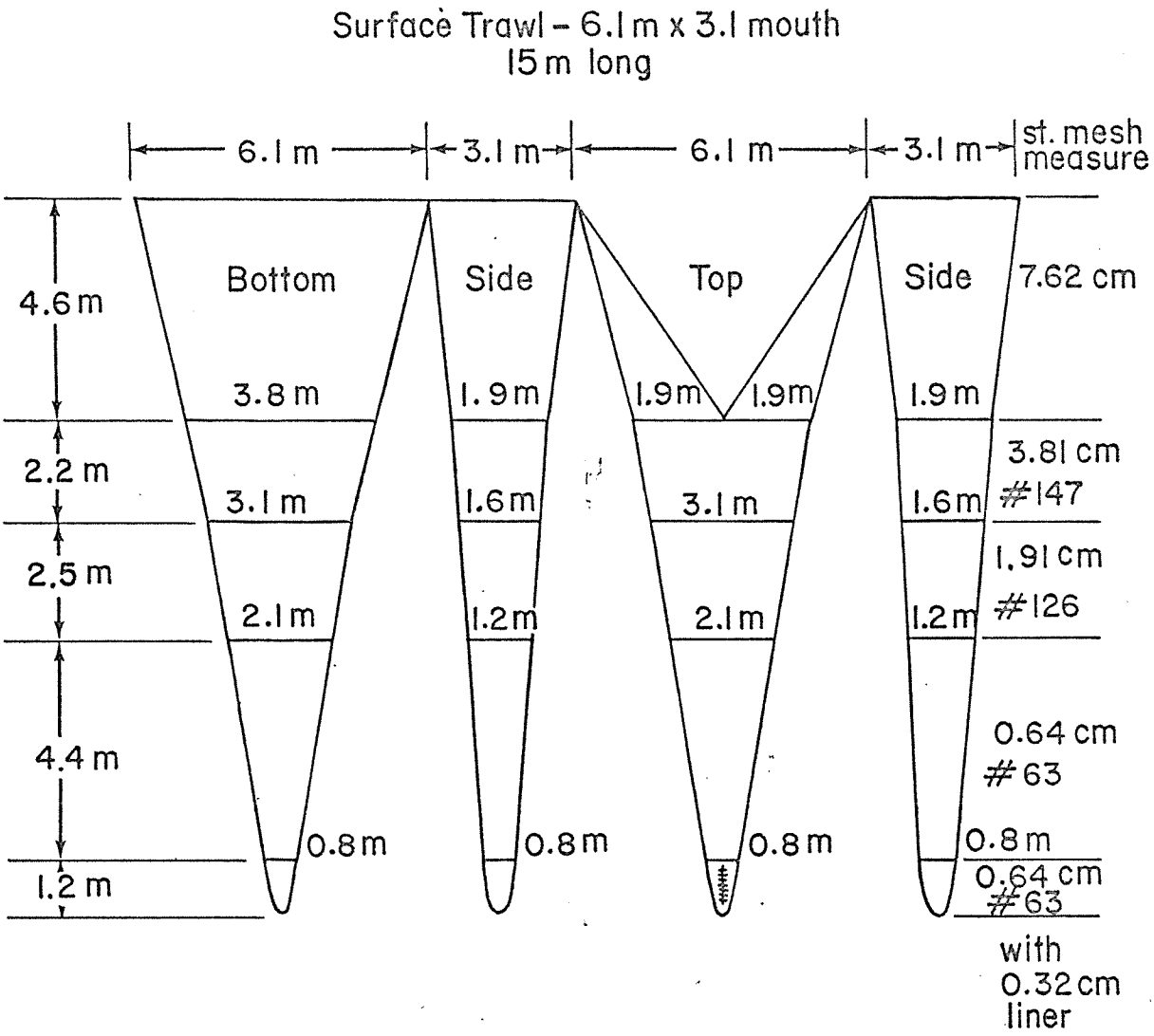


Fig. 5. 1977 beach seine sampling stations for shoreline salmonid out-migration studies, Bangor Annex, Hood Canal, Washington.



All seams are of 3.81 cm and smaller mesh reinforced with heavy 2.54 cm nylon tape including center lines of bottom and top panels; rib-lines of 0.95 cm diameter polypropylene on four corner seams full length. Mouth of net is double twine and hung on 0.35 cm polypropylene single braid with mimbles at each corner. A 0.9 m nylon coil zipper is in the cod end and on liner in the top panel. Six 4-oz leads are spaced evenly along the foot line. 5.08 cm rings are sewn on top panel at 1.91 cm - 0.64 cm seam.

Fig. 6. Surface townet utilized for offshore sampling in Hood Canal, Washington in 1977.

caused by debris in the net. The cod end of the net was pursed every 10 min by crewmen in a 3.9-m (13-ft) outboard skiff and all fish were removed. Fish were then transported in 19-liter (5-gal) or 76-liter (20-gal) buckets to the R/V TENAS to be processed. The scheduled number of tows was designed to bracket the beach seine sites. The transects followed the 5-10-m (15-30 ft) bottom contour near the shoreline and also traversed the canal. Sampling was conducted from Ayres Point to Foulweather Bluff (Fig. 4). Bangor townet transects are shown in Fig. 7.

Analysis of Catch

Fish were held in aeriated 76-liter (20-gal) containers whenever processing was delayed. Subsamples of fish were selected randomly from the catch, anesthetized with MS-222 (tricaine methanesulfonate) and fork lengths were taken. The fish were then examined for pigment under ultraviolet light in a "black box" (Pribble 1976) (Fig. 8).

RESULTS

Marking

On April 18-19, 256,000 chum fry (mean fork length-53.7 $\pm$ 8 mm) were marked with "rocket red" pigment in groups of 500-750 fish. Groups were sprayed for 6 sec at a distance of 45.7 cm (18 inches) with one pass at 6.9 kg/cm^2 (100 PSI) pressure. A subsample of marked fish was held in aquaria for 4 weeks to evaluate mark retention and post-marking

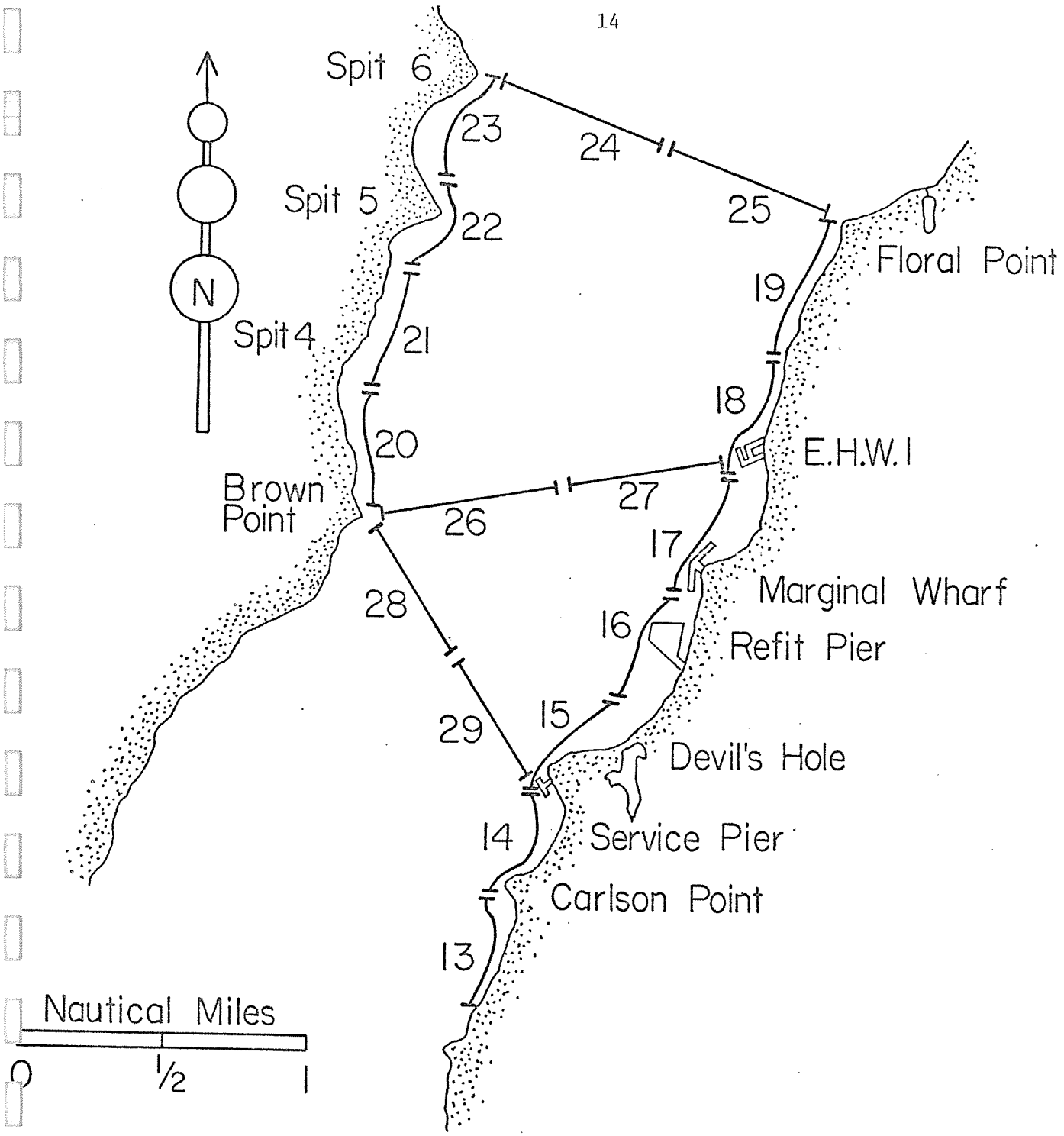


Fig. 7. 1977 townet surface trawl pattern used during salmonid out-migration studies, Bangor Annex, Hood Canal, Washington.

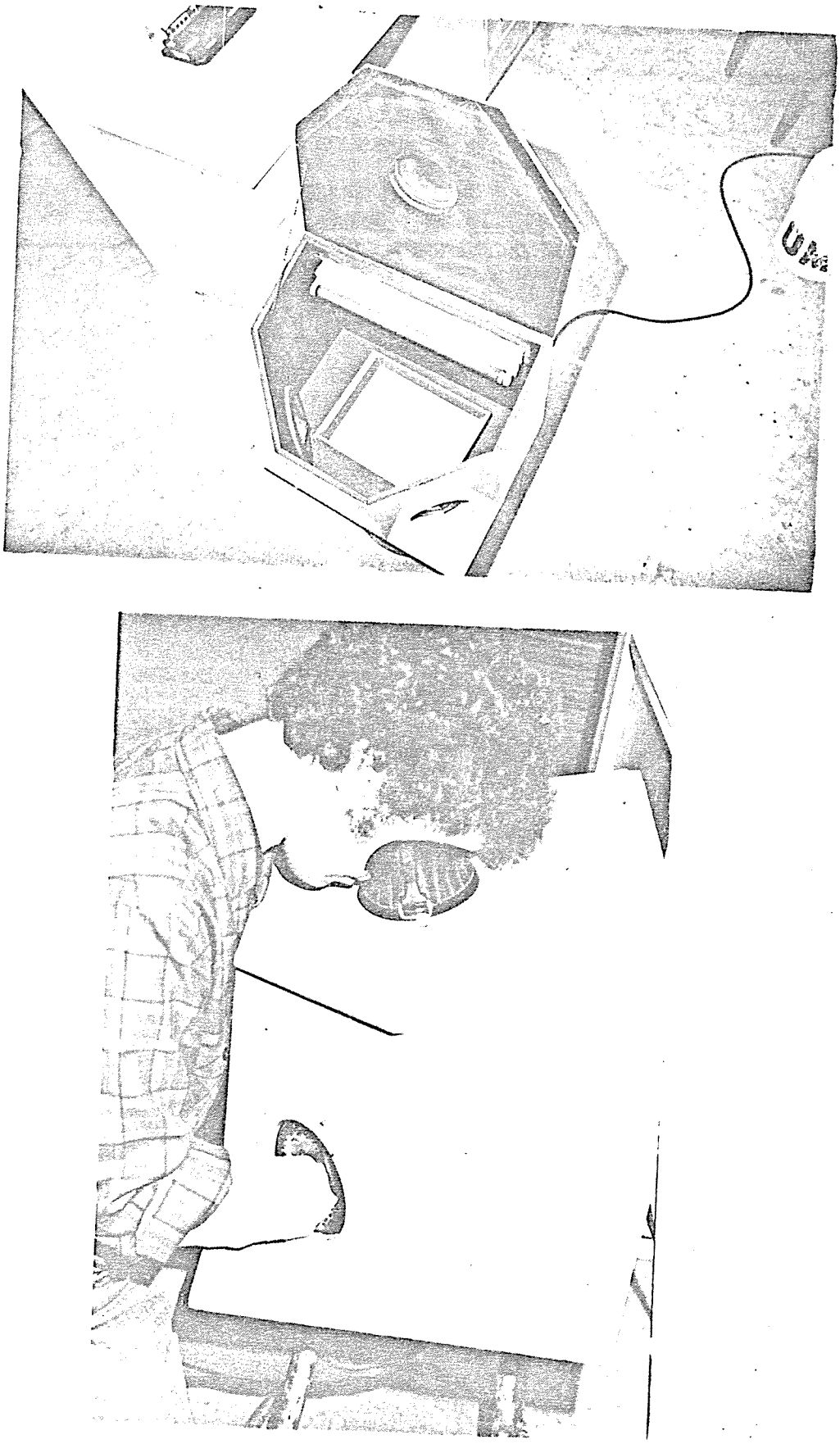


Fig. 8. Ultraviolet illuminated box for the examination of fish for fluorescent pigment.

mortality (Table 1). There was a 1.2% initial marking mortality and a 0.6% mortality for the 25 day post-marking period. One week after marking, 95.9% of the fish had retained the pigment. Although the percentage of fish retaining pigment was high, the amount of pigment present on the fish was generally very small (one or two granules). This made detection difficult and probably accounted for a significant error during examination for marks.

On June 1-3, a total of 402,000 (57.2 $\pm$ 5.5-mm) fish were marked with "arc yellow" pigment. The fish were marked at 40.6 cm (16 inches) with one pass at 8.3 kg/cm^2 (120 PSI) for 6 sec. An effort was made to increase the amount of pigment retained by the fish without increasing the mortality. This increase in pressure and decrease in distance caused a 10% initial mortality. The mortality was identified by James Wood, WDF Fishery Pathologist, as physical damage. There was erosion of the epithelium causing edema of the body musculature. To limit physical damage, the pressure was reduced to 6.9 kg/cm^2 (100 PSI) for marking on June 2 and 3. The overall initial marking mortality was approximately 6.2%. There was a subsequent mortality of 3.2% in the subsample over the 24-day period after marking. One week after marking, retention of the pigment in the subsampled fish was 89% with a significant increase in the amount of pigment on the fish, over the April marking.

Analysis of Catch

During the first recapture efforts, only small samples (n = 1-30) were examined aboard the TENAS, while the larger samples were retained

Table 1. Mark retention data for subsample of chum salmon marked with fluorescent pigment on April 18-19, 1977 and June 1-3, 1977 at the Hood Canal Hatchery, Hoodsport, Washington.

Date marked	Pigment color	No. marked	Date evaluated	Mean length (mm) ± 1 S.D.	% mark retention
April 18-19	Rocket red	256,000	April 21	53.7 ± 2.8	95.9
April 18-19			April 28	50.3 ± 2.7	85.6
April 18-19			May 6	53.7	85.5
April 18-19			May 12	57.2 ± 2.8	81.5
June 1-3	Arc yellow	402,000	June 7	54.9 ± 4.7	89.1
June 1-3			June 13	56.0 ± 4.2	89.5
June 1-3			July 15	-	60.0

and stored in ice water for later examination and length-weight information. This was found to be unsatisfactory; the fish were handled more, which allowed an undetermined amount of pigment to slough off. Later tests showed a length and weight loss with storage, and the mark determinations varied depending on the expertise of the observer. To overcome this source of an unknown amount of error, additional personnel (for a total of 13) were used in the second monitoring effort. The fry were measured aboard the TENAS, and then examined for pigment. Sample sizes for measurement and pigment analysis ranged from 2 to 455 fish, while catches ranged from 0 to 2,800. After a subsample was removed and anesthetized the remaining fish were enumerated and released. The fish that were sampled were placed in seawater until revived, then released. Coho (O. kisutch) and chinook salmon smolts (O. tshawytscha), along with bait fish, were also enumerated and released.

Catch-Per-Unit-Effort (CPUE)

CPUE was used as the measure of relative abundance of marked fish at each sampling site. CPUE is defined as:

$$CPUE = C_t/I_t$$

where C is the number of captures, I is the intensity of the effort (number of tows or seines), and t is any unit of time (Ricker 1968). Since daily movements of fish between sites were under consideration and many transects had to be sampled each day, the sampling effort was

usually 1 to 3 (number of seines or tows in the sampling area). Due to the short sampling season, the CPUE was not averaged over a large number of samplings, therefore one effort (townet or beach seine) with 0 catch could drastically reduce the CPUE value. Because the 0 value might not be representative of the relative abundance of marked fish in the sampling area, there was an inherent bias to the CPUE value. The 0 values were left in the calculation of CPUE for comparison with results of concurrent salmon outmigration studies in Hood Canal (Schreiner 1977a) where the zero values were valid because of extensive sampling effort. To some extent, the zero CPUE may reflect the schooling behavior of chum fry. The CPUE by area for both releases are shown in Tables 2 and 3. The CPUE of marked fish at Bangor is shown in Table 4.

Distribution

The distribution of marked fish was determined by monitoring for a period of 10 days after release. Subsequent sampling was conducted 1 day per week south of Bangor and four times per week at Bangor in conjunction with the outmigration studies.

The first group of fish appeared to spread north and south of Hoodsport in their initial movement (Fig. 9). The locus appeared to be at the Hamma Hamma Delta on the second day after release with a range of more than 37 km (23 miles), i.e., from south (Potlatch) to north (Quatsap Point). The initial rate of movement for group 1 was 8-10 km (5-6 miles) a day for the locus and more than 32 km/day (20 miles) for

Table 2. Catch-per-unit-effort by area for marked chum salmon released from Hood Canal Hatchery, April 20, 1977.

Date	Area sampled	East-West shore		East shore		West shore		Cross Canal
		BS	TN	BS	TN	BS	TN	TN
1977								
April 22	Hoodsport - Hood Pt.	3.8	2.3	5.5	-	3.5	2.3	-
April 25	Hamma Hamma - Hazel Pt.	0.22	0.27	0.5	0	0.14	0.29	-
April 25	Bangor	0	0	0	0	-	0	0
April 26	Bangor	0	2.9	0	2.0	0	3.6	0.3
April 27	Thorndyke Bay - Foul-weather	0	0.1	0	0	0	0.2	-
April 27	Bangor	0.2	1.0	0.3	1.0	0.2	-	-
April 28	Bangor	0.6	0.9	0.6	0.9	-	-	-
April 29	Bangor	0.5	-	0.8	-	0	-	-
May 2	Bangor	0.4	0.4	1.0	0.6	0	0	0.5
May 3	Bangor	-	0.1	-	0	-	0.3	0
May 4	Bangor	0.2	0	0	0	1.0	0	-
May 5	Bangor	0.2	0.2	0.2	0.2	-	-	-

Table 3. Catch-per-unit-effort by area for marked chum salmon released from Hood Canal Hatchery, June 5, 1977.

Date	Area sampled	BS	TN	East shore BS	East shore TN	West shore BS	West shore TN	Cross Canal TN
1977								
June 6	Musqueti Pt - Hamma Hamma	19.7	20.0	14.0	27.9	30.7	13.9	22.5
June 7	Quatsap Pt - Dewatto	23.3	18.7	38.5	15.0	15.8	32.5	7.5
June 8	Potlatch - Stavis Bay	12.6	3.1	10.2	8.3	14.7	0.7	4.4
June 10	Hamma Hamma - Tskutsko Pt.	35.0	29.4	80.3	15.9	12.4	49.0	1.6
June 13	Hood Pt - Cable crossing	14.8	5.4	4.8	3.0	19.3	7.8	-
June 13	Bangor	0	1.0	0	1.0	0	-	-
June 14	Bangor	0.2	0.4	0.5	0.3	0	0.4	1.5
June 14	Pulali Pt - Cable crossing	13.2	-	19.5	-	11.4	-	-
June 15	Bangor	1.3	2.7	1.7	2.7	0	-	-
June 17	Pleasant Hrb - Hazel Pt	5.1	-	1.0	-	6.3	-	-
June 20	McDaniel Cove- Hazel Pt	3.7	3.3	0	0	4.4	4.0	-
June 20	Bangor	0.8	0.8	0.7	0.7	0.5	1.0	2.0
June 21	Bangor	0	1.8	0	-	0	1.8	1.0
June 22	Bangor	2.0	2.0	-	2.0	2.0	-	-
June 27	Hamma Hamma - Tskutsko Pt	0.4	0	0.5	0	0.3	0	-
June 27	Bangor	0.3	2.0	0.3	2.0	-	-	-
June 28	Bangor	0.5	0.5	1.0	0	0	1.0	-
June 29	Bangor	0.3	0.6	0.1	0.6	0.5	-	-
July 5	Bangor	0	0.1	-	0	0	0	0.5
July 6	Bangor	0	0.2	0	0.2	0	-	0.3

Table 4. Catch-per-unit-effort at Bangor Annex for marked chum salmon released from Hood Canal Hatchery, April 20, 1977 and June 5, 1977.

Date of release	East shore		West shore	
	BS	TN	BS	TN
April 20 1977	0.3	0.6	0.4	2.6
June 5 1977	0.6	1.4	0.5	1.1

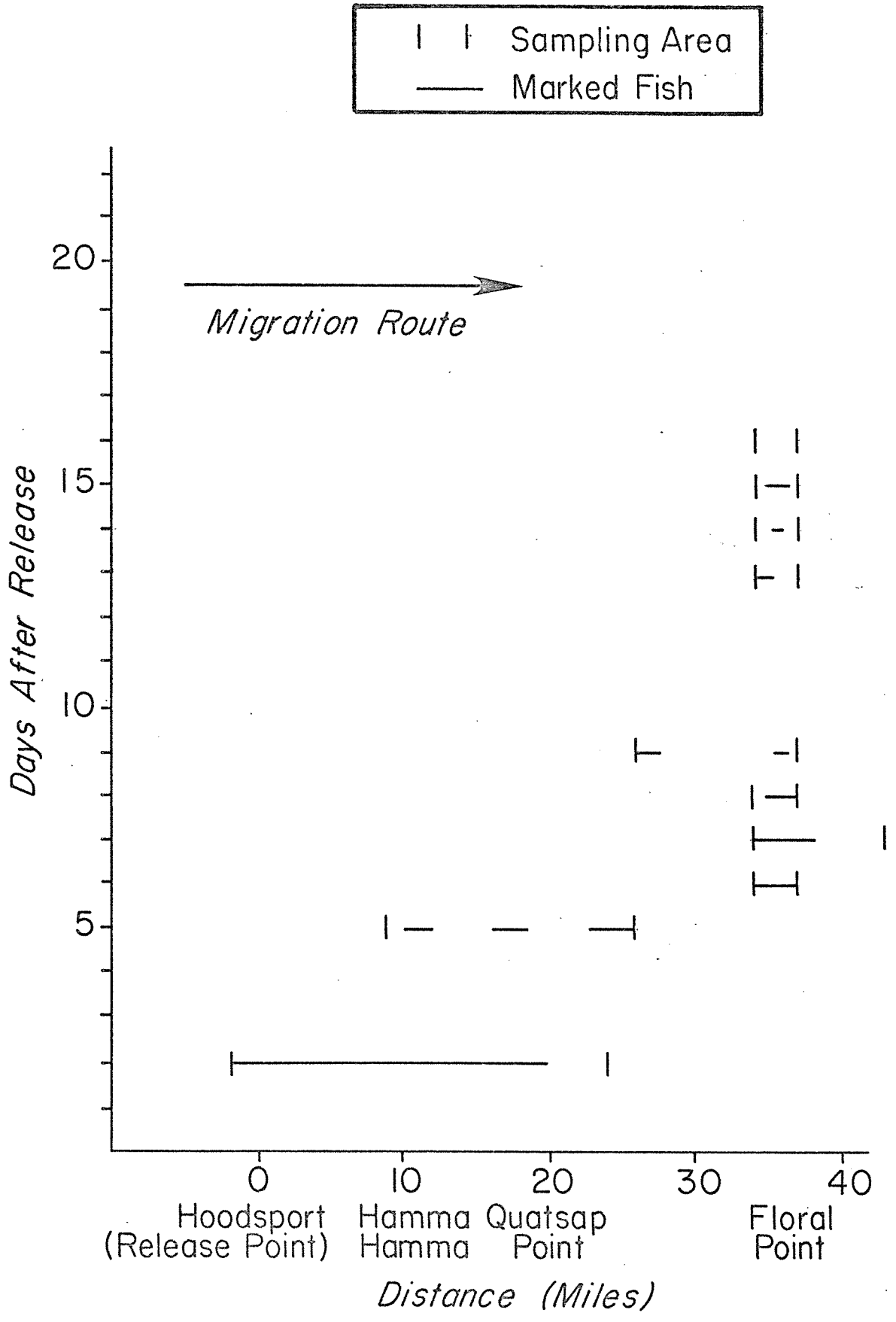


Fig. 9. Time and distance travelled for chum salmon marked with fluorescent pigment and released from Hood Canal Hatchery, April 20, 1977.

the fastest individual recaptured. Mark recaptures on May 6 (day 16) ranged from Carlson Spit to Indian Island (about 93 km (58 miles)).

The April catches consisted of wild and hatchery fish of two size groups, 30-44 mm and 45-60 mm. Beach seining initially had a greater CPUE, but larger fish (greater than 45 mm) were more prevalent in the townet. By the second week, the majority of fish captured were greater than 44 mm and were caught by the townet.

The movement of the second group (June 5, release) was similar to the first during the initial post-release period, with marked chum located both north and south of Hoodsport. The definition of southern movement was more precise for the second release due to more intensive sampling.

The rate of northern movement for the June group appeared slightly slower, with the marked fish progressing only two-thirds as far north as the smaller (April release) fry after the same time interval (day 5 after release) (Fig. 9). Figures 9 and 10 illustrate the areas of Hood Canal where marked fish (n = 1-74) were found temporally, and include samples from both east and west shores. On the first release, observations for the presence of marked fish were discontinued after day 16 (May 16); observations for the second release continued until day 22 (June 27), at which time it appeared that few marked fish were south of Quatsap Point. Marked fish were still being found at Bangor, indicating that a few were still in Hood Canal after 3 weeks. The locus of marked fish for the second release was well defined on the first day after

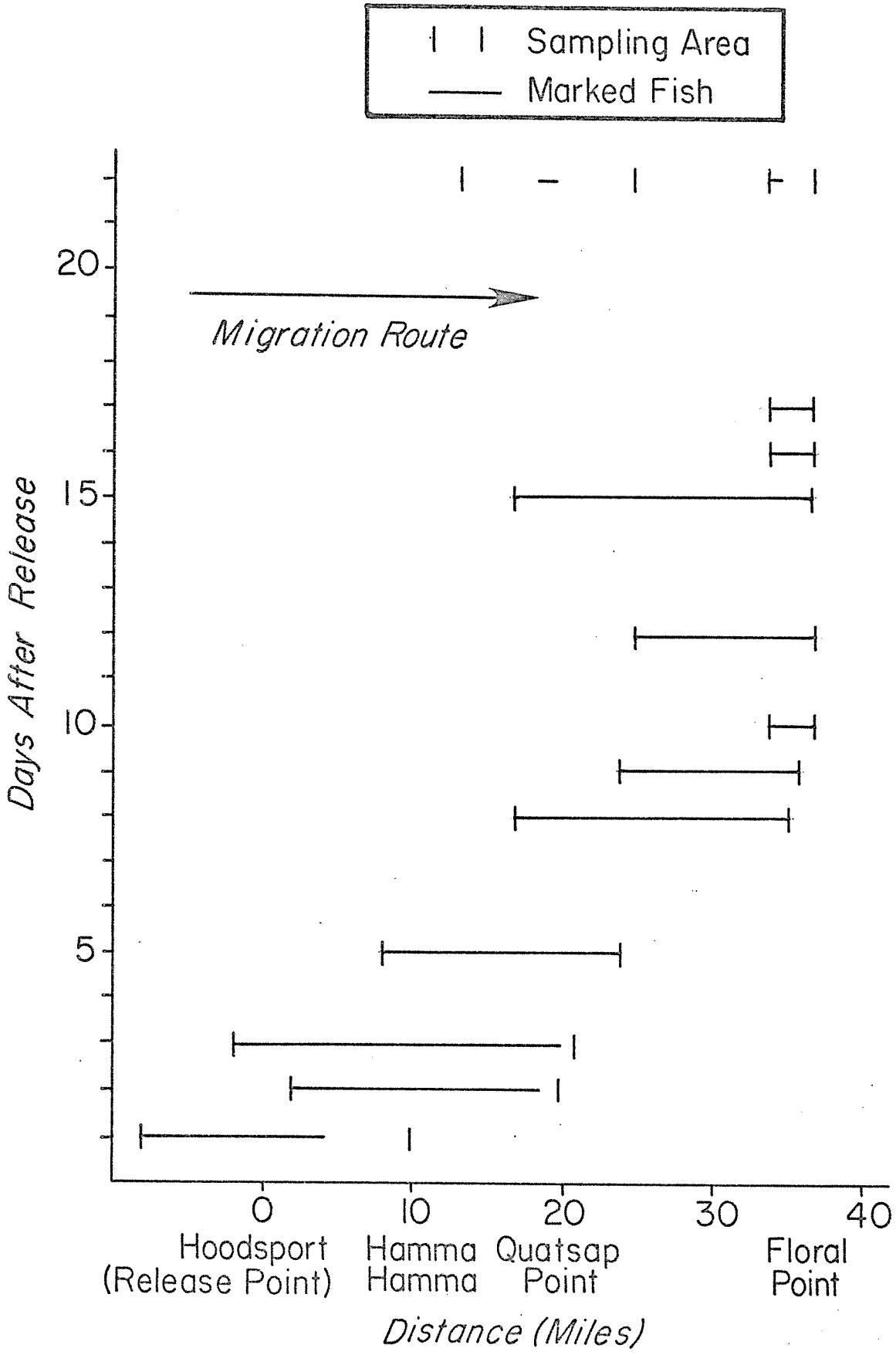


Fig. 10. Time and distance travelled for chum salmon marked with fluorescent pigment and released from Hood Canal Hatchery, June 5, 1977.

release. Figure 11 shows the catch and illustrates that the east and west shores had similar numbers of marked fish, while the west shore had a slightly more northerly range. Of the 1,689 fish analyzed on the first day (June 6), 561 (33.4%) were marked. The ratio of marked and unmarked fry is approximately the same for both beach seining and townetting up to the Chinom Point site where no fish were caught in the beach seines and only unmarked fish in the townet. On day 8 (June 13), the locus was undefined. As illustrated in Fig. 11 there is a suggestion that the sampling effort was too far north, as the numbers of marked fish declined progressively northward. Sampling on day 15 indicated that small numbers (n = 1-15) of marked fish were still at the sites previously sampled (Fig. 11) but unmarked fish greatly outnumbered marked fish.

Offshore Movement

Several cross-canal transects were made in June in an attempt to define the size at offshore movement. Table 5 gives the fork length range and average for chum fry captured in the cross-canal transects. The mean fork length for all samples is 72.6 mm and the range is 42-111 mm. All but one fish were longer than 48 mm, indicating that chum salmon of that size are capable of existing in the pelagic region, but fry greater than 60 mm are the more typical.

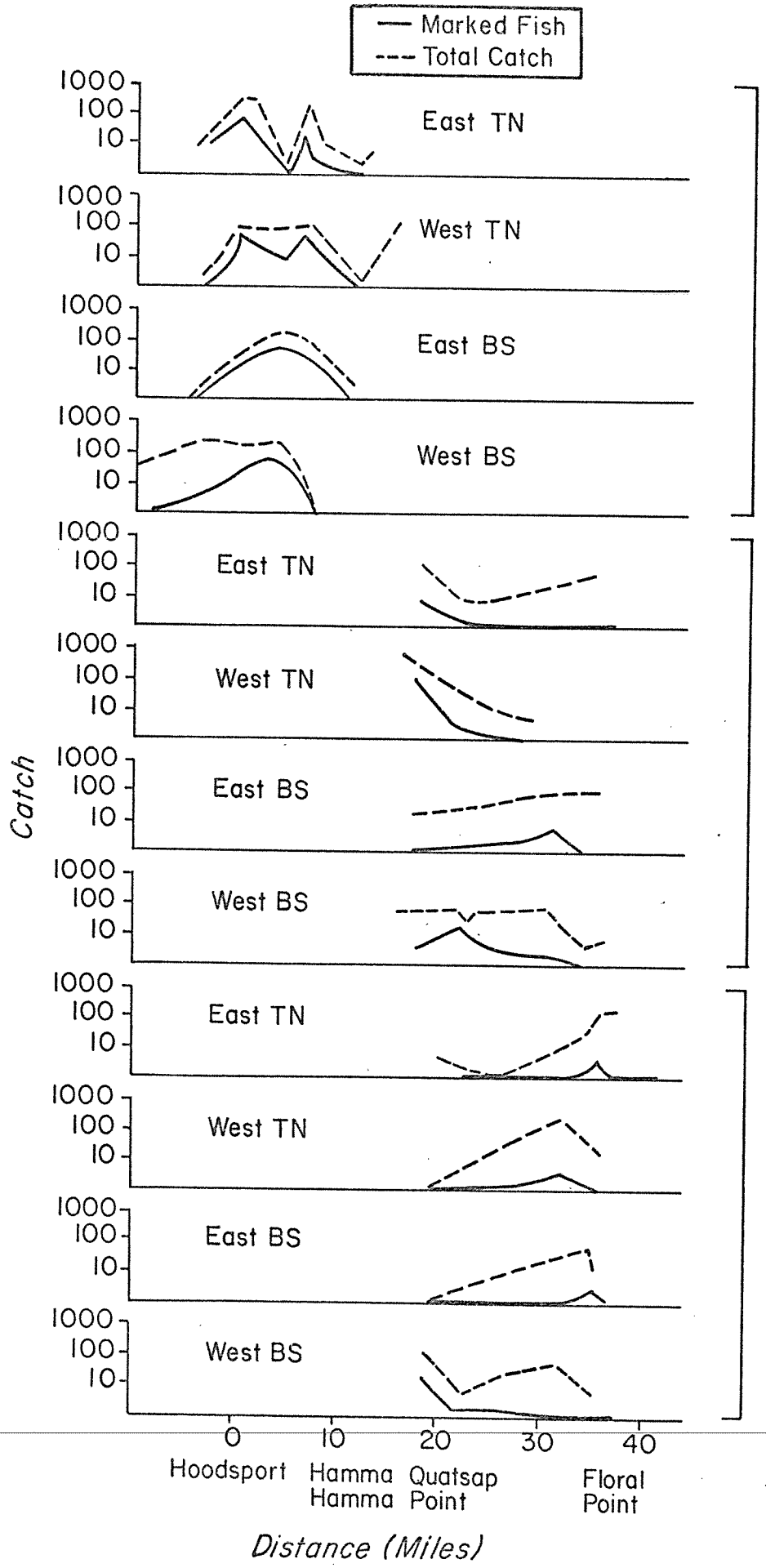


Fig. 11. Number and range of captured marked chum salmon released from Hood Canal Hatchery, June 5, 1977.

Table 5. Fork length range and mean for chum salmon captured in cross canal transects.

Date	Transect[a]	Mean fork length (mm)	Range (mm)
June 6	215	68.2	51-102
6	214	76.1	52-111
7	262	66.0	61-73
7	261	63.4	53-72
8	138	64.7	58-81
8	137	62.9	55-67
10	137	60.0	54-71
10	301	64.4	59-68
10	302	76.9	61-95
10	303	67.0	61-78
14	48	75.8	53-95
14	49	77.5	42-94
21	51	70.8	58-95
21	50	70.5	52-91
21	51	66.9	49-97

[a]for location, see Appendix B, Maps I-IV.

Growth Rate

Length and weight data on marked fish were taken only on the second release. An exponential curve was fitted by regressing log weight on day, yeilding the following regression formula:

$$\text{Log } Y = 0.32838 + 0.02204(x).$$

Only data from day 9 to day 30 after release was used. From this expression growth was calculated as 5.7% body wt/day. A linear regression of length on day and condition factor ($W/L^3 \cdot 10^5$) on day was also computed; here W is wet weight and L is fork length. From these regressions, it was found that the fish were growing at 1.7 mm/day while condition factor decreased 9.9% from day 9 to day 30. In contrast, condition factor increased 14% in the first 9 days after release, from 0.85 (day 0) to 0.99 (day 9).

Visual Surveys

The visual survey estimates indicated that large numbers of chum fry were present in the canal during monitoring for marked fish (June 5 release), as may be predicted from unmarked hatchery releases (Table 6). Five days after the release of the second group (June 10), 124,000 chum fry were observed between Pleasant Harbor and Wawa Point (in Dabob Bay), with no marked fish in the subsample. On day 8 (June 13), 35,000 chum fry were observed in the same area with marked fish present as far north as Pulali Point. By day 9 (June 14), marked chum had disappeared.

Table 6. Summary of 1977 chum salmon hatchery releases in Hood Canal, Washington.

Date of release	Release location	Number released	Mean fork length ± 1 S.D. n = 25
March 11	Hoodsport	283,000	39.6 ± 1.8
April 5	Hoodsport	2,040,000	40.0 ± 2.0
April 4-22	Geo. Adams	1,500,000	
April 20	Hoodsport	717,000	
April 20	Hoodsport	266,000	53.7 ± 2.8
April 22	Geo. Adams	3,500,000	40.9 ± 2.8
April 28	Hoodsport	662,000	51.0 ± 3.7
April 30	Hoodsport	225,000	
May 11	Hoodsport	518,000	58.1 ± 4.5
May 16	Hoodsport	185,000	
May 19	Hoodsport	3,030,000	
May 23	Quilcene	534,000	
May 31	Quilcene	178,000	
June 1	Quilcene	296,000	
June 2	Quilcene	286,000	
June 3	Quilcene	146,000	
June 5	Hoodsport	39,000	60.2 ± 3.3
June 5	Hoodsport	375,000	60.2 ± 3.3
June 8	Quilcene	566,000	
June 13	Quilcene	341,000	64.1 ±16.6
June 14	Quilcene	363,000	64.1 ±16.6
June 15	Quilcene	130,000	64.1 ±16.6
June 16	Quilcene	391,000	64.1 ±16.6
June 17	Quilcene	385,000	58.4 ±20.9
June 20	Quilcene	337,000	63.4 ±29.3
June 21	Quilcene	155,000	
June 27	Quilcene	774,000	
June 28	Quilcene	679,000	
June 29	Quilcene	631,000	
July 5	Hoodsport	520,000	
	TOTAL RELEASED	20,036,000	

Visual survey observations require:

1) sunny conditions
2) no wind
3) favorable water transparency
4) trained observers
5) established standardized sampling transects and techniques.

When the distance and conditions are standardized (as for natural run estimates) in each estimation area (index area), then comparisons can be made among areas surveyed at different time periods. The estimates of numbers of chum fry in this study are only indications of relative numbers present in an area during the subsampling effort. The distance from shore and depth of fish schools varied from 0-30 m and from 0-4 m respectively, for these observations. The majority of fish were 30 m offshore and were not available for sampling with the 10-m beach seine, thus, the numbers of fry in the catch were not representative of the numbers of fry present in an area.

Visual observations could not be related to the catches of the townet and beach seine. On only one occasion were visual observations, townetting, and beach seining comparable. On June 10 at Stavis Bay, 1,150 chum fry were observed about 4.6 m depth (12 feet offshore) over a 0.5 km transect. Townetting was conducted at the 5 to 10 m contour and resulted in a catch of 1,005 chum fry of which 70 were marked. The beach seine catch at this site was zero.

DISCUSSION

The fry released in April appeared to migrate north at a faster rate than the fry released in June (37 km versus 22 km on day 2). The difference in rate became less by day 5, but was still present 8 days after release. The range of the distribution of the April fry 16 days after release was from Carlson Point to Indian Island (38.6 km). The majority of the June release had migrated north as far as Carlson Point by day 22 after release.

The initial distribution pattern of both groups appeared to be a dispersing effect, rather than a direct northerly movement. Marked fry were found north and south of the Hoodsport release site, and almost equal numbers on the east and west shores.

The distribution of fish, along the shoreline near Bangor, varied from previous years. Schreiner (1977a) noted that in 1975 and 1976 more chum juveniles were along the east shoreline of Bangor. He speculated that the movement of fish to the east shore may be due to a "push" from spring runoff assisted by the Coriolis effect. The 1977 releases showed a more random distribution with the majority of the April release migrating on the west shoreline of Bangor. The second release showed near-equal numbers on both shorelines. This randomness may be related to the extremently low freshwater runoff in 1977.

The initial locus of marked fish was well defined and appeared to be located in the Hamma Hamma River delta for both releases. Within 1 week, the locus could not be defined for either release, although marked fish were being caught throughout the system.

Since the two releases appeared to disperse, it was difficult to determine a peak of migration past the Bangor area, even though the sampling effort was more intensive at those sites. A small rise in CPUE was observed in the Bangor area 6-8 days after the June release.

Residence time in the nearshore area appeared to be related to fish size for the April release, with fish over 45 mm more prevalent in the townet catches. The beach seine catches were characterized by two size groups for the April release, while only one size group appeared in the June catches. On the second release, the fish size relationship was not clear, as some beach seine catches of chum fry averaged 69 mm in fork length. The cross-canal transect catches during the second release indicated that larger fish (average 72.6 mm fork length) were present farther offshore in Hood Canal.

The growth rate was calculated on a limited number of marked fish taken during the second release. The condition factor went up the week after release and then decreased. This initial increase in condition factor indicates a rapid weight gain with a smaller gain in length, suggesting intensive feeding upon release. This gain in condition factor may reflect the ability of the fish to feed at will during the 24-hr day, whereas in the hatchery they are restricted to an 8-hr feeding schedule.

The locus of marked fish was well-defined during the first week after release for both releases but it was difficult to define afterwards.

The inability to define a locus may be due to several factors:

1) The fish may spread out in random distribution patterns due to swimming ability and/or this distribution pattern may increase the probability of successful feeding, resulting in patchiness.

2) Differences in slope, rockiness, exposure, and/or weather, may reduce the catch near the locus.

3) The majority of the fish may move offshore, but stay shallow (less than 4.6 m deep) which may be beyond the reach of the beach seine, but too shallow for the townet efforts.

4) Some fish may enter Dabob or Quilcene bay and therefore delay or spread out the migration pattern extensively.

5) Unknown numbers of fish migrated south from Hoodsport which may also delay and spread the distribution.

6) The majority of fish may have passed the sampling areas during the nonsampling periods.

7) Fish may have passed in midcanal where there was very little sampling effort.

8) There were not enough fish released.

9) There was a large mortality, as suggested by Parker (1965).

10) Fish may migrate at a deeper level than that sampled after reaching a larger size.

Any combination of the above reasons may account for the lack of identification of the locus or actually locating any marked fish.

Visual survey estimates indicated that large numbers of chum fry were present in the system throughout the monitoring period. This was substantiated in the mark-recapture catches where unmarked chum were caught even when marked chum were not present. The visual observations also indicated a patchy distribution, possibly related to schooling behavior, and feeding preference. The visual surveys were useful in covering a large sample area, indicating the presence or absence in assessing the distribution and rate of migration of marked fish in the system.

SUMMARY

1) Large numbers of fish may be marked efficiently with fluorescent pigment.

2) Fish from the April release ($\bar{x}$ length 53.7 mm) appeared to migrate northward faster than the June release ($\bar{x}$ length 57.2 mm). This disparity in rate of migration is possibly due to temporal changes or difference in size of the two groups.

3) Fish migration patterns indicate a more random distribution of fish in the Bangor area than observed in the 1975 and 1976 outmigration studies.

4) Fish from the April release indicate an offshore movement when they reached 44 mm in length, whereas the June release of fish moved offshore at approximately 69 mm in length.

5) The June release of fish showed a growth rate of approximately 5% of body weight per day over a 4-week period.

6) A large increase in condition factor from week 0 to week 1 indicated a rapid and intensive feeding after release.

7) The visual surveys, combined with subsampling for the presence or absence of marked chum fry, assisted in assessing the distribution and rate of migration of marked fish in the system.

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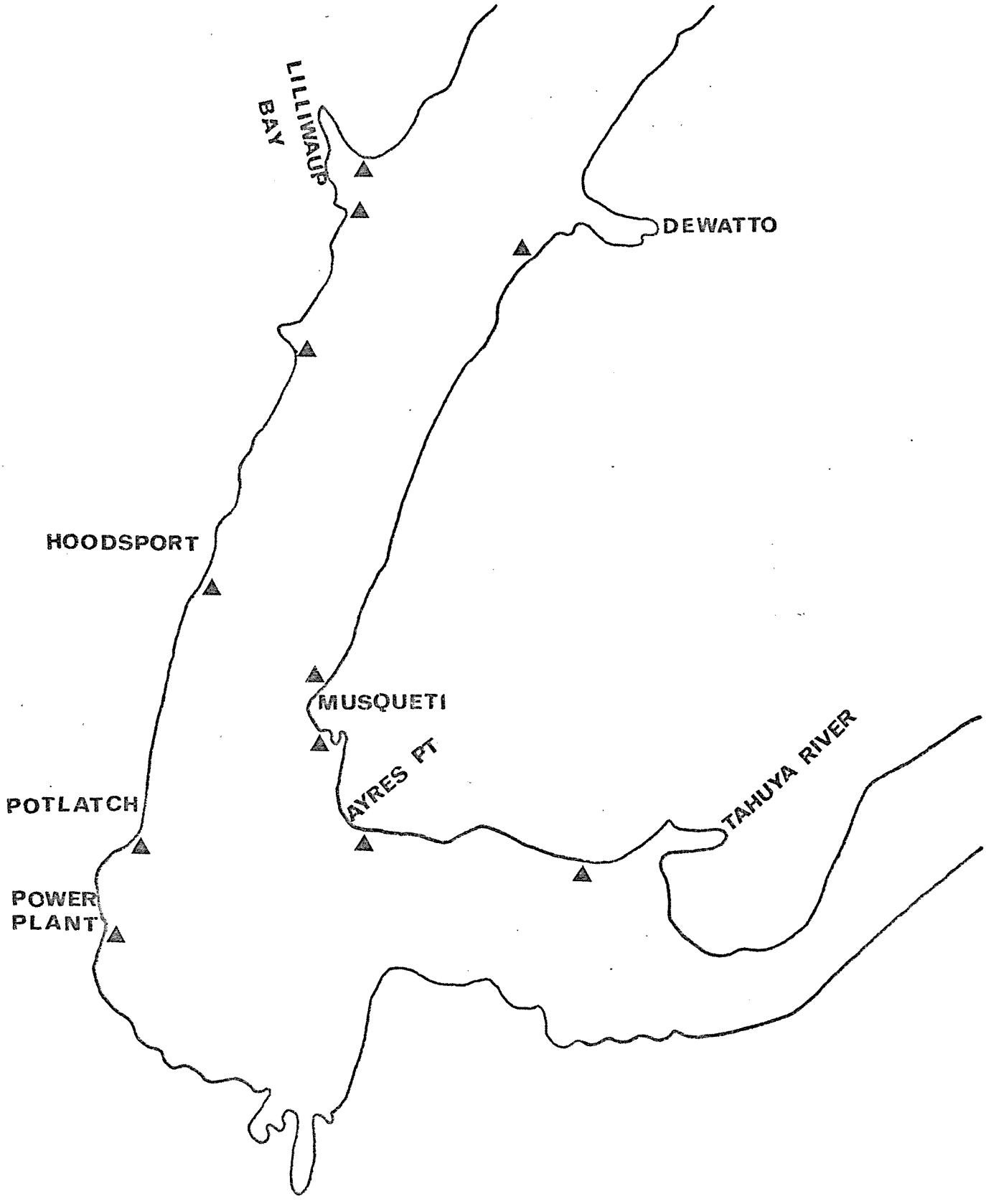
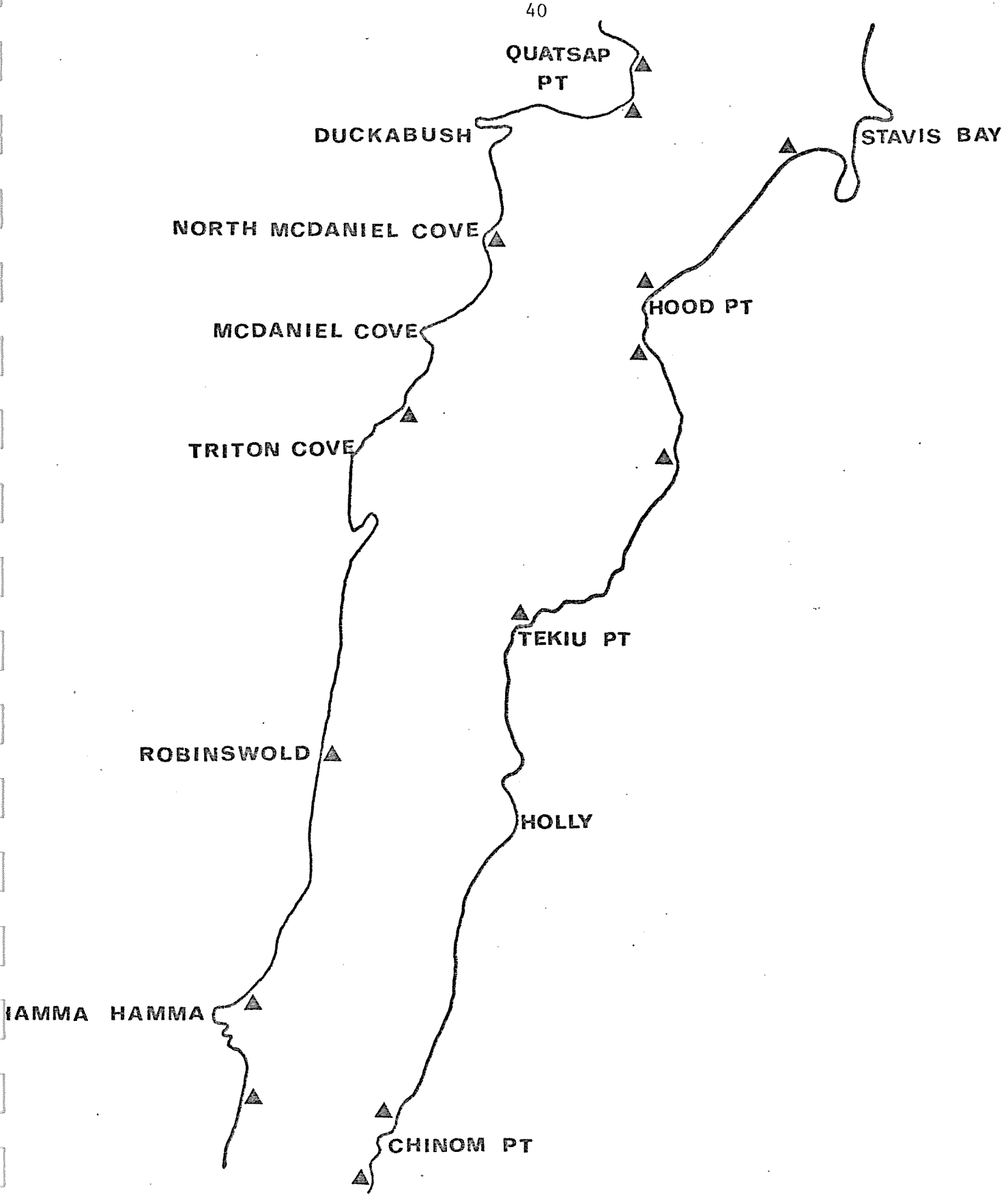
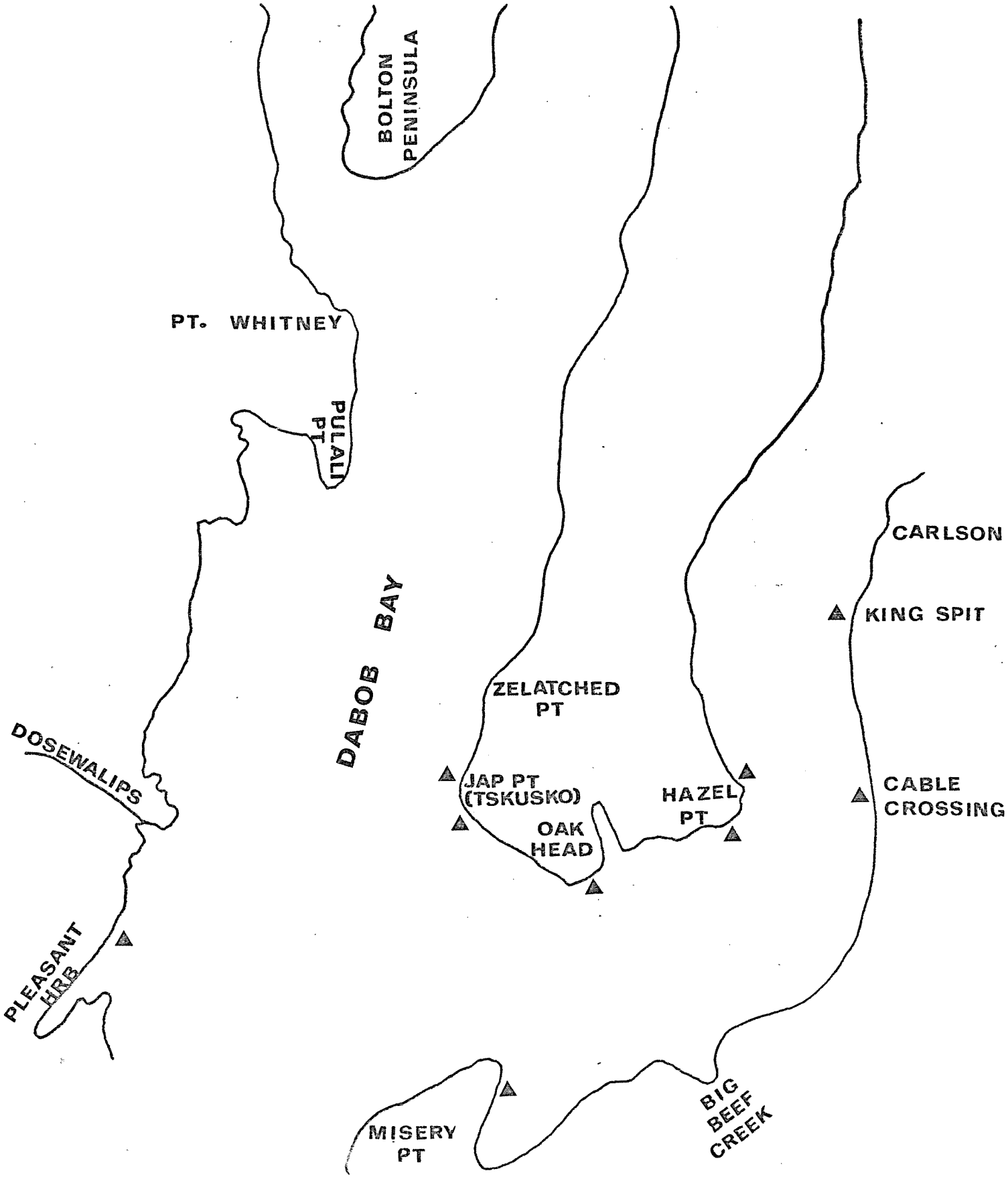
APPENDICES



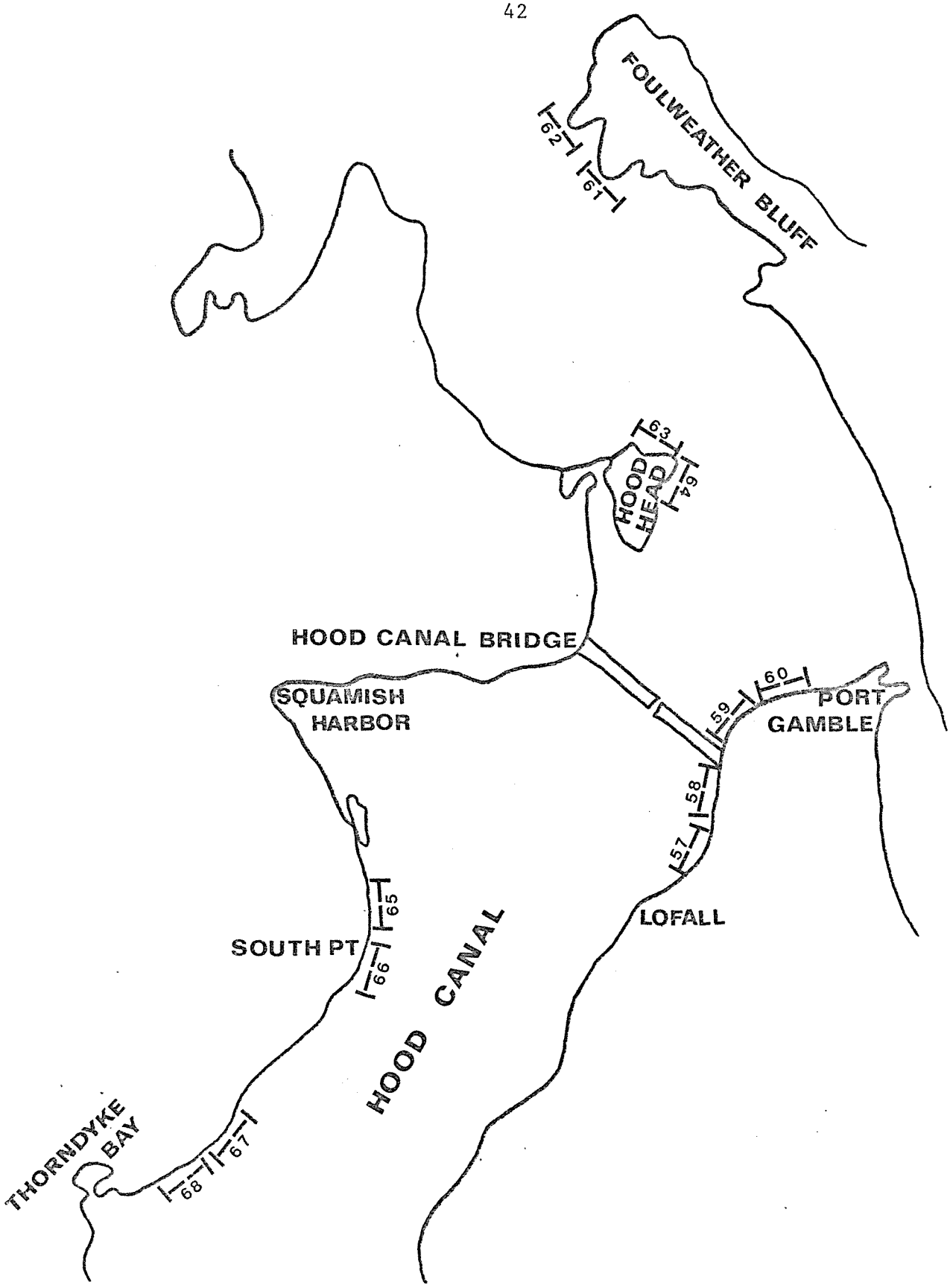
Appendix A - Map I. Beach seining sites, Hood Canal, Washington.



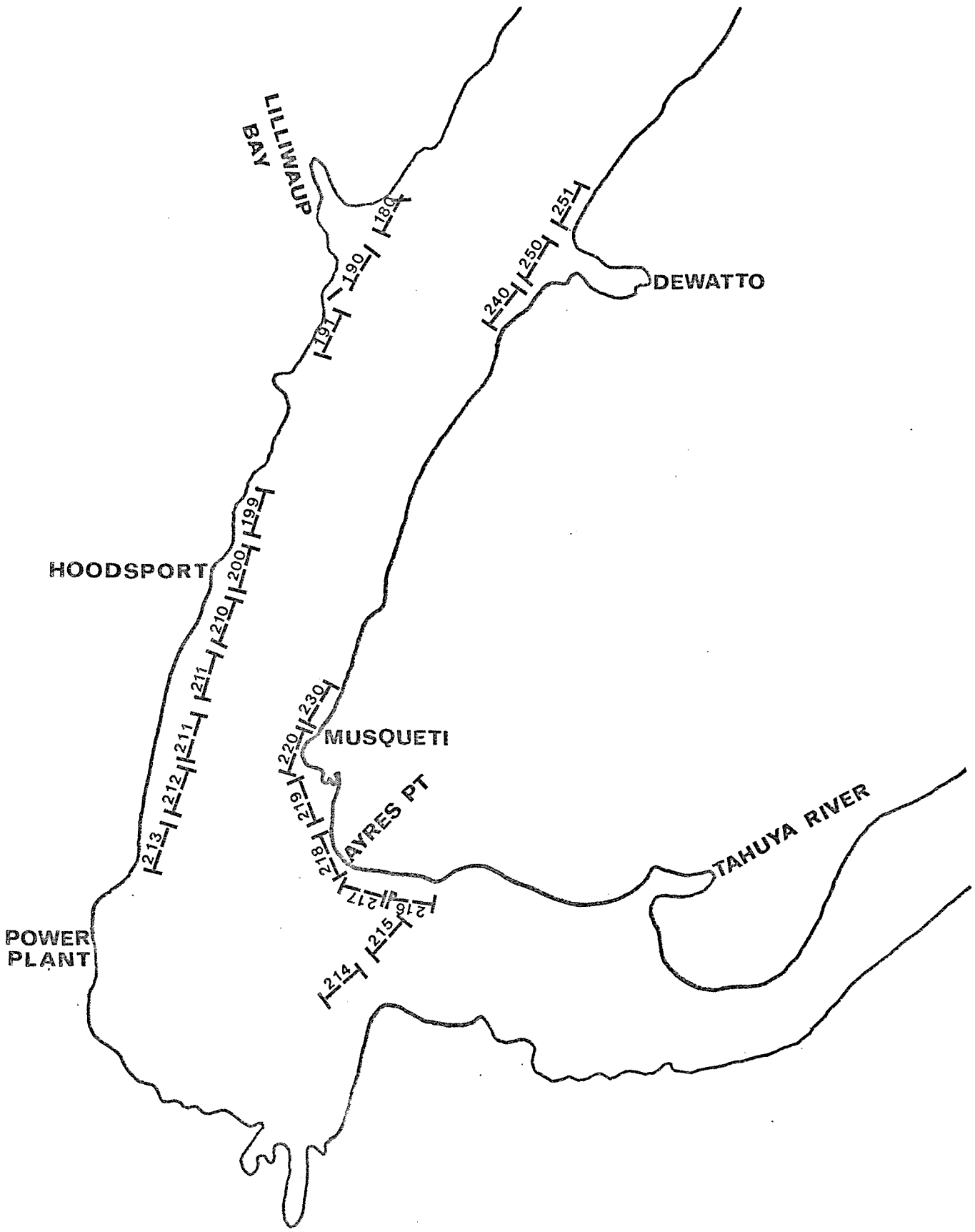
Appendix A - Map II. Beach seining sites, Hood Canal, Washington.



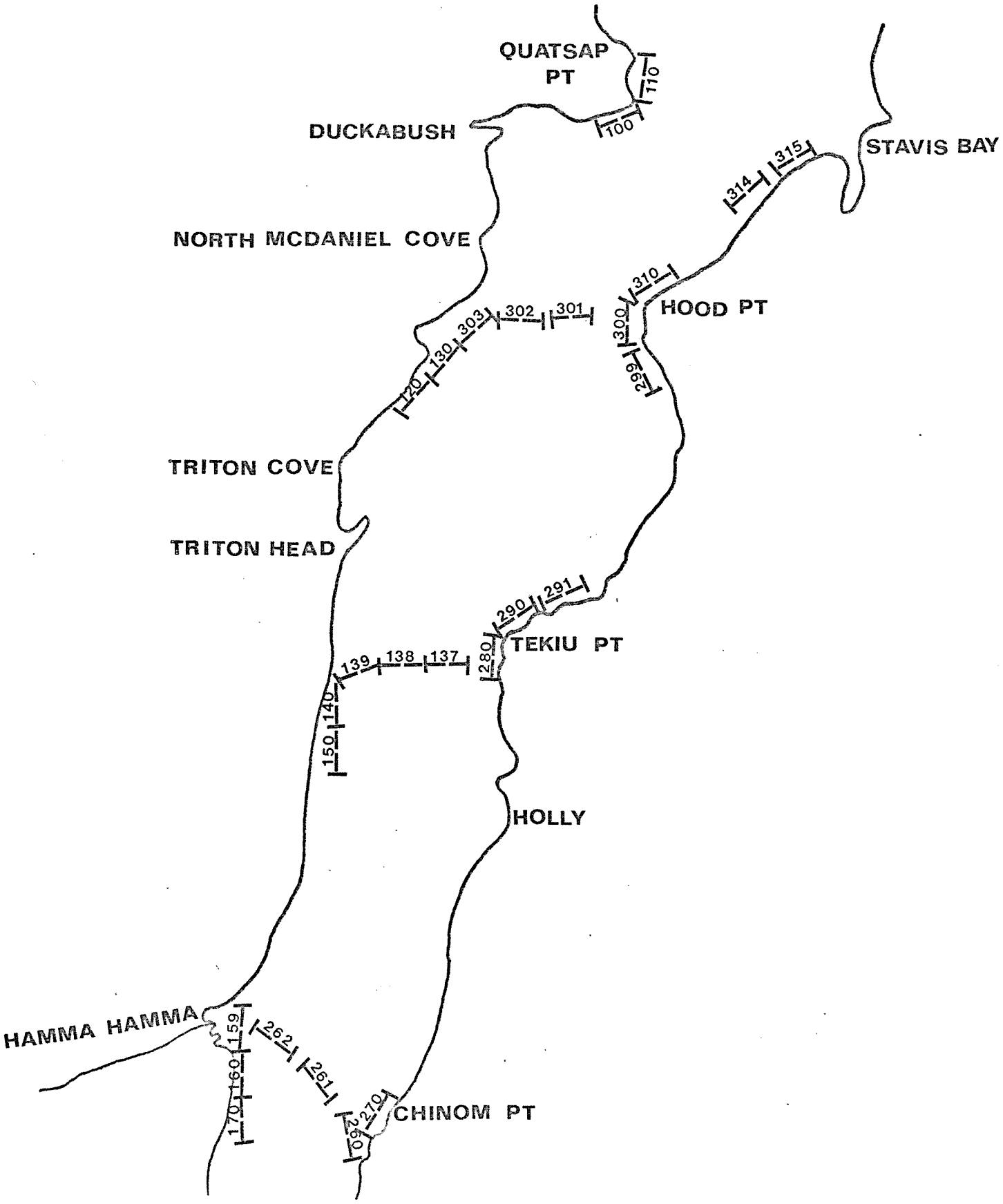
Appendix A - Map III. Beach seining sites, Hood Canal, Washington.



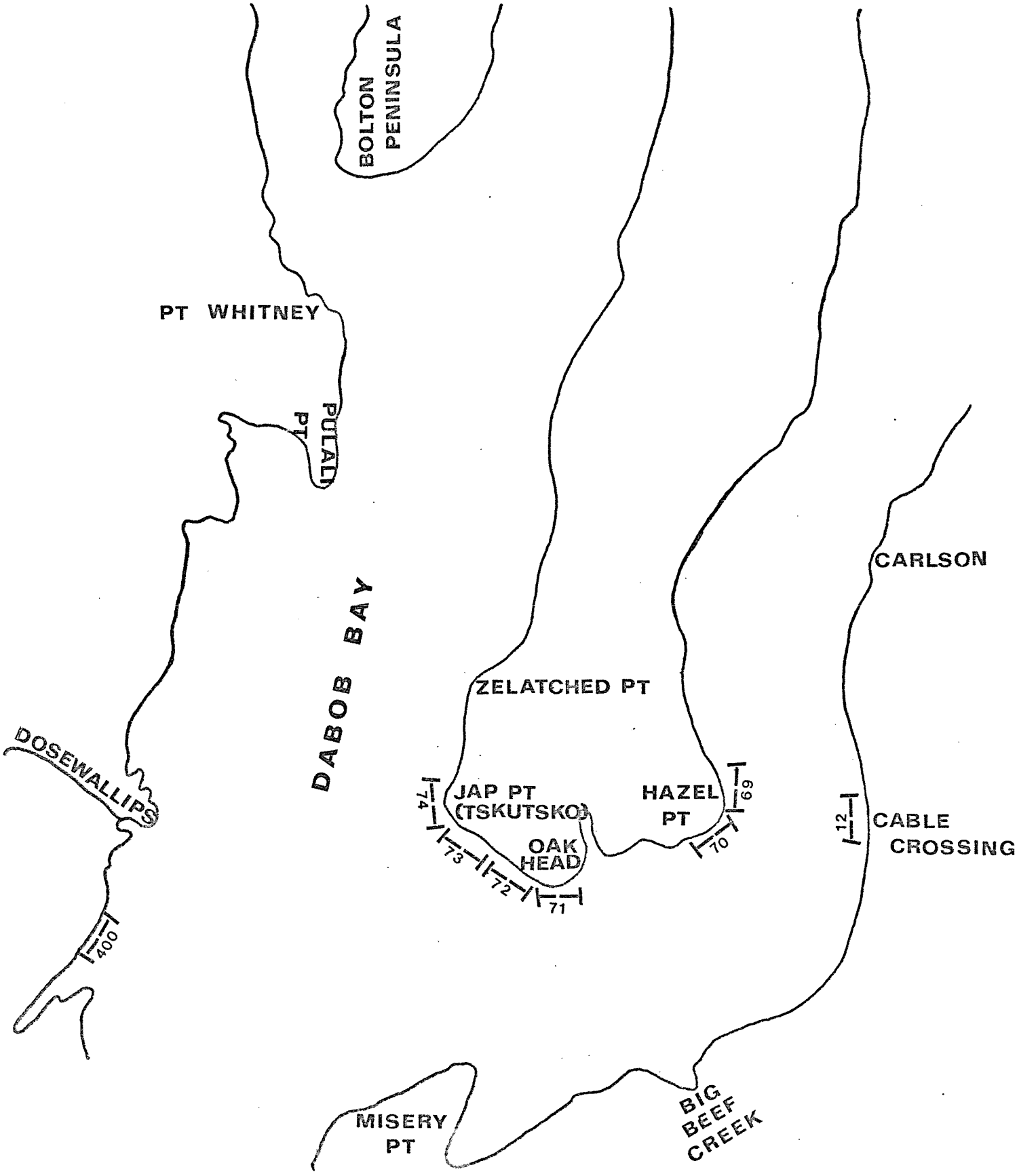
Appendix A - Map IV. Beach seining sites, Hood Canal, Washington.



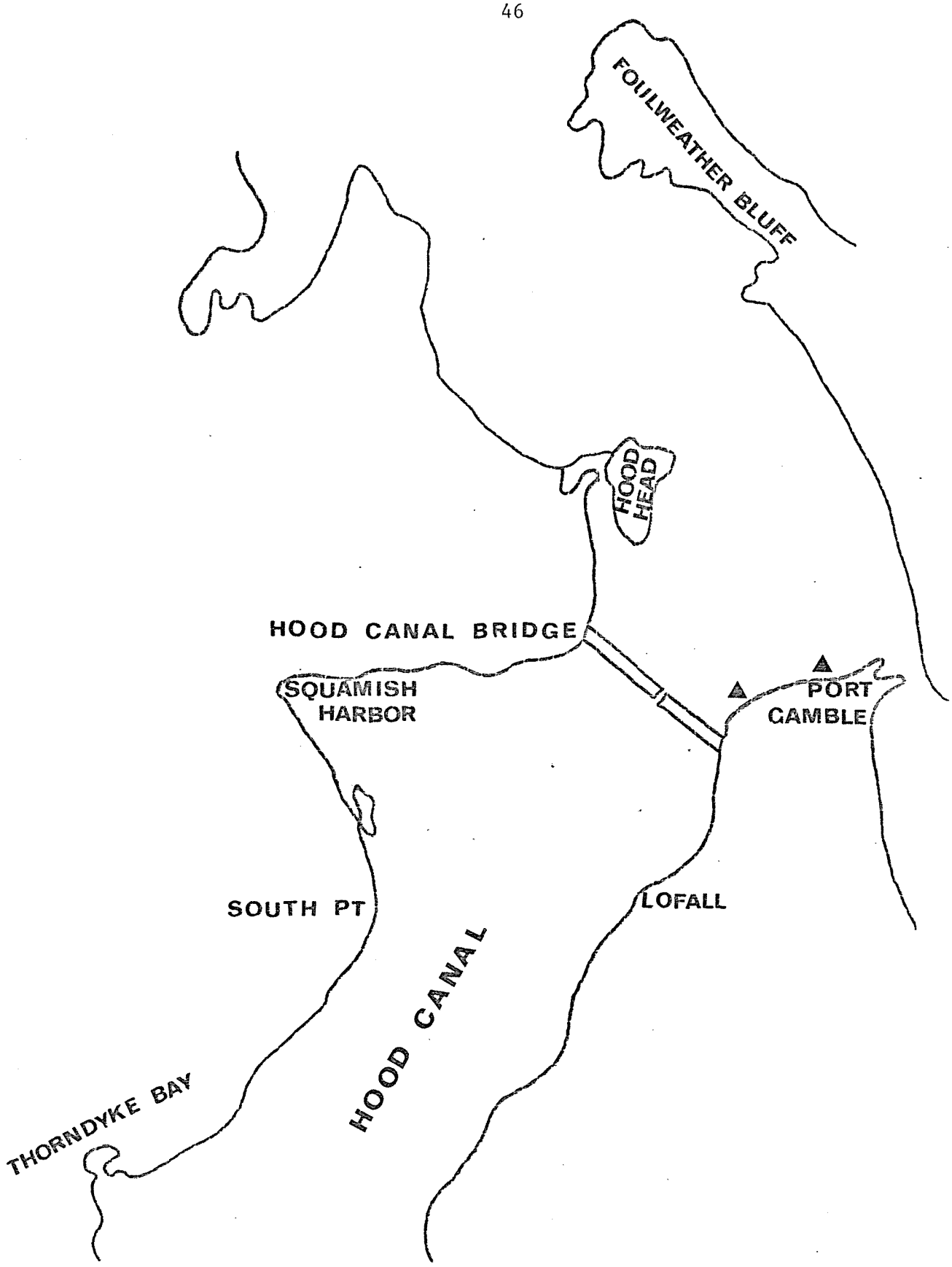
Appendix B - Map I. Townetting sites, Hood Canal, Washington.



Appendix B - Map II. Townetting sites, Hood Canal, Washington.



Appendix B - Map III. Townetting sites, Hood Canal, Washington.



Appendix B - Map IV. Townetting sites, Hood Canal, Washington.