CODED-WIRE TAG RECOVERIES FROM VANCOUVER ISLAND SPORT CAUGHT STEELHEAD 1982-1986

by

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ABSTRACT

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Hatchery reared steelhead trout (Salmo gairdneri) released into various streams on Vancouver Island between 1979 and 1983 were adipose fin clipped and coded-wire tagged (C.W.T.). Sport anglers, who harvested the returning adult steelhead, were encouraged to submit the fish's head to depots located throughout the Island.

Between 1982/83 and 1985/86 steelhead anglers harvested a portion (23%) of the hatchery steelhead they caught and voluntarily returned heads from 13% of the fish they killed. A total of 1660 heads were recovered from 17 watersheds on Vancouver Island. The heads represented 0.11% of the total coded-wire tags released. Depending on the stream stocked, each adult C.W.T. recovered represented 40 to 200 dollars in tagging costs.

Significant numbers of marked steelhead were caught in streams other than where they were released as juveniles. For six study watersheds, the straying rate averaged 9.6% and ranged from 4.3% for streams where incubation and rearing was on-site to 32.7% for smolts outplanted to a receiving stream. Depending on the recovery stream, stray steelhead (non-indigneous) made up varying proportions (0-44%) of the total hatchery returns. Coded-wire tagged steelhead were recovered from eight unstocked watersheds.

Fisheries management implications of hatchery steelhead production and assessment are discussed.

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INTRODUCTION

Since the start of steelhead (Salmo gairdneri) enhancement through hatchery propagation, it has been the policy of the Recreational Fisheries Branch of the Ministry of Environment and Parks to mark all hatchery steelhead smolts and, whenever possible, to utilize native wild brood stock. Between 1972 and 1983, virtually all hatchery reared steelhead smolts released into Vancouver Island streams were both adipose fin clipped and coded-wire tagged (C.W.T.). This provided the means to evaluate a variety of hatchery steelhead rearing and release strategies, commercial interception rates, and hatchery fish contribution to the sport fishery within and outside the release streams. Prior to 1981 captured hatchery fish were sampled in the sport fishery during creel surveys of Big Qualicum (Hooton and Lewynsky 1985), Campbell/Quinsam (Carswell et al. 1986), and Stamp/Somass Rivers (Horncastle 1981). After 1981 both the number of smolts and streams that were stocked increased rapidly. Sport fishermen were encouraged to voluntarily turn in heads from hatchery steelhead taken from Vancouver Island streams. This report summarizes the results of coded-wire tag recoveries from sport caught hatchery steelhead on Vancouver Island between 1982 and 1986 and, in particular, from six watersheds where stocking levels and angler cooperation were relatively high (Fig. 1).

METHODS

Between 1978 and 1983, over one million adipose fin clipped and coded-wire tagged juvenile steelhead were released into the Big Qualicum, Cowichan, Englishman, Little Qualicum, Campbell/Quinsam and Stamp/Somass rivers (Table 1). These releases represented over sixty different coded-wire tag groups from six brood years. After 1983 all hatchery steelhead smolts were adipose fin clipped, but only selected groups were coded-wire tagged for future analysis (mainly summer-run steelhead).

Returning hatchery adults were recovered from anglers during the fishing seasons 1982/83 to 1985/86. Anglers were encouraged by advertisement and streamside notices to turn in heads from harvested steelhead with adipose fin clips. Head depots were established at tackle shops, hatcheries and district government offices. A cooperative recovery program with the Federal Department of Fisheries and Oceans was established. Personnel under contract to the Federal government to collect salmon heads from depots throughout the Island also collected steelhead heads and returned them to Fish and Wildlife Branch staff in Nanaimo. The heads were dissected, the pins were removed and read, and the data was put onto a DIGITAL PRO-350 computer for analysis. The coded-wire tags and pertinent data were put onto Department of Fisheries and Oceans' head-return labels and sent to Vancouver for their records.

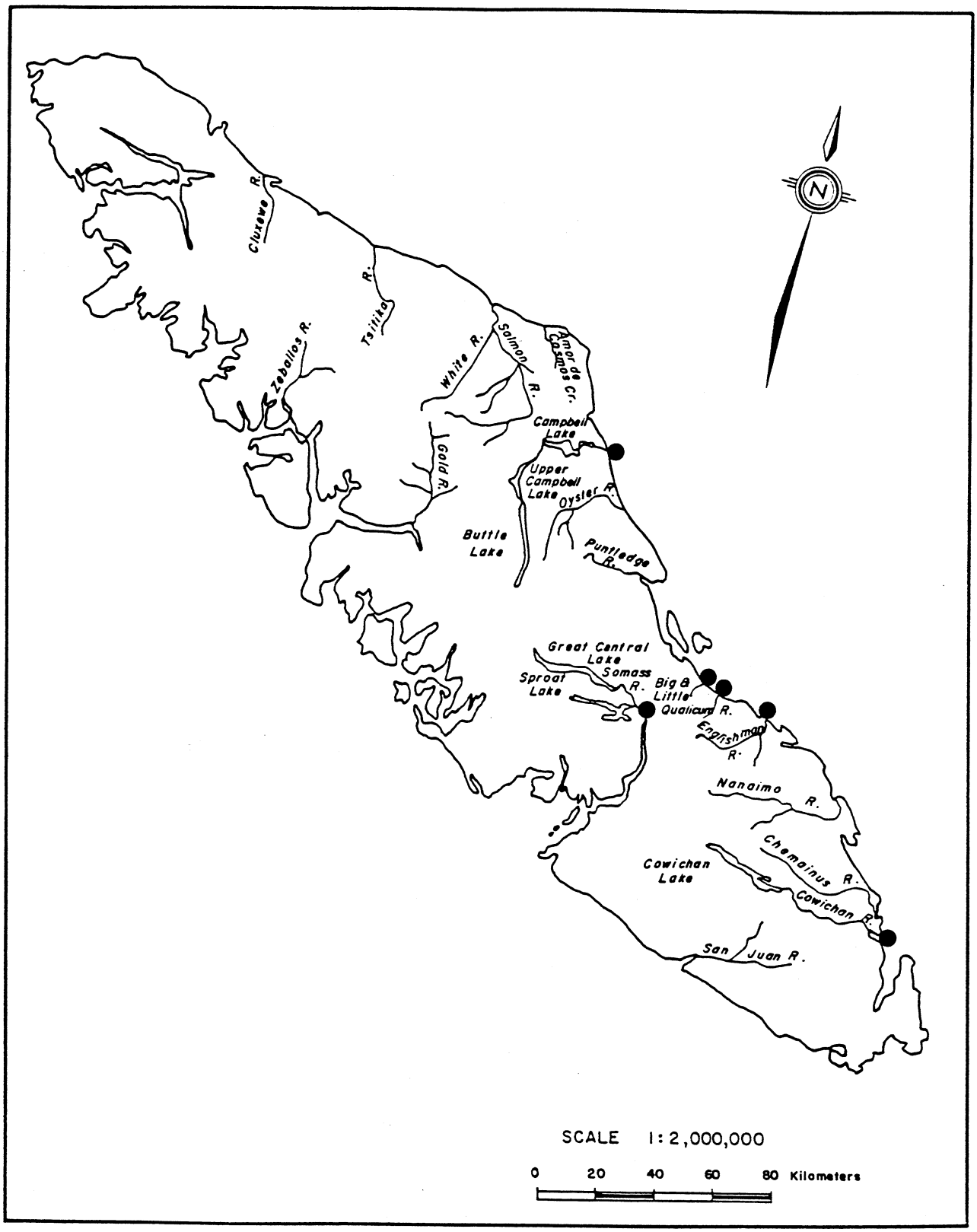

Fig. 1. Vancouver Island streams with coded-wire tagged steelhead sport recoveries (key streams ●).

Table 1. Release of steelhead with coded-wire tags and sport harvest returns for Vancouver Island study streams, 1982/83 to 1985/86.

Stream	Brood Year	Tag No.	Number Released	Date	Mean Size (gm)	Coded-wire Tags Recovered in release stream	Tags Recovered in other Streams (%)
Big Qualicum	1982	122029	24531	010583	64.1	69	1 (1.4)
	1981	121812	25671	120582	66.8	132	12 (8.3)
	1980	121756	13339	--0581	68.5	29	2 (6.5)
	1979	121817	22295	280580	28.4	36	2 (5.3)
	1979	121819	13760	280580	12.3	8	0
	1978	121728	20277	080579	51.0	5	0
	1978	121741	4735	150480	227.0	1	0
	1978	121736	6852	150479	42.9	1	0
					Subtotal	281	17 (5.7)
			131460 released and 298 recovered (441:1 or 0.23%)				
Cowichan	1982	122015	11743	210483	66.7	59	1 (1.7)
	1982	122016	14031	050583	58.0	34	0
	1982	122017	19927	170583	53.2	26	0
	1981	121909	627	120582	74.8	1	0
	1981	121910	2647	120582	35.2	9	0
	1980	121604	4682	210481	59.9	16	0
	1980	121820	4685	210481	65.0	11	0
					Subtotal	156	1 (0.6)
			58342 released and 157 recovered (372:1 or 0.27%)				
Englishman	1982	122030	30546	180583	22.4	5	8 (61.5)
	1981	121608	11067	200582	41.9	5	11 (68.8)
	1981	121609	11606	--0582	20.2	4	6 (60.0)
	1980	121605	24365	--0081	41.9	8	5 (38.5)
	1979	121821	32287	--0580	32.4	9	5 (35.7)
					Subtotal	31	35 (53.0)
			109871 released and 66 recovered (1665:1 or 0.06%)				
Little Qualicum	1982	121913	2493	060583	52.7	8	8 (50.0)
	1982	122010	12493	060583	52.4	12	2 (14.3)
	1981	121707	23640	010582	54.3	8	7 (46.7)
	1981	121708	2060	280582	32.0	13	7 (35.0)
	1980	121606	10000	010581	46.0	2	0
	1979	121818	20027	060580	43.2	29	8 (21.6)
	1978	121729	20062	230479	37.8	12	3 (20.0)
					Subtotal	84	35 (29.4)
			90775 released and 119 recovered (763:1 or 0.13%)				

Table 1. continued

Stream	Brood Year	Tag No.	Number Released	Date	Mean Size (gm)	Coded-wire Tags Recovered in release stream	Tags Recovered in other Streams (%)
Quinsam	1982	122025	21090	260483	47.9	6	0
(winter run)	1981	121950	17599	180482	77.8	25	1 (3.8)
	1980	121650	700	----81	----	2	0
	1980	121701	6552	060581	54.7	12	0
	1980	121705	10246	091080	6.0	4	0
	1980	121822	13995	060581	54.7	37	0
	1979	121644	1869	----80	73.0	1	0
	1979	121662	10100	060580	59.7	7	0
	1979	121663	10120	060580	53.9	21	2 (8.7)
	1978	121738	8595	250479	69.8	1	0
					Subtotal	116	3 (2.5)
			100866 released and 119 recovered (848:1 or 0.12%)				
Campbell	1982	122127	5470	040584	73.0	1	0
(summer run)	1981	121963	7518	110583	50.6	5	2 (28.6)
	1981	122002	7188	110583	84.2	6	0
	1980	121915	3315	180582	38.0	7	1 (12.5)
	1980	121916	8065	150583	73.0	16	0
					Subtotal	35	3 (7.9)
			31556 released and 38 recovered (830:1 or 0.12%)				
Stamp/Somass	1984	122147	32344	240485	33.9	1	1 (50.0)
	1983	122112	39348	100484	49.8	1	1 (50.0)
	1983	122113	28861	100484	52.1	7	1 (12.5)
	1983	122114	25729	100484	54.6	13	0
	1983	122115	27939	100484	63.3	15	1 (6.3)
	1983	122116	26551	100484	78.2	35	0
	1983	122117	26304	100484	65.8	62	1 (1.6)
	1982	121753	76486	260483	62.1	40	3 (7.0)
	1982	121944	18523	260483	60.0	9	1 (10.0)
	1982	121945	18524	260483	60.0	9	3 (25.0)
	1982	122027	18795	280483	63.0	56	1 (1.8)
	1981	121947	23482	040582	52.3	58	3 (4.9)
	1981	121946	24601	200482	56.0	5	0
	1981	121810	37342	200482	57.0	25	2 (7.4)
	1981	121806	9809	040582	67.2	4	1 (20.0)
	1981	121702	27227	040582	54.9	10	2 (16.7)
	1980	121612	23460	020481	52.7	11	0
	1980	121603	71900	020481	48.2	9	1 (10.0)
	1979	121600	16165	010580	51.6	7	0
	1979	121748	18276	010580	51.6	11	0
	1979	121824	6236	010580	69.8	5	0
	1977	121627	2096	010578	62.0	1	0
					Subtotal	394	22 (5.3)
			599998 released and 416 recovered (1442:1 or 0.07%)				
					TOTAL	1097	116 (9.6)
			1122868 released and 1213 recovered (926:1 or 0.11%)				

RESULTS AND DISCUSSION

SAMPLING BIAS

Due to the nature of data collection, mainly volunteer, caution must be used in developing conclusions. Sample sizes were generally small and sampling bias likely existed. Additionally, the streams involved supported varying annual effort, harvest and return rates. In spite of these limitations, some important trends regarding hatchery steelhead managment programs were evident.

HATCHERY CATCH

During the four fishing seasons between 1982 and 1986, the number of hatchery steelhead (adipose fin clipped) captured on Vancouver Island increased steadily (Table 2). For the 1985/86 season, nearly half (25,247) of all steelhead caught on Vancouver Island were of hatchery origin (Billings 1987). The ratio of hatchery steelhead to wild fish varied between streams and years depending on hatchery smolt release quantity/quality and variations in wild production. Between 1982 and 1986 the average catch of hatchery steelhead varied from 11% of the total catch on the Cowichan River to 59% on the Stamp/Somass rivers.

In spite of regulations allowing the harvest of hatchery fish, identifiable by an adipose fin clip, sport anglers preferred to release most of their catch (77%). This tendency may have been a hold over from when catch and release was actively promoted to save declining wild stocks (Hooton 1987). Some anglers believe that more spawners, regardless of their origin (i.e., hatchery or wild), will produce larger adult populations in the future. For the study streams, the number of hatchery steelhead killed varied from 19% to 36% of the hatchery catch on the Englishman and Cowichan rivers, respectively.

Released hatchery steelhead can contribute to additional captures by other anglers. The recapture rates of early winter-run steelhead have ranged from 22% to 39% on some Vancouver Island streams (Hooton and Lirette 1986; Ministry of Environment and Parks Unpubl. data).

Table 2. Estimated angler catch and harvest* and the number of hatchery steelhead heads recovered from the study streams on Vancouver Island, 1982/83 to 1985/86

Streams	Season	Total Catch	Hatchery Catch (%)	Hatchery Killed (%)	Heads Recovered Number	Heads Recovered % of Harvest
Big Qualicum	1982/83	3298	1341 (41)	362 (27)	98	27
	1983/84	3310	1806 (55)	481 (27)	174	36
	1984/85	3166	1645 (52)	452 (27)	69	15
	1985/86	1766	1140 (65)	359 (31)	77	21
			Mean 53	28		25
Campbell/ Quinsam	1982/83	2476	1172 (47)	366 (31)	56	15
	1983/84	3314	1483 (45)	314 (21)	70	22
	1984/85	6008	3048 (51)	489 (16)	33	7
	1985/86	7335	4304 (59)	520 (12)	28	5
			Mean 51	20		12
Cowichan	1982/83	1881	135 (7)	45 (33)	36	80
	1983/84	4310	223 (5)	87 (39)	14	16
	1984/85	7225	920 (13)	410 (45)	113	28
	1985/86	5077	841 (17)	232 (28)	57	25
			Mean 11	36		37
Englishman	1982/83	903	153 (17)	55 (36)	12	22
	1983/84	1497	545 (36)	68 (12)	10	15
	1984/85	3105	1219 (39)	198 (16)	14	7
	1985/86	1814	907 (50)	103 (11)	12	12
			Mean 36	19		14
Little Qualicum	1982/83	1829	850 (46)	296 (35)	43	15
	1983/84	2742	1179 (43)	258 (22)	33	13
	1984/85	3141	1379 (44)	372 (27)	30	8
	1985/86	2635	1674 (64)	484 (29)	57	12
			Mean 49	28		12
Stamp/Somass	1982/83	4348	2631 (61)	606 (23)	40	7
	1983/84	9816	5386 (55)	1453 (27)	90	6
	1984/85	11413	5273 (46)	1336 (25)	79	6
	1985/86	17432	13121 (75)	2222 (17)	239	11
			Mean 59	23		8
All Vancouver Island Streams Combined	1982/83	29569	6810 (23)	1885 (28)	289	15
	1983/84	47082	12960 (28)	2953 (23)	449	15
	1984/85	54301	16586 (31)	3863 (23)	391	10
	1985/86	51806	25247 (49)	4484 (18)	531	12
			Mean 33	23		13

*Data from annual steelhead harvest analyses (Billings 1983, 1984, 1986, 1987)

CODED-WIRE TAGGED HEAD RECOVERIES

During the period between 1982 and 1986, a total of 1,660 heads from adipose fin clipped steelhead were returned by anglers from Vancouver Island streams. Coded-wire tags (n = 1,301) were recovered from 17 watersheds and represented indigenous and non-indigneous fish from stocked and unstocked rivers. For the six study watersheds, the coded-wire tag recoveries (n = 1,213) averaged 0.11% and ranged from 0.06% (Englishman River) to 0.27% (Cowichan River) of the total marked smolts released into each stream (Table 1). This was approximately one-quarter of the 0.4% to 0.7% recovery of coded-wire tags from released smolts obtained during creel surveys on the Campbell/Quinsam and Big Qualicum rivers between 1977 and 1980 (Hooton and Lewynsky 1985; Carswell et al. 1986).

The number of hatchery steelhead heads voluntarily turned in by anglers, relative to the number of fish reported killed (from Steelhead Harvest Analysis), varied considerably between streams and between years (Table 2). For Vancouver Island steelhead, heads were recovered from 13% of the estimated fish harvested between 1982 and 1986. The steelhead recovery rate was similar to the recovery rate of freshwater marked salmon (10-15%) but considerably less than the 21% and 23% recovery of marine coho (Oncorhynchus kisutch) and chinook (O. tshawytscha) caught by saltwater sportfishermen (J. Thomas pers. comm.). In spite of the reward incentive and advertising program, steelhead sport anglers returned few of the heads from marked steelhead. Head recovery associated with a creel survey, where anglers were contacted personally, resulted in higher (approximately three times) return rates (42%) of marked adult coho on the Vedder/Chilliwack River (Hickey et al. 1987).

For the six study streams, 372 to 1,665 tagged smolts were released for each tagged adult harvested and turned into a head recovery depot (Table 1). At a cost of 12 cents per tagged smolt (B. Ludwig pers. comm.), each single adult recovered was worth between 45 and 200 dollars in tagging costs. On this basis, general coded-wire tagging appears not to be cost effective without a greatly improved adult recovery program.

STRAYING

The present study examined the rates of straying for within system releases and outplantings (Table 3). For all but two of the programs (Campbell River summer-run and Little Qualicum winter-run steelhead) native brood stock was used.

Among programs where smolts were reared and released within a watershed, the recoveries of strays in neighbouring rivers averaged 4.3% and ranged from 0.6% (Cowichan) to 5.7% (Big Qualicum) of the total recoveries (Table 3). For the Big Qualicum River most of the strays (59%) were from an adjacent watershed, the Little Qualicum River (Appendix 1, Fig. 1), but included recoveries from the Chemainus (100 km south) and the Salmon River (160 km north).

Table 3. Number and percent of stray hatchery steelhead of various stocks and rearing strategies among all coded-wire tag bearing steelhead heads voluntarily submitted by sport anglers on Vancouver Island, 1982-86.

Stream Stocked	Brood Source	Incubation	Rearing	C.W.T.'s RECOVERED Total	In Other Streams	% Strays
Big Qualicum	Big Qualicum	Big Qualicum	Big Qualicum	298	17	5.7
Cowichan	Cowichan	Well Water (Cowichan R)	Cowichan Lk net pens	157	1	0.6
Quinsam	Quinsam	Quinsam	Quinsam	119	3	2.5
Stamp/Somass	Stamp/Somass	Robertson Ck (Stamp)	Robertson Ck (Stamp)	416	22	5.3
		Within River Release Subtotal		990	43	4.3
Campbell	Tsitika (summer run)	Well Water (Cowichan R)	O'Conner Lk (Keogh R)	38	3	7.9
Englishman	Englishman	Big Qualicum	Big Qualicum	66	35	53.0
L. Qualicum	Big Qualicum	Big Qualicum	Big Qualicum	119	35	29.4
		Outplanting Release Subtotal		223	73	32.7
			TOTAL	1213	116	9.6

Strays from the Stamp/Somass River (5.3%) were recovered mainly from the Gold (81%) and Zeballos Rivers (18%)(Appendix 1, Fig. 4). Both of these rivers are located over 200 km (by water) north on the west coast of the island. The Gold River is a wild-steelhead-only stream with an estimated catch of marked hatchery fish ranging from 109 to 417 fish in 1982/83 and 1984/85, respectively (1.9% to 5.8% of the total catch) (Billings 1983, 1986). The straying between these two widely separted watersheds may appear unusual, but if one considers the importance of olfactory senses to identifying home stream odours (Wisbey and Halser 1954; Groves et al. 1968; Hasler et al. 1978; cited in Lister et al. 1981), then factors such as watershed geology, water chemistry and waste effluents (sewage, pulpmill, etc.) could affect the rate of straying between systems. The Gold and Somass rivers are located at the head of long inlets with pulp mill effluent discharges near their estuaries.

The Cowichan and Quinsam Rivers had the lowest recovery of strays, 0.6% and 2.5%, respectively (Appendix 1, Figs. 2 and 3). One Quinsam River stray was recovered from the San Juan River located over 300 km away on the southwest coast of the Island.

Straying was highest from outplanting steelhead smolts raised at a central hatchery facility. Recoveries of strays outside of the release stream averaged 32.7% and ranged from 7.9% (Campbell River summer-runs) to 53% (Englishman River winter-run steelhead) of the total stock-specific recoveries (Table 3). The recovery of stray adults from the smolts released into the Little Qualicum River (29.4%) were mainly from the adjacent originating hatchery stream, the Big Qualicum River (80%) (Appendix 1, Fig. 6).

Steelhead released into the Englishman River, from the Big Qualicum River hatchery, resulted in extremely high rates of straying (53%). The majority of these recoveries, 37%, 34% and 23%, were from the originating hatchery stream, the Big Qualicum River and the two adjacent watersheds, the Nanaimo and Little Qualicum rivers, respectively (Appendix 1, Fig. 7).

The rate of straying from smolts released into the Campbell River (7.9%) was considerably less than that found for smolts outplanted into the Englishman and Little Qualicum rivers. The strays were recovered from streams along the migration route to Campbell River (Appendix 1, Fig. 5). The low straying rate may have been related to the type of rearing (lake net pen) and distance between rearing and release stream (160 km).

These results supported some of the conclusions of Lister et al. (1981):

1) the rate of straying increases with decreasing distance between the release and rearing sites;

2) straying back to the rearing site comprises a significant portion of total straying.

Straying resulting from outplanting smolts from a central hatchery river (Alsea River) is thought to be a significant occurrence in Oregon (Garrison and Peterson 1978, sited in Lister et al. 1981; Kenaston and MacHugh 1985). In this study, the practice of outplanting steelhead smolts resulted in an average increase in the incidence of straying by eight times, from 4.3% to 32.7% (Table 3). Outplanting steelhead juveniles at the smolt stage does not provide for adequate imprinting to the release stream. Straying may be reduced by rearing juveniles in the release stream prior to smolting.

The number of hatchery steelhead straying between Vancouver Island streams can make up a large proportion of the returns to an individual river. This non-indigenous component ranged from 0% in the Stamp/Somass to 43.9% of hatchery returns in the Nanaimo River (Table 4). For the Big Qualicum River 14.3% of the returning hatchery steelhead were strays from other programs (mainly from fish outplantings to Little Qualicum and Englishman rivers). Stray steelhead recoveries in the Big Qualicum River, from outplantings, were observed previously by Hooton and Lewynsky (1985) between 1978 and 1981.

Table 4. Number of steelhead heads returned by anglers, the number of heads containing C.W.T.'s, and the number and percent of C.W.T. recoveries not indigenous to the recovery streams, 1982-86.

Recovery Stream	Season	Heads Returned Total	Heads Returned With C.W.T.	Number not Indigenous to the Recovery Stream (%)
Big Qualicum	1985/86	77	36	7 (19.5)
	1984/85	69	65	5 (7.7)
	1983/84	174	143	20 (14.0)
	1982/83	98	84	14 (17.9)
	Subtotal	418	328	47 (14.3)
Cowichan	1985/86	57	41	2 (4.9)
	1984/85	113	87	3 (3.4)
	1983/84	14	7	0 (0.0)
	1982/83	36	27	1 (3.7)
	Subtotal	220	162	6 (3.7)
Englishman	1985/86	12	6	3 (50.0)
	1984/85	14	14	6 (42.9)
	1983/84	10	9	1 (11.1)
	1982/83	12	12	0 (0.0)
	Subtotal	48	41	10 (24.4)
Little Qualicum	1985/86	57	15	1 (6.7)
	1984/85	30	22	8 (36.4)
	1983/84	33	30	9 (30.0)
	1982/83	43	37	2 (5.4)
	Subtotal	163	104	20 (19.2)
Nanaimo	1985/86	17	14	3 (21.4)
	1984/85	24	19	7 (36.8)
	1983/84	8	8	8 (100)
	Subtotal	49	41	18 (43.9)
Puntledge	1985/86	9	6	0 (0.0)
	1984/85	4	4	0 (0.0)
	1983/84	9	8	1 (12.5)
	1982/83	2	2	0 (0.0)
	Subtotal	24	20	1 (5.0)
Quinsam and	1985/86	28	27	3 (11.1)
Campbell	1984/85	33	29	1 (3.4)
	1983/84	70	53	0 (0.0)
	1982/83	56	49	0 (0.0)
	Subtotal	187	158	4 (2.5)
Oyster	1985/86	2	2	0 (0.0)
	1984/85	6	6	0 (0.0)
	1983/84	19	15	2 (13.3)
	Subtotal	27	23	2 (8.7)
Stamp/Somass	1985/86	239	215	0 (0.0)
	1984/85	79	70	0 (0.0)
	1983/84	90	75	0 (0.0)
	1982/83	40	34	0 (0.0)
	Subtotal	448	394	0 (0.0)
	TOTAL	1584	1271	108 (8.5)

Unstocked stream recoveries: Gold (n = 16), Salmon (n = 6), Tsitika (n = 1), Amour de Cosmos (n = 1), Chemainus (n = 1), San Juan (n = 1), and Zeballos (n = 3).

There were 30 recoveries of adipose fin clipped hatchery steelhead with C.W.T. data in unstocked watersheds (Table 4). These streams included the Gold (N = 16), Salmon (N = 6), Tsitika (N = 1), Amour de Cosmos (N = 1), Chemainus (N = 1), Cluxewe (N = 1), San Juan (N = 1) and Zeballos (N = 3) rivers. For the Gold and Cluxewe rivers, non-indigenous hatchery steelhead made up 3.4% (198) and 41% (106) of the total catch, respectively, during the 1985-86 season (Billings 1987). The potential impact of stray hatchery fish on wild stocks in unenhanced streams adjacent to production facilities is a concern. Wild stocks in streams having a large central hatchery used for outplanting smolts may also be at risk because of increased hatchery fish returns due to straying back to the rearing stream. Hiss et al. (1986) estimated that 34% to 41% of hatchery steelhead returning to the Hoh River were adults returning from releases to other river systems. A large proportion of steelhead returning to the Alsea River, 21% to 40%, were strays from outplanting programs (Kenaston and MacHugh 1985).

MANAGEMENT IMPLICATIONS

The cost of coded-wire tagging and adult recovery is expensive, and must be considered relative to the benefits anticipated. Adult recovery for evaluation and assessment should not rely solely on sport anglers without considerable additional efforts or incentives for head returns. Future coded-wire tagging projects must have clear objectives and methods of evaluating recovery success.

Straying frequency is potentially a problem with hatchery smolt releases. Straying rates averaged 4.1% for within river releases and 32.7% for outplanted smolts. When formulating production numbers and method, fisheries managers must consider the impact of straying relative to the spread of disease, genetic dilution of wild runs and the consequences to the sport fishery (returns of hatchery steelhead higher or lower than expected due to straying). Alternatives to outplanting smolts should be considered.

Concerns have been raised by fisheries managers regarding the potential impact of hatchery steelhead smolt augmentation on native wild stocks (Boydstun 1977; Crawford 1977; Reinsenbichler and McIntyre 1977; Hiss et al. 1986). To maintain the integrity of wild stocks, it is important that the number of hatchery smolts released complements the natural wild smolt output within a system and that a large proportion of returning hatchery fish are harvested. If over-escapement or straying of hatchery steelhead is a concern, then a reduction in the number of hatchery smolts released should be considered.

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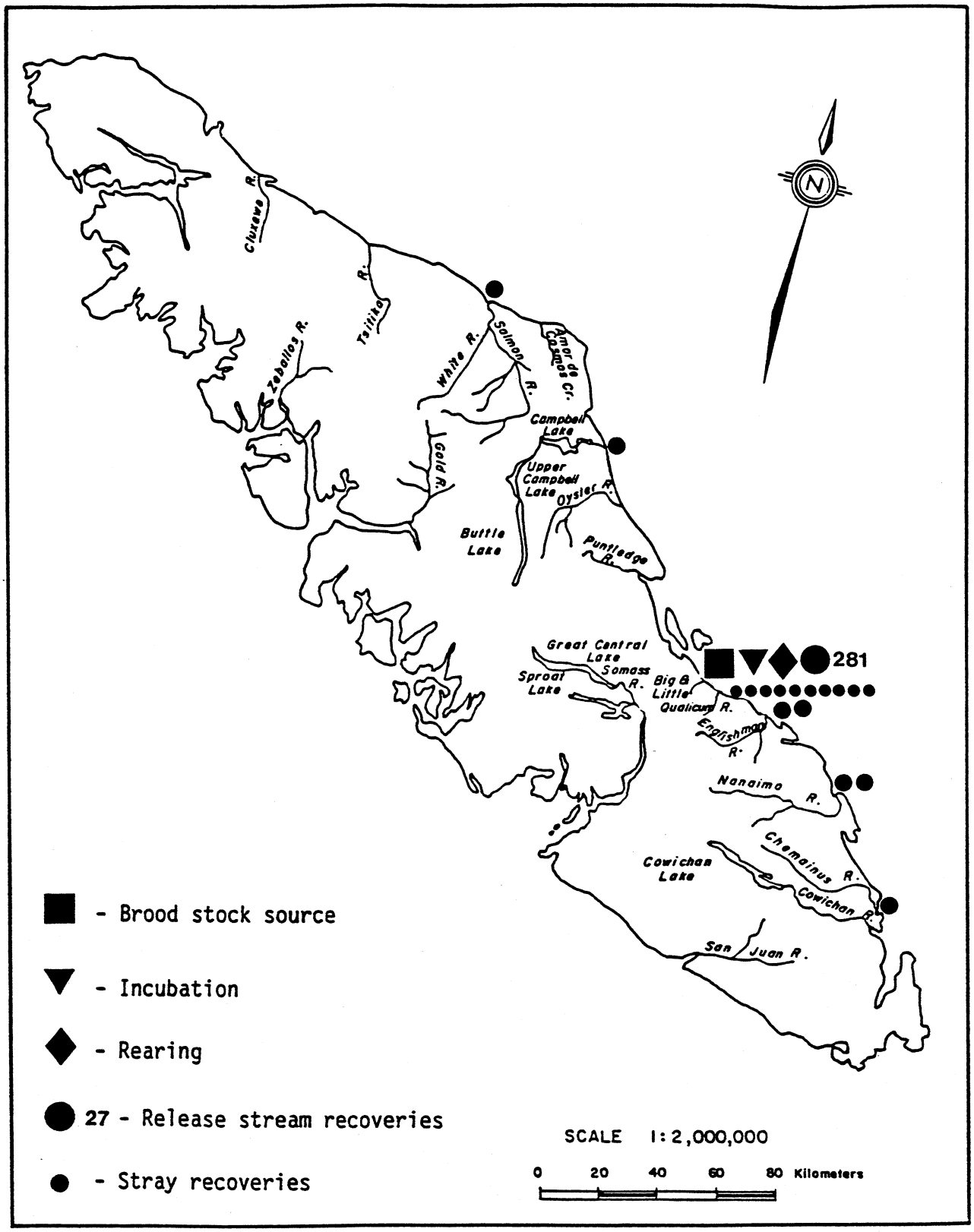
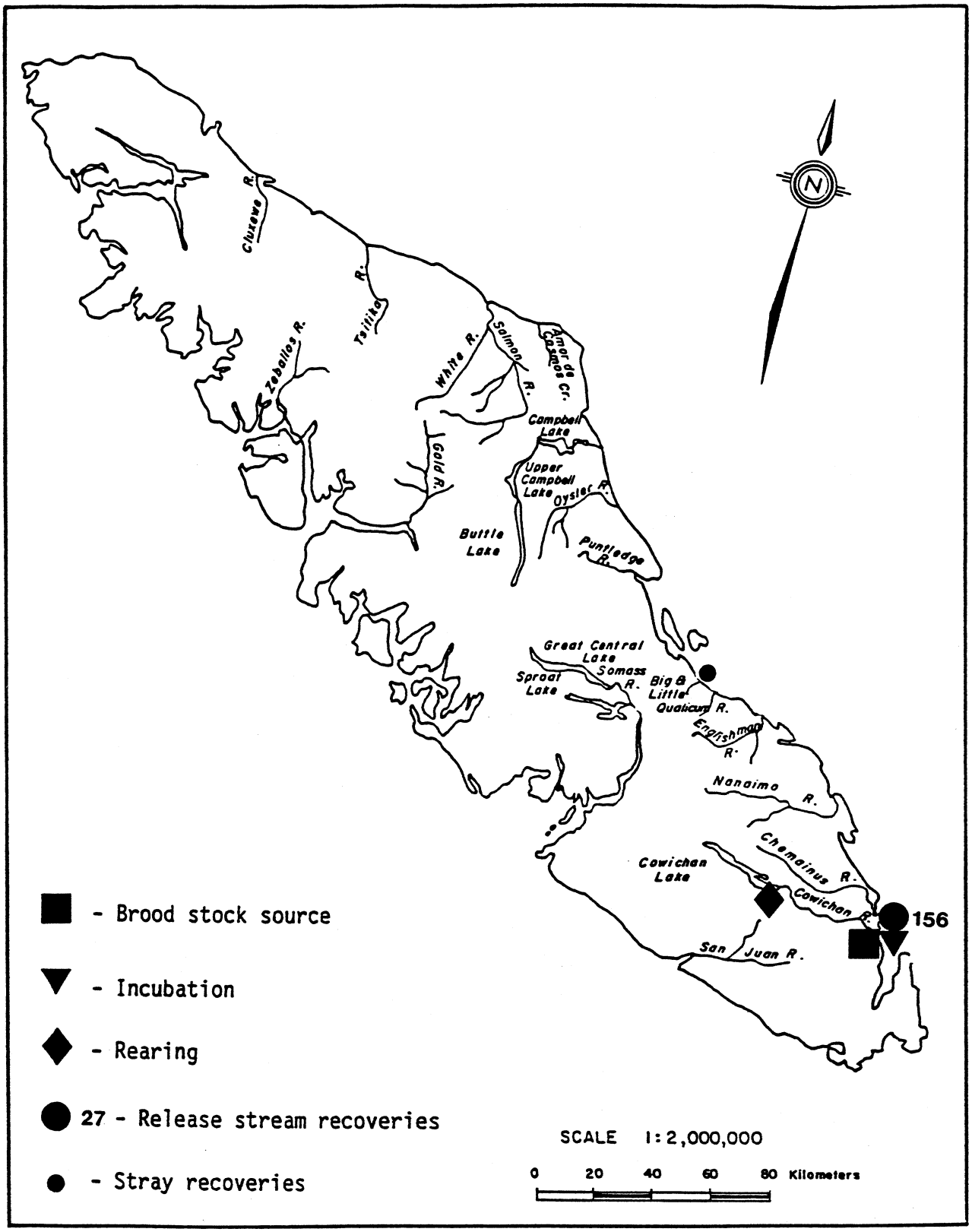
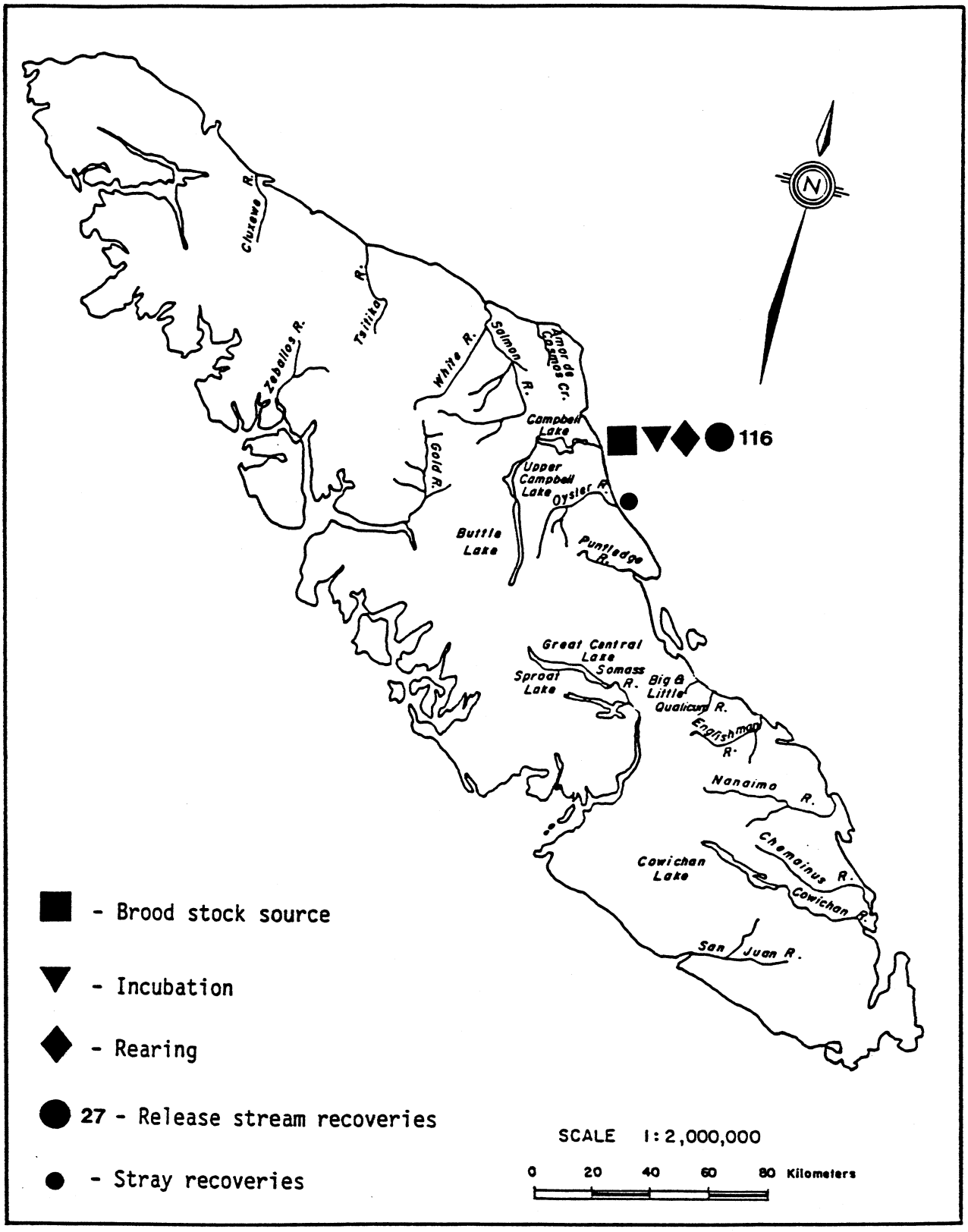


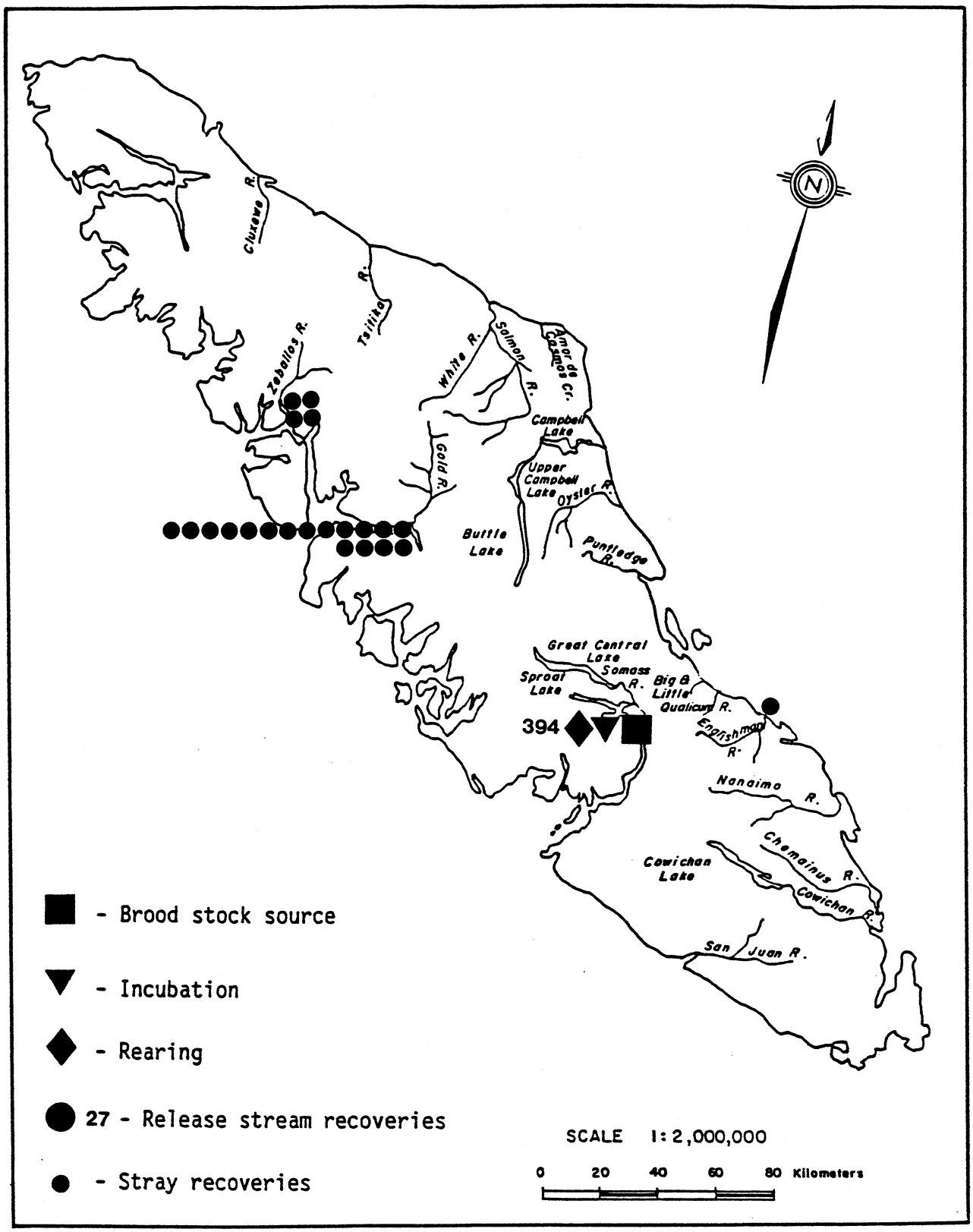
Appendix 1, Fig.1. Big Qualicum River coded-wire tagged steelhead sport recoveries, 1983 to 1986.



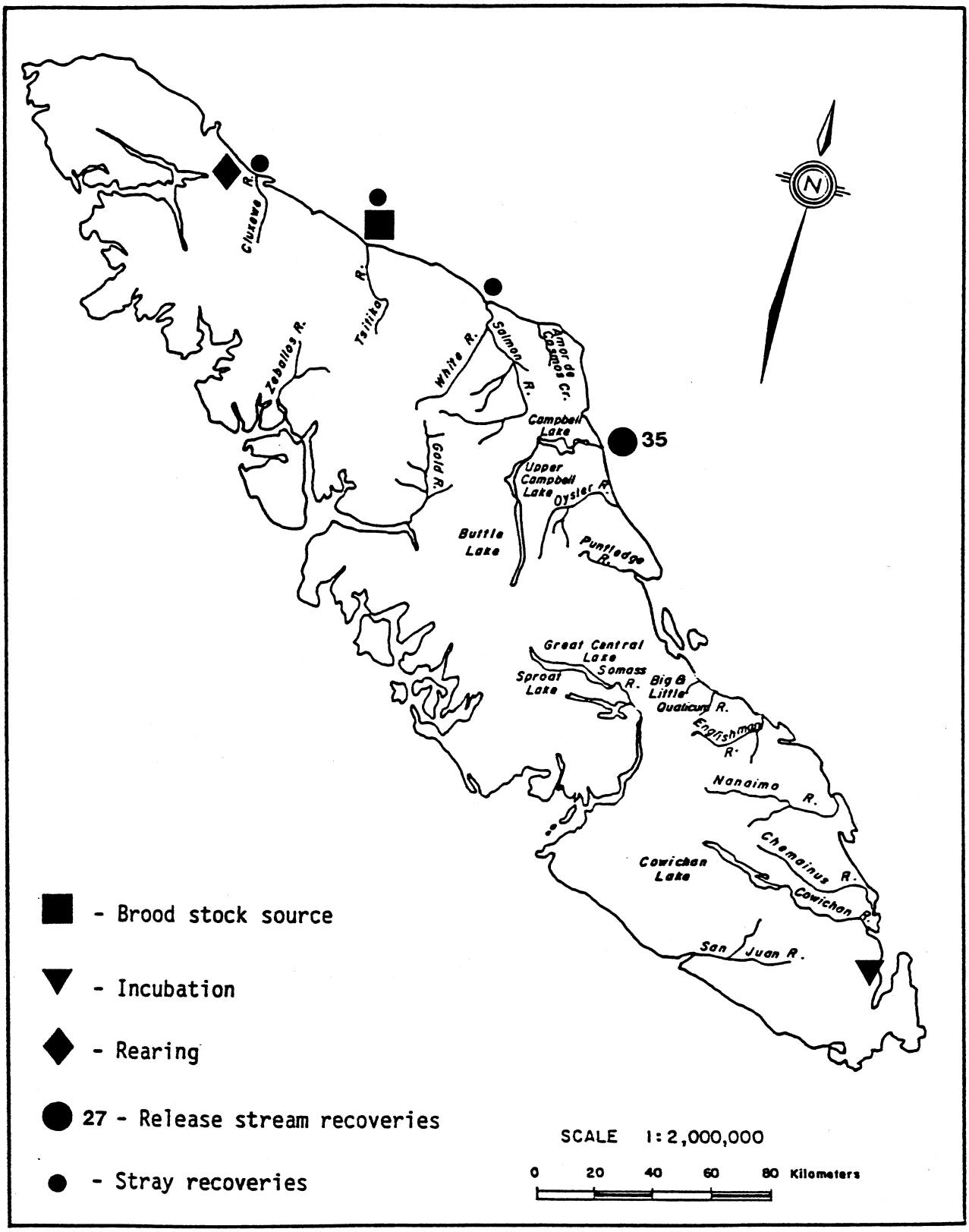
Appendix 1, Fig.2. Cowichan River coded-wire tagged steelhead sport recoveries, 1983 to 1986.



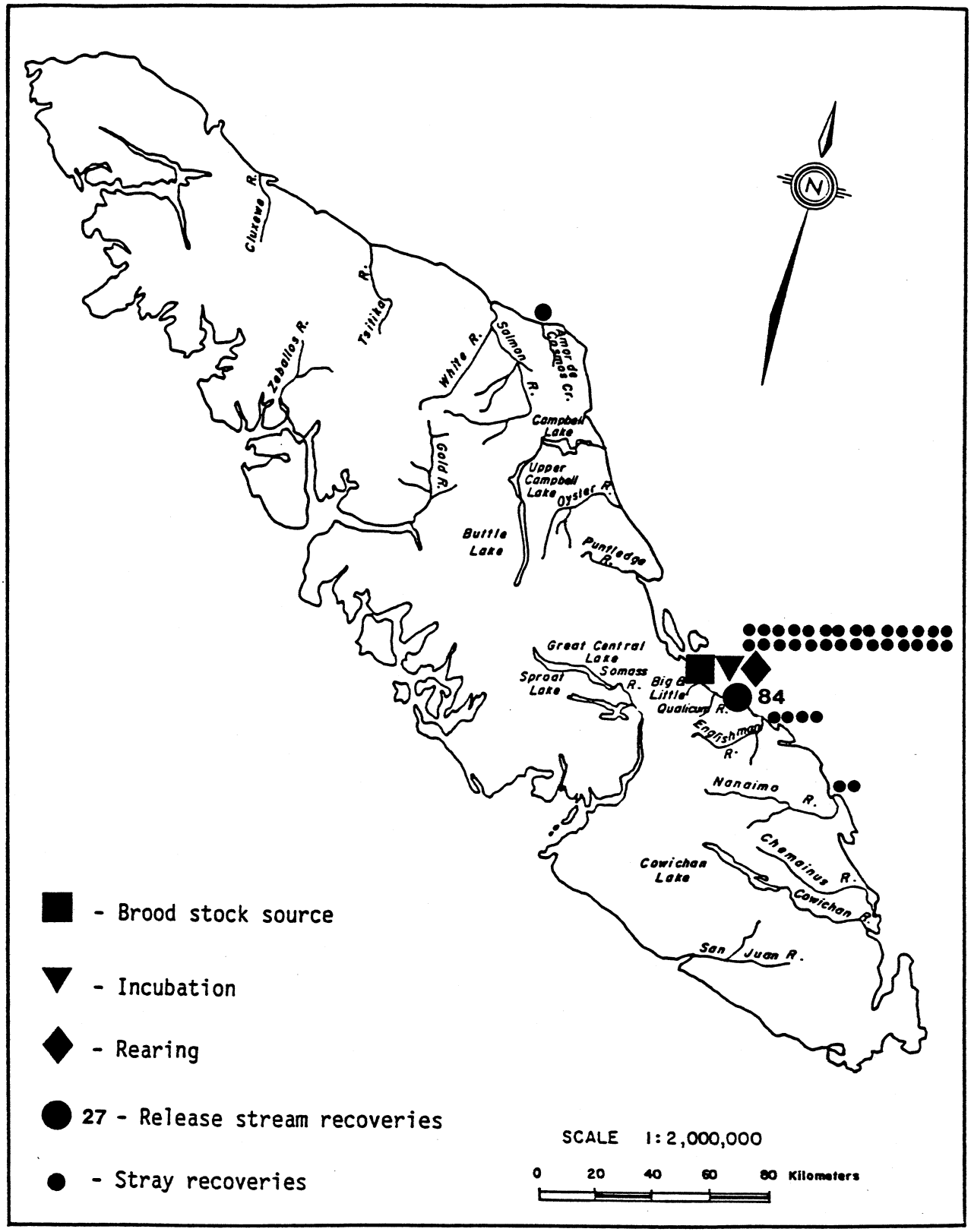
Appendix 1, Fig.3. Quinsam River coded-wire tagged steelhead sport recoveries, 1983 to 1986.



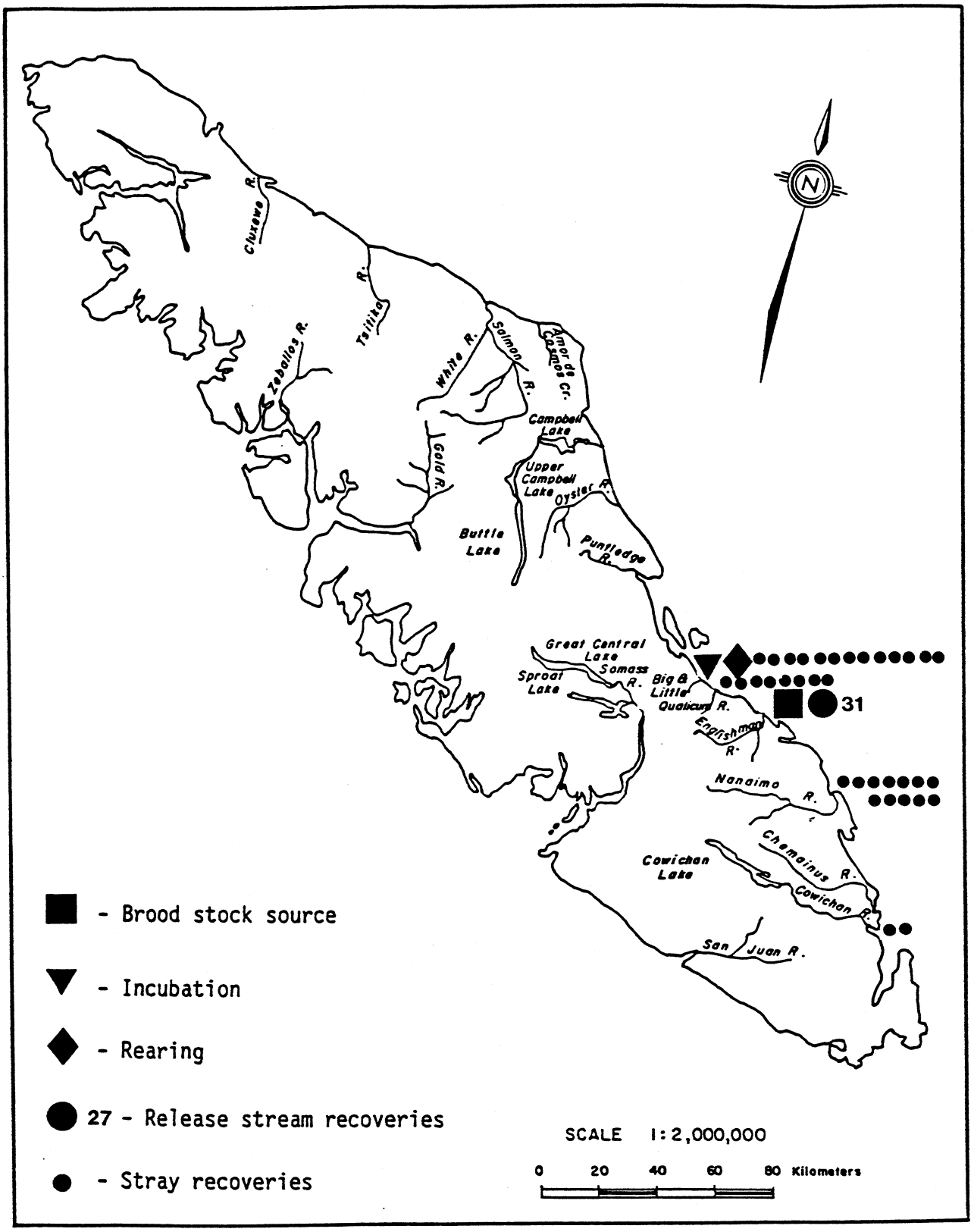
Appendix 1, Fig.4. Stamp/Somass River coded-wire tagged steelhead sport recoveries, 1983 to 1986.



Appendix 1, Fig.5. Campbell River coded-wire tagged steelhead sport recoveries, 1983 to 1986.



Appendix 1, Fig.6. Little Qualicum River coded-wire tagged steelhead sport recoveries, 1983 to 1986.



Appendix 1, Fig.7. Englishman River coded-wire tagged steelhead sport recoveries, 1983 to 1986.