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AN ACCOUNT OF AN EXPERIMENTAL RELEASE OF MARKED JUVENILE CHINOOK TO FRESHWATER, ESTUARINE, AND MARINE HABITATS NEAR CAMPBELL RIVER, B.C., 1984

by

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ABSTRACT

M. S. Kotyk, C. D. Levings, T. J. Brown, C. D. McAllister, J. S. Macdonald, J. R. McBride, and U. H. M. Fagerlund. 1985. An account of an experimental release of marked juvenile chinook to freshwater, estuarine, and marine habitats near Campbell River, B.C., 1984. Can. Tech. Rep. Fish. Aquat. Sci. 1397: 31 p.

Smolt to adult survivorship of juvenile chinook salmon was tested by releasing hatchery reared fish into four contrasting (river, estuarine, transition, and marine) habitats. Transport of 142,000 marked chinook smolts (3 g) by helicopter from the Quinsam River Hatchery to the four release sites near Campbell River was performed. The transport did not unduly aggravate the state of stress already induced during holding in painted troughs after marking. The furthest site, Deepwater Bay, was about 10 minutes flying time from the hatchery, but air time for the other three treatments was equalized to balance the experiment. At Deepwater Bay (marine release) fish were released directly into sea water. Short term high cortisol levels were noted in fish released at the marine and estuarine sites. Nevertheless, there was no evidence of immediate direct mortality due to stress or osmoregulatory shock. SCUBA observations showed that the fish schooled and aggregated near surfaces and suggested that behaviour was normal. However the marine release fish were exposed to more bird and fish predation. Feeding may have been re-initiated more slowly at the marine site and transition sites compared to estuarine locations. However the forage ratio at the marine site surpassed all other locations after a three week period. Mortality of cage-held chinook was very low at all sites (<1%). Seawater challenge tests indicated that the chinook were smolted and "ready for sea". Beach seine data obtained up to 10 weeks after the releases showed that the marine fish did not disperse into the Campbell River estuary or transition zones and were not found after one week following the release. Recaptures of chinook from the other releases also suggest rapid and wide dispersal.

Key words: juvenile chinook, estuarine utilization, salmonid transport, stress measurements, experimental release, Campbell River estuary

RESUME

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La survie, entre les stades de saumoneau et d'adulte, de saumons quinnats juvéniles a été évaluée par la mise en liberté de poissons d'élevage dans quatre habitats différents (cours d'eau, estuaire, zone de transition et mer). On a transporté par hélicoptère 142 000 saumoneaux quinnats marqués (3 g) des installations piscicoles de Quinsam vers quatre points de mise en liberté situés à proximité de la rivière Campbell. Le transport n'a pas augmenté de façon trop considérable l'état de stress provoqué par la mise en bacs peints des poissons après leur marquage. Le point de mise en liberté le plus éloigné, la baie Deepwater, était situé à environ dix minutes de vol de la pisciculture et les autres temps de vol ont été allongés afin d'uniformiser ce paramètre. À la baie Deepwater (habitat marin), les poissons ont directement été mis à l'eau. Des teneurs à court terme élevées de cortisol ont été notées chez les poissons relâchés dans les habitats marin et estuarien. Aucune mortalité directe immédiate par stress ou choc osmorégulatif n'a cependant été constatée. Des observations par plongeurs autonomes ont montré que les poissons se rassemblaient en bancs et se regroupaient près des surfaces; leur comportement semblait donc normal. Les saumoneaux libérés en milieu marin étaient cependant exposés à une plus grande prédation par les poissons et les oiseaux. Il est possible que l'alimentation ait repris plus lentement chez les poissons de l'habitat marin et de l'aire de transition que chez ceux de la zone estuariene. Cependant, le rapport du temps de recherche de nourriture en habitat marin était supérieur à ceux des trois autres habitats après trois semaines. La mortalité des saumons quinnats maintenus en parcs a été très faible à tous les sites (<1%). Des essais en eau de mer ont montré que les saumons quinnats avaient atteint le stade de la "smoltification" et étaient adaptés au milieu marin. Des captures par senne de rivage effectuées jusqu'à dix semaines après les mises en liberté indiquaient que les poissons libérés en mer ne s'étaient pas dispersés dans l'estuaire de la rivière Campbell ou la zone de transition et qu'ils étaient impossibles à localiser une semaine après leur mise en liberté. Les recaptures de quinnats des autres points de mise en liberté indiquent aussi une dispersion rapide et étendue.

Mots-clés: Quinnat juvénile, utilisation de l'estuaire, transport de salmonidés, mesure du stress, lâcher expérimental, estuaire de la rivière Campbell

INTRODUCTION

In 1984 approximately 142,000 chinook smolts were reared and marked at the Quinsam River hatchery and released at contrasting habitats in the Quinsam River, Campbell River estuary, and Discovery Passage (Fig. 1). The object of the research was to test the smolt to adult survivorship of chinook that were not exposed to the normal sequence of river - estuary - marine habitats. This experiment was a repeat of that performed by Levings et al. (1984). This report provides details on several topics related to the releases. These include transport techniques, results of caged fish to examine short term mortality, growth, feeding and stress, surface and SCUBA observations of released fish, data on sizes and weights of released fish, and tag codes used for the various groups.

MARKING PROCEDURES

A total of 141,899 chinook fry, taken from the production stock of the Quinsam Hatchery, were marked and tagged during the period from April 9-13, 1984 (see footnote Table 1). All fish were anaesthetised and marked by having their adipose fin clipped then tagged by inserting the appropriate magnetic binary coded wire tag into the nose cartilage. Approximately 35,000 fish were tagged for each of the release sites, with each area represented by 3 separate tag codes (Fig. 1; Table 1). When tagging was completed 50 fish from each trough were sampled for length-weight determinations (Table 2).

Fish were then transferred to green-painted aluminum holding troughs approximately 6.1 m x 81 cm x 60 cm, each containing a separate release group and held for 12 to 14 days before release. The day prior to release 75 fish from each trough were sampled for length-weight determinations (Table 2). Data on total number of fish marked per tag code, mortalities from each number removed for various studies, and the total released are presented in Table 3.

RELEASE PROCEDURES

On April 25, 1984, a Hughes 500D helicopter and two 545 L monsoon buckets were used for transport and release of the fish. The bucket had a wall of semi-collapsible rubber with two pneumatically controlled doors on the bottom. Each bucket had a 10 L oxygen cylinder attached to it to aerate the water during transport.

The buckets were placed on a pallet and transported with a forklift to the holding troughs for filling with water and loading of fish using

dipnets. Approximately 12,000 fish were loaded into the bucket for transport to the release locations. This resulted in a loading density of approximately 0.067 kg/L, well below 0.12-0.25 kg/L as recommended by D.F.O. Salmonid Enhancement Program (1984). The forklift then took the bucket approximately 50 m to where the helicopter could hook up to it for transport. While the helicopter was enroute, the second bucket was filled and loaded. On the first release at each site, the helicopter set the bucket down near the drop site, for approximately one minute, where 65 to 156 fish were removed to be placed in holding cages. These fish were transported by foot or boat to the cages in 22 L buckets, with the maximum time not exceeding twenty minutes. The helicopter took the bucket to the drop site, lowered it into the water, opened the doors and slowly lifted it out of the water releasing the fish. On the remaining two releases at each zone the helicopter released the fish directly and did not stop on the beach. An effort was made to have approximately the same amount of air time for each of the release trips, therefore at the river, estuarine and transiton zones the helicopter either flew in circles or hovered in place until the time was similar to the marine site releases (Table 4).

On the second trip to Deepwater Bay (marine site) it was discovered that the bucket was leaking water through the pneumatic doors with about half of the water escaping by the time the helicopter reached the drop site. This bucket was used alternately with the properly working one for the first two release zones until it was decided to operate with only one. The remaining releases at each of the zones proceeded without incident.

RELEASE OBSERVATIONS

Observations on predator activities and mortalities

There were no avian or mammalian predators observed during the three drops at the river release location. One mortality was removed from one of the holding cages 4 hours after the fish were released. Two mergansers were near the shore of the estuarine drop site and one seal was seen at the northern confluence of Baikies Slough and the Campbell River. After the first release at the transition zone approximately 40 - 100 Bonaparte gulls were seen sitting on a sand/gravel bar 350 m from the drop site, however they showed no response to the drop. There were also four mergansers near the drop site which showed no response to the release of the fish. No mortalities of caged fish were observed at this zone. There were no observations made of the first release at the marine zone. After the second and third drops approximately 1000 Bonaparte gulls were seen actively feeding on the released fish. These birds were diving approximately 30 cm into the water in order to capture their prey, and seemed to follow the fish as they moved out into the bay. The response of the chinook is reported below. Three mortalities were seen by the SCUBA divers minutes after the release, these fish had bad bruise marks along both sides of their bodies. One small damaged fish, was seen swimming in circles. Two Dolly Varden char (Salvelinus malma) were caught by beach seine two hours after the release, near the drop site, one of which contained two released chinook. There was no observed predation by Buffalo

sculpins (Enophrys bison) on the released chinook compared to that which occurred in 1983 (Levings et al. 1984).

OBSERVATIONS OF FISH BEHAVIOUR

Fish that were released at the river location seemed to form schools, five or six of these were observed containing 50 to 300 fish in each. After the first drop at the estuarine zone approximately 10 fish were seen to be swimming out of Baikie Slough towards the river and going upstream. After the second release a school of approximately 50 fish also swam towards the river. After the third drop there were many fish at the surface that seemed to be scattering randomly in all directions. Observations below the surface were impossible because of high turbidity in the Baikie Slough area. Fish that were released in the transition zone formed into many small schools and dispersed northward with the ebb tide. A few held position near the holding pens and the observers boat. SCUBA observations were made for the second and third drops at Deepwater Bay. The drop site was in 5 m of water, with a visibility of about 10 m. Fish came out of both the top and the bottom of the bucket once it was immersed. They dispersed in all directions but did not appear overly frightened or stressed. For the first few minutes after the release the fish used the divers and a piling as protection, and did show some escape response to sudden movement produced by the divers. The fish that were being preyed upon by the Bonaparte gulls, i.e. those <30 cm below the surface, were also showing some escape behaviour, while fish below this depth showed no escape response. Since the distribution of the diving gulls gave an indication to the distribution of the salmon, it appeared the fish fanned out into the bay heading both north and west. Few fish remained in the shallows. During the entire observation period the fish seemed to form into loose schools. No feeding was observed during the 1 1/2 hours of observations.

CAGE RESULTS

Between 65 and 156 fish were removed from the monsoon bucket, at each site, and placed into three holding cages, 80 cm x 50 cm x 60 cm, covered in 1 cm stretched mesh, supported in the water column by polystyrene foam. These pens were located in such a manner as to expose them to water typical of the release environment (Fig. 1). The cages at the river site were lashed together and tied to a cement retaining wall in a pool above the counting fence 225 m upstream of the Quinsam River Hatchery on the Quinsam River. The estuarine cages were tied to a slip in a covered marina, and were exposed to slight to moderate currents. The transition cages were tied to a float in a channel approximately 650 m northwest of the mouth of the river. This channel is subjected to strong tidal currents on both the ebb and flood tides. On a

low tide the water is static as the southern end of the channel has a marked sill. The marine zone cages were held at a marina slip at Brown Bay, approximately 2 km southwest of the release site at Deepwater Bay. They were subjected to moderate (0-4 kts) currents. The fish were held in cages for 19 days with some being removed for a variety of studies, including stress observations, length-weight determinations, gut contents and acclimation tests.

There was only one mortality from the river cages, which was discovered 4 hours after placement, and one from the marine site after 2 days. This was in sharp contrast to that which occurred in 1983 when there was a 9% mortality rate in the marine zone for the first 8 days after placement (Levings et al. 1984). However the fish released in 1984 were not significantly different in size than those released in 1983 (ANOVA; $p<0.05$, Table 2). The fish released into the transition zone were significantly greater in length, but not in weight, when compared to 1983 released fish (ANOVA; $p<0.05$). The river and estuarine fish were significantly different in both length and weight to those in 1983, the 1984 fish being smaller.

SEAWATER CHALLENGE

Prior to release, 52 fish from the holding troughs were taken to the Pacific Biological Station, Nanaimo, and were exposed to sea-water challenge tests to determine the ability to control blood sodium content (Clarke and Blackburn 1977). Forty-one fish were exposed to 29§ seawater for 24 hours, with the other 11 remaining in freshwater to act as a control. The control fish had a blood sodium level of 154.9 milliequivalents/mL and were thus within the "perfect smolt" category (i.e. <165 milliequivalents/mL) (Table 5). These fish were therefore physiologically ready to be exposed to marine and estuarine conditions and would have satisfied the criteria for release established by hatchery managers. The fish exposed to seawater had a mean blood sodium level of 165.6 milliequivalents/mL (S.E. 1.5), which was a significant increase over the control (ANOVA; $p=0.05$). This however is to be expected when the fish are in seawater and the sodium levels were acceptable under the conditions imposed.

FEEDING

Ten fish from each zone were sampled at day 15 and day 20 to check the adaptation to natural food from hatchery fed Oregon Moist Pellets (Tables 6-9). The weight of stomach contents at the river site did not significantly increase (ANOVA; $p<0.05$) over time when measured as percent body weight (forage ratio). There was a high proportion of fish with empty guts, with 60% and 50% recorded on the first and second sampling respectively. The

predominant item found in the gut was wood debris. There was a very low diversity of items found in the guts, which could be due to the low food availability in the river at that time of year. The fish sampled in the estuarine zone showed a similar trend in that there was no significant difference in the forage ratio between the sampling periods. However there was a large diversity of prey found in the guts with the predominant item being the isopod Gnorimosphaeroma oregonensis. There was a high incidence of the fresh-water cladoceran Bosmina sp. found in the second sampling period, with none found in the first period. This could possibly be due to a change in river current patterns resulting from a difference in the tidal activity on the different days. The fish sampled in the transition zone showed a significant increase in the forage ratio between the first and second sampling periods. There was a wide diversity of both fresh-water and marine prey consumed by the fish with the predominant items being calanoid and harpacticoid copepods, the cumacean Cumella vulgaris and the freshwater cladoceran Bosmina sp.

The marine zone fish showed a ten fold increase in the forage ratio between the first and second sampling periods. The fish had a high percentage of empty guts in the first period (40%) with none being empty in the second. The predominant prey item during the latter sampling was the various stages of calanoid copepods, but virtually none of these items were found in the earlier sampling.

STRESS EXPERIMENTS

In order to monitor the severity of stress induced by transfer of fish to the various release sites and also to assess the fishes' ability to adapt to the environmental conditions at the sites two stress indices were measured, namely plasma cortisol concentrations, responding to acute stressors and interrenal nuclear diameters, responding to chronic stress conditions. In addition the health of the fish was assessed by determining haematocrits.

Plasma cortisol - Cortisol concentrations (Fig. 2) were measured in only two (estuary and marine) of the four troughs. The same two groups were also sampled immediately after arrival by helicopter at the release sites. The concentrations found in these groups were considered representative of all four groups.

Plasma cortisol concentrations in samples taken from fish held in the Burrows' pond were typical of those of unstressed fish. Mean cortisol concentrations found 12-16 days after transfer into the troughs and 12-16 days after the fish had been tagged were only moderately, although significantly higher than in fish sampled from Burrows' pond. The elevation in cortisol values may have been caused by fish not being fully acclimated to the troughs. In the previous year's study, 1983, in which unpainted troughs were employed the plasma cortisol levels (mean ± S.D., mg/mL) for the fish in the two troughs tested were 70.6±32.5 and 153.4±111.6.

Transfer of salmon by helicopter to the two release sites sampled (estuary and marine) induced a sharp increase in cortisol levels. One day after relocation to the cages cortisol concentrations were highly variable from site to site. It is not possible to determine whether the high values, particularily in river and estuarine cages were caused by disturbances in the environment or whether acclimation to the conditions in the cages was slow. However, during the following six days cortisol values generally decreased to levels only moderately higher than the initial resting values.

Haematocrits - Haematocrits in fish taken from the Burrows' pond were 37.4 + 5.6% (mean + SD, N=14). Values in fish taken from cages were not significantly different from this value at any time.

Interrenals - Interrenal cell nuclear diameters (ICNDs) were obtained on Day 0 from fish in Burrows' pond and in two troughs and on Day 7 from fish at all four cage sites. There were only small fluctuation in ICNDs, the highest value being 6.03 ± 0.04 (mean ± SD) found in fish from the Burrows' pond and the lowest value 5.99 ± 0.01 in fish from the river cage. These values are typical for chinook smolts and do not indicate a stress response.

In summary the results of this years study show that (1) transfer of the chinook from the Burrows' pond to troughs induced a mild stress, (2) painting of the troughs to reduce the reflection of light appears to have largely if not totally alleviated stress induced by these holding facilities, (3) movement of fish by helicopter evoked a sharp but transitory stress response and (4) relocation of chinook to the 4 test sites in the Campbell river estuary did not result in a chronic stress response.

DISPERSION

Marked fish were recovered by intensive beach-seining over the period April 25-28 and every second week till September, 1984. Dispersion patterns and presumed migration routes are shown in Figures 3-7. The study area was divided into four zones: river, estuarine, transition and marine. The river zone included the non-tidal area of the Quinsam and Campbell Rivers. The estuary zone included the tidal area of the Campbell River behind Tyee Spit. The transition zone was defined as the area outside the mouth of the Campbell River that a fish could swim to and from within one tidal cycle. The marine zone was the area outside the influence of the Campbell River. Seining was most intense during the period April 25-28 with 101 sets in the marine zone, 34 sets in the transition, and 81 sets in the estuarine zone with every station indicated on the figure sampled at least once. The river zone was not sampled. Detailed catch data are presented in Brown et al. (1985). Some of the river, estuarine and transition released fish moved out of release sites quickly (Fig. 3). One river released fish migrated from the hatchery area to just south of Seymour Narrows in 2 days (Kotyk et al., in press), a distance of approximately 15 km. Fish released in the marine zone tended to stay in the general release area, with three crossing Discovery Passage moving

southward towards Seymour Narrows. One week after the release fish from all 4 release groups were found at one station directly across the Campbell River estuary on the east side of Discovery Passage (Fig. 4). One fish from the estuarine zone was found south of the river mouth. Six weeks after release only 2 fish from the transition zone were found outside the estuary in inner Menzies Bay (Fig. 5). Eight weeks after release both river and estuarine release groups were found near the river mouth, to the north and south (Fig. 6). There were no transition or marine fish caught outside the estuary. Ten weeks after release one estuarine fish was caught in Menzies Bay, with two caught south of the river mouth (Fig. 7) (unpublished data). There were no other release fish caught outside the estuary after this date, however, fish occurred within the estuary (i.e. behind Tyee Spit) as late as August 28, 1984. The subsampling effort in the estuarine zone for 1984 was similar to that of 1983 with 14.5% and 12.5% of the sample analysed respectively. There was an increase in subsampling effort in the transition zone in 1984 compared to 1983 with 36.0% and 23.3% of the sample kept, and there was a sharp drop in the subsampling effort in the marine zone in 1984 over 1983 with 19.35% and 67.7% of the fish kept respectively. Dispersion patterns and residency time of fish within the estuary (i.e. behind Tyee Spit) will be described in a later report.

CONCLUSIONS

The helicopter transport of 142,000 marked juvenile chinook (3 g, 66 mm) from the Quinsam hatchery to four contrasting habitats was performed without major problems. The flying time for each of the release groups averaged at about 10 minutes, with a bucket loading density of 0.067 kg/L. At Deepwater Bay (marine release) the fish were introduced directly into seawater. Marking, tagging and transfer of the fish induced a mild amount of stress while the movement by the helicopter evoked a sharp increase in the stress response as measured by cortisol concentrations. However, the fish returned to a level near the initial resting values of cortisol after a 6-day period. Interrenal cell nuclear diameters taken at day 0 and day 7 were typical of chinook smolts and did not indicate any stress response. Seawater challenge tests showed that the chinook were smolted and thus were "seawater ready". SCUBA observations in the marine zone showed that the fish schooled at or near the surface and did not appear overly frightened or stressed. The fish did exhibit some escape response to sudden movement by the divers, and those less than 30 cm below the surface showed some avoidance response to predatory Bonaparte gulls. The fish quickly moved out of the drop site into deeper water. Feeding by caged fish seemed to be initiated more slowly in the transition and marine zones than in the river and estuarine zones. However, once feeding commenced in the marine zone the forage ratio was 2-4 times that found in the other zones. There were only 2 mortalities during the duration of the cage study. Beach seine data obtained up to 10 weeks after the release showed that the marine release fish did not move back into the estuarine or transition zones. The river fish moved quickly (<3 days) downstream into the estuarine, transition and marine zones. River and estuarine released fish remained in the vicinity of the river mouth one month longer than the

transition released fish. The marine released fish were not seen after May 4 indicating they moved off shore into deeper water or out of the area completely more quickly than the other groups. The residence time and movements of fish that remained in the estuary will be published in future reports. Returns of marked fish will be monitored in the commercial and sport fishery and in the spawning escapement. From these data it will be possible to compute mortality rates for the marked groups released to the various habitats.

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Table 1. CWT tag codes assigned to each habitat groups, including number marked, percent tag loss, and dates of marking.

Release group	Code	Number marked	% tag loss
River[1]	08-22-57	11700	
	58	11786	6%*
	59	11725	
Estuarine[2]	08-22-60	12418	
	61	11848	1%
	62	11700	
Transition[3]	08-22-63	11944	
	08-23-01	11553	1.5%
	02	11730	
Marine[4]	08-22-13	11794	
	20	11773	0.75%
	21	11728	
		141899	

* high on first day due to machine failure - problem rectified for the duration of the marking.

Dates of marking

[1] River - April 9 - April 11
[2] est - April 9 - April 12
[3] Trans - April 12 - April 13
[4] Marine - April 11 - April 13

Table 2. Mean lengths and weights for each release group at time of marking and at release.

Group	Length when marked (April 13)			Length when released (April 25)		
	mean length (mm)	S.D.	number measured	mean length (mm)	S.D.	number measured
River	63.7	4.90	50	66.3	7.31	75
Estuarine	64.6	4.40	50	66.5	5.03	75
Transition	66.2	4.78	50	65.1	9.38	75
Marine	64.2	4.77	50	65.6	8.21	75
	Weight when marked (April 13)			Weight when released (April 25)		
	(g)	S.D.	number weighed	(g)	S.D.	number weighed
River	2.86	0.75	50	3.2	1.03	75
Estuarine	2.93	0.68	50	3.1	0.77	75
Transition	3.18	0.70	50	3.0	0.89	75
Marine	2.79	0.70	50	3.0	1.12	75

Table 3. Number of fish tagged and number released per tag code including the number removed for the various experiments and the mortalities.

Tag code	Number tagged	Number removed	Pre-release Mortalities	Number released
082257	11700	82	2	11616
082258	11786	36	35	11715
082259	11725	38	4	11683
082260	12418	25	14	12379
082261	11848	31	13	11804
082262	11700	9	18	11673
082263	11944	37	3	11904
082301	11753	16	13	11724
082302	11730	24	6	11700
082213	11794	24	10	11760
082220	11773	31	7	11735
082221	11728	26	4	11698

Table 4. Transport time and related information for movement of marked chinook in 1984.

Release zone	Drop number	Time out of hatchery	Time of release	Elapsed time	Comments
Marine	1	1000	1013	13	
	2	1042	1056	14	Bucket #2 leaking
	3	1140	1150	10	Refueled at Tyee Spit
River	1	1232	1242	10	
	2	1249	1259	10	Refueled
	3	1340	1349	9	Bucket #2 discarded
Estuarine	1	1355	1405	10	
	2	1411	1418	7	
	3	1430	1440	10	
Transition	1	1447	1457	10	Refueled at Tyee Spit
		1520	1529	9	
		1541	1549	8	

Table 5. Results of seawater challenge tests (as described in Clark and Blackburn 1977) with juvenile chinook prior to release (April 24, 1985).

	n	mean length (mm)	S.E.	mean weight (g)	S.E.	mean plasma sodium	S.E.	mean plasma potassium mM	S.E.	mean condition factor mM	S.E.
Control (FW)	11	69.5	0.13	3.31	0.22	154.9	0.7	8.0	1.64	0.97	0.02
Challenged (29‰)	41	65.8	0.12	2.76	0.14	165.6	1.5	6.19	3.38	0.92	0.01

Table 6. Stomach contents of caged fish held in Quinsam River (river zone). Included are fish number and forage ratio (% body weight).

River Zone

Date	Fish No.	Wood debris	Insect parts	Lichen	Fish No.	% body weight
84/05/10	210				210	0
	209				209	0
	216				216	0
	217				217	0
	219				219	0
	220	+			220	0.57
	206	+			206	0.52
	223				223	0
	224		+		224	0.55
	218	+++			218	1.19
						0
84/05/14	35	+	+		35	0.76
	39		++		39	1.05
	40				40	0
	41			+	41	1.21
	42				42	0
	30	++			30	0.95
	27	++			27	0.69
	28				28	0
	31				31	0
	32				32	0

\+ - <5 items found

++ - 5-10 items found

+++ - >10 items found

Table 7. Stomach contents of caged fish held at freshwater marina (estuarine release). Included are fish number and forage ratio (% body weight).

Estuarine Zone															
Date	Fish No.	Gnorimosphaeroma oregonensis	Bosmina sp.	Unid Isopod	Insect parts	Unid Gammarid	Juv Gammarid	Dipteram larvae	Eogammarus conflervicolus	Plant seed	Juv Calanoid	Adult Coleoptreran	Wood debris	Fish No.	% body weight
84/05/10	89	7				2					1			89	1.11
	94	2												94	0.38
	85										2			85	0.25
	98	3												98	0.99
	97						1		1					97	0.43
	95								1	1				95	0.45
	99	5												99	1.48
	83											1		83	1.04
	88	3				1			2					88	1.36
	84	1				1				1	14			84	0.53
84/05/14	51	3	3							1				51	1.80
	49		24	1	+									49	1.12
	50	2	4			2								50	1.20
	46	4	4				1							46	1.27
	47	2	17		+		1	2						47	1.36
	13	7	9										++	13	1.37
	11	1												11	0.18
	7	2											+	7	0.73
	10												+	10	0.18
	12												+	12	0.34

+ - <5 items found; ++ - 5-10 items found; +++ - >10 items found

UNID - Unidentified due to partial digestion or some key features missing.

Table 8. Stomach contents of caged fish held at Painters Channel (transition zone). Included are fish number and forage ratio (% body weight).

Transition Zone

Date	Fish No.	Calanus pacificus	Unid Calanoids	Harpacticoids	Cumella vulgaris	Bosmina sp.	Insect parts	Barnacle cypris	Sand	Plant debris	Juv Gammarid	Decapod larvae	Digested animal material	Unid Gammarid	Algae	Chironomid larvae	Wood debris	Juv Calanoid	Unid Mysid	Stonefly nymph	Caprellid	Corophium sp.	Gnorimosphaeroma oregonemsis	Fish No.	% body weight
84/05/10	105			1	1		+		++															105	0.35
	109			10					+++															109	1.05
	100				42										+									100	0.71
	108			3		7			++							1	+							108	0.82
	113				1	18												10						113	0.35
	110					1	+										+							110	0.32
	103				2	23									+			23						103	0.68
	104					6												7	1					104	0.31
	102			1		29			+								+	10						102	0.57
	101				3	19			+						+			5						101	0.36
84/05/15	69	6	6	11	1	2	+	1	+															69	1.01
	67		8	7	3		+			+	1													68	0.62
	66			9	7	2	+		+															66	0.58
	70		20	5	2	9			+			1												70	1.46
	65			3		6							++	2										65	0.58
	81		18	13	3					+							+	1		1				81	0.92
	78			7	1	14															1	1		78	0.74
	80		45	1	2	8	+																	80	1.99
	79		17	6	2	22																2		79	1.58
	82			3	2	5			+								+			1			2	82	0.82

+ - <5 items found; ++ - 5-10 items found; +++ - >10 items found

UNID - Unidentified due to partial digestion or some key features missing.

JUV - Juvenile.

Table 9. Stomach contents of caged fish held at Brown Bay (marine zone). Included are fish number and forage ratio (% body weight).

Marine Zone

Date	Fish No.	Calanus pacificus	Copepod nauplii	Unid Calanoids	Juv Calanoids	Crab zoea	Decapod larvae	Wood	Sand	Gastropod	Barnacle cypris	Harpactacoids	Algae	Mush	Fish No.	% body weight
84/05/10	205														205	0
	203														203	0
	204														204	0
	197											2		+	197	0.42
	199												+		199	0.24
	189														189	0
	196							+							196	0.26
	190				3										190	0.17
	202						1								202	0.26
	200												+		200	1.05
84/05/14	59	13				1	1	+	+						59	8.21
	57	2	3		4		1	+							57	0.58
	58	25	2												58	3.71
	56	28		14				+		2	1				56	4.80
	61			2	6		3								61	0.31
	22			12											22	2.63
	23			10											23	1.28
	19			9	14								++		19	2.04
	17			7	5		7	+							17	1.90
	16			1		2		+		+			+		16	0.78

+ - <5 items found; ++ - 5-10 items found; +++ - > 10 items found

UNID - Unidentified due to partial digestion or some key features missing.

JUV - Juvenile.

Fig. 1. Study area showing release sites at Quinsam River estuary release site (Baikies Slough, Stn. 7), transition release site (Painters Lodge, Stn. 34), and marine release site (Deepwater Bay; Stn. 32). Fish were held in cages at Quinsam River, at a marina near Stn. 7, at a float near Stn. 34, and at a marina in Brown Bay.

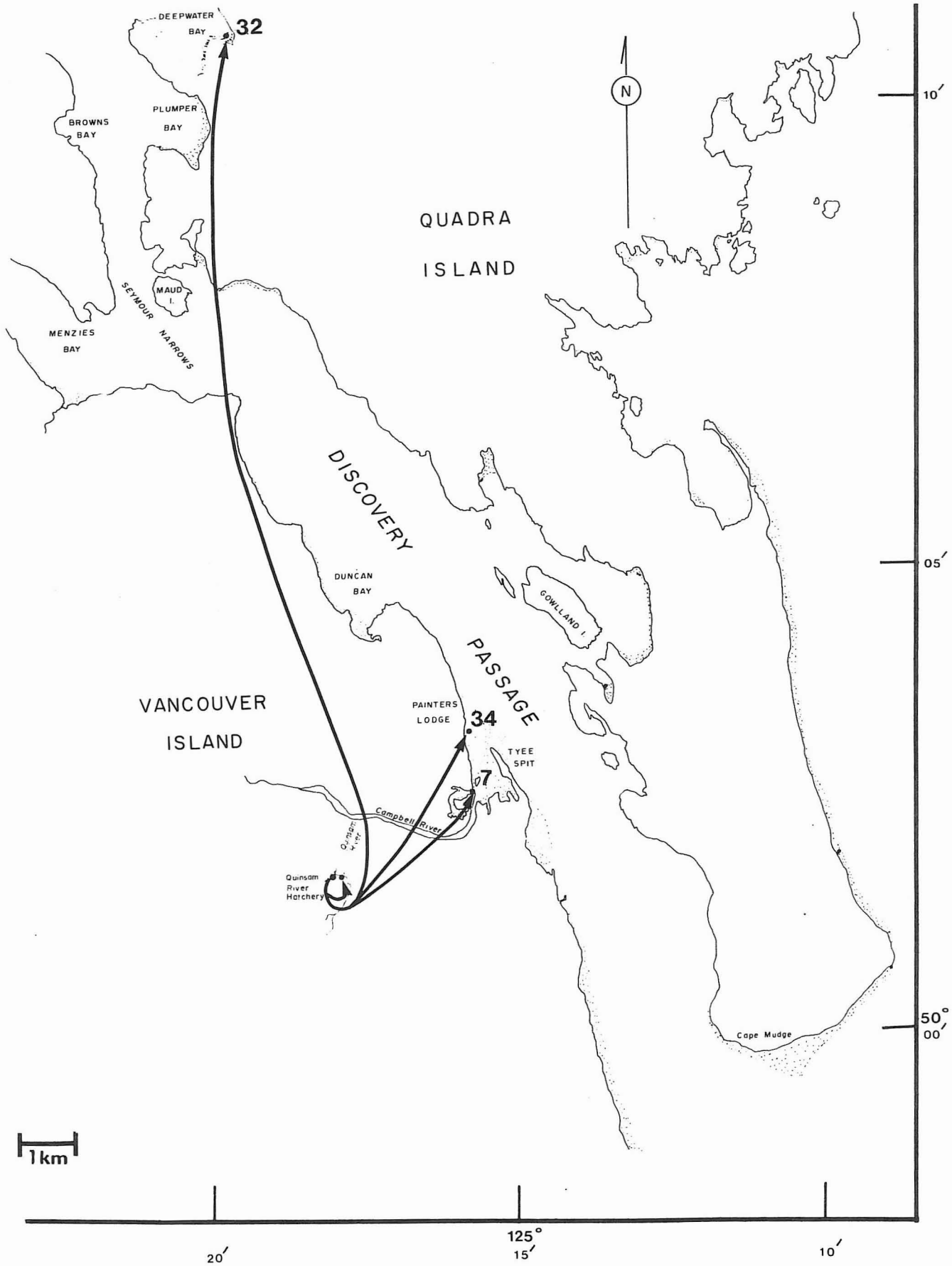

DEEPWATER BAY
32
BROWNS BAY
PLUMPER BAY
QUADRA ISLAND
N
MAUD I.
SEYMOUR NARROWS
MENZIES BAY
DISCOVERY PASSAGE
DUNCAN BAY
GOWLLAND I.
VANCOUVER ISLAND
PAINTERS LODGE
34
TYEE SPIT
7
Campbell River
Quinsam River
Quinsam River Hatchery
Cape Mudge
1km
10′
05′
50° 00′
125° 15′
20′
10′

Fig. 2. Plasma cortisol (ng/mL +/- SD) concentrations before marking (Burrows Pond), after marking (troughs), immediately after helicopter transport, and during time in the cages. When compared in pair-wise F-test all relocated fish had significantly ($P < 0.025$) higher cortisol concentrations than fish in the Burrow's pond.

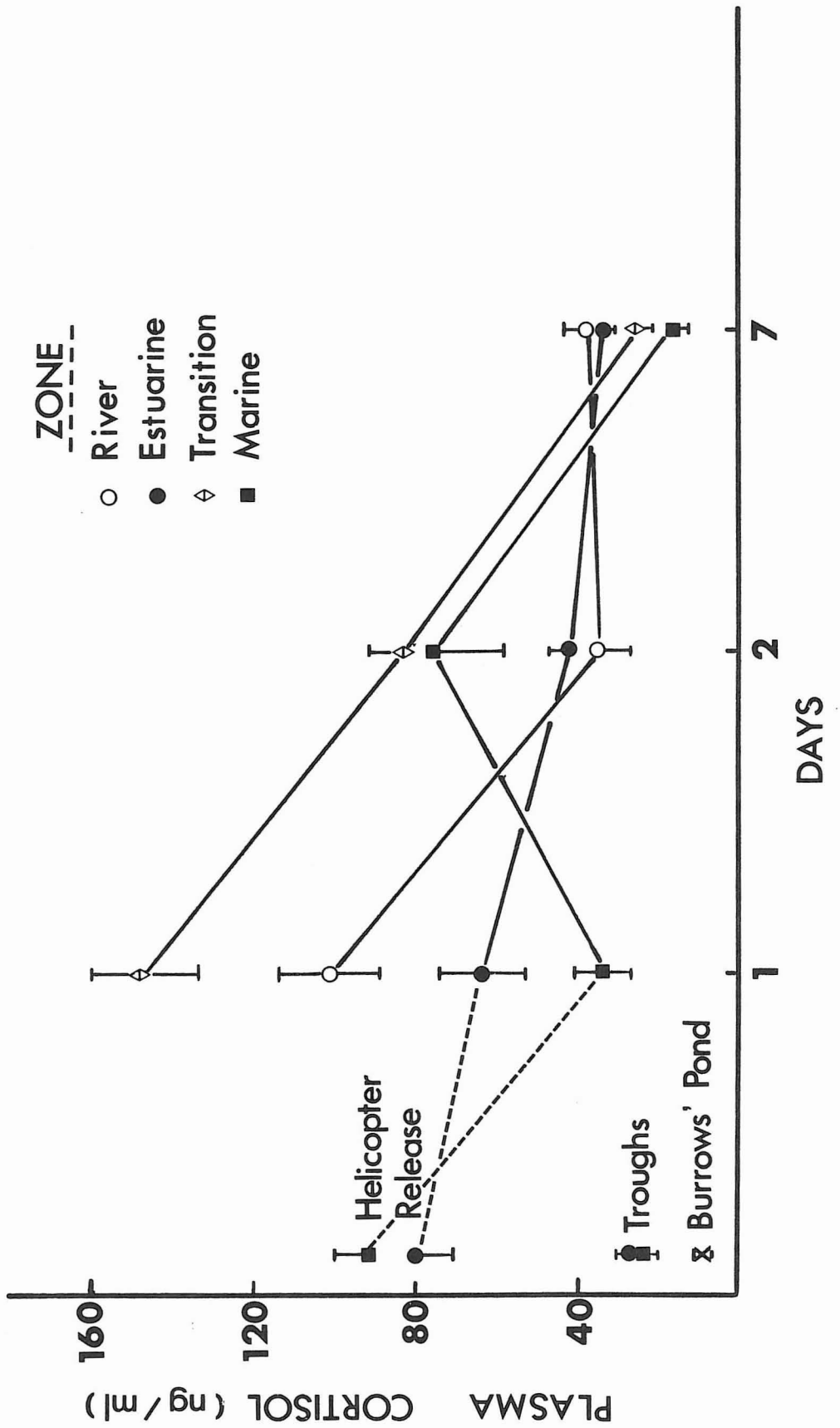

ZONE
River
Estuarine
Transition
Marine
Helicopter Release
Troughs
Burrows' Pond
PLASMA CORTISOL (ng/ml)
160
120
80
40
1
2
7
DAYS

Fig. 3. Recapture locations for release fish sampled April 25-28, 1984. "Fish" symbol indicates location of capture along with number of River (R), estuarine (E), transition (T) and marine (M) released fish caught. If no number and letter is indicated then no fish from that particular zone was caught.

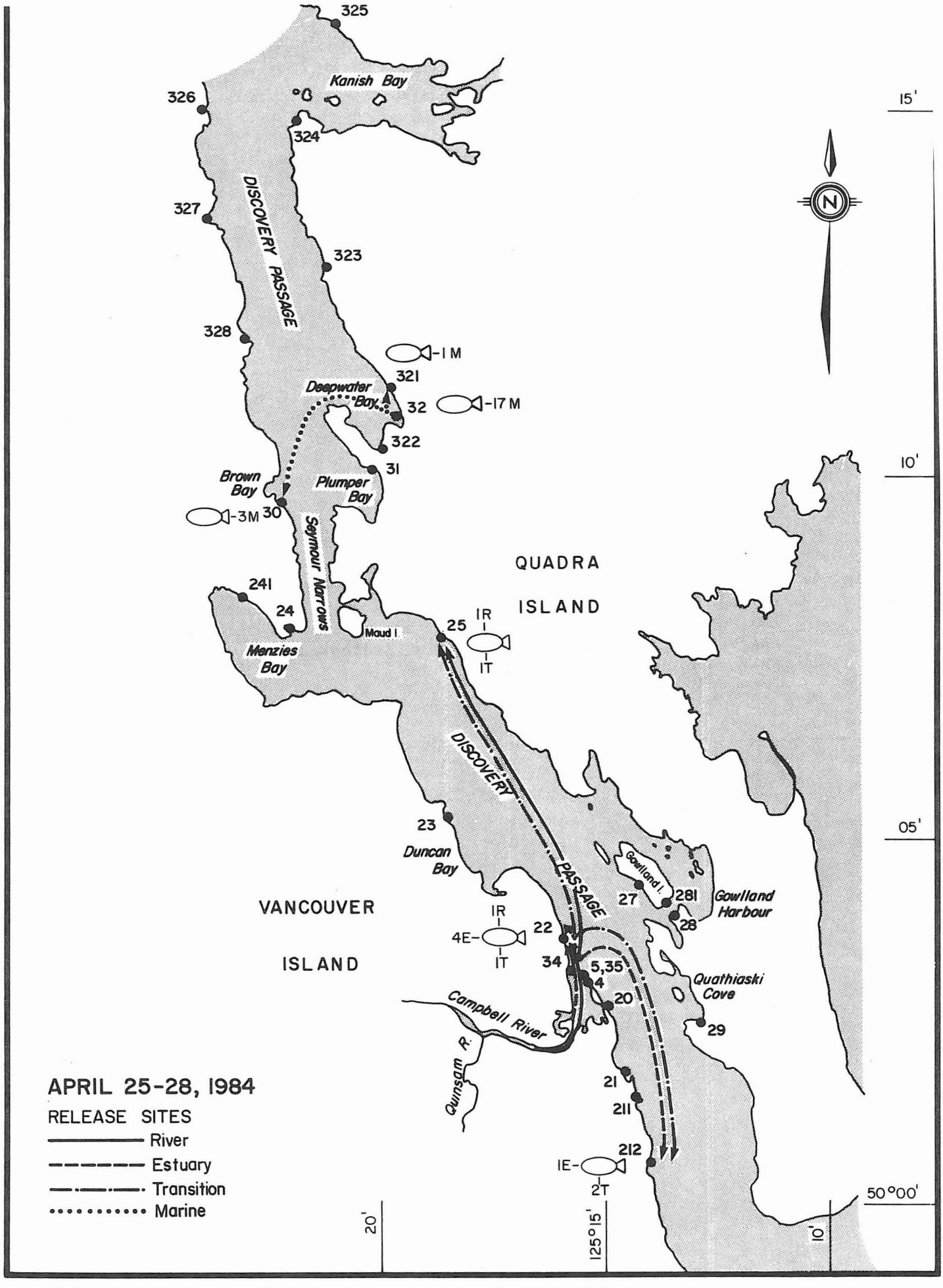

325
Kanish Bay
326
324
DISCOVERY PASSAGE
327
323
328
-1 M
321
Deepwater Bay
32
-17 M
322
31
Brown Bay
Plumper Bay
-3M
30
Seymour Narrows
241
24
Menzies Bay
Maud I.
25
IR
IT
QUADRA ISLAND
DISCOVERY PASSAGE
23
Duncan Bay
VANCOUVER ISLAND
IR
4E-
IT
22
34
5,35
4
20
Campbell River
Quinsam R.
Gowlland I.
27
281
Gowlland Harbour
28
Quathiaski Cove
29
21
211
212
1E-
2T
15'
10'
05'
50°00'
20'
125°15'
10'
N
APRIL 25-28, 1984
RELEASE SITES
River
Estuary
Transition
Marine

Fig. 4. Recapture locations for release fish sampled May 1-4, 1984. "Fish" symbol indicates location of capture along with number of River (R), estuarine (E), transition (T) and marine (M) released fish caught. If no number and letter is indicated then no fish from that particular zone was caught.

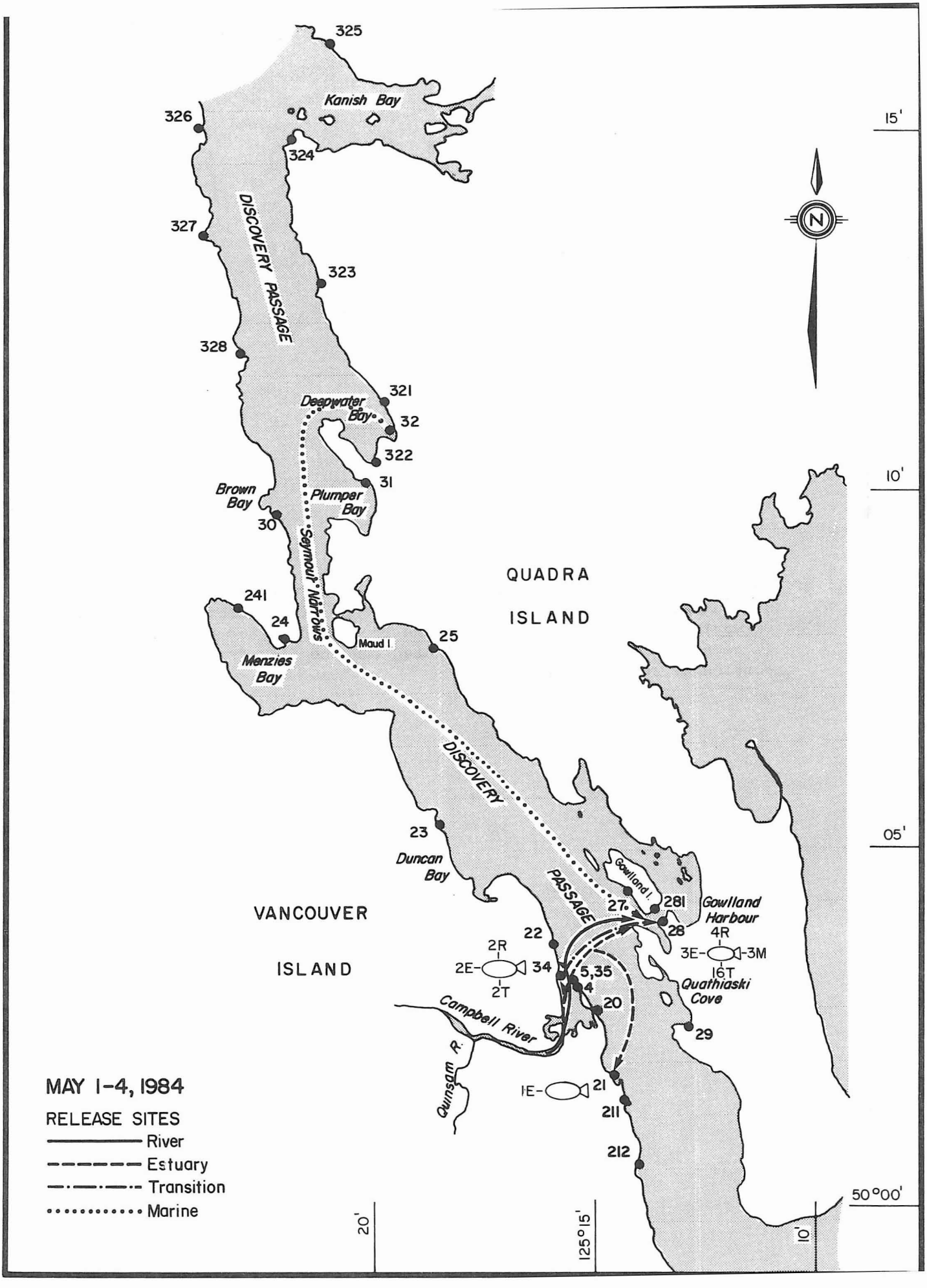

325
Kanish Bay
326
324
DISCOVERY PASSAGE
327
323
328
321
Deepwater Bay
32
322
31
Brown Bay
Plumper Bay
30
Seymour Narrows
241
24
Maud I
25
Menzies Bay
QUADRA ISLAND
DISCOVERY PASSAGE
23
Duncan Bay
VANCOUVER ISLAND
Gowlland I.
27
281
Gowlland Harbour
28
22
2R
2E-
34
2T
5,35
4
20
4R
3E-
3M
16T
Quathiaski Cove
Campbell River
Quinsam R.
29
1E-
21
211
212
15'
10'
05'
50°00'
20'
125°15'
10'
N
MAY 1-4, 1984
RELEASE SITES
River
Estuary
Transition
Marine

Fig. 5. Recapture locations for release fish sampled June 4-6, 1984. "Fish" symbol indicates location of capture along with number of River (R), estuarine (E), transition (T) and marine (M) released fish caught. If no number and letter is indicated then no fish from that particular zone was caught.

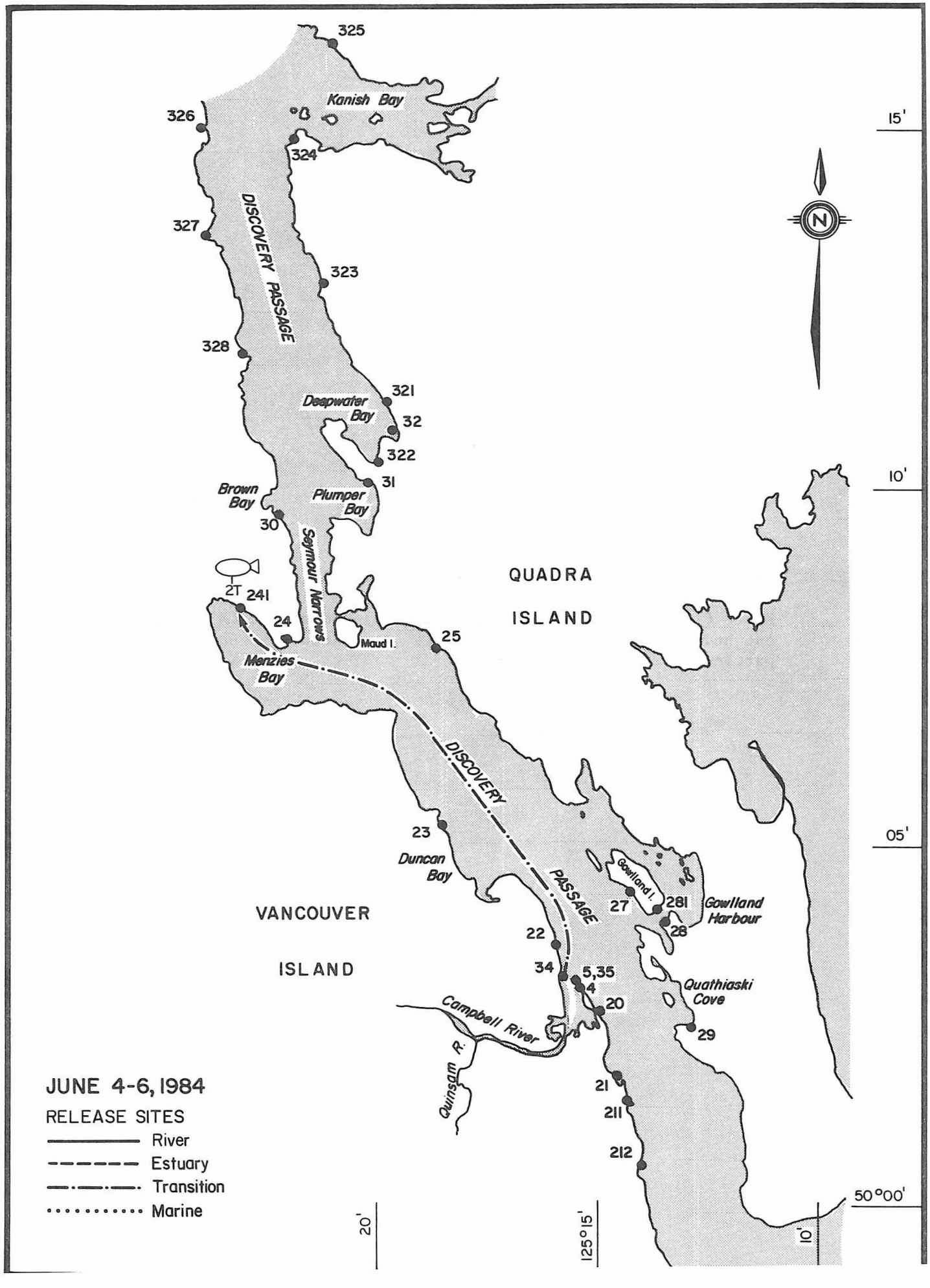

325
Kanish Bay
326
324
DISCOVERY PASSAGE
327
323
328
321
Deepwater Bay
32
322
31
Brown Bay
Plumper Bay
30
Seymour Narrows
2T
241
24
Maud I.
25
Menzies Bay
QUADRA ISLAND
DISCOVERY PASSAGE
23
Duncan Bay
VANCOUVER ISLAND
Gowlland I.
27
281
Gowlland Harbour
28
22
34
5,35
4
20
Quathiaski Cove
29
Campbell River
Quinsam R.
21
211
212
15'
10'
05'
50°00'
10'
125°15'
20'
N
JUNE 4-6, 1984
RELEASE SITES
River
Estuary
Transition
Marine

Fig. 6. Recapture locations for release fish sampled June 18-21, 1984. "Fish" symbol indicates location of capture along with number of River (R), estuarine (E), transition (T) and marine (M) released fish caught. If no number and letter is indicated then no fish from that particular zone was caught.

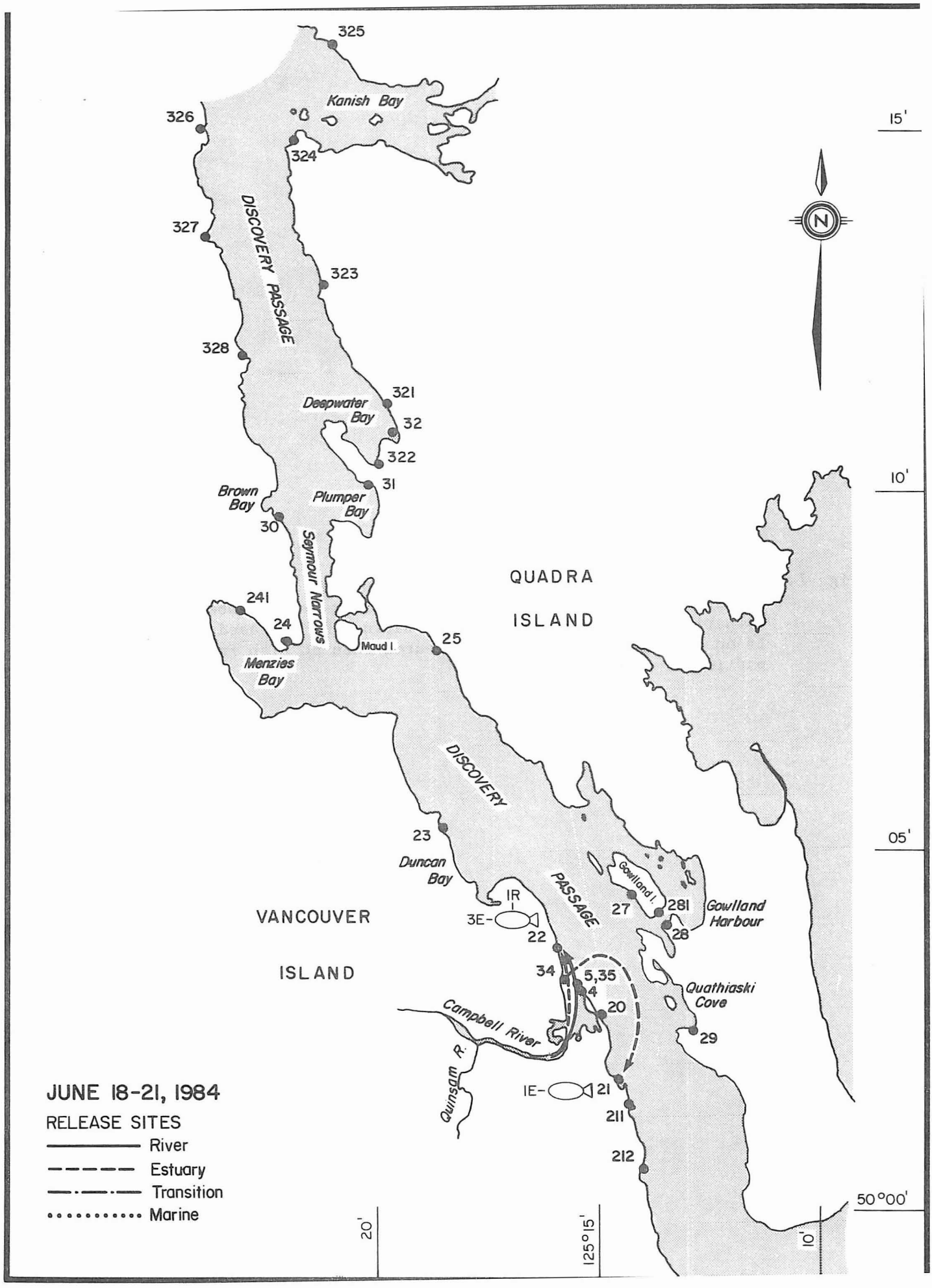
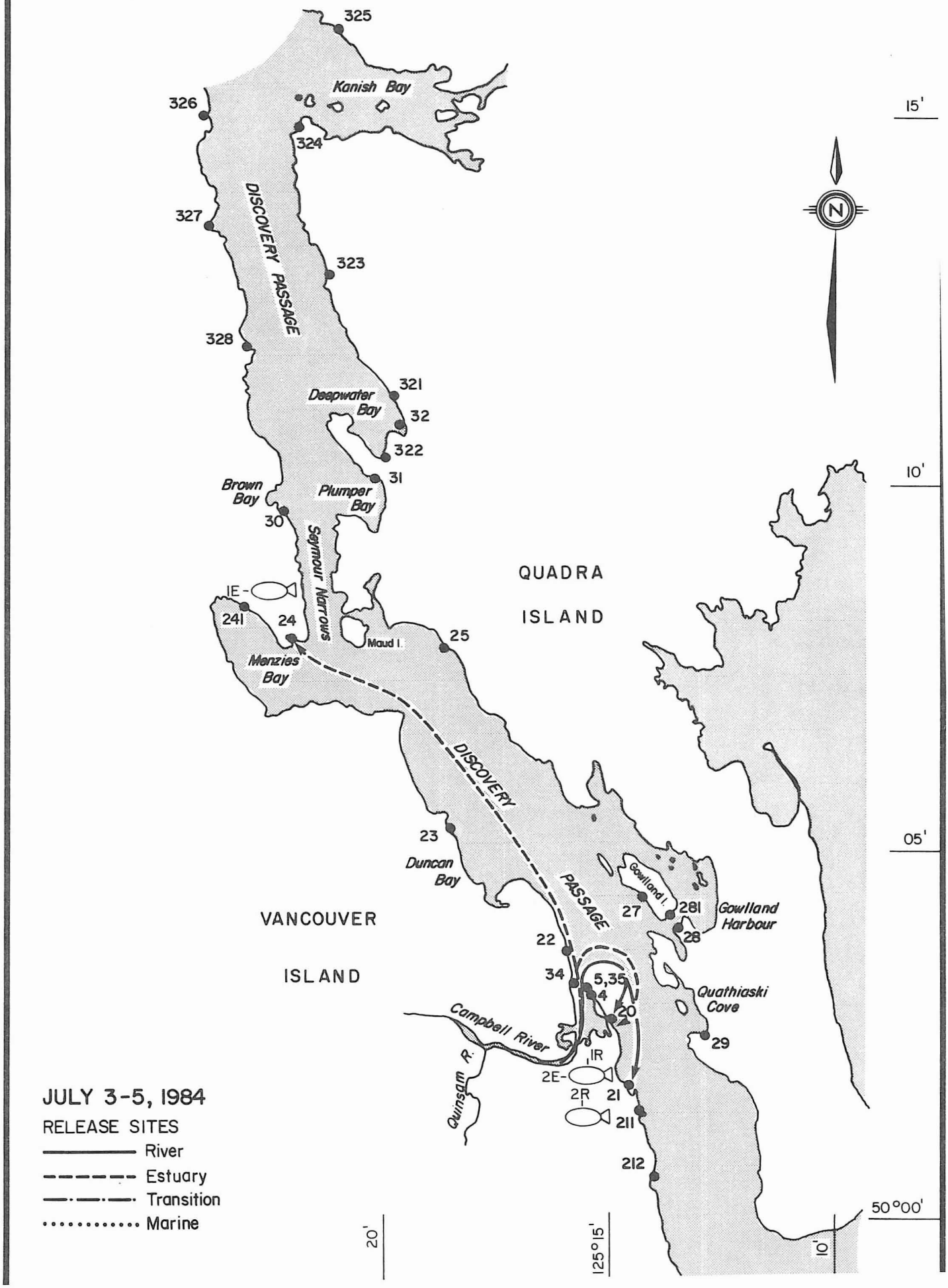

325
Kanish Bay
326
324
DISCOVERY PASSAGE
327
323
328
321
Deepwater Bay
32
322
31
Brown Bay
Plumper Bay
30
Seymour Narrows
241
24
Maud I.
25
Menzies Bay
QUADRA ISLAND
DISCOVERY
23
Duncan Bay
IR
3E
22
PASSAGE
Gowlland I.
27
281
28
Gowlland Harbour
VANCOUVER ISLAND
34
5,35
4
20
Quathiaski Cove
Campbell River
29
Quinsam R.
1E
21
211
212
15'
10'
05'
50°00'
20'
125°15'
10'
N
JUNE 18-21, 1984
RELEASE SITES
River
Estuary
Transition
Marine

Fig. 7. Recapture locations for release fish sampled July 3-5, 1984. "Fish" symbol indicates location of capture along with number of River (R), estuarine (E), transition (T) and marine (M) released fish caught. If no number and letter is indicated then no fish from that particular zone was caught.


325
Kanish Bay
326
324
DISCOVERY PASSAGE
327
323
328
321
Deepwater Bay
32
322
31
Brown Bay
Plumper Bay
30
Seymour Narrows
1E
241
24
Maud I.
25
Menzies Bay
QUADRA ISLAND
DISCOVERY PASSAGE
23
Duncan Bay
VANCOUVER ISLAND
Gowlland I.
27
281
Gowlland Harbour
28
22
34
5,35
4
20
Quathiaski Cove
29
Campbell River
IR
2E
2R
21
211
212
Quinsam R.
15'
10'
05'
50°00'
20'
125°15'
10'
N
JULY 3-5, 1984
RELEASE SITES
River
Estuary
Transition
Marine