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by

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ABSTRACT

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A questionnaire survey of the herring bait fishermen in Georgia and Johnstone straits was undertaken in 1986 to obtain information on the distribution and abundance of local herring populations. Forty-two of the 95 questionnaires returned provided useable information. Bait fishermen concentrate their effort in Statistical Areas 13, 17, and 18. Most fish are taken with small seine nets and the herring are sold live for the salmon sport fishery or the expanding live rockfish fishery. A substantial amount is also taken to supply the commercial market for halibut bait. Estimated total catches in all areas based on reports from the respondents agree with permit allocations. Estimates of spawning biomass for some of the local herring populations suggest a recent decline as well as a disappearance from some locations. Estimated harvest rates have also increased during the past decade in some areas and suggest that the current exploitation of local herring populations in Statistical Areas 13 and 17-20 may be too high to be sustained in the long term.

RÉSUMÉ

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Une enquête par questionnaire a été entreprise en 1986 auprès des personnes qui pêchent le hareng comme poisson d'appât dans les détroits de Géorgie et de Johnstone afin de recueillir de l'information sur la répartition et l'abondance des populations locales de hareng. Des 95 questionnaires retournés, 42 fournissaient des renseignements utilisables. Les pêcheurs au poisson d'appât concentrent leurs activités dans les zones statistiques 13, 17 et 18. Pour l'essentiel, le poisson est pêché à la senne avec de petits filets. Le hareng est vendu vivant aux fins de la pêche sportive au saumon ou la pêche au sébaste, qui connaît un essor aujourd'hui. Une partie importante des prises sert à approvisionner le marché commercial en poisson d'appât pour le pêche au flétan. Les prises totales, estimées à partir des déclarations des répondants, concordent avec les allocations stipulées dans les permis. D'après les estimations de la biomasse de géniteurs, les populations locales de hareng semblent avoir chuté dans certains secteurs et disparu dans d'autres. Le volume estimatif de prises a augmenté dans certaines zones au cours de la dernière décennie, ce qui laisse croire que l'exploitation des stocks locaux de hareng dans les zones statistiques 13 et 17-20 est peut-être trop intensive actuellement pour être maintenue à long terme.

INTRODUCTION

The herring bait fishery in Georgia and Johnstone straits has become an increasingly important component of the total utilization of the British Columbia herring resource as the demand for and price of live bait continues to rise. This increase in both catch and demand for bait herring, particularly in the Campbell River area, has generated concern about the impacts of possible reductions in local herring populations on the salmon sport fishery and salmon stocks throughout the straits.

The adult herring populations targetted by the bait fishery appear to be fairly localized and probably represent non-migratory stocks of fish not sampled or assessed as part of the routine monitoring of the major adult migratory populations harvested in Georgia Strait by the roe fishery during March and April each year. The information available from sales slips appears to be incomplete at best and so provides little data on the actual exploitation rates of these populations. In addition, there is no data available on the size distribution of bait catches to indicate what proportion of this harvest is actually taken from local adult populations and how much is contributed by the large stock of juvenile fish which are primarily the progeny of the large migratory stocks. As a result there is little background information on the distribution, abundance, and harvest of the bait fish stocks at different times of the year.

Responsible management of the Georgia and Johnstone straits herring resources is thus hampered by inadequate information. To provide better management of the bait herring fishery, it is necessary to more clearly understand the nature of the fishery. It seemed most logical to obtain this information by going directly to the fishermen, to determine their concerns about the stocks and the fishery and what they felt could be done to improve bait herring stocks and the fishery in general. The results of the questionnaire reported on in this paper collates information from the bait fishermen on the scope and magnitude of the fishery. Additionally, we derived a crude estimate of the potential impact of this fishery on the herring resource in these areas.

METHODS

The Department of Fisheries and Oceans (DFO) issues herring bait permits of 1 ton (previously 3 tons) for personal bait use annually to any applicants who hold a valid A, B, C, L, or K fishing license. Three-ton licenses are available for live sport bait impoundment operations or for domestic food fisheries. There are also a limited number of 50-ton licenses available for impoundment operations to supply bait to the halibut longline fishery. Hence, the only records that the DFO has of the extent and magnitude of the herring bait fishery is the allocation by permit. By contrast, participation in the herring roe fishery is strictly controlled by the number of licenses issued and the catch is regulated by quota.

We obtained the names and addresses of bait herring fishermen licensed to fish statistical areas 12-20, in 1986, from the permits issued by DFO district offices in Georgia and Johnstone straits. A questionnaire and a covering letter were sent to ninety-five bait herring fishermen in November of 1986 requesting an anonymous reply. The questionaire asked for specific information on fishing locations, methods, and operations, and for comments about the management and licensing of the bait herring fishery.

A copy of the questionnaire is reproduced in Appendix 2. The following section provides a brief explanation of the rationale for the questionnaire and the questions.

BAIT FISHERY LOCATIONS

Respondents were separated from question 1 into one of Areas 12, 13, 14, 15, 16, 17-20. The spatial separation of the fishermen provided some insight into regional differences in the type of fishery and target size and utilization of the bait.

Subsequent questions focussed on the specific fishery locations, and respondents' observations on the spatial and temporal distribution of herring. Fishing sites were plotted on maps to identify concentrated bait fishery activity. Personal reasons for fishing a certain site was used to determine whether the site was fished because herring were abundant, and therefore useful in considering herring distribution, or was convenient ("ease of access") for the respondent to fish, in which case the area may not be a useful indicator of herring abundance.

FISHING METHODS

This section was designed to better understand the practical aspects of catching bait herring. Information about successfully used gear types and about the timing of fishing operations would assist in decisions on how and when to sample juvenile and adult herring for future research studies. Information on fishing success relative to the tide, time of day, and season was helpful in determining movements of herring in response to various environmental factors.

The question on the use of a knotless web provided information on the level of awareness of and adherence to fishery regulations by bait fishermen; DFO regulations disallow knotted webs which cause descaling and increased mortality in live bait. The answers to the other questions required some practical knowledge of bait herring fishing, which provided indirect information on the bait fishery experience of the respondent, and hence on the usefulness of his responses. Although we did not weight responses by experience, the responses from long-time bait fishermen more significantly affected our perception of the bait fishery.

FISHING OPERATIONS

Estimation of how much bait herring is caught in the Georgia and Johnstone straits annually is complicated by the fact that few sales slips are turned in to DFO. This required an alternate method for estimating the total catch. Direct questioning of fishermen about their total annual catch, probably provides low estimates, especially as the amount quoted approaches or exceeds their bait limits. We used the midpoint of any ranges reported as the best estimate in calculating the annual tonnage caught. Unless metric tonnes were explicitly given as the measurement unit, we converted responses from assumed Imperial tonnage into metric tonnage.

The answer to the question about the size of herring sought was useful in describing distributional patterns of local herring populations, since juvenile and adult herring may travel in different school groups, and stock abundance may vary across areas and seasons. This information also indicates the size of fish in the target catch by time of the year (eg. small juvenile fish, or "firecrackers", for summer bait; larger fish for cut plug for frozen sports bait).

When a bait herring licence is issued, the fishermen must indicate the intended use of the herring he catches, and where and how he will keep them until sold. The answer to the question about uses and impoundment of bait herring was to augment this information. We were interested in determining how much bait herring is allocated to various uses, such as sports bait. It was expected that most sports bait would be impounded but this could not be tested. Impoundment locations provided data on distribution of herring stocks, assuming that most fishermen would not transport their live catch any great distance from the herring fishing location.

MANAGEMENT CONSIDERATIONS AND COMMENTS

The request for comments about any observed changes in herring stock distribution and abundance and possible causes for these changes was to encourage respondents to provide firsthand accounts and opinions. We hoped to get some indication from long-time bait herring fishermen of whether they felt local herring stocks had increased or decreased, and if they reflect the concern about declining herring stocks of salmon sportfishing groups.

We also solicited suggestions for improving the management of the bait herring fishery and information about bait herring that had not been covered previously, or which managers had not considered.

EXPLOITATION RATE

In an effort to obtain at least a crude estimate of the harvesting rate of the bait fishery on the various local herring stocks we have made a number of assumptions. First, we

assume that all herring in Georgia and Johnstone straits from mid-April to mid-October older than 1 year belong to local non-migratory stocks. We also assume that most of the demand for live bait for the salmon sport fishery will occur during this period. Thus, all bait fishery catches are assumed to come from these stocks. Migratory stocks of herring overwinter in Georgia and Johnstone straits prior to spawning in March and returning to offshore feeding areas (mid-October to mid-April). Next, we assume that the age composition of the local stocks is similar to that in the migratory stocks.

Finally, we have had to make some assumption about which spawning locations represent migratory and non-migratory populations of herring. The approach we took was to assume that all of the spawning beds which currently support a large body of fish which spawn in the same general location at a similar time represent migratory stocks. The spawning grounds felt to represent local populations were readily identifiable for most areas being geographically well separated from the usual migratory spawning beds, particularly in areas 12, 13, 15, 16, and 19. The local spawning beds in area 14 were assumed to be those occuring in Baynes Sound from Deep Bay to Union Bay although there have been few reports of spawning in this area since the roe fishery commenced in 1971. Similarly, in area 17S the local stocks were assumed to be those which were separate from the usual migratory spawning bed along the Vancouver Island shore from Dodd's Narrows to Ladysmith Harbour including Thetis and Kuper islands. Virtually all of the spawnings in the numerous small inlets in area 18 were assumed to represent local populations of herring which are found in the various tidally active passes throughout the year. Many of these smaller spawnings also differ in timing from those of the migratory herring stocks (see Appendix 1 for a list of these spawning locations). We further assume that the spawning ground surveys in each area give a reasonably accurate estimate of the size of the spawning populations of non-migratory fish. Because the coverage of some of the smaller or more remote spawning beds is uneven between years and may have changed over time we derived estimates for the entire time period 1942-88 and for the recent past, 1981-88. The catch data is only available from 1950 so average bait catch is calculated for the period 1950-88. Combining our assumptions we obtained an estimate of the average total population of 1 year and older herring in each area as follows:

$$\text{Total stock} = \text{Bait catch} + \text{Spawning stock} + \text{Tonnes age 2} + \text{Tonnes age 1}$$

where

Bait Catch = av. tonnes of fish caught from sales slip data,
Spawning Stock = tonnes of fish age 3 and older,
No. of age 3 = (spawning stock• % age 3) / av. wt. at age 3,
No. of age 2 = no. of age 3 / survival rate,
Tonnes age 2 = no. of age 2 • av. wt. at age 2
Tonnes age 1 = (no. of age 2 / survival rate) • av. wt. at age 1

For this analysis we assume survival rates for juveniles are comparable to those of adults (64% annual survival rate) which may be too high. On the other hand, the sales slip catch data are probably too low. The spawning biomass estimates are derived from the escapement model (Haist and Schweigert 1990) using information from the surface spawn surveys. Some of the estimates are probably on the high side due to the surface width correction which may not be applicable to some of the narrow inlet spawning beds in Areas 12, 13, 15, and 16. Nevertheless,

this provides us with a first approximation to the size of the herring stocks being exploited by the bait fishery.

RESULTS

Of 95 questionnaires sent out, 48 were returned, a 51% return rate. Of these, 42 were used to compile information. The six which were unuseable were either incomplete or the respondents no longer fished bait herring generally acquiring their bait from other fishermen.

BAIT FISHERY LOCATIONS

Both annual herring licensing records and questionnaire responses show that bait herring fishing is concentrated in the waters surrounding Stuart and Quadra islands (Area 13), Egmont and Texada Island (Area 15) and North and South Pender islands (Area 18). All sites classed by at least one respondent as being their most productive fishing site are presented in Figures 1-9, and are listed in Table 1.

The locations mentioned as good fishing sites were, understandably enough, also those in which fishermen had noticed concentrations of herring that occur regularly or occasionally each year. In cases where the preferred sites differed from actual fishing sites, the variance could be attributed to both physical and legal access problems. In particular, Cowichan Bay and some waters surrounding the Gulf Islands (Area 18) were listed as areas with abundant herring stocks, but which are not licensed fishing regions. It was noted by respondents that in order to get herring for bait in Areas 17-18-19, one had to travel some distance from habitual fishing grounds to legally fish, even though herring appear to be plentiful closer to home.

"Ease of access" and "abundance of herring" were rated as equal factors in the decision to fish a particular site by the majority of respondents. This equivalence can be explained by the fact that many respondents only fished herring for use as bait in their primary fishing livelihood (eg. rock cod fishing, or sportsfishing), and so fished in areas close to their main fishing grounds; and that most respondents did not have the boats nor the equipment to fish on a large scale, nor a great distance from their ports. In addition, respondents fishing for live bait herring felt that the distance live fish can successfully be transported limited their fishing range.

FISHING METHODS

Most of the respondents (86%) use seine nets to catch bait herring (Table 2). Seine net sizes ranged from a small beach seine (46 m x 7 m, 150 ft x 22 ft) to a small salmon seine (201 m x 27 m, 660 ft x 90 ft.). Most fishermen comply with fishery regulations by using knotless web, but 5 of 31 (16%) continue to use illegal knotted web.

Gillnetting and a hook-and-line each, account for 5%. Other methods, such as jigging, hoopnets, ringnets, and dipnets are used occasionally for catching herring in small amounts for personal bait use. These fishermen often buy their bait herring and fish for themselves only when there is a shortage. One large operation uses midwater trawling to catch fish.

There was little agreement between respondents in the timing of fishing effort (Table 3). All times related to tide, day, and season were considered by some respondent to be "the best time to catch herring."

Tide is thought to play an important role in fishing, especially with adult herring (juveniles are somewhat independent) but half of the respondents either didn't mention any tide relationship or said it was important but didn't elaborate enough to make the response useable. Of the 50% who did time their fishing activity according to tide, (62%) preferred slack tide; some further specified highwater slack or lowwater slack. A third of the responding fishermen preferred flood tide, and 5% preferred the ebb. These variations are probably related to physical and geographical differences in the fishing areas or simply personal preference.

There was a preference for fishing at dawn or dusk. Nearly half of all respondents mentioned some combination of these times. Again, variations in time preferences can in part be accounted for by local variations in geography.

Annual timing of fishing effort and the best months for catching fish (i.e. the months when the greatest proportion of total annual catch is taken) were equally varied. As the bait herring fishery is closed from 15 February to 15 April due to the roe fishery, it is surprising that many respondents recommended this time period for fishing bait. However, this may be because of the large stocks of migratory fish in the straits at this time. Every month except December was mentioned as a preferred time to fish. Subdividing the year into the four seasons of Winter (January-March), Spring (April-June), Summer (July-September) and Fall (October-December) failed to show trends. Some of the difficulty arises because the question was phrased to encompass both the time of year when the respondent begins fishing and the time of year when he gets his greatest catch. This ambiguity resulted in respondents answering only one or the other part of the question, or answering both unclearly.

FISHING OPERATIONS

Respondents fished for bait herring in the straits from three weeks to forty-five

years. Predictably, knowledge about bait herring fishing locations and methods increases with experience. There were concerns about inexperienced fishermen mishandling bait herring resulting in increased mortality. Some suggested a limitation in licensing for novice fishermen that would give them a reduced permit until they became proficient at handling bait herring.

Fifty-one percent of fishermen were looking for adult herring (Table 2). There was the general feeling that the fish being caught are not as large as those they used to or would like to catch. The majority used their herring catch for commercial bait (45%), or for fresh sports bait (34%) and 19% fished for personal bait occasionally. Very few fishermen used their fish for frozen sports bait. A single large operator provides all of the frozen sports bait in the straits.

The tonnes of bait herring usually caught each year, according to respondents' estimates, was summed for each area as the reported catch. The actual total annual catch was estimated for each statistical area as follows:

$$\text{Estimated Catch} = \frac{\text{Total Reported Catch}}{\text{No. of Respondents}} \bullet \text{Total no. of permits}$$

We estimated an annual catch of 592 tonnes (Table 4), about 12% higher than the permit allocation for these areas. About three quarters of the total catch comes equally from area 13 and areas 17-20.

EXPLOITATION RATE

The estimates of the harvest rates of local herring populations are presented in Table 5. Estimates of the spawning biomass are the sum of the average biomass at each reported spawning location during the period 1942-1988 and 1981-1988. Many of the areas report larger historical spawning populations then currently exist so biomass estimates for the two periods should encompass the range of stock sizes one might expect in these areas. The spawning biomass estimates ranged from a low of 4 tonnes in area 15 to a high of 4126 tonnes in area 17N. However, some of the spawning beds in area 15 may have been missed while most of the fish in the latter area probably belong to migratory stocks (Appendix 1). Given our estimates of the potential biomass of age 1 and older herring in the straits we obtained harvest rate estimates ranging from 0.004 in area 19 to 0.080 in area 13 in the period 1942-88 and 0.020 in Area 18 to 2.000 in Area 15 in the period 1981-88. It is evident from Table 5 that spawning stock biomass estimates have declined in all areas in the last decade. This is also shown in Appendix 1 where many spawning locations utilized regularly in the past have not been used at all in the past decade.

Estimates of the bait catch have remained stable or declined for most areas based on sales slip estimates. However, the estimated 1986 bait catch from the questionnaire survey and permit allocations exceed these estimates for most areas. Consequently, the estimated harvest rates are probably quite conservative. Although there is some uncertainty about the accuracy of our

spawning biomass estimates for the various areas we feel that harvest rate estimates are probably realistic if not somewhat low and as such the current harvest rates and declining stock sizes in both areas 13 and 15 may be cause for concern about the viability of bait herring stocks in these areas.

DISCUSSION

The major hurdle to our understanding of the impacts of and the significance of the herring bait fishery is our limited understanding of the size and stock structuring of the various local or non-migratory herring populations found throughout Georgia and Johnstone straits. Both Tester (1937) and Stevenson (1954) were cogniscent of the existence of local or resident populations of herring in Georgia and Johnstone straits but their interrelationships with the migratory stocks remains as perplexing as ever. For this analysis we are assuming that any stocks of fish older than age 1 found within Georgia or Johnstone straits during the summer period (May through October) represent local populations since it is felt that the young of the year or juveniles of the migratory stocks migrate offshore at the end of the first summer of life similarly to the Barkley Sound herring as demonstrated by Taylor (1964). Adults of migratory herring stocks are found in the straits only from October through April. Actually identifying which spawning beds are representative of the local populations is obviously very difficult. In this study we have assumed that any spawning locations which are geographically distinct from what are currently the usual spawning beds of the large offshore migratory stocks represent local populations of herring although these stocks may also migrate within the straits to some extent. In many instances, the spawnings associated with these local populations are temporally distinct occurring one to two weeks before or after the major migratory spawnings.

A better resolution of the stock structure clearly has important implications to the bait fishery since if the stocks being targetted are fairly localized and of limited size they may be quite easily depleted. Additionally, if the bait fishery is targetting primarily on the larger herring then the impact is more pronounced than if the bait being sought includes large quantities of the young of the year herring produced by the large migratory populations which are ubiquitous throughout the straits.

The available data indicate that the herring bait catches are localized in a few restricted locations throughout the straits (Fig. 1-9). This suggests that these areas which coincidentally are generally associated with a tidally active passage support distinct populations or stocks of possibly genetically unique fish which are separate from one another and the large migratory populations of herring which occur in the straits from October to April each year. The absolute harvest of bait herring does not appear to be large, in the order of 200 tonnes in areas 13 and 17-20, respectively. The catch consists almost equally of mature and immature fish although there is an expressed preference for the larger fish whenever they are available. The catches reported here are all essentially the same as the allocations based on the number of permits issued to bait fishermen suggesting that the catch estimates we derived are reasonable estimates of the

total annual take of bait herring independent of what is utilized by sports fishermen who "rake" bait for salmon fishing.

The estimates of spawning biomass presented here are somewhat uncertain because there is some question about the applicability of the conversion methods applied to the surveys of the spawning beds in these areas (Schweigert and Stocker 1988). It is possible that the spawning beds for these areas are narrower than for the migratory stocks in which case some of the spawning biomass estimates would be inflated. As well, due to the infrequent reporting of the spawn deposition in many of the localities felt to represent local populations averaging over longer time periods might underestimate stock abundance because of the many years with no reported spawn deposition. Nevertheless, these two counteracting forces probably produce a realistic estimate of stock abundance in most areas. One notable exception is the 1981-88 estimate for area 15 where the estimated catch greatly exceeds the stock estimate. It seems probable that there was either an underestimate of the true total spawn deposition or that most of this catch consisted of young of the year herring from spawning associated with the large migratory stocks in Georgia Strait.

If we can accept the foregoing estimates of stock abundance as a first approximation to the true abundance of the local herring populations in the straits then there are some alarming trends. First, there appears to have been a decline in herring abundance in all areas during the last decade relative to earlier periods (Table 5). Secondly, with the apparent declines in stock sizes there has been an increase in harvest rates by the bait fishery in particular areas, such as 13 and 15. There also appears to have been decrease in the number of localities in which herring regularly spawn in Georgia and Johnstone straits over the last 50 years (Appendix 1; Haegele and Fitzpatrick 1983). However, because of the uneven spawn survey coverage of the smaller spawning beds associated with the non-migratory stocks it is not possible to say for certain that we have seen the disappearance of populations or merely movement of fish between areas between years. It is possible that some populations of fish have disappeared due to habitat alteration and foreshore development so an accurate assessment of the impact of the bait fishery itself is very difficult. However, the exploitation rates we have estimated for areas 13 and 15 may not be sustainable indefinitely (Doubleday 1985). It appears that we should increase our efforts to accurately monitor spawn deposition and bait catches in these areas over the next several years to assess more clearly the impact of current harvest rates on these populations.

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Table 1. Preferred fishing sites for bait herring in Georgia and Johnstone straits.

Statistical Area	Number of Respondents	Catch allocation (tonnes)	Fishing Locations	
			Primary[a]	Secondary[b]
12	8	115.80	Bates Passage, Blackfish Sound, Browning Passage, Christle Passage, Gordon Channel, Stubbs Island.	Beaver Cove, Goletas Channel, Glendale Cove, Hardy Bay, Knight Inlet, Wells Passage.
13	17	140.61	Deepwater Bay, Dent Island, Discovery Passage, Duncan Bay, Francisco Point, Stuart Island.	Campbell River, Evans Bay, Hole in the Wall, Heriot Bay, Kanish Bay, Okisollo Channel, Quartz Bay, Quathiaski Cove, Ramsay Arm, Seymour Narrows, Steep Island, Yaculta Rapids.
14	1	12.25	Mapleguard Reef.	French Creek.
15	4	63.00	Lund, Scuttle Bay.	Copeland Islands, Thulin Passage, Westview.
16	4	75.30	St. Vincent Bay.	Agamemnon Bay, Bjerre Shoal, Blind Bay, Boat Cove, Jenkins Island, Killam Bay, Pender Harbour, Quarry Bay, Spring Bay.
17,18	8	120.88	Bedwell Harbour, Navy Channel, Porlier Passage, Port Browning, Sansum Narrows, Swanson Channel.	Active Passage, Cowichan Bay, Kulleet Bay, Stuart Channel.
Total	42	527.84		

[a]Sites identified as spots habitually containing fish and fished routinely.

[b]Sites containing fish sometimes but not fished on a routine basis.

Table 2. Fishing methods, catch disposition, size range of fish, and gear utilized to catch bait herring in Georgia and Johnstone straits.

Statistical area	Number of respondents	Catch disposition[a]				Herring size[b]			Fishing Gear			
		Personal bait	Sports bait		Commercial bait							
			Fresh	Frozen		Small	Medium	Adult	Seine	Gillnet	Jigging	Other
12	8	1.50	1.00	0.00	5.50	3.50	1.00	3.50	5	1	0	2[c]
13	17	4.83	7.83	0.00	4.33	4.50	2.50	10.00	17	0	0	0
14	1	0.00	0.50	0.00	0.50	1.00	0.00	0.00	1	0	0	0
15	4	1.25	0.25	0.25	2.25	0.50	0.00	3.50	3	1	0	0
16	4	0.00	4.00	0.00	0.00	1.50	0.00	2.50	4	0	0	0
17	3	0.00	0.00	0.00	3.00	2.00	0.00	1.00	2	0	1	0
18	5	0.50	0.50	0.50	3.50	4.00	0.00	1.00	4	0	0	1[d]
Total	42	8.08	14.08	0.75	19.08	17.00	3.50	21.50	36	2	1	3

[a] Disposition of catch was often reported for more than one category with no indication of how much was allocated to each group so it was split equally among the number of categories reported. Numbers indicate permit allocation by area and disposition.

[b]Bait herring sold as live sports bait are categorized as small, medium, and large; these categories are roughly less than 100mm, 100 to 150 mm, and greater than 150mm.

[c] Hoopnet or ringnets.

[d] Midwater trawl.

Table 3. Summary of variation in fishing effort seasonally, dielly, and tidally by Statistical Area.

	Statistical Area (number of respondents)						
	12 (8)	13 (17)	14 (1)	15 (4)	16 (4)	17 (3)	18 (5)
Time of year							
Spring	3	1	0	1	2	0	0
Summer	1	12	1	0	1	0	2
Fall	1	0	0	0	0	1	1
Winter	0	2	0	3	0	2	2
Whenever needed	3	1	0	0	1	0	0
Response Unusable	0	1	0	0	0	0	0
Time of Day							
Dawn or Dusk	3	9	1	2	4	1	4
Night	0	0	0	1	0	2	0
Day	0	1	0	0	0	0	1
Response Unusable	5	7	0	1	0	0	0
Time of Tide							
Slack	4	7	0	1	0	1	0
Flood	1	0	1	1	0	0	4
Ebb	0	0	0	0	1	0	0
Response Unusable	3	10	0	2	3	2	1

Table 4. Estimates of bait herring catch taken in 1986 in Georgia and Johnstone straits.

Statistical area	Number of respondents	Reported catch[a] (tonnes)	Total[b] Permits	Bait Permit Allocations (tonnes)	Estimated Total catch (tonnes)
12	8	47.85	16.44	115.80	98.33
13	17	76.20	47.49	140.61	212.87
14	1	2.72	3.01	12.25	8.19
15	4	15.39	14.44	63.00	55.56
16	4	55.34	6.00	75.30	83.01
17-20	8	50.80	34.17	120.88	216.98
Totals	42	248.30	133.01	527.84	591.93

[a]The total reported catch is based on the estimates provided by respondents in each area. Where a range was reported, eg. 3-10 tons, the midpoint (6.5) was converted to tonnes and added into the total.

[b]A number of respondents reported fishing in more than one Statistical area so permits were prorated as a proportion of the permit, usually .50, in each of two areas. Where a respondent held more than one permit for different areas the permit was considered as belonging to the vessel and permits were apportioned to the areas in relation to the tonnage allocation for the various areas. This was necessary because an individual could be filling permits for several people but the questionnaires were only sent to vessel owners so it was assumed that the individual returning the questionnaire would report the total catch for all his permit holders.

Table 5. Estimates of exploitation rates by the bait herring fishery for Statistical Areas 12-20 during 1986.

Statistical Area	Spawning Biomass[b]		Biomass Age 1,2[c]		Bait Catch		Est. 1986 Bait Catch (tonnes)[d]	Harvest Rate	
	Average 1942-88	Average 1981-88	Average 1942-88	Average 1981-88	Average 1950-88	Average 1981-88		1942-88	1981-88
12	1132	986	707	615	41	40	98	0.022	0.025
13	461	291	288	182	60	73	213	0.080	0.154
14N	1221	962	762	601	25	0	8	0.013	0
14S[a]	4101	3875	2561	2420	0	0	0	0	0
15	350	4	219	2	9	13	56	0.015	2.000[e]
16	1753	583	1095	364	65	58	83	0.023	0.061
17N[a]	4126	2480	2576	1549	0	0	0	0	0
17S	1135	325	709	203	126	60	-	0.068	0.114
18	2562	2234	1600	1395	89	71	-	0.021	0.020
19	311	16	194	10	2	3	-	0.004	0.115
17S-19	4008	2575	2503	1608	217	134	217	0.033	0.032

[a]The stocks in areas 14S and 17N are probably mostly migratory fish and there are no bait fisheries in this area at present.

[b]The spawning biomass represents the escapement model estimate as described in Haist and Schweigert (1990). The estimated tonnages are the averages for the historical and recent periods for all spawning locations in each statistical area. We suspect that survey coverage has been inconsistent over time so that the long term average should provide an estimate of what the average biomass expectation for each area should be. We also note that a number of the spawning locations throughout the Strait of Georgia no longer appear to support spawning populations present in 1940's and 1950's.

[c]The biomass of age 2 and age 1 herring contributed by the local populations was calculated as follows. It was assumed that the long term average % of age 3 fish during the roe fishery period is 40.5. The weight of age 3 fish averaged 82.5 g. The observed number of age 3 fish represents 64% of the age 2 fish which weighed 56.9 g and represents 64% of the age 1 fish which averaged 15.7 g each.

[d]The bait catch was divided about equally between adult and immature herring and was so assumed in estimating the harvest rates.

[e]It is apparent that the biomass estimates for this area are in error either through incomplete spawn coverage or the catches are being taken from juvenile or adult stocks moving through the area from other spawning stocks.

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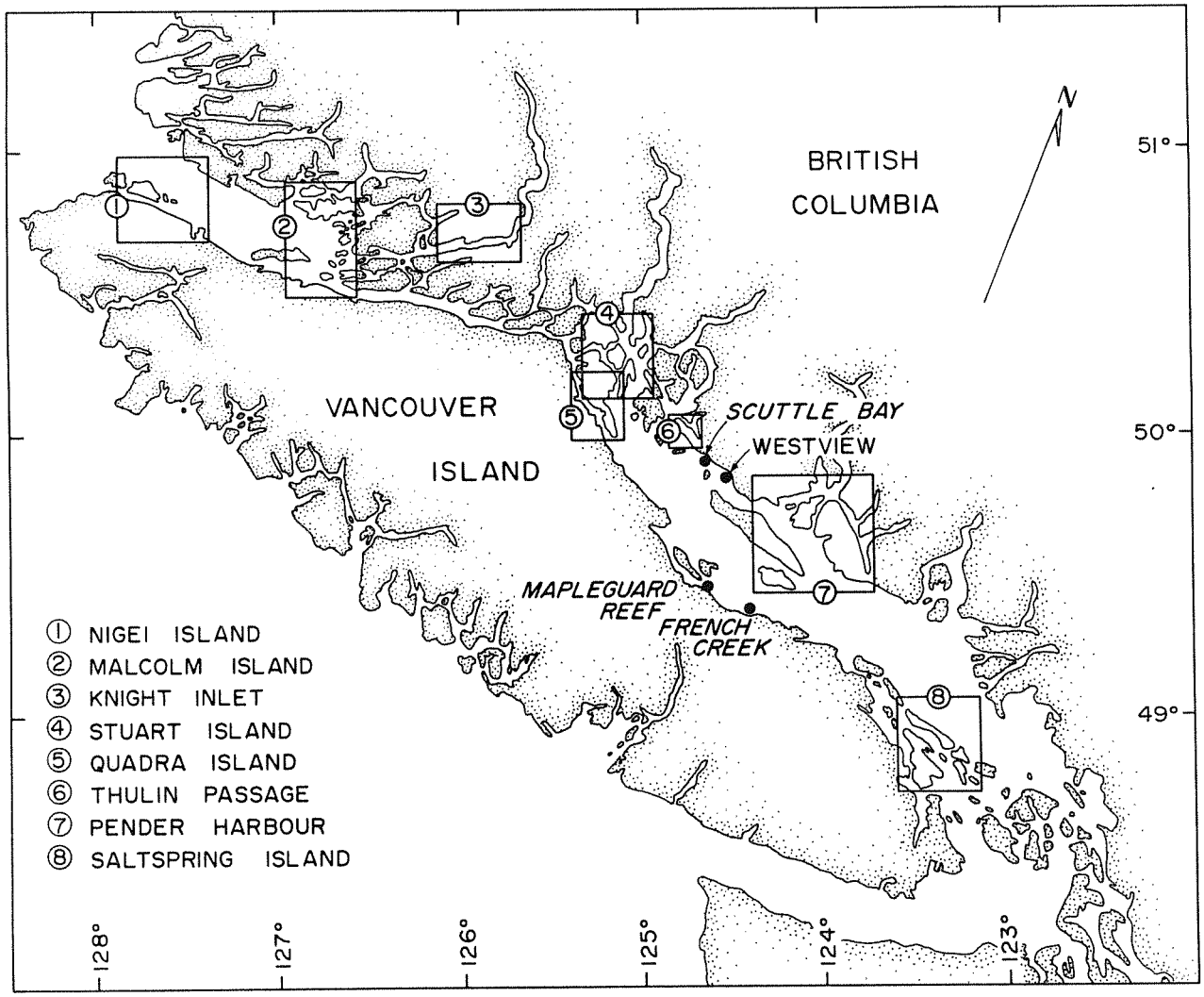

Fig. 1. Overview of the herring bait fishery locations in Georgia and Johnstone straits.

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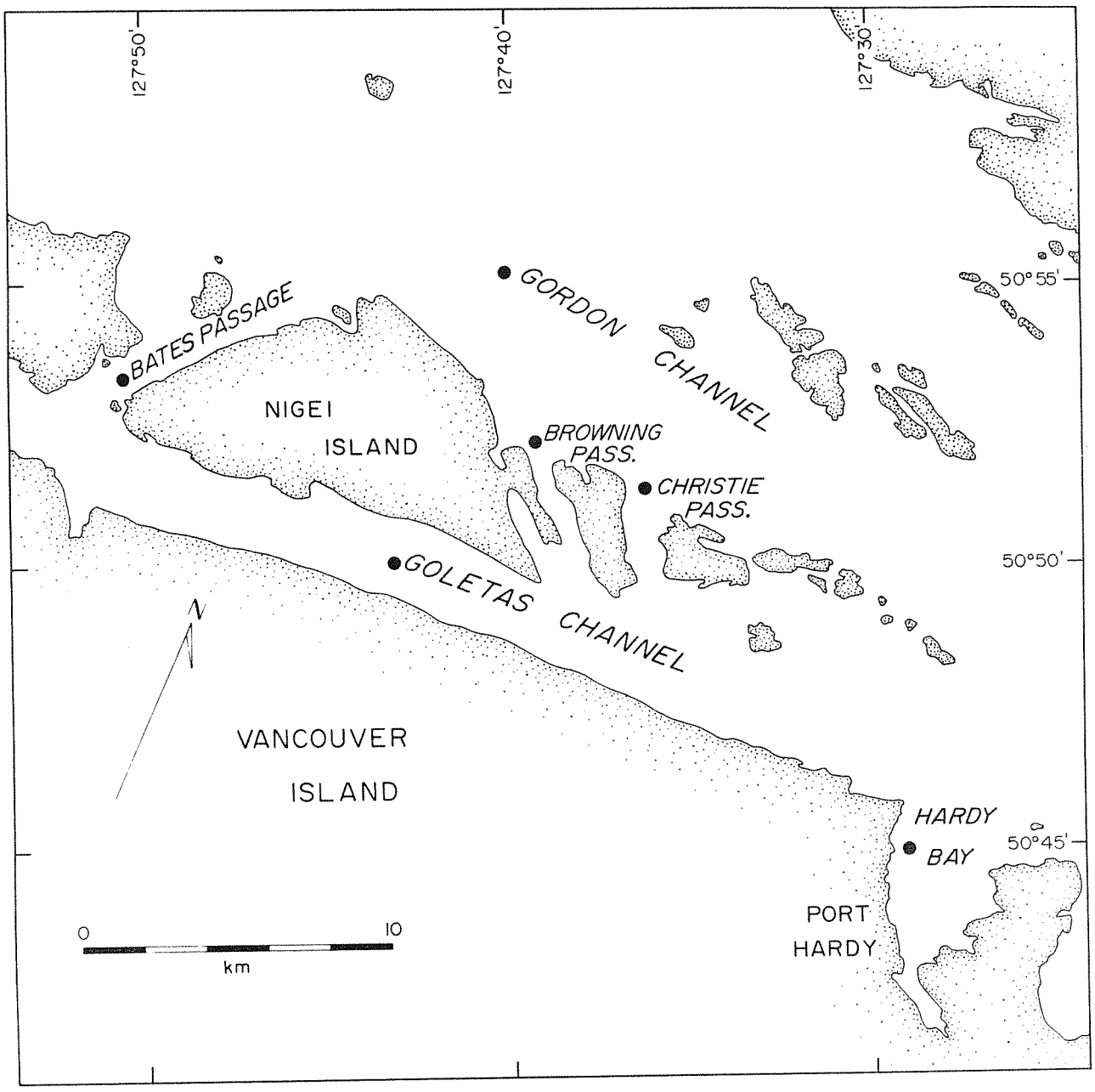

Fig. 2. Herring bait fishery locations in the Nigei Island area.

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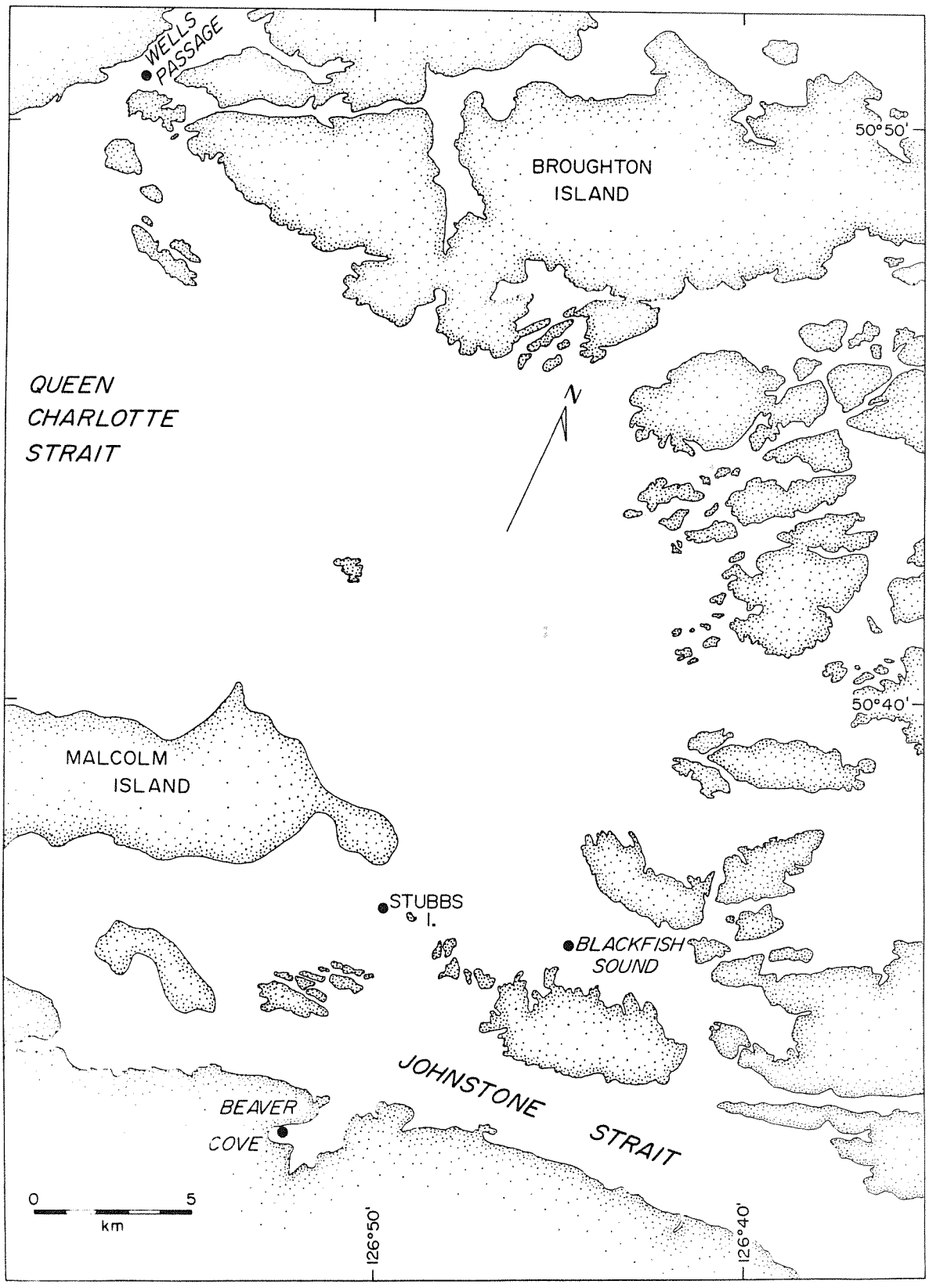

Fig. 3. Herring bait fishery locations in the Malcolm Island area.

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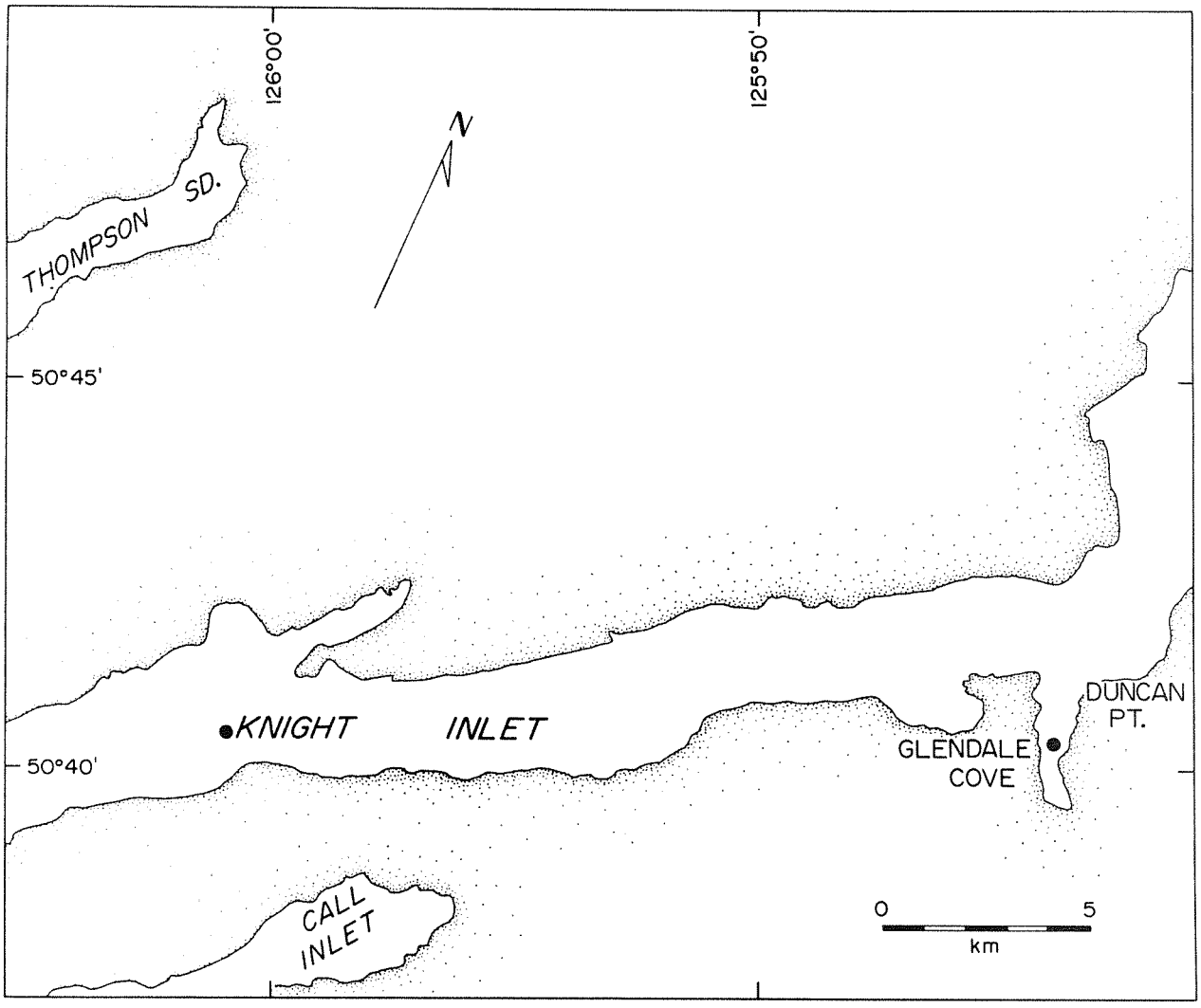

Fig. 4. Herring bait fishery locations in the Knight Inlet area.

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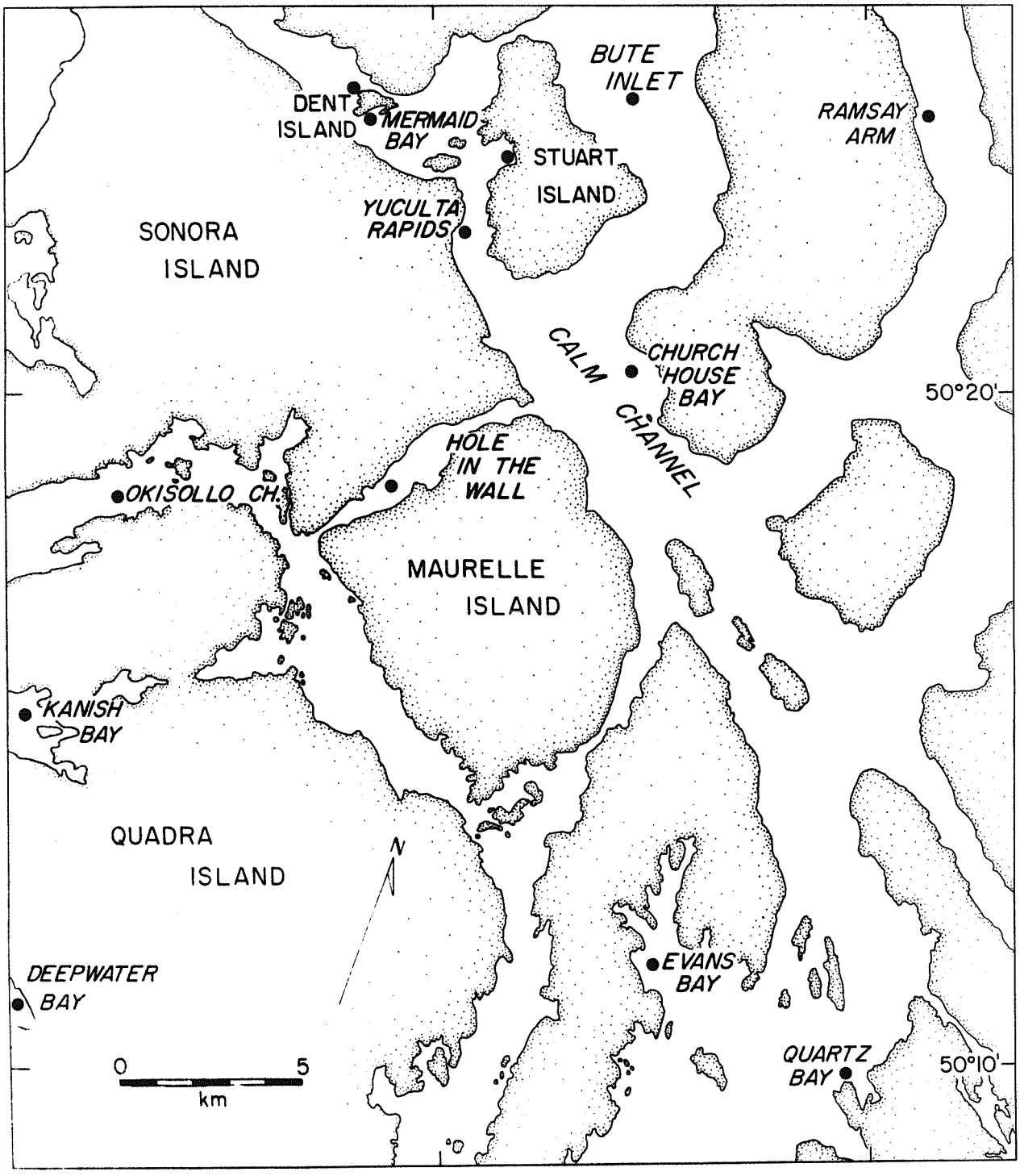

Fig. 5. Herring bait fishery locations in the Stuart Island area.

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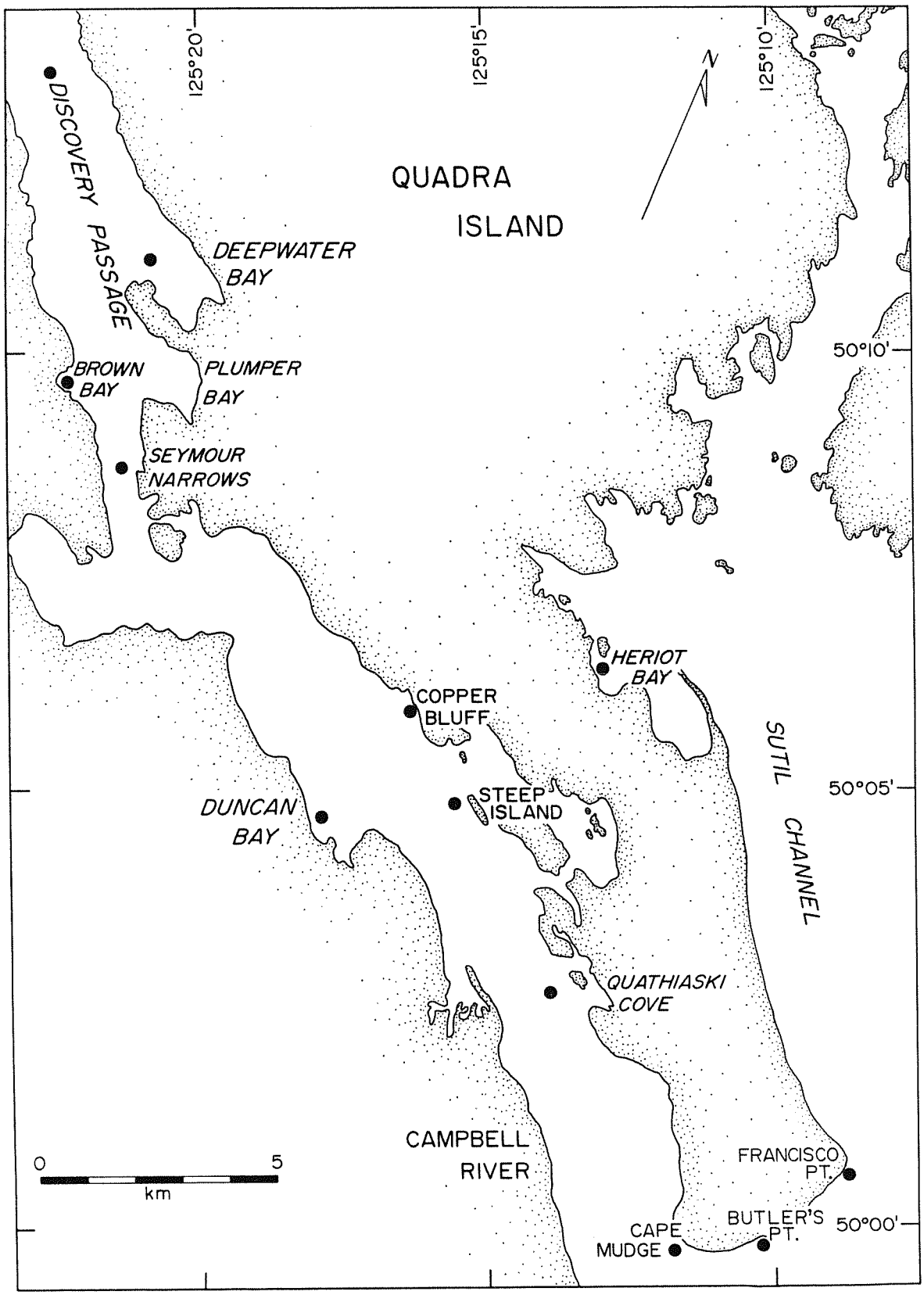

Fig. 6. Herring bait fishery locations in the Quadra Island area.

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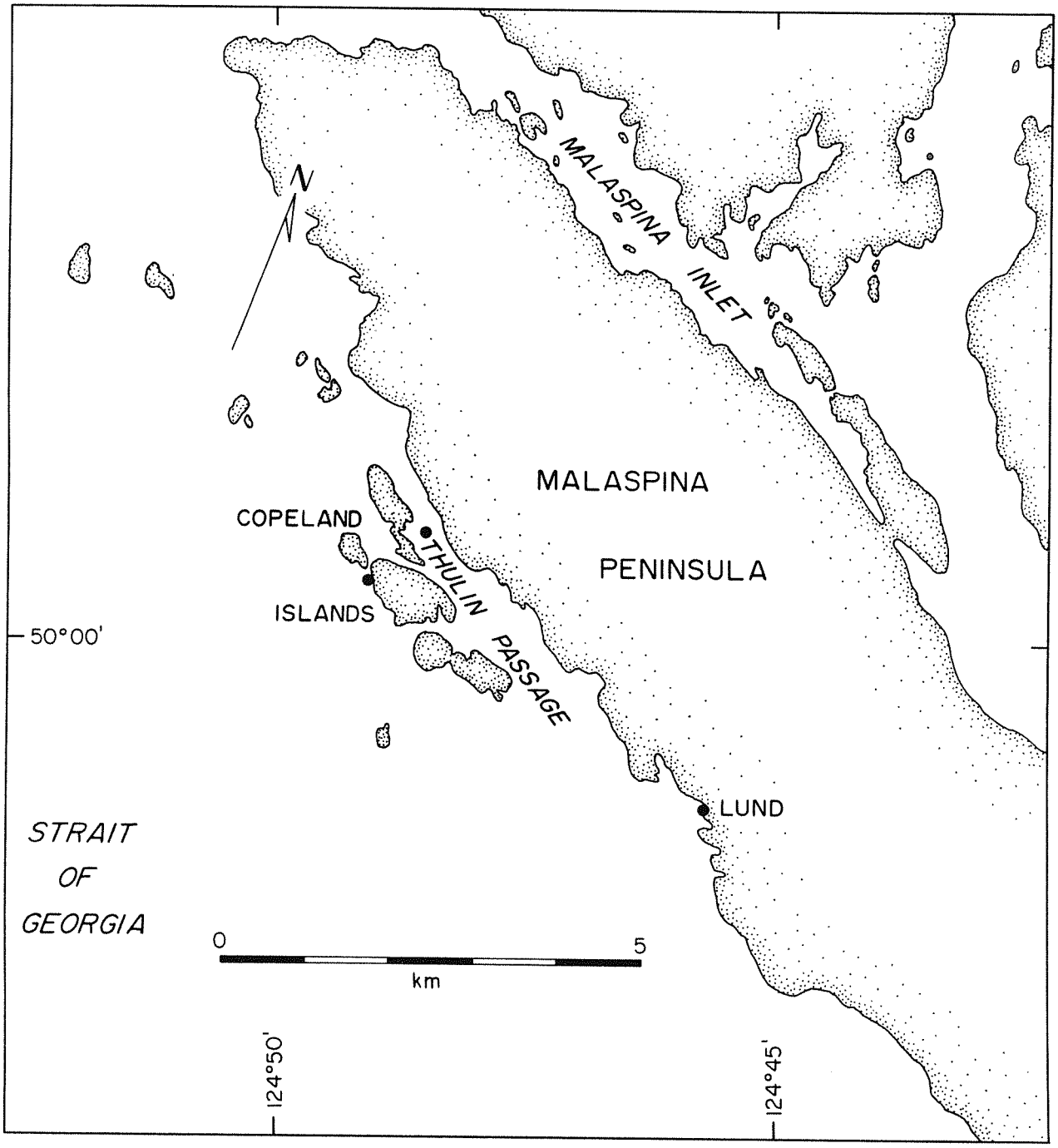

Fig. 7. Herring bait fishery locations in the Thulin Passage area.

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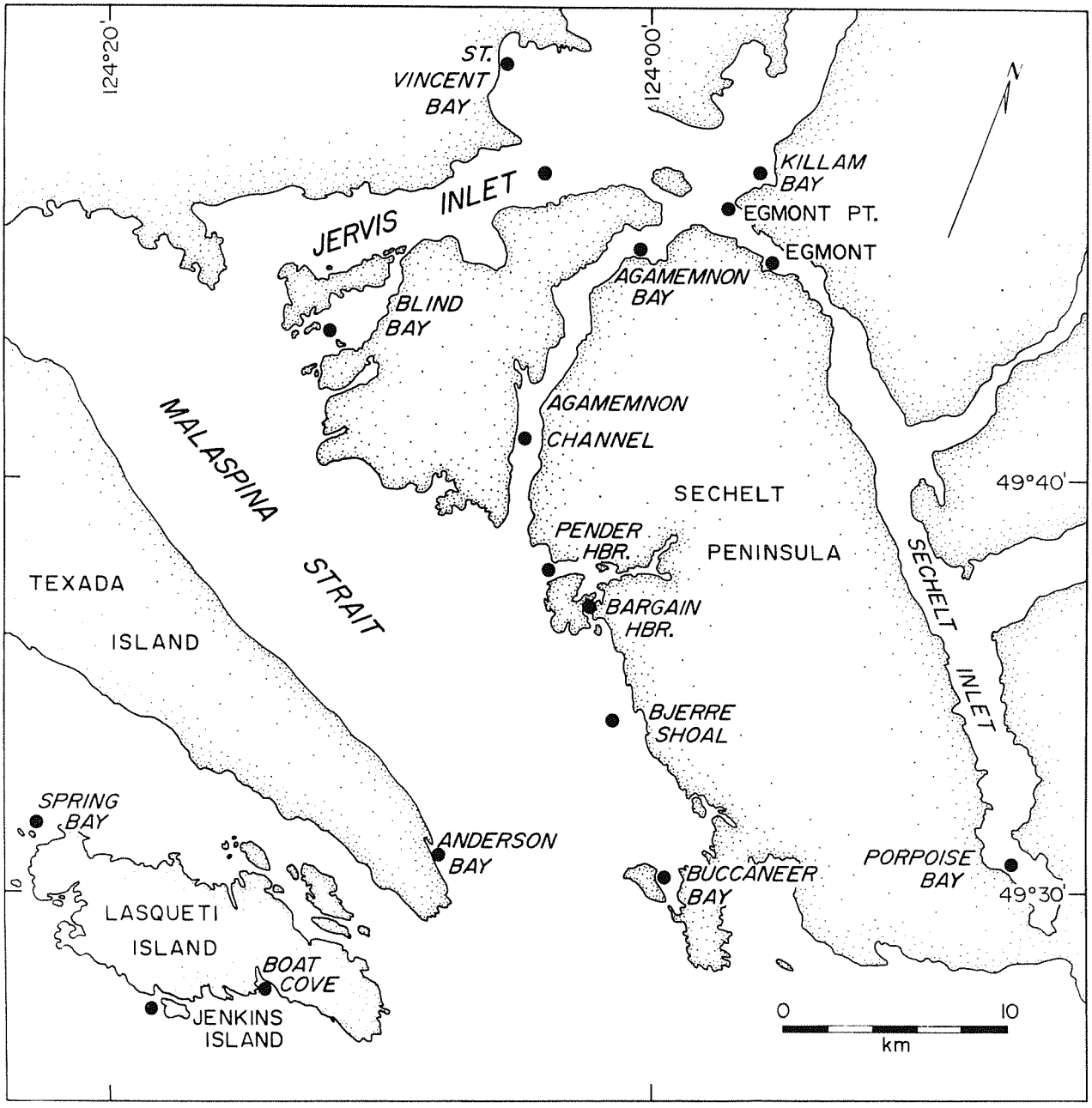

Fig. 8. Herring bait fishery locations in the Pender Harbour area.

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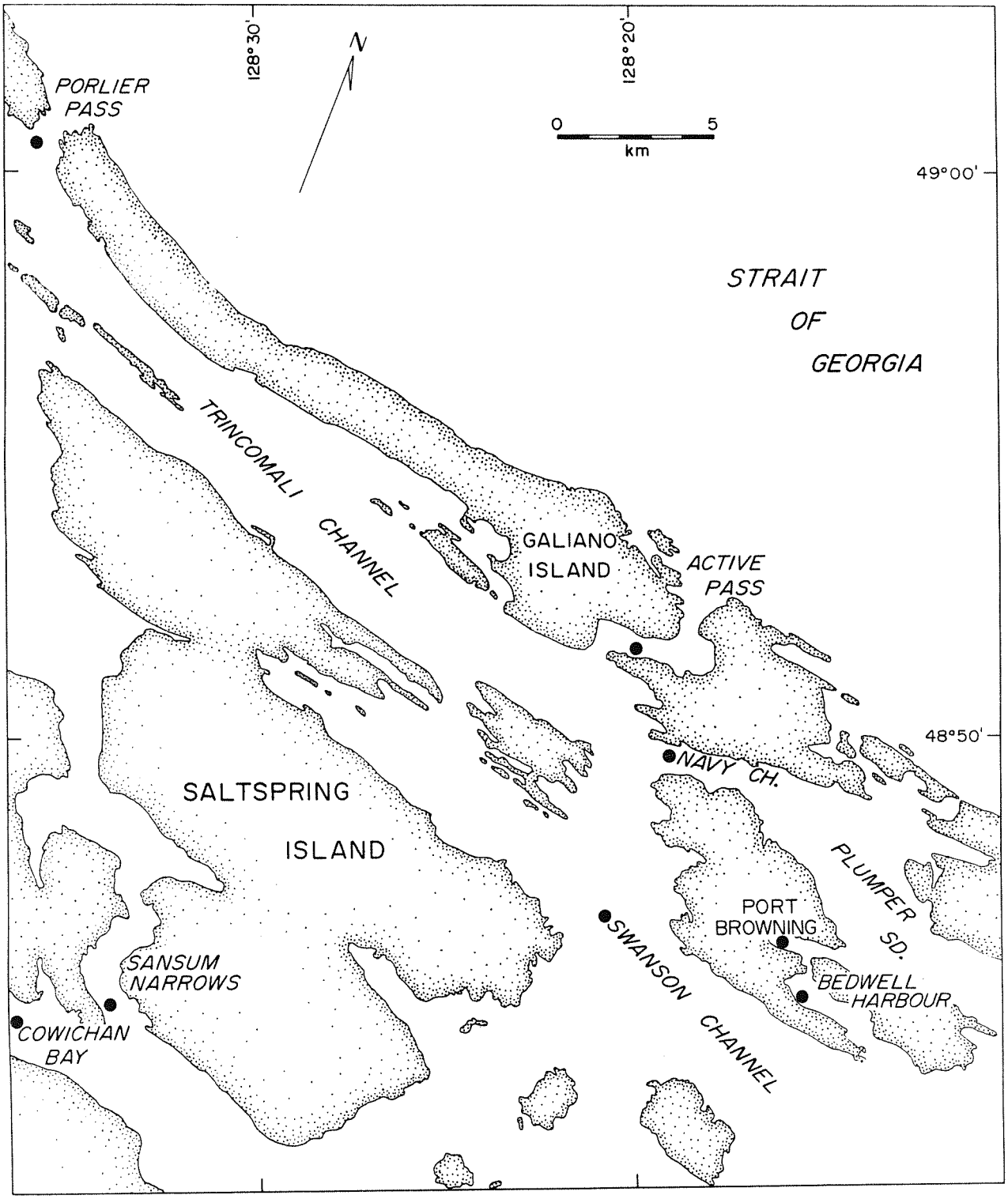

Fig. 9. Herring bait fishery locations in the Saltspring Island area.

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Appendix 1. Spawning locations assumed to represent local and migratory stocks of herring for assessing exploitation rates of the bait fisheries in Georgia and Johnstone Straits.

Section[c]	Non-Migratory Spawning Locations	Migratory Spawning Locations
121	Bull Harbour, Jula Island[a], Shelter Bay[a].	
122	Beaver Harbour, Deer Island[a], False Head, Hardy Bay, Keogh Shoals[a].	
123	Bend Island, Beware Passage, Bones Bay[a], Boughey Bay, Canoe Passage[a], Caution Cove[a], Clio Channel, Cutter Cove[a], Lagoon Cove[a], Mink Point[b], New Vancouver[a], Potts Lagoon[a].	
124	Burly Bay[a], Claydon Bay, Grappler Sound, Hopetown Passage[a], Kenneth Passage, Kinnaird Island[a], Mackenzie Sound[a].	
125	Cramer Passage[a], Echo Bay[a], Eden Island[a], Grebe Cove[a], Health Bay[a], Health Lagoon[a], Joe Cove, Meade Bay[a], Monday Anchorage, Retreat Passage[a], Scott Cove[a], Shoal Harbour[a], West Gilford Island, Thompson Sound[b], Viner Sound[a].	
126	Greenway Sound[a], Gregory Island[a], Kingcome Inlet, Moore Bay[a], Obrien Bay, Shawl Bay[a], Simoom Sound[a], Wakeman Sound.	

Appendix 1 (cont'd)

Section	Non-Migratory Spawning Locations	Migratory Spawning Locations
127	Ahnuhati Point, Axe Point, Bolivar Creek[b] Cascade Point[b], Deer Bay[b], Franklin Flats[a], Glacier Bay, Hatchet Point[b], Knight Inlet, Knight Inlet (head)[b], Rubble Point, Wahkash Creek[b], Wahshihlas Bay.	
132	Bells Bay, Chonat Bay[a], Deepwater Bay, Discovery Passage[b], Granite Bay[a], Kanish Bay[a], Okisollo Channel[a], Plumper Bay[a], Rocky Islets[b], Small Inlet[a].	
133	Fraser Bay, Loughborough Inlet, Mcbride Bay, Pym Point[a].	
134	Bear Bay[a], Bute Inlet[a], Bute Inlet (head), Hamilton Point[b], Orford Bay[a], Purcell Point[b], Southgate River[b], Teaquahan River[b], Waddington Harbour, Ward Point[b].	
135	Cape Mudge, Drew Harbour[a], Francisco Point, Heriot Bay, Hyacinthe Bay, Marina Island[a], Open Bay[a], Quadra Island East[b], Quadra Island South[a], Quathiaski Cove, Rebecca Spit, Smelt Bay[a], Sutil Channel[a], Whaletown Bay[a].	
136	Carrington Bay[a], Dent Island[a], Evans Bay, Quartz Bay[a], Von Donop Inlet[a].	

Appendix 1 (cont'd)

Section	Non-Migratory Spawning Locations	Migratory Spawning Locations
141	Kye Bay, Oyster Bay[b], Oyster River[a].	
142	Baynes Sound[a], Buckley Bay[a], Deep Bay, Fanny Bay[a], Hart Creek[a], Hindoo Creek[a], Mud Bay[a], Point Holmes[b], Repulse Point[a], Union Bay.	Boyle Point, Cape Lazo, Chrome Island[b], Comox Bar, Comox Harbour, Denman Island, Denman Island (East), Denman Island (West), Downes Point[a], Fillongley Park[b], Gartley Point, Hornby Island[a], Komas Bluff, Lambert Channel, Norman Point[b], Phipps Point[a], Seal Islets, Shingle Spit, Tribune Bay, Whaling Station Bay[a], Willemar Bluff.
143		Big Qualicum River, Bowser, Cottam Point[a], Eagle Crest[b], Englishman River, French Creek, Little Qualicum River, Madrona Point[a], Mapleguard Point, Nile Creek, Northwest Bay[a], Nuttal Bay, Parksville, Parksville Bay[b], Qualicum Bay[b], Qualicum Beach, Qualicum River[b], Rathtrevor Beach, Thames Creek.
151	Junction Point[a], Squirrel Cove[a].	
152	Albion Point[b], Bliss Landing[a], Cortes Bay[a], Frolander Bay[a], Lang Bay[a], Malaspina Inlet[a], Okeover Inlet[a], Sarah Point[a], Stillwater Bay[a], Sutil Point[a], Twin Islands[a].	Blind Creek[a], Copeland Islands[a], Dinner Rock[a], Emmonds Beach[b], Grace Harbour[a], Grief Point, Harwood Island, Hernando Island[a], Hurtado Point[a], Kiddie Point[b], Lund[a], Myrtle Point[a], Mystery Reef[b], Savary Island, Scuttle Bay, Sliammon Village, Thulin Passage[a], Westview[a].

Appendix 1 (cont'd)

Section	Non-Migratory Spawning Locations	Migratory Spawning Locations
161	Sabine Channel[a].	
162	Blind Bay[a], Green Bay[a], Saltery Bay[a], Saint Vincent Bay[a], Thunder Bay[a], Vanguard Bay[a], Willingdon Beach[a].	
163	Anderson Bay[a], Bargain Bay, Bargain Narrows[a], Buccaneer Bay[a], Calder Island[a], Churchill Bay[a], Fisher Island[a], Francis Point[a], Garden Bay[a], Gerrans Bay[a], Irvines Landing, Pender Harbour[a], Quarry Bay[a], Secret Cove[a], Texada Island[a].	
164	Deserted Bay[a], Jervis Inlet Head[a], Potato Creek[a], Vancouver Bay[a].	
165	Egmont[a], Four Mile Point[a], Porpoise Bay, Salmon Inlet[a], Secret Bay[a], Snake Bay[a], Storm Bay[a].	
172	Ballenas Channel[a], Blunden Point, Departure Bay[a], Dorcas Point, Fleet Point[a], Gabriola Is. (N. Shore)[b], Hammond Bay[a], Horswell Bluff[a], Icarus Point, Jack Point[a], Lagoon Head[a], Lantzville[a], McKay Point[a], Nankivell Point[a], Nanoose Bay, BNnoose Bay Entrance[a], Nanoose Bay Head, Nares Point[a], Neck Point[a], Newcastle Channel[a], Newcastle Island East[a], Protection Island East[a], Ranch Point[a], Richard Point[a], Schooner Cove[a], Sunrise Beach,	

Section	Non-Migratory Spawning Locations	Migratory Spawning Locations
	Taylor Bay[a], Wallis Point[a]	
173	Blackberry Point[a], Breakwater Island, Cardale Point[a], Crofton[a], Degnen Bay, False Narrows, Flat Top Islands[b], Gabriola Island South[a], Gabriola Passage[a], Hospital Point (Chemainus)[a], Montague Harbour[a], Porlier Passage[a], Pylades Channel[a], Ruxton Island[a], Ruxton Passage[a], Sear Island[a], Shingle Point[a], Trincomali Channel[a], Valdes Island[a], Willy Island[a].	Boat Harbour, Boulder Point[a], Cedar Ramp[a], Clam Bay[a], Coffin Point, Crescent Point[a], Dayman Island[a], De Courcy Island[a], Dodd Narrows South, Dunsmuir Islands[a], Evening Cove, Flewett Point[a], Fraser Point, Hudson Island[a], Kulleet Bay, Kuper Island, Ladysmith Harbour, Leech Island[a], Link Island[a], Mudge Island, North Cove, Pilkey Point[a], Preedy Harbour, Round Island, Scott Island[a], Sharpe Point[b], Stuart Channel[a], Telegraph Harbour[a], Thetis Island, Yellow Point.
181	Annette Inlet, Annette Point[b], Bedwell Harbour[a], Birdseye Cove[a], Captain Passage[a], Chain Islands, Colburne Passage[a], Ellen Bay[a], Fulford Harbour[a], Ganges Harbour, Genoa Bay[a], Glenthorne Passage, James Bay[a], Long Harbour, Nose Point[a], Prevost Island[a], Selby Cove, Welbury Bay.	
182	Boot Cove, Campbell Bay[a], King Islets[a], Lyall Harbour, Payne Point[a], Port Browning[a], Samuel Cove[a], Saturna Island[a], Winter Cove[a].	

Appendix 1 (cont'd)

Section	Non-Migratory Spawning Locations	Migratory Spawning Locations
191	Coal Point[a], Coles Bay[a], Deep Cove[a], Finlayson Arm[a], Goldstream Flats[a], Patricia Bay[a], Saanich Inlet[a], Tod Inlet[a], Towner Bay[a], Tsehum Harbour[a], Esquimalt Harbour[a], Esquimalt Lagoon[a], Ogden Point[b], Portage Inlet[a].	

[a]Spawning locations utilized prior to 1981 only.
[b]Spawning locations utilized only since 1981.
[c]Section boundaries and spawning locations are described in Haist and Rosenfeld (1988).

Appendix 2. Sample bait fishery questionnaire distributed to all permit holders in Areas 12-20 in 1986.

HERRING BAIT FISHERY QUESTIONNAIRE

I. Bait Fishery Locations

Which areas do you fish bait herring in:

Statistical areas: _____

Locations: _____

Do you fish these locations because of:

(1) The abundance of bait herring _____

(2) Ease of access _____

(3) Nearness to market

Are the fishing areas restricted by the distance fish can be transported?

_____

_____

Which locations have concentrations of herring that occur regularly each year?

_____

_____

Are there some areas that contain an abundance of herring only occasionally?

_____

_____

Are the fish found in these concentrations all year long and if not when do they disappear and where do you think they go?

_____

_____

Where do you catch most of your fish? _____

_____

II. Fishing Methods

What type of gear do you usually use?á If seine, how long and how deep is the net? Do you use knotless webb? _____

_____

_____

Do you think a small beach seine could be used to catch herring?

_____

When is the best time of the day to catch bait herring? Is it related to the tide?

_____

_____

What time of year do you usually go out to look for fish and when do you get most of your catch? _____

_____

III. Fishing Operations

How long have you been fishing bait herring and how long have you fished in this area?

_____

_____

How many tons of bait herring do you usually catch each year?

_____

_____

What size of bait herring are you usually looking for:

juveniles (firecrackers): _____

or adults: _____

What do you use the herring for:

(1) Personal bait _____

(2) Sports bait - fresh _____

- frozen _____

(3) Commercial bait _____

Do you impound your bait herring? If so, where do you hold them?

_____

_____

IV. Management Considerations

Have you seen major changes in the abundance or distribution of herring in your area since you began fishing for bait. If so, what do you feel is the cause? _____

_____

_____

_____

What changes would you like to see in the management and licencing of the bait fishery?

_____

_____

_____

V. Comments: _____

_____

_____

_____

_____

_____

_____

_____

Please return to:

J. Schweigert
Fisheries Research Branch
Pacific Biological Station
Nanaimo, B.C.
V9R 5K6
Phone: 756-7203