CHARACTERISTICS AND PROCESSES
OF THE COASTAL ZONE
IN SKAGIT COUNTY, WASHINGTON

BY

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INTRODUCTION

This report summarizes the results of an investigation of coastal zone processes and characteristics in Skagit County, Washington. The study was incorporated as part of the author's research for graduate study in geology at Western Washington University. The author wishes to thank the Skagit County Planning Department, especially Mr. Robert Schofield, Director, and Mr. Stephen Harvey. Both of those gentlemen expressed an interest in the project in it's initial stages, and also made logistical and partial financial support possible.

The investigation covers a number of aspects of coastal zone processes and morphology. Among those subjects are: 1) delineation of drift sectors within the county, 2) directions of net long term sediment transport on beaches, 3) identification of prograded beaches, 4) study of shoreline erosion rates, and 5) delineation of hazardous zones with respect of landslides in coastal bluffs.

This report is designed to be used in conjunction with and to supplement the Coastal Zone Atlas presently in preparation by the Washington Department of Ecology. That atlas, by it's very nature, is a generalized reconnaissance of the coastal zone. This study is more detailed in a number of respects, and the emphasis is on beach and erosional processes.

PHYSICAL SETTING

Little study of winds and wind generated waves has been done in western Skagit County. Until 1973 no wind data was collected on a regular basis. Table 1 is a summary of winds near Anacortes collected at the Shell Oil Company refinery. Since Anacortes is located approximately in the center of the coastal zone area the winds there are thought to be fairly representative of the area as a whole.

Based on that wind data the larges waves that would commonly occur would be about 6 feet. That estimate is produced by utilizing wave forecast graphs used by the U.S. Army Corps of Engineers (1973). Further confirmation comes from an unpublished study done in the southern Strait of Georgia in British Columbia (B.C. Research, 1974). There the fetch of open water is much longer than those found in Skagit County; at that site extreme winds produced waves up to 8 feet high.

Of equal significance in Skagit County is the large amount of time during the year that wind velocities are quite low. As noted in Table 1 the winds are under 12 mph for 80% of the year. Those mild winds produce waves that have no importance with regard to coastal erosion.

The generally low wave heights, relatively high tidal range, and the poorly sorted sediments inherited from glacial deposits combine to produce a beach morphology in this area that is not particularly common worldwide. The upper part of local beaches (the high tide beach) is typically composed of sand, gravel,

Table 1. Wind Velocity and Direction
Shell Refinery, Anacortes, 1975-1977*

Velocity (mi/hr)	0-2.99	3-6.99	7-11.99	12-17.99	18-23.99	>24
Velocity %	4.4	38.4	37.2	14.2	5.0	.9

Direction	Direction %
N	5.8
NNE	7.2
NE	2.5
ENE	2.7
E	6.1
ESE	7.0
SE	13.7
SSE	13.2
S	6.3
SSW	3.3
SW	3.1
WSW	5.7
W	7.2
WNW	5.2
NW	5.7
NNW	5.4

*Based on 25,168 hourly observations over the 3 year period.
Courtesy of Northwest Air Pollution Authority, Mt. Vernon, Wn.

cobbles, and boulders intermixed in varying proportions. The high tide beach is moderately steep with slopes typically being 4 to 11 degrees. The lower portion of the beach (the low tide terrace) normally is composed primarily of sands and finer materials and is nearly horizontal. The junction point between the high tide beach and low tide terrace most often occurs at about the mean lower low water mark (zero feet) and the change in slope at that point is often quite abrupt (figure 1).

In areas where the shoreline is composed of rocky cliffs two morphological settings are common. In the first, where almost no erosion has occurred, the cliffs plunge directly into deep water. The second, where the rock is less resistant to erosion, has an abrasion platform developed due to the removal of rock. These are planar features that slope seaward at 2 to 4 degrees and can be in excess of 150 feet wide (figure 2).

The effect of precipitation in Skagit County plays an occasionally significant role in the coastal zone, but generally is only a minor factor. Average annual precipitation in the Anacortes area is about 26 inches; however, only about 25% of that amount appears as stream flow (Phillips, 1966). The balance is released back to the atmosphere as evaporation and transpiration by plants. As a result, most local streams are small with sediment contributions to the beaches being negligable. Furthermore, the size of sediments delivered to beaches is generally significantly smaller than the particles useable in building the beaches. In very localized areas precipitation

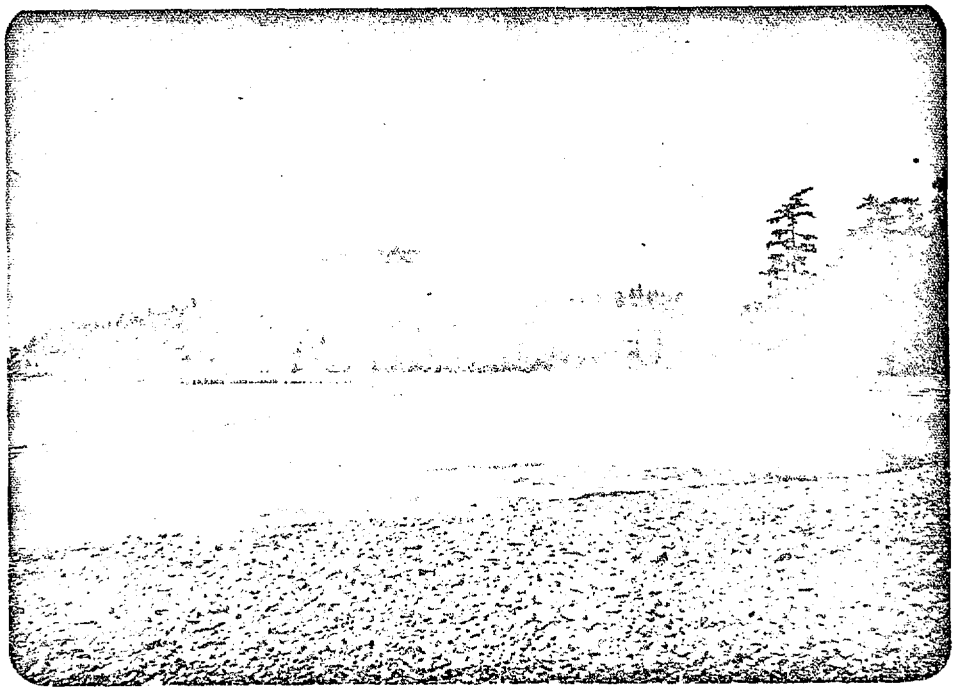

Figure 1. High tide beach and low tide terrace exposed during a very low tide. Note the abrupt change in slope between the horizontal low tide terrace and the steep high tide beach.

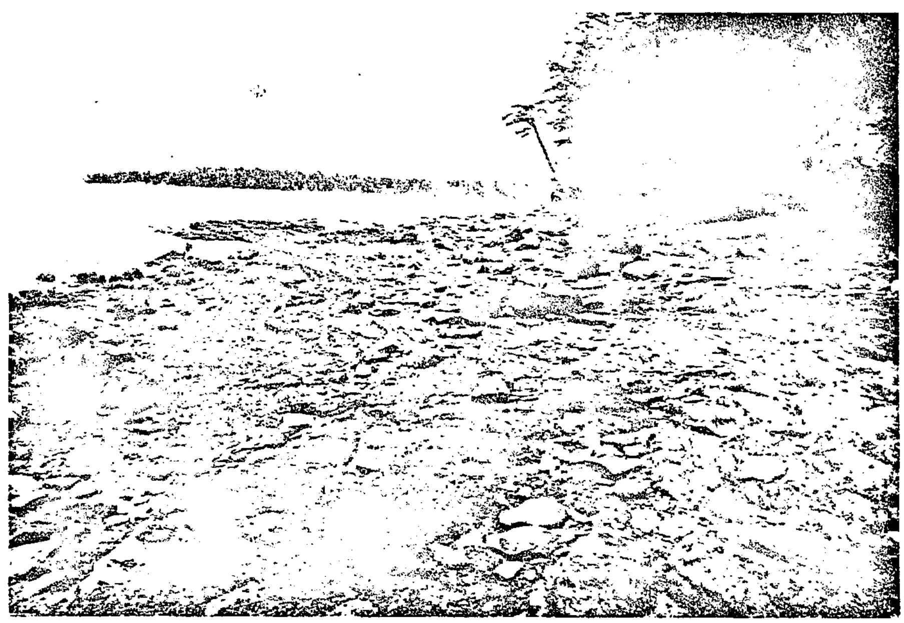

Figure 2. Abrasion platform eroded into bedrock; approximate width is 100 feet.

can be of importance in that infrequent, heavy rainfall triggers landslides which can be a substantial contribution to the sediment budget of a drift sector.

PHYSICAL DESCRIPTION AND NATURAL PROCESSES WITHIN DRIFT SECTORS

A drift sector, as commonly understood in the earth sciences, spans a shoreline segment from an area that is contributing sediment (the beginning) to an area that is receiving and accumulating the transported sediment (the terminus).

As noted previously, there are few streams in Skagit County that contribute any significant amount of sediment in sizes suitable for beaches. Locally the contributions of sediment are derived mainly from the erosion of shoreline bluffs. Therefore, within a drift sector the beginning is an entirely erosional setting, whereas further along the length of the sector the more abundant transported beach materials afford greater protection to the bluffs. All other factors being equal then, erosion will proceed at a faster rate at the beginning of a sector than at a point down drift from there. The results of the above erosion/transport processes are usually clearly manifested in the appearance of the beach, the beach sediments, and the bluffs.

The beginning of nearly every drift sector within the county is typified by very low angle beaches (slope of 2-4 degrees), with the profile being essentially planar. The sediment on the beach is usually very coarse cobbles and boulders, often with the bare, eroded sub-beach surface visible beneath the cobbles. At the foot of the cliff there is little or no accumulation of finer sediment in the form of a berm or backshore deposit. Often a high tide will lap at the foot of the cliff. The bluff itself usually is at a very steep angle (greater than 50-60 degrees) and in many cases, nearly devoid of vegetation. All of the above features can be seen in Figures 3 and 4.

The physical setting just described is in sharp contrast to the appearance of the shore zone further along the length of the drift sector. Figure 5 is typical of a beach and backshore located about 3/4 of the way along a drift sector. Here the much steeper beach angle (6-7 degrees) is immediately obvious, as are the smaller particle sizes of the beach sediment, typically mixed sand, gravel, and a few cobbles. Also noticeable in the photo is the beach ridge or berm (partially vegetated) which helps protect the bluff. The face of the bluff is well vegetated, with a low slope indicating that wave erosion is not proceeding at a rapid rate.

Figure 3. Beginning of drift sector to the east of Dewey Beach. The coarse beach sediment, bare patches of eroded beach surface, and steep cliff are evident.

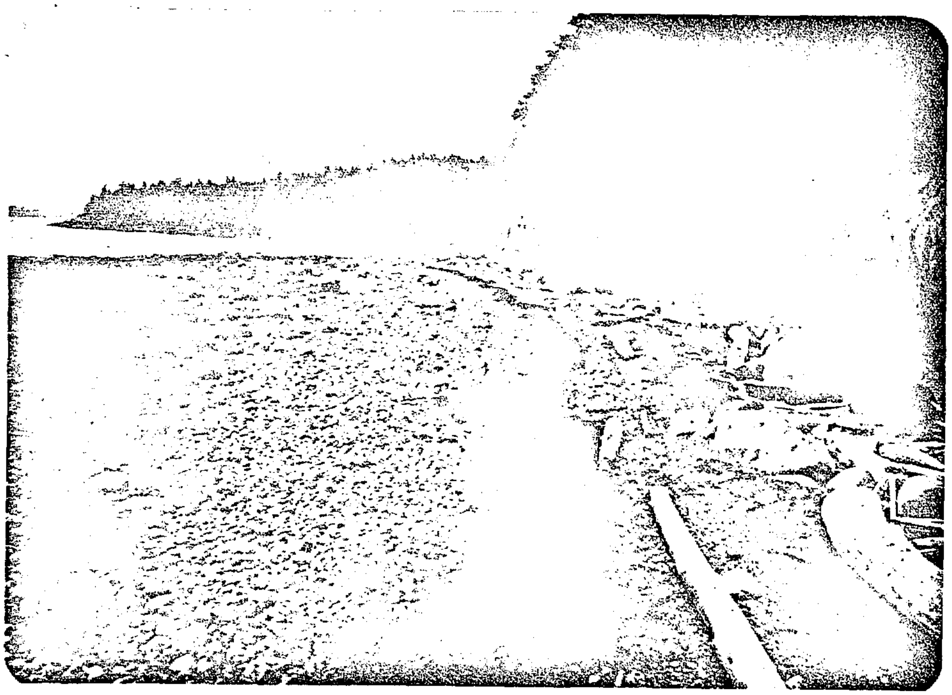

Figure 4. Near the beginning of the East Sinclair Island drift sector. Here also characterized by coarse sediment, no berm, and steep cliff face.

Figure 5. Photo taken about 3/4 of the way along the length of a drift sector. Note the steeper beach slope, the finer beach sediment (mixed gravel and sand), a partially vegetated berm, and well vegetated bluff.

PROGRADED BEACHES

Throughout this report the term "prograded beach" is used as opposed to other terms, such as "accretion beach", that have been used by some investigators to decribe beaches that have accumulated sediment and built seaward. The difference is not simply one of individual preference; rather, the word "prograded" directly implies a beach that has built seaward due to additions of sediment supplied by beach drift (American Geological Institute, 1972). The term accretion does not necessarily carry the same implication. Furthermore, the word prograded (past tense) does not imply that the building process is continuing at present. Indeed, there is evidence that some beaches in the county that have prograded in the past are presently being cut back. In still other cases continuing progradation cannot be established without long term monitoring.

As noted earlier, prograded beaches are typically located at the terminal ends of drift sectors where they receive accumulations of transported sediment. In my investigation I have found that there are many more prograded beaches in Skagit County than have been previously recognized or reported. Table 2 is a listing of prograded beaches associated with the terminal ends of drift sectors.

In addition to the prograded beaches covered in the previous paragraph and Table 2 there are also prograded beaches occasionally located within drift sectors. These are formed where there is a reentrant or embayment in an otherwise relatively straight

Table 2. Listing of Prograded Beaches Associated With the Terminal Ends of Drift Sectors

Geographic Name/ Location	Appears on Map	Comments
Strawberry Bay/ SW Cypress Is.	A	The active beach fronts an extensive system of older, vegetated beach ridges and backshore marsh
Tide Point/ W. Cypress Is.	A	Nearly all progradation has occurred on the north facing side of the point; southerly waves drive sediment around the point.
none/ NE Cypress Is.	A	A small beach (about 500 feet long). Sediment is derived from short drift sector to the north
Eagle Harbor/ NE Cypress Is.	A	A bayhead beach, most sediment provided by the slow erosion of a rocky shoreline to the south.
Cypress Head/ E. Cypress Is.	A	A tombolo connecting Cypress to Cypress Head; sediment supply similar to Eagle Harbor
Secret Harbor/ SE Cypress Is.	A	Description and sediment supply very similar to Eagle Harbor above.
none/ S. Cypress Is.	A	Most sediment supplied from the west.
none/ SW Sinclair Is.	A	Slight erosion of prograded sediment along the northwestern part.
none/ N. Sinclair Is.	A	One of the larger accumulations of transported beach sediments in Skagit County
none/ S. Guemes Is.	B	Probably the finest example of a prograded beach in Skagit County. Sediment is supplied from both the east and west.

Table 2 continued

none/ W. Guemes Is.	B	Begins approximately where Edens Road meets the shoreline and continues north another 2200 feet
Indian Village/ W. Guemes Is.	B	
none/ NW Guemes Is.	B	Begins about 1000 feet south of Clark Point and continues south for about 1200 feet
none/ NE Guemes Is.	B	Some slight erosion near the southern boundary of the public park
none/ E. Guemes Is.	B	Begins where Guemes Is. Road meets the east shore; continues north for approx. 2000 feet.
Sleepy Hollow/ E. Guemes Is.	B	Sediment almost all derived from bluffs to the north.
Kirby Spit/ SW Samish Is.	C	It appears that most of the sediment comprising the spit was supplied in the past; the present rate of beach drift along the south shore is not plentiful.
Samish Beach/ Blue Herron Beach/ Fish Point/ N. Samish Is.	C	A very large prograded beach that is being presently eroded; see text for complete discussion.
Scotts Point/ E. Samish Is.	C	
Ship Harbor/ NW Fidalgo Is.	D	
Weaverling Spit/ W. Fidalgo Bay	D	Even though the shoreline to the north has been extensively industrialized and filled a moderate amount of sediment is still being supplied to the spit
Crandall Spit/ NW March Point	E	The spit is now mostly inactive; surrounded mostly by mudflats. Very little sediment is being supplied because of rip-rap on the bluffs and because of docks associated with oil refineries.

Table 2 continued

none/ NE March Point	E	A small prograded point; upper parts of beach are rip-rapped.
Dewey Beach/ N. Skagit Bay	G	Small prograded area on the east end of Dewey Beach.
Similk Beach/ N. Similk Bay	G	
Turners Bay/ N. Similk Bay	G	Spit now mostly inactive due to sedimentation on mudflats
Kiket Island/ same	G	Tombolo connecting Kiket Is. to Fidalgo Is.
Kiket Island/ same	G	Small prograded beach at west tip of Kiket Is., sediment derived from erosion on S. shore of Kiket Is.
Lone Tree Point/ E. Skagit Bay	G	
Hope Island/ SE Hope Is.	G	Small beach.
Snee-oosh Beach S. Fidalgo Is.	H	
Flounder Bay/ NW Fidalgo Is.	F	Eroding spit that has been rip-rapped; see text for full discussion

shoreline. These embayments, over the course of time, have had a barrier accumulate across the mouth. The barrier beach initially was a spit that progressively lengthened until it became connected to the opposite side of the bay mouth. Presently these beaches pass transported sediment along their length which then continues onward to the ultimate terminus of the sector. Some of the barriers are still accumulating sediment, others are being cut back as the bluffs on either side of what was the former bay mouth are eroded. Table 3 lists the locations of the mid-sector prograded beaches.

Table 3. Prograded Beaches Located Within Drift Sectors

Geographic Name/ Location	Appears on Map	Comments
none/ NW Guemes Is.	B	
Anaco Beach/ NW Fidalgo Is.	D	Presently undergoing erosion; owners have installed shore defense structures
Alexander Beach/ NW Fidalgo Is.	D	
Gibraltar/ N. Skagit Bay	G	Three prograded beaches within this drift sector which spans the shoreline from Dewey Beach to northern Similk Bay. Most have a moderate amount of shore defense structures installed.

SHORELINE EROSION

Erosion of Skagit County shorelines, particularly bluffs composed of glacial materials, is a highly intermittant process. The process is very much dominated by extreme climatic events. That is, beaches protect cliffs from wave attack except during large, infrequent storms when berms are overtopped and beach sediment is temporarily removed, leaving little effective protection. The exact timing of those erosion episodes is random in the same sense that river flooding is random. They can only be predicted in a statistical manner; that is, expressed as a probability such as the 50 year event or the 100 year event. Since very little study has been done on the frequency of occurrence of extreme winds and waves there is, at present, no way of even attempting a statistical prediction. Therefore, to be able to estimate what erosion rates might be in the future one can only assess what erosion has been in the past and assume that it will continue at least at the same rate into the future. While analysis of past erosion is useful in determining an average rate of shoreline retreat, that average rate itself obscures the great year to year variability mentioned above. Because of that variability it should be emphasized at the outset that an erosion rate of 0.1 feet/year does not mean an owner can look at his shorefront and expect to see a tenth of a foot eroded every year; nor does it mean that after 10 years a foot will have been removed. It is entirely possible to lose 3 feet in a single storm and then not experience an easily noticeable loss for a long period thereafter. The average rate does mean that over a longer period of time (greater than 20 years or more) the extreme events will probably occur often enough to maintain an overall rate of erosion somewhere near the average.

Methods Used to Evaluate Erosion Rates

The rates of erosion shown on the accompaning maps were derived in a variety of ways. The most reliable method makes use of bench marks installed in shoreline areas by the U.S. Coast and Geodetic Survey. By comparing the distance from the marker to the bluff when it was installed, to the present distance,a net change can be ascertained. Unfortunately, those markers are not numerous and only some have had the necessary original measurements recorded for comparison with the present measurement. If benchmarks were not available, then more indirect methods were used. Those include: 1) the amount of undercutting of a structure whose age and position relative to the original shoreline is fairly well known, and 2) the amount of root system exposed on bluff-top trees. Under certain conditions sea stacks found on rock abrasion platforms and lag deposits of boulders can also be used to yield an indirect assessment of past erosion. The indirect methods described often give only minimum rates of erosion that may be only 50% of the true average rate. However, on some shoreline segments nothing else is available so knowing at least the minimum rate is helpful.

Erosion Rates

As displayed on maps A through H the rates of erosion for glacial materials ranges from about 1 foot per 10 year period to 4 feet per 10 years. The most reliable of those values cluster at 1.5 to 3 feet per 10 years. Some of the values shown are derived from the indirect methods described above so tend to be lower, mostly in the area of 1 foot per 10 years. But since those methods underestimate what erosion has been, the higher, more reliable figures remain as the best guide. For general planning purposes the county will be most nearly correct if it assumes an average rate of shoreline retreat of 2 to 3 feet per 10 year period in areas where the shoreline is composed of glacial drift materials. This is especially true near the beginning of drift sectors where erosion tends to proceed more rapidly as described earlier.

The most rapid rates of removal in rock occur where the rock is highly fractured. But even in those areas the erosion rate is very much slower than in glacial materials, typically 0.4 feet (5 inches) per 10 year period. In less fractured rocks the rates are only one half of that cited above, and in some areas there is little or no evidence of removal in the last 5000 years.

SHORE DEFENSE STRUCTURES

A wide variety of defense structures are visible along the county shorelines. They range from massive rip-rap used by Burlington Northern along their right-of-way to imaginative attempts by individual owners using many different materials. In looking at these schemes one fact seems to be repeated over and over. Where defense structures are set too far out into the beach, that is, where they protrude to the mean higher high water mark or beyond, they tend to disrupt the normal protective nature of the beach to a significant degree. That is particularly true where the structure is an impervious concrete wall or bulkhead. Under normal conditions (no wall) the swash of the just broken wave moves up the beach and it's energy is dissipated. Also the volume is reduced by percolation into the underlying sediment so the backwash is significantly reduced. With an impervious wall in place, whose foot is at the water's edge or below, the normal swash dissipation cannot operate. The result is wave reflection from the wall, with a much stronger backwash, which scours the beach and removes the protective beach sediment. In these cases the owner is in essence trading no erosion of the bank for an eroded beach. That unconcious choice is ironic in that the presence of the beach is one of the most desireable features owners look for in acquiring shorefront property. Figure 6 shows one example of beach scour due to a concrete wall being placed too far out into the beach.

It would seem that owners would be well advised to locate defense structures as far back of the high tide mark as possible.

Figure 6. An example of beach scour due to an impervious concrete wall. Compare the steep, unmodified beach in the foreground having good sediment cover with the very low angle beach with many cobbles in front of the bulkhead in the background. Also note the pronounced drop from the unmodified beach down to the scoured beach. Location: west side of Similk Bay.

SLOPE STABILITY

Mass movements in bluffs are quite common along all Skagit County shorelines. However, it is important to distinguish between small, non-hazardous slope readjustments that go on more or less continuously, as opposed to large mass movements that have the potential for economic loss or loss of life.

In the former category are small slumps, soil falls, and rock falls that are ubiquitous in coastal bluffs and are basically adjustments to wave cutting at the toe of the slope. I have found that those type of slope movements present no particular hazard unless a structure were located at the very edge of a bluff. I found no such examples of poor building practice in Skagit County.

Several zones of large hazardous mass movements are found on Fidalgo, Guemes, and Samish Islands. Those are shown on Maps B, C, F, and G; with the area between Biz Point and Edith Point (western Fidalgo Island, Map F) being the largest and potentially most dangerous. In that area there are 7 large bowl or amphitheater-shaped scars representing sites of long continued landsliding (see figures 7 and 8). Active sliding into these amphitheaters is continuing to occur.

At the time of slope failure a wedge of material is released from the upper rim of the bowl, falls or slides to the bottom of the bowl, and then travels to the beach through a narrow chute as a debris slide or flow. In some cases the broken up, failed material does not evacuate all the way to the beach;

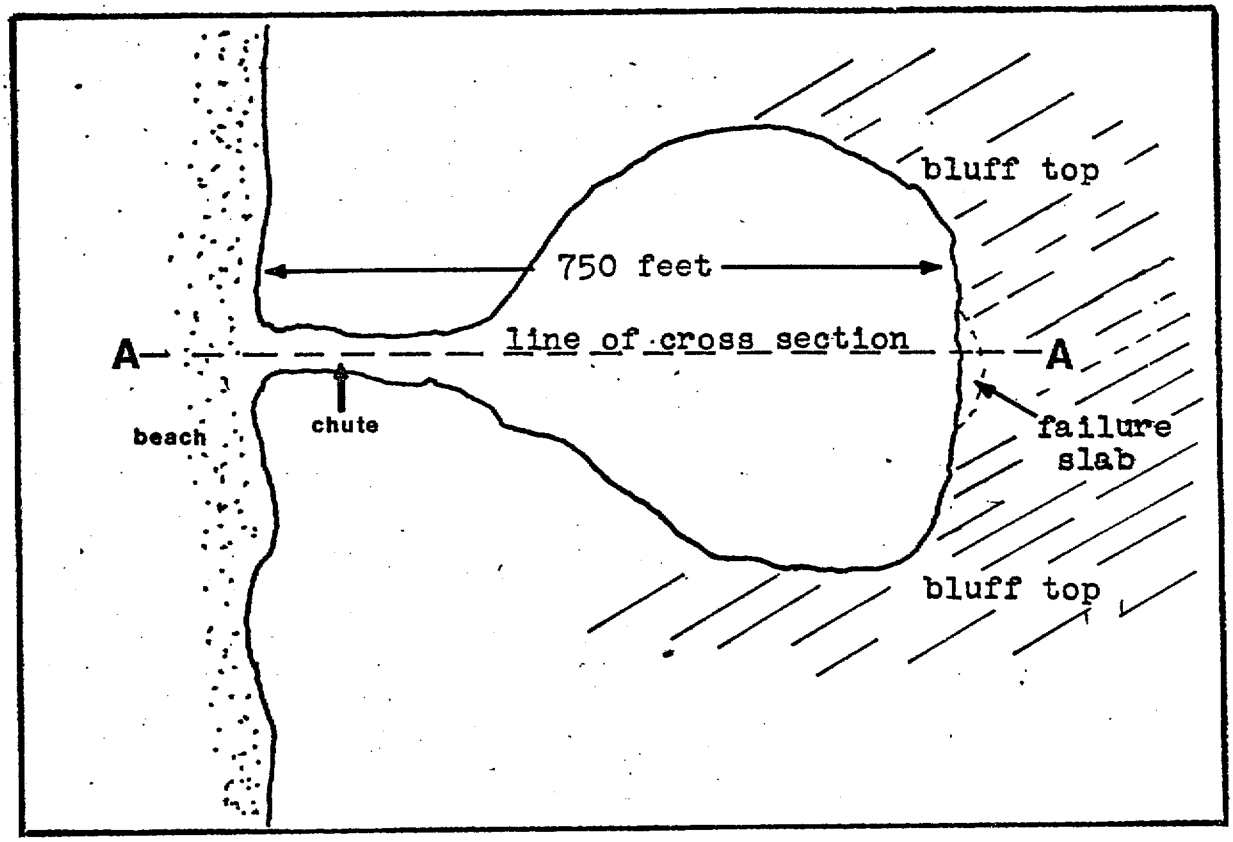

Figure 7. Diagrammatic map view of amphitheater-type landslide site (not to scale)

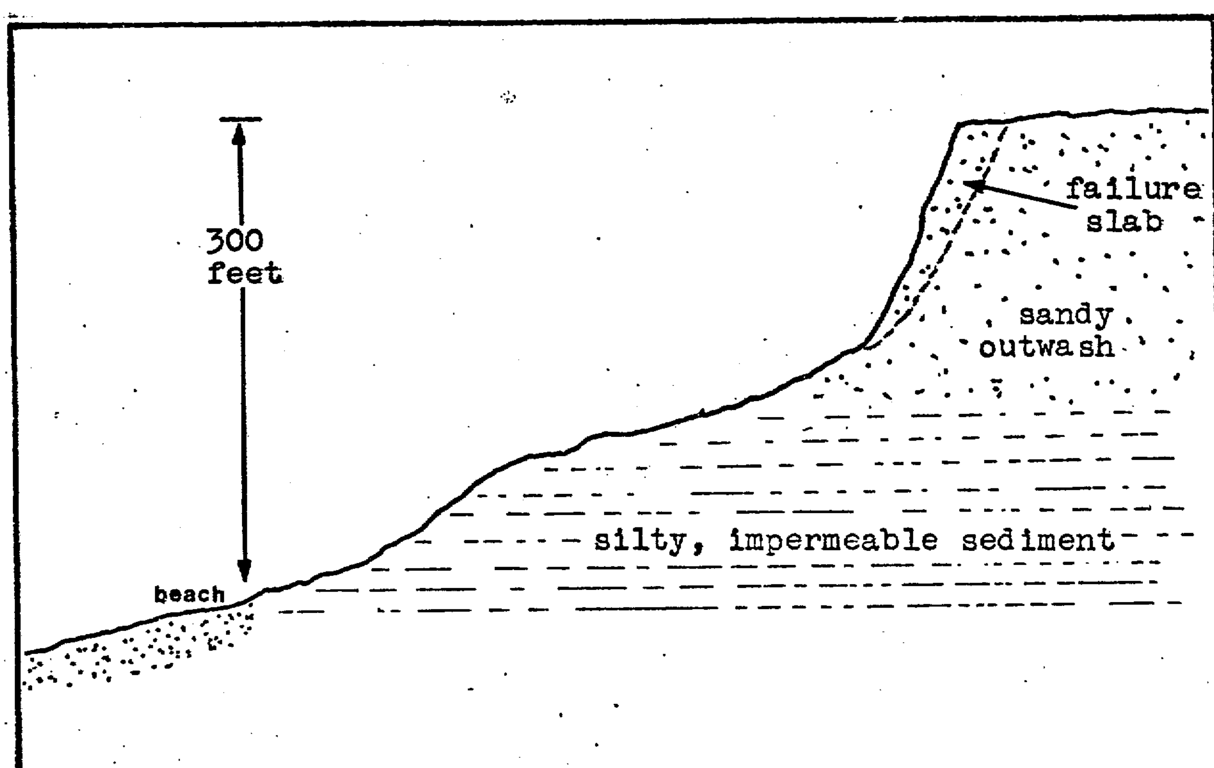

Figure 8. Diagrammatic cross section of amphitheater-type landslide site (not to scale)

rather, it comes to rest in vegetation in the bottom of the amphitheater or forms a plug inside the chute so that the evidence of failure is not easily visible. The most recent failure (winter of 1975/76) occurred in the amphitheater labeled number 4 on Figure 9. A conservative estimate of the volume of that failure is 1000 cubic yards of material. At least 3 of the 7 amphitheaters have had major failures along their upper rims within the last 20 years, and probably all 7 have been active during that time.

The amphitheaters are old features, surely pre-European settlement, and quite possibly greater than 1000 years old. The most landward portion of the bowl rims have now retreated inland an average of 750 feet from the beach implying their continued activity has little if anything to do with wave erosion at the base of the slope. They will continue to regress inland because the headward portions have steep slopes (all at least 45 degrees) and because the failed material does not usually come to rest at the foot of the steep headscarps which might begin to stabalize them.

One of the primary factors controlling landsliding in this zone is the particular combination of sediments that make up the bluffs. As shown in Figure 8, the base of the slope is composed of relatively impermeable silt which is overlain by a large thickness of glacial outwash sand. That particular combination has been found repeatedly in western Washington to be susceptible to landsliding (for example Tubbs, 1974; and Heller, 1978). The time of failure is nearly always during wetter than

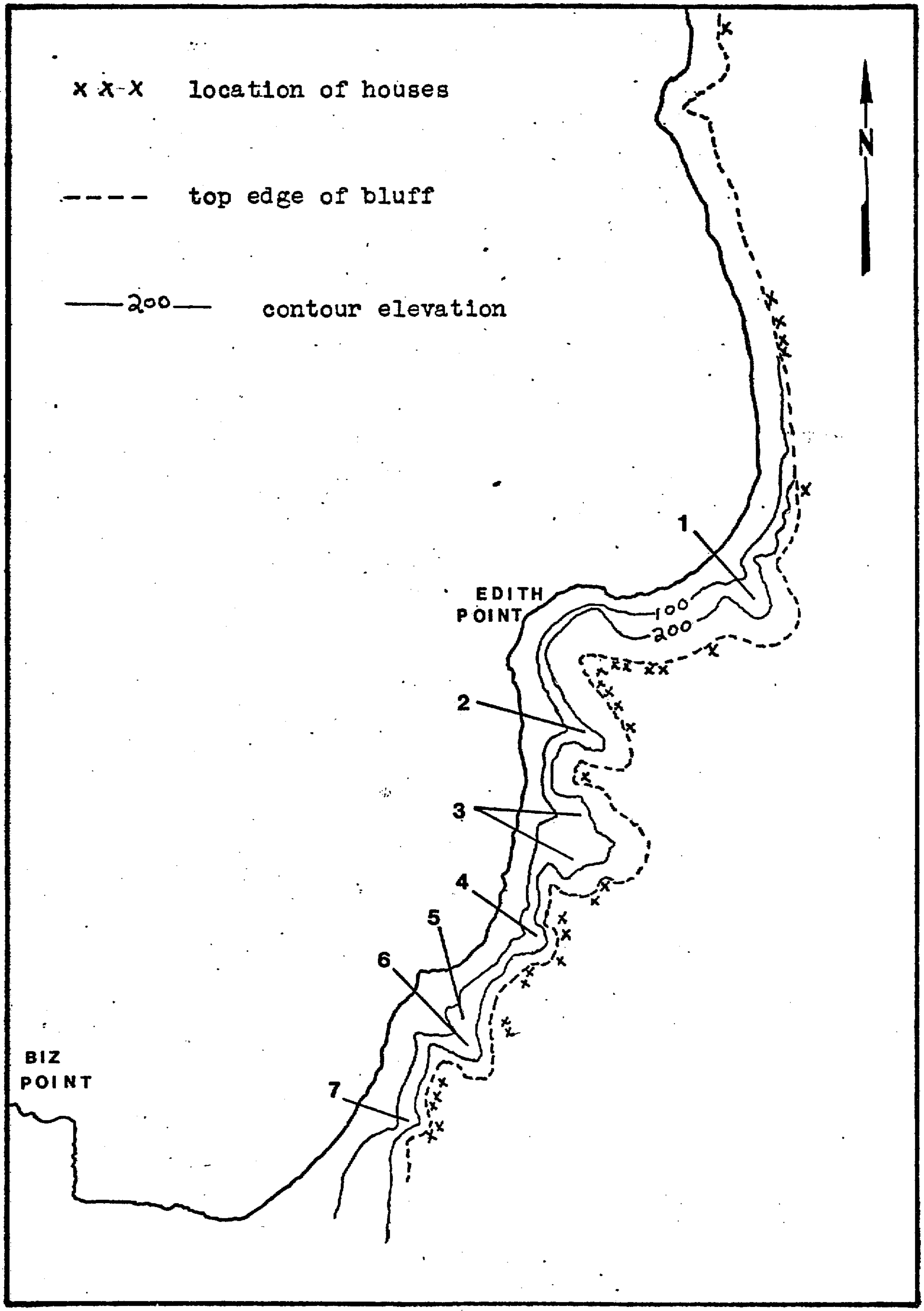

Figure 9. Sketch map of the Biz Point/Edith Point area. Amphitheater-type landslide sites are arbitrarly numbered from north to south.

normal winters followed by heavy individual rainfalls. Since excess water seems to be the triggering factor, large additions of water to these slopes should be avoided. In that regard, the amount of water added by septic systems is not commonly realized. Using U.S. Government figures on average per-person water usage, and assuming a housing density of 3 per acre, computations show a net input of an extra 12 inches of water per acre per year. Since the average runoff in this area is only about 6 inches per year as explained earlier, the 12 inches of added water would be a 200% increase which could exacerbate an already difficult situation.

The same combination of materials are present in the bluffs that continue north for more than 0.6 miles from Edith Point. With the exception of one large amphitheater immediately adjacent to the north side of Edith Point, no other amphitheater-type failures have yet developed in that northerly part. However, there are many places along the bluff top where wedges of material have failed and traveled to the beach. Those failure wedges produce a scalloped bluff edge where the failures have cut back into the bluff 20 feet or more. Furthermore, the top surface of the bluff has a number of small semicircular depressions and cracks ranging up to at least 15 feet from the edge indicating incipient failures that will occur in the not too distant future.

Nearly identical situations exist in each of the mass movement zones listed on Table 4. That is, all have the unfavorable combination of materials where fine grained, relatively impermeable deposits, are overlain by a sandy/gravelly deposit. No

Table 4. Listing of major landslide zones

Geographic Name	Location	Map
Edith Point	Western Fidalgo Island, from Biz Point north to 0.6 miles beyond Edith Point	F,D
Similk Bay	Western Shore of Similk Bay	G
Miller Bay	East of Deception Pass	F
Yellow Bluff	Southwestern Guemes Island	B
none	Northwestern Guemes Island, 2000 feet south of Indian Village	B
Clark Point	North tip of Guemes Island	B
none	Northeastern Guemes Island, 1500 feet south of the public park	B
none	Northern Samish Island, 2000 feet west of public picnic area	C

very large amphitheater-type failures have yet developed in those other zones, rather the scalloped cliff edge type failures predominate. It should be noted however, that each of those zones has at least one failure that has cut back into the bluff top further than the adjacent failures. In doing so those larger failures developed a small bowl-shaped scar and chute on the bluff face. Whether or not those failures are in the process of developing into large amphitheater type failures is somewhat speculative, but the possibility cannot be ignored.

The hazard in all these zones, particularly in the Edith Point area, is that a failure might include a dwelling that is close to the edge of the bluff. Based on the depth of the scars left by failed wedges that cut back into the bluff an average of 20 feet (more than 30 feet in some cases) it is obvious that any structure closer than about 30 feet could be severely damaged or tumbled down the cliff. The 30 foot value given should be considered as an absolute minimum for safety because it might only be a reasonable setback for one episode of failure. Since houses are considered to have a useful life well in excess of 50 years, doubling the setback to 60 feet or more would be quite reasonable. Those values are only approximate and might serve as a rule-of-thumb guide; in no case should they be considered as a substitute for site evaluation by qualified personnel. At present, in the Edith Point area, there are a number of houses that are less than 30-50 feet from the bluff edge. In addition, there are several houses built on the narrow finger of land that separates two adjacent amphitheaters.

DISCUSSION OF SELECTED INDIVIDUAL DRIFT SECTORS

NORTH SAMISH ISLAND (Map C). Owners of shoreline property within this drift sector have experienced problems with erosion for a number of years. In the past most of the problems seem to have been near the center of the island where it is narrowest. A couple of shore defense structures in that area date back over 20-30 years. In talking with residents there is an indication that more recently the problem is also being experienced further to the east, in the vicinity of Samish Beach and Blue Herron Beach. Comparison of an old photo to a recent one (Figures 10 and 11) confirms, on the basis of beach morphology, that conditions have indeed changed within this sector. The visible change in the amount and size of beach sediments is the result of an overall decrease in the amount of sediment in transport along the length of the sector, rather than an isolated occurrence at Samish Beach.

A number of pieces of evidence indicate that the deficiency of sediment is more closely related to a very long term depletion of the original source of supply instead of construction of shore defense structures. As shown on Map C, the entire northeastern portion of Samish Island is a prograded beach (200-500 acres). That huge volume of sediment implies a prolific supply source in the past, far larger than anything now visible in the shoreline bluffs. A second feature which provides a similar indication is a very wide, sandy low tide terrace that becomes visible at low tides. In other parts of the

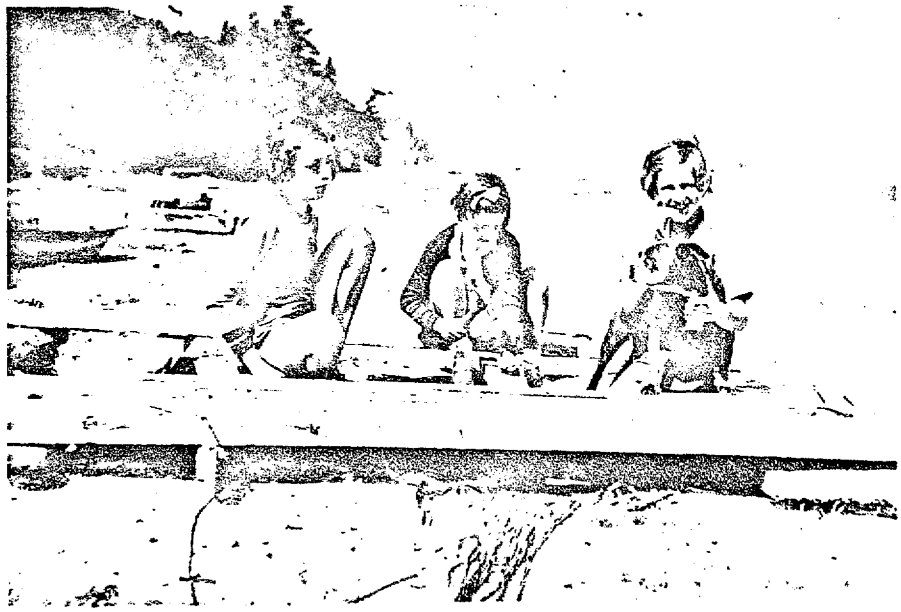

Figure 10. Photo taken about 1930 at Samish Beach. Note the large accumulation of fine gravel that forms the slightly convex upper beach.

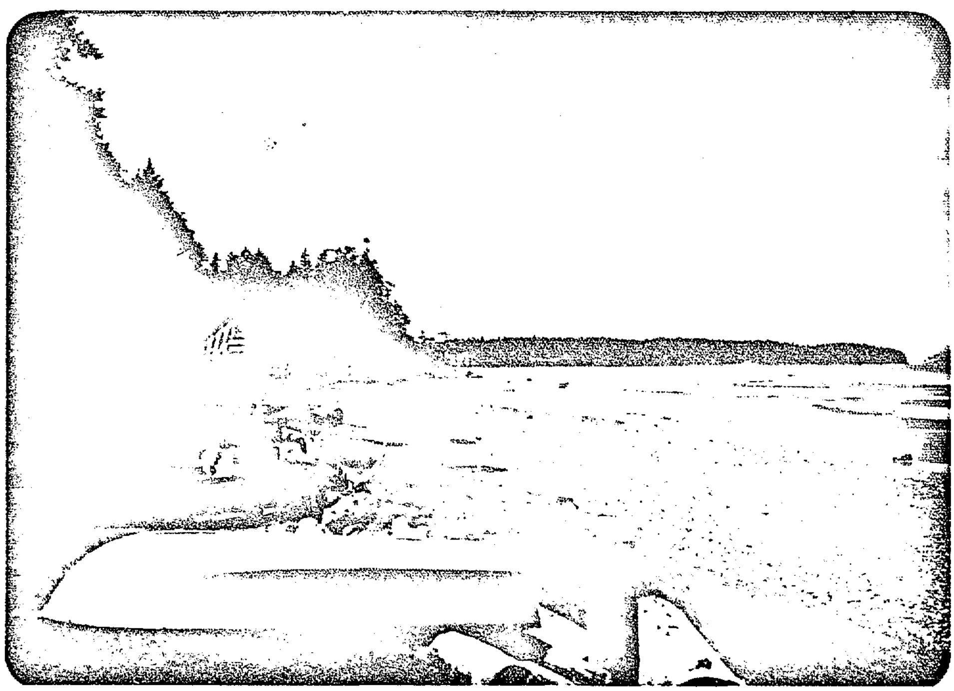

Figure 11. Photo taken in 1977 in almost the same spot as figure 10 above. Easily noticeable are: the beach surface is now concave, the sediment is coarser, and the high tide drift line is almost to the edge of the lawn.

county similar low tide terraces preferentially occur where eroding bluffs contain abundant sand. At present, only a relatively short stretch of shoreline (300-400 yards), located to the west, at the beginning of the drift sector, has glacial outwash sand and gravel exposed in the bluff. While that deposit does supply a moderate amount of useable material to the beach system by erosion and landslides, it appears to be far too small to have supplied the large volume of sediment present in the prograded beach and on the low tide terrace. All of the above evidence indicates that a large supply of sand/gravel material has been removed by erosion and as a result, the drift sector is presently in a net sediment deficit due primarily to natural causes. There is no doubt that the shore defense structures already built slow the erosion and deprive the beaches of still more sediment, which exacerbates the situation. However, when the volume of sediment involved is considered it becomes obvious that man's activities play a relatively small part in the problem.

The erosion rate of 4 feet per 10 years shown on Map C is derived from one measurement and the period of time assessed was only 15 years. Because of that short time period the indicated rate may be somewhat faster than if a longer time period had been available on which to base the computation.

Since erosion will continue along this sector, possibly even faster than it has, the question of a solution arises. Unfortunately, in a sector with a naturally low sediment supply rate, none of the choices are particularly appealing. The alternatives are:

(1) NO ACTION. By taking no action and letting moderate erosion continue the beaches would be partially supplied with needed sediment. Adjustments might be able to be made in locating new buildings and/or relocating existing buildings back from the shore.

(2) ARTIFICIAL BEACH NOURISHMENT. Sediment of suitable size could be brought in and placed on the beach near the beginning of the drift sector. This would allow the sediment to move naturally along the length of the drift sector and provide shoreline protection.

(3) SHORE DEFENSE STRUCTURES. Additional defense structures could be built. In the longer term this alternative could conceivably involve every property owner.

NORTHWESTERN FIDALGO ISLAND (BIZ POINT TO FLOUNDER BAY, Maps F and D). Upon initial evaluation the southern portions of this sector appear to have no influence on the northern part. That is, it appears as if the rocky headlands interspersed between embayments form large pocket beaches that have no transfer of material between them. Upon closer inspection, I find that there is indeed movement of sand past the headlands. The headlands do stop an appreciable amount of coarser material (gravel) which normally resides higher on the beach. The sand on the low tide terrace is easily transported around the headlands as can be seen in Figure 12. The longshore transport of only sand results in both Alexander Beach and Anaco Beach being totally sandy beaches, which is in sharp contrast to the situation of other beaches in the county. Virtually every other beach has at least some gravel and coarser material mixed with the sand; most, in fact, are predominately gravel and coarser material, as explained earlier.

Most of the length of this drift sector is essentially unmodified by man. Near the terminus however (Flounder Bay and Anaco Beach), a number of shore defense structures have been put in. Older navigational charts show the mouth of Flounder Bay mostly blocked by a westward growing spit that had it's base where the mouth of the marina is now. As a consequence of cutting through the base of the spit, the supply of sediment was cut off and the seaward face then required rip-rap to protect it. Some small amount of sediment may presently be transported across the marina entrance.

Figure 12. Low tide terrace sands visible at the tip of Edith Point at low tide, indicating that sand is easily transported past the headland.

At Anaco Beach seawalls and bulkheads have been installed along most of the shoreline. One property owner claims that the structures became necessary due to 30 to 60 feet of erosion that occurred during the last 13 years. I have not been able to find any direct evidence to dispute that claim. However, since that rate of erosion would be 6 to 12 times faster than anything encountered elsewhere in the county it is probably greatly exaggerated. In fact, such a rate would be 4 to 8 times faster than the highest rates reported from the western part of Whidbey Island (Island County) where the wave energy is significantly higher than in Skagit County.

The continued movement of sand past the headlands in this sector is obviously vital to the continued health of the beaches. Therefore, I would suggest that the county evaluate carefully any proposal that might interfere with sediment transport in this sector.

As covered in the slope stability section of this report, this drift sector derives a significant portion of it's sediment from landslides that are occurring on the bluffs. While it has been impossible to estimate the percentage contribution from that source, the fact that very few sandy bluff materials are exposed at the base of the slopes is significant. Since the primary material transported alongshore is sand, that would suggest that the landslide contribution from the sandy, upper portion of the slopes is quite important in the sediment budget of this sector.

SUMMARY

The north Samish Island and northwestern Fidalgo Island drift sectors were chosen for an expanded discussion because they illustrate a number of important points that are applicable to all drift sectors in Skagit County.

First and foremost is the question of sediment supply and transport. It becomes immediately obvious that beach sediment can be supplied in a variety of ways other than direct wave erosion. Additionally, the sediment one sees on the beach today, or lack of it, may be intimately connected to events that happened in the distant past. Equally significant is the fact that one must be aware that sediment transported alongshore is not necessarily stopped by imposing rocky headlands. The traditional view that a prograding beach is being supplied it's sediment by the nearest large bluff is overly simplistic, at best.

A third point that should be made is that interfering with the natural transport of sediment can often cost more in the long run in shore defense measures and property lost than any short term benefit gained.

Finally, it is worth noting that the alternatives for remedying erosion problems in sectors with a low sediment supply are not easy choices. There are other sectors in Skagit County that also are not well supplied. The difference in one major respect, is that those other sectors are not as heavily developed as Samish Island is. Therefore, the problem does not affect as many people.

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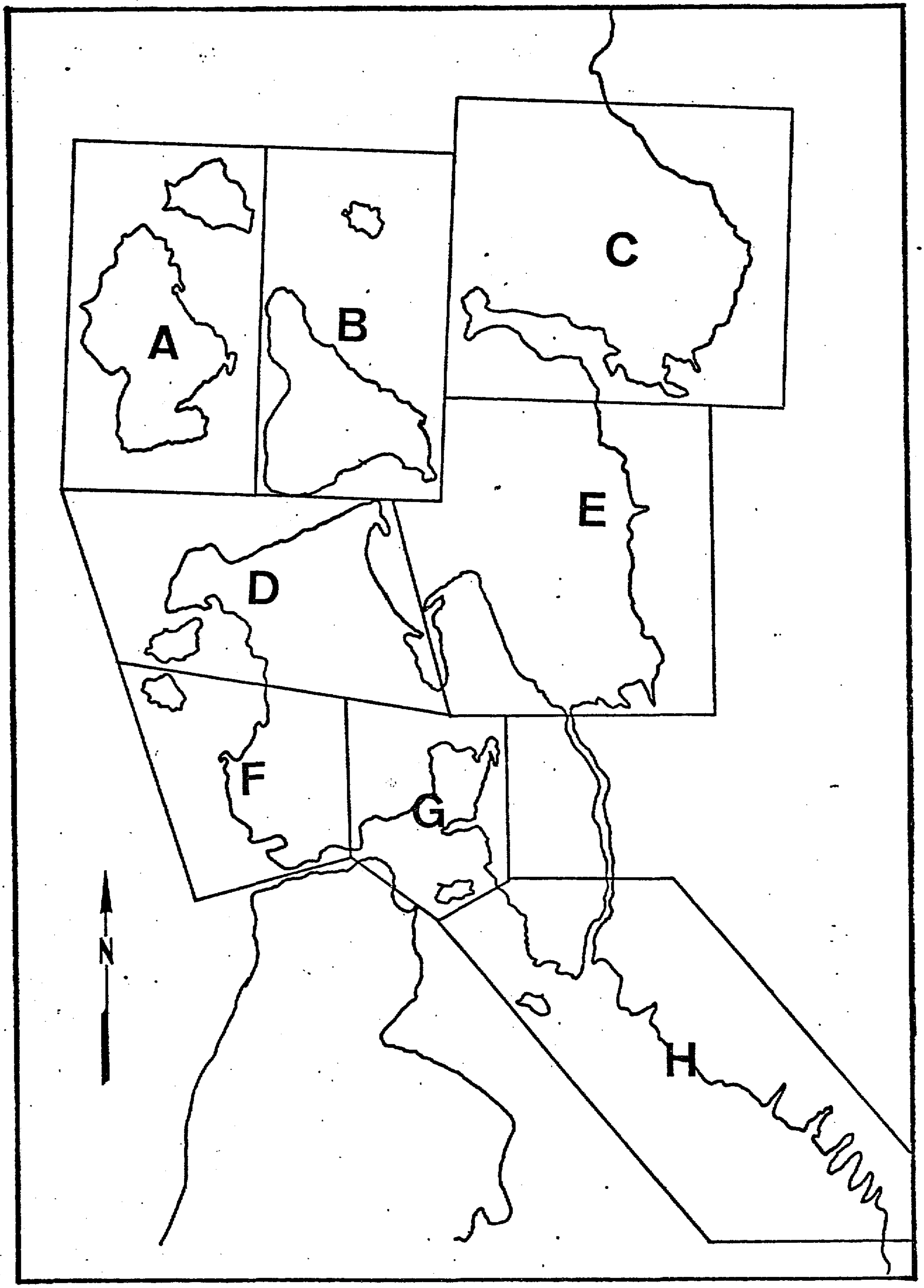


Figure 13. Index to the maps accompaning this report

KEY TO MAP SYMBOLS USED

oooooo — Bluffs composed of glacial and interglacial materials, less than 10 meters (30 feet) high

Bluffs composed of glacial and interglacial materials, more than 10 meters (30 feet) high

Rock shoreline with abrasion platform

Plunging rock cliffs, no abrasion platform

Bluffs composed of mixed or alternating glacial materials and rock

Prograded beaches

Mudflats

Direction of net long term sediment transport

Lightly modified shoreline, small shore defense structures

Significantly modified shoreline, large shore defense structures, original shoreline now isolated.

Heavily modified shorelines, industrialized or filled, original shoreline now nonexistant

Major landslide zones

30(1) — Centimeters (feet), mean minimum erosion per 10 year period

EXPLANATORY NOTES FOR MAP SYMBOLS

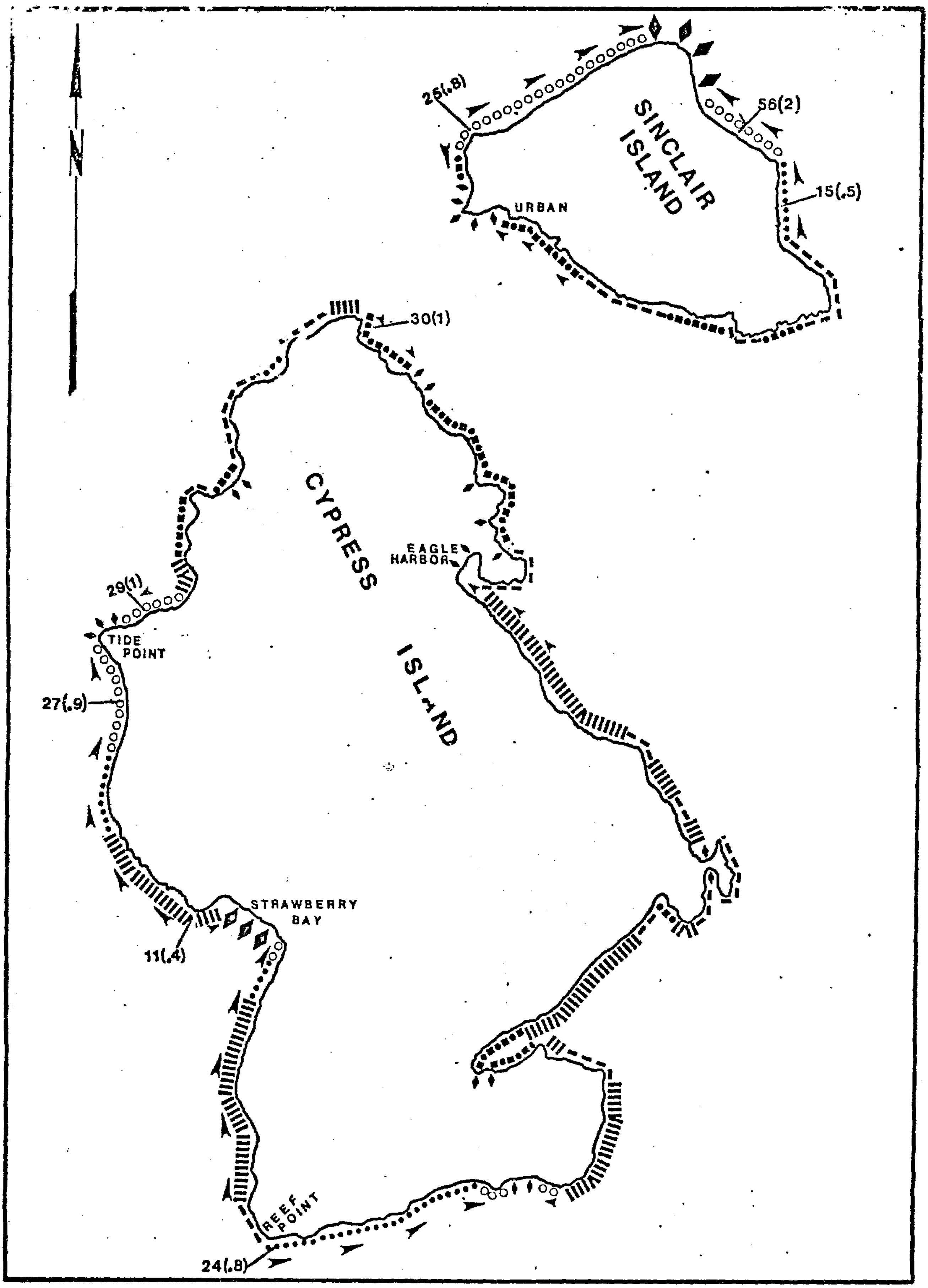
A) Where the round symbols (low and high bank glacial materials) are used it may be assumed that a typical beach of mixed gravel/sand is also present. If the mudflat symbol is combined with the above, then the mudflat forms what normally would be the low tide terrace.

B) If used alone the mudflat symbol means that the shoreline itself is a low lying area with no beach, typically found adjacent to the Samish delta(e.g. Bow and Edison vicinity)

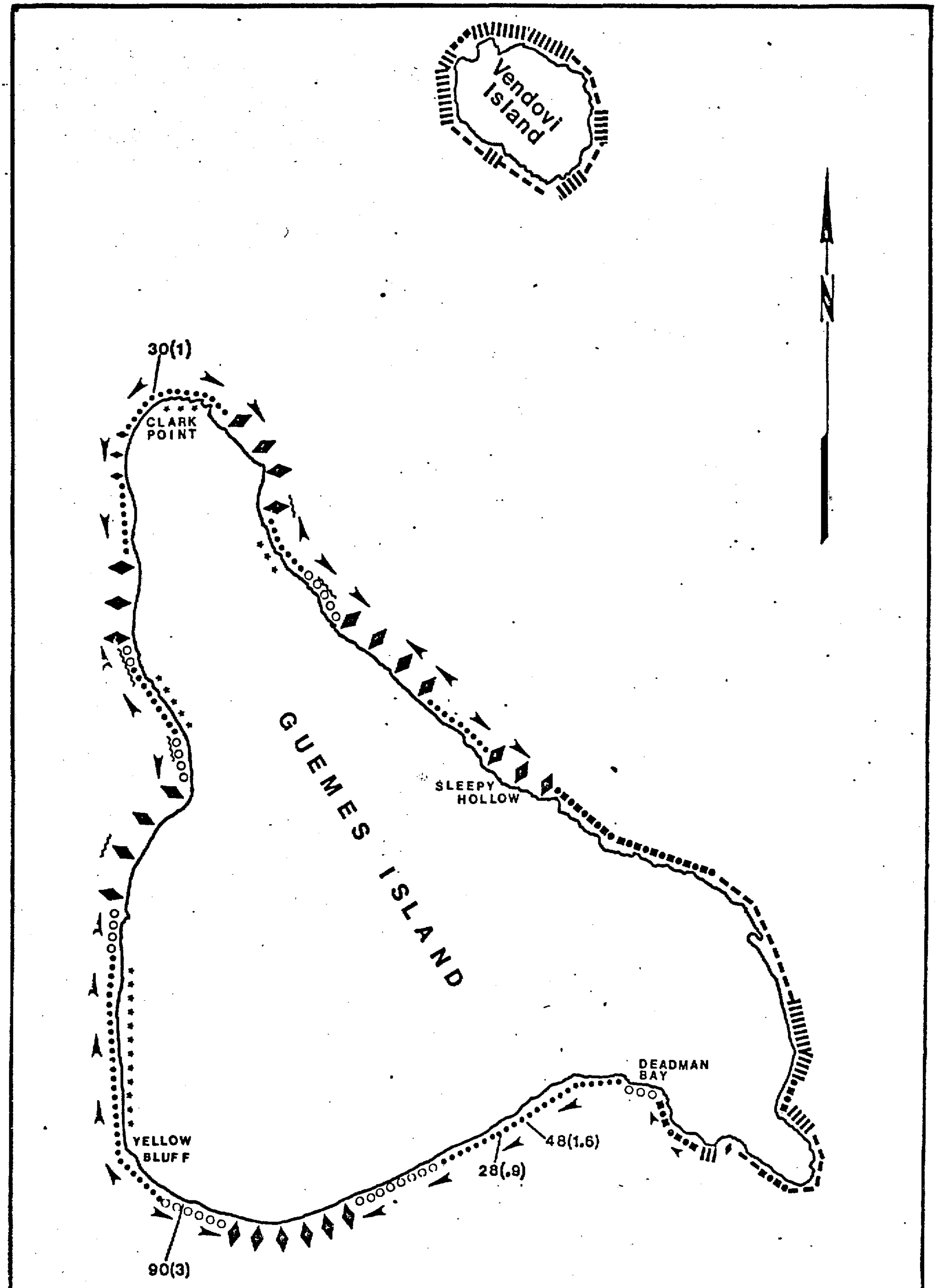
C) The size of the beach drift arrows are a qualitative measure of the supply of sediment in a sector and the rate at which the sediment is transported.

D) A diamond (prograded beach) used without sediment transport arrows means a pocket beach.

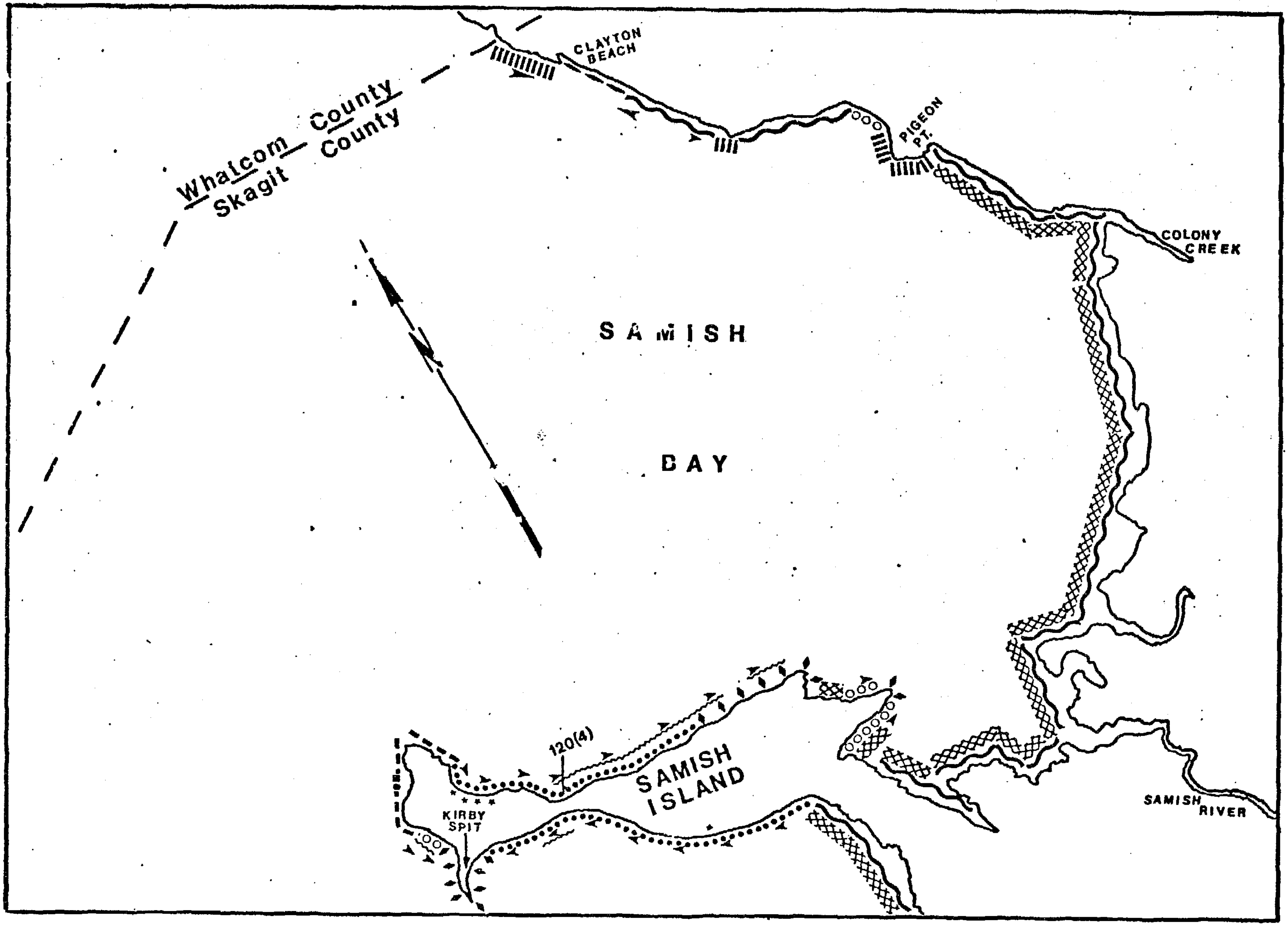
E) For ease of display, the symbols indicating modified shorelines are shown on the seaward side of the symbol which indicates the nature of the bluff and beach. In all cases defense structures are associated with the bank and not out in the middle of the beach as might be implied by their placement on the maps.



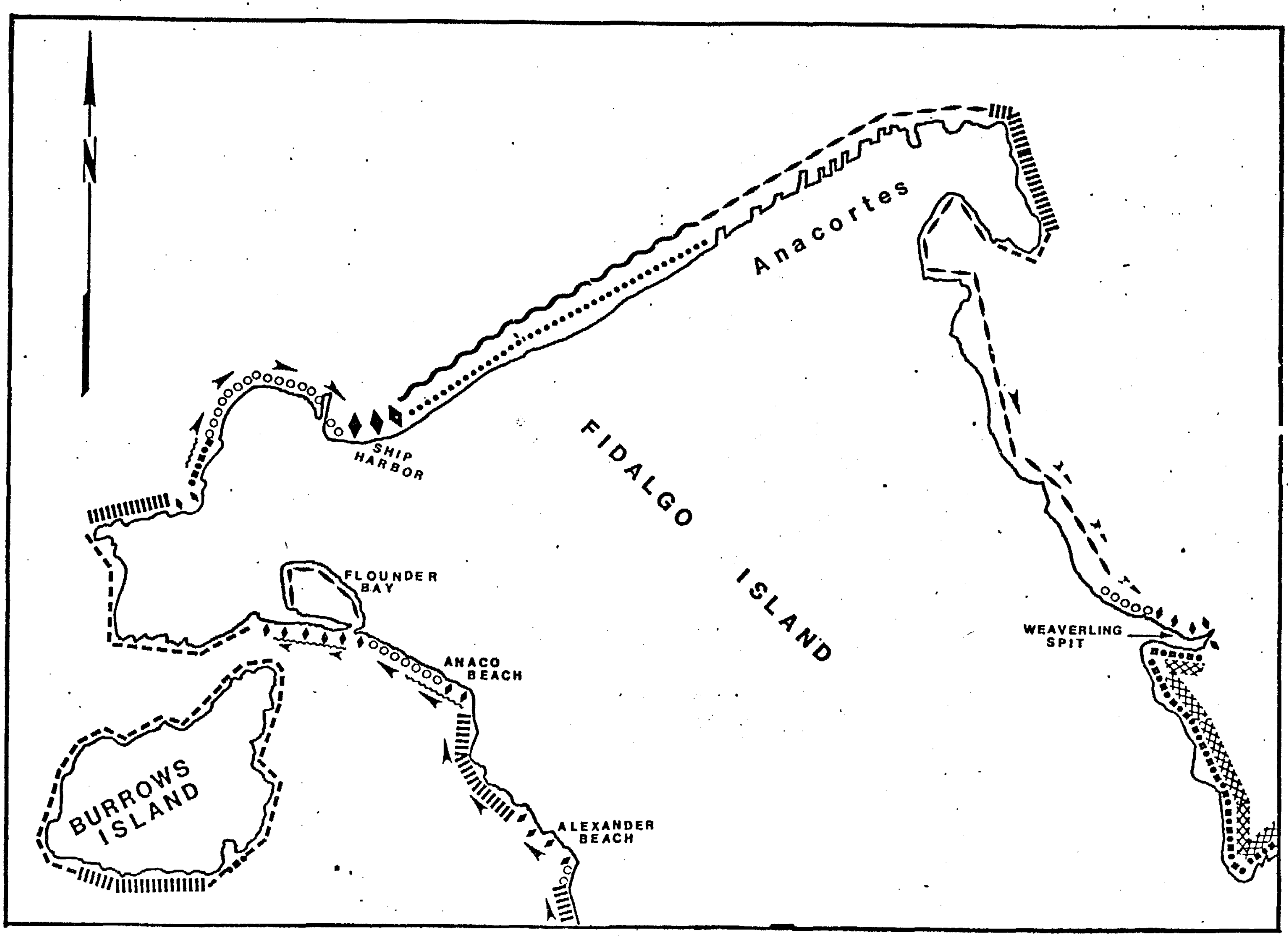
MAP A. SINCLAIR AND CYPRESS ISLAND



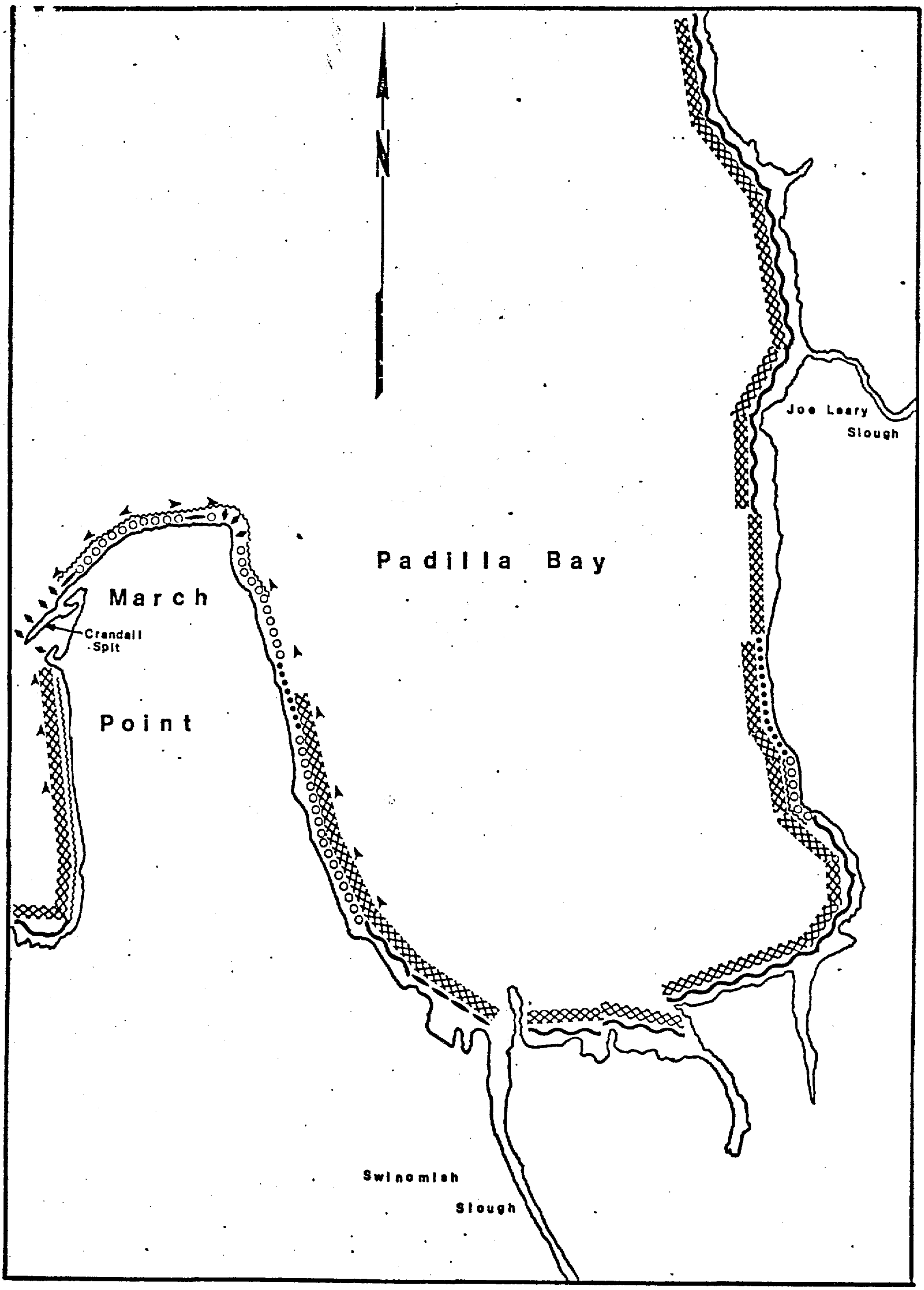
MAP B. VENDOVI AND GUEMES ISLAND



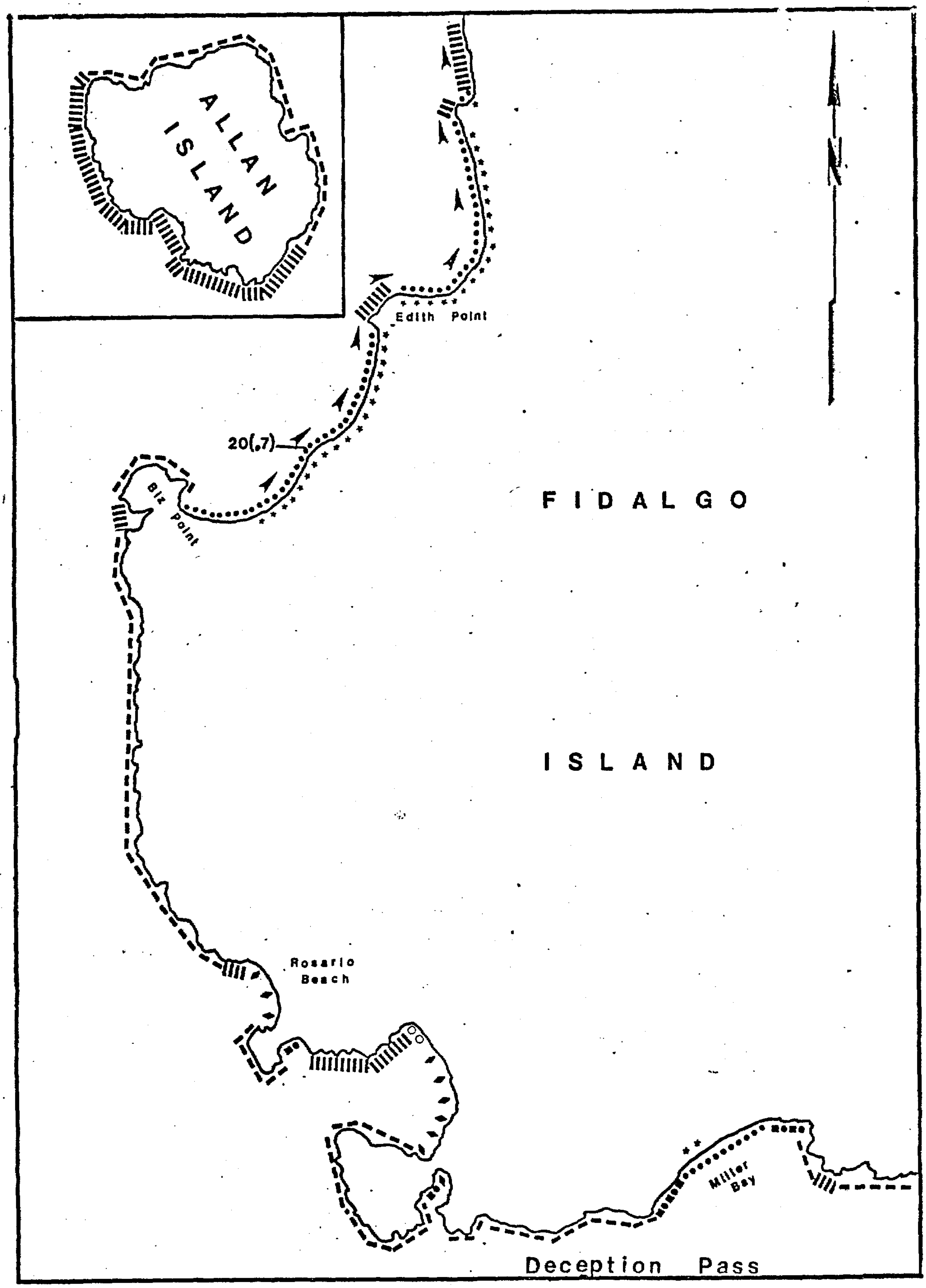
MAP C. SAMISH ISLAND AND THE SOUTHERN AND EASTERN PORTIONS OF SAMISH BAY



MAP D. NORTHERN FIDALGO ISLAND AND BURROWS ISLAND

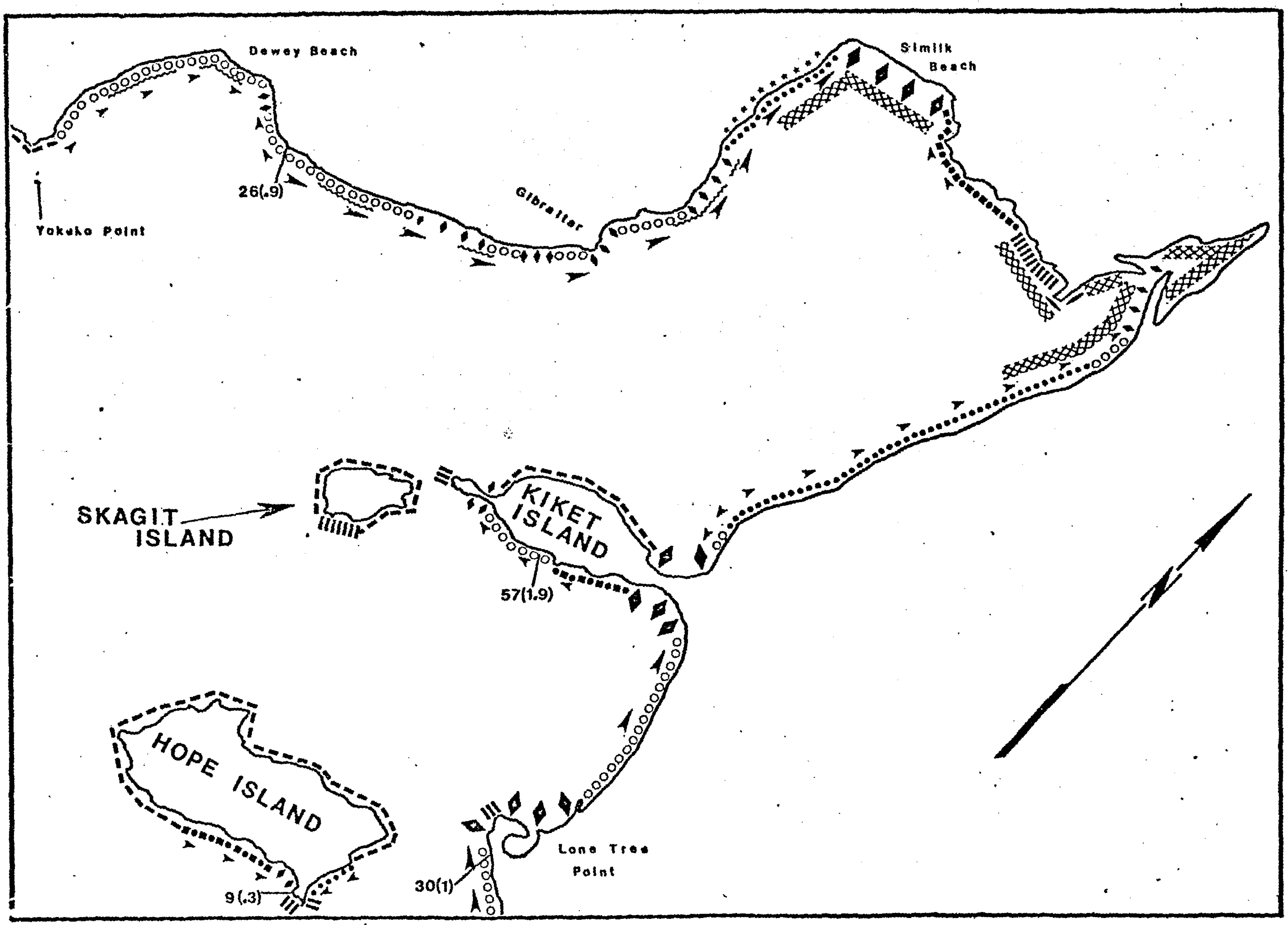


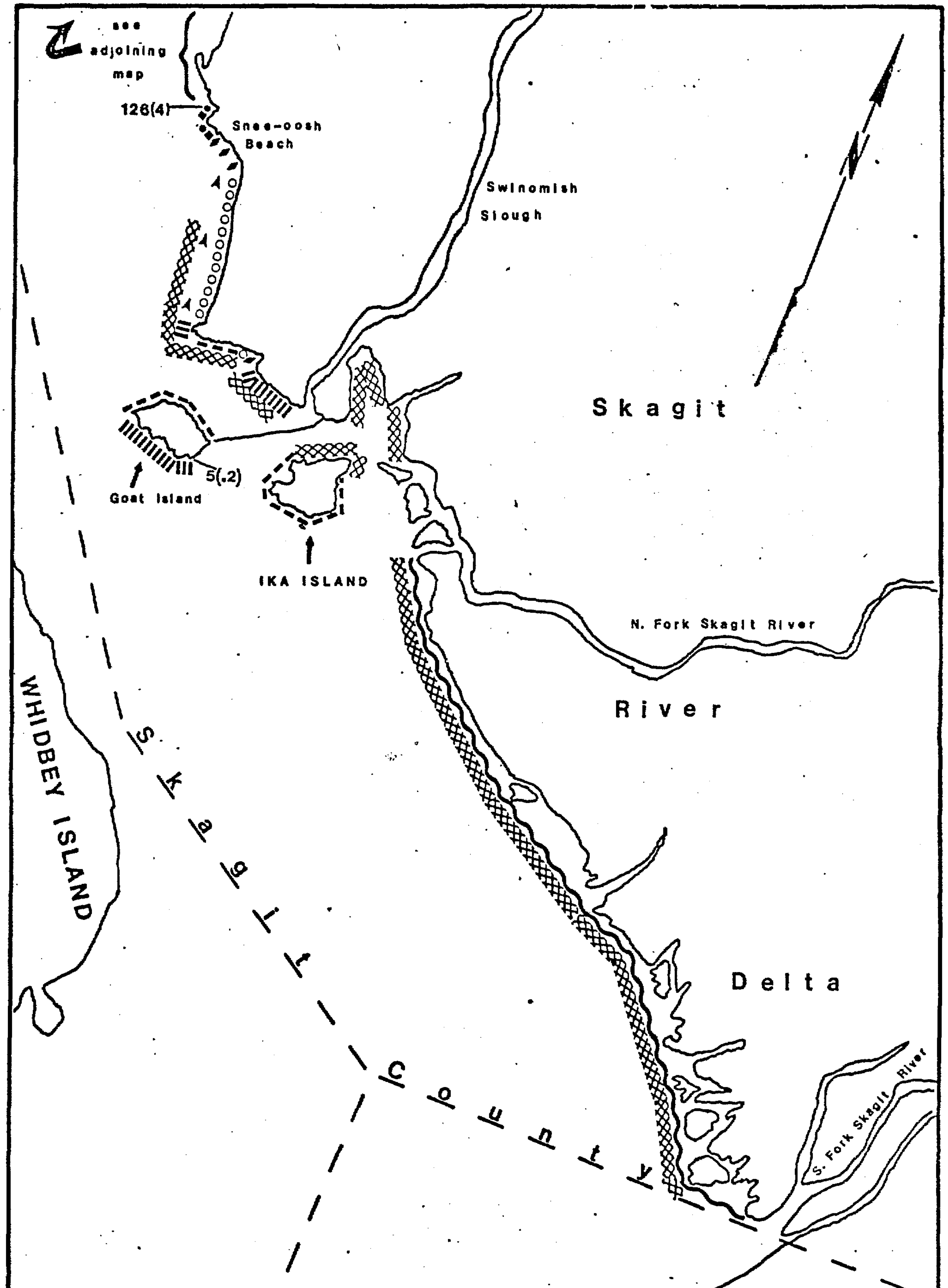
MAP E. MARCH POINT AND EASTERN PADILLA BAY



MAP F. WESTERN AND SOUTHWESTERN FIDALGO ISLAND, DECEPTION PASS, AND ALLAN ISLAND

MPA G. SOUTH CENTRAL FIDALGO ISLAND, SIMILK BAY, AND HOPE ISLAND





MAP H. SOUTHEASTERN FIDALGO ISLAND AND SKAGIT RIVER DELTA