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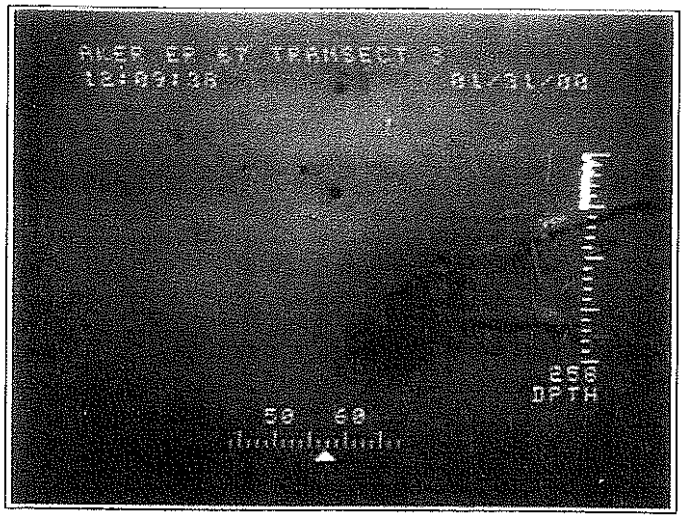
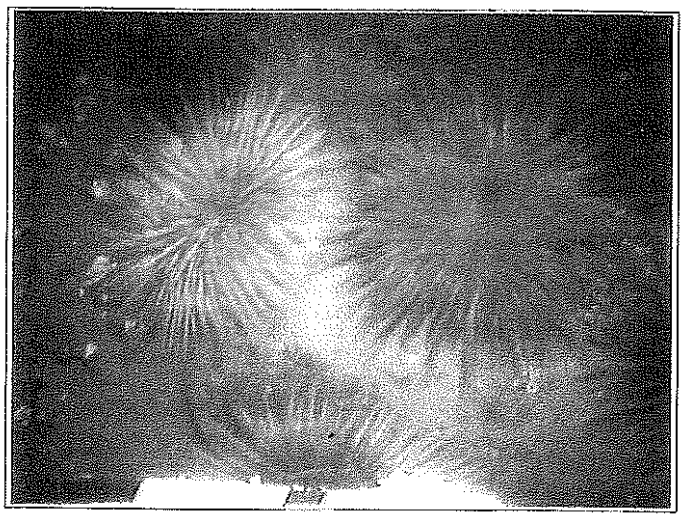
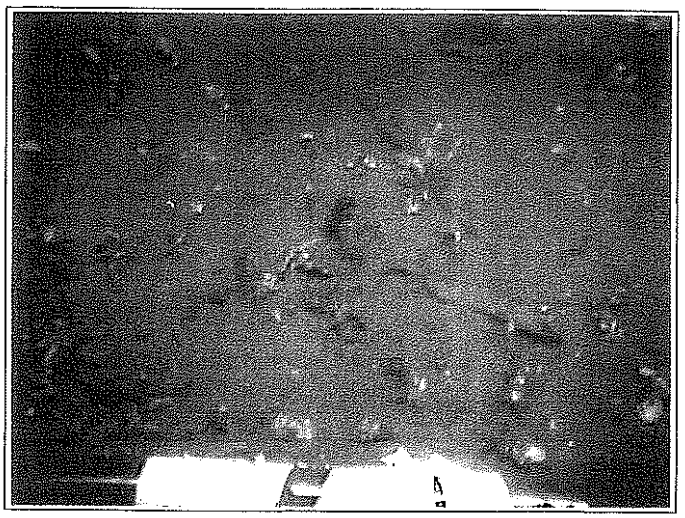
Prepared for:

Georgia Strait Crossing Pipeline Limited

ENVIRONMENTAL ASSESSMENT OF THE ECOLOGICAL SIGNIFICANCE OF INSTALLING A NATURAL GAS PIPELINE AROUND OR THROUGH ER67







Prepared by:

tera ENVIRONMENTAL CONSULTANTS (ALTA.) LTD.

December 2000

ENVIRONMENTAL ASSESSMENT OF THE ECOLOGICAL SIGNIFICANCE OF INSTALLING A NATURAL GAS PIPELINE AROUND OR THROUGH ER67

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Calgary, Alberta

December 2000

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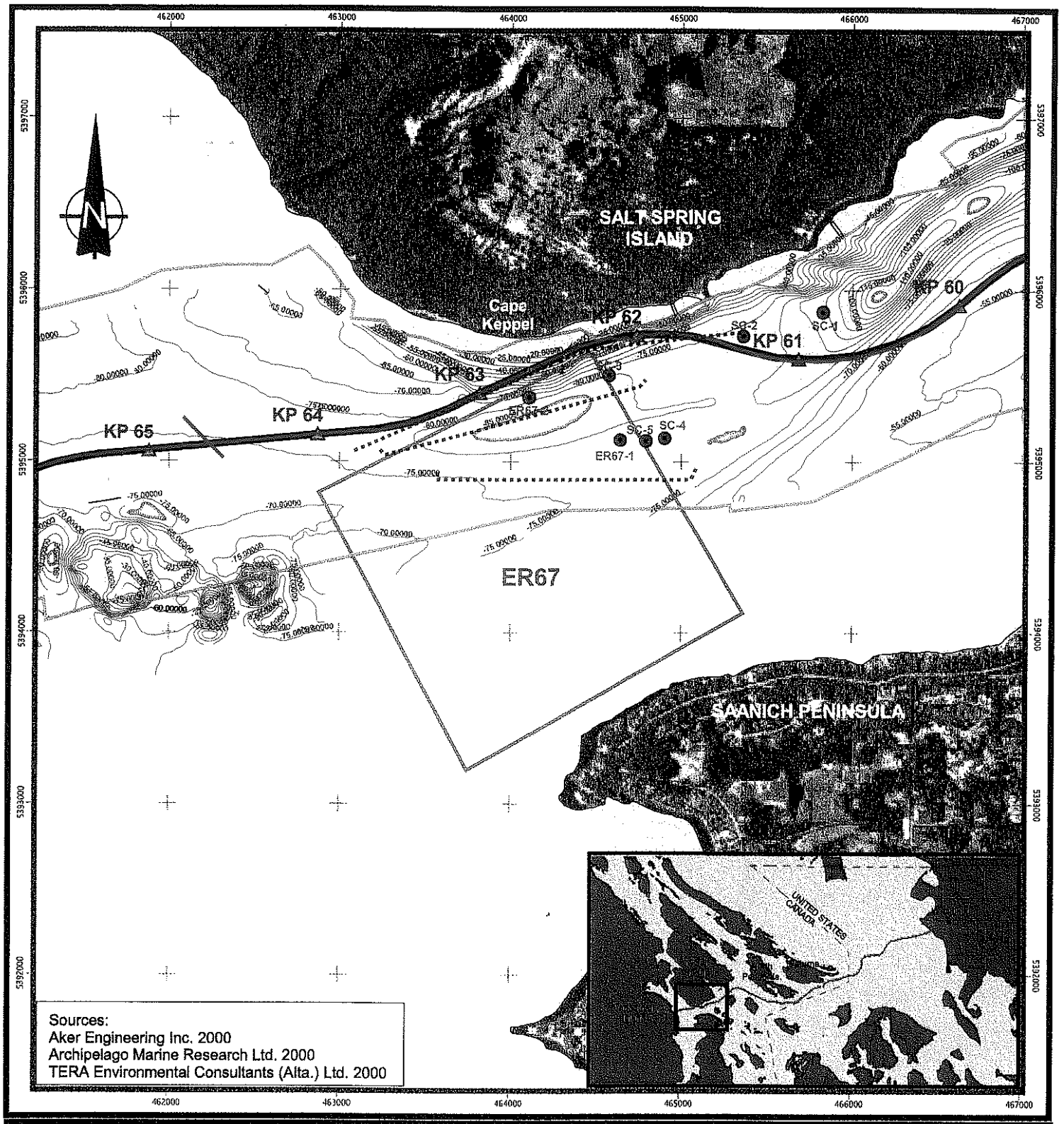
1.0 INTRODUCTION

Georgia Strait Crossing Pipeline Limited has applied to the National Energy Board to construct its proposed Georgia Strait Crossing Pipeline Project (GSX PL) from Sumas, Washington to Vancouver Island, British Columbia. This project includes installation of approximately 44 km of marine pipeline in Canadian waters, with approximately 1 km subject to deep trenching and approximately 22 km subject to shallow key-in trenching. The remaining 21 km will be surface laid. Routing for the pipeline by design, generally follows broad, flat, soft-bottom terrain for most of its length, however, the route is forced onto more steeply sloping terrain off the south end of Salt Spring Island to avoid Ecological Reserve 67 (ER67) (Figure 1). The approximate 2 km northerly deflection causes the route to divert from the level bottom environment of Satellite Channel to ascend a moderately steep slope before descending back down to the main channel.

Management authority of the seabed within ER67 and elsewhere in Georgia Strait is held by the BC Ministry of Environment, Lands and Parks while the federal government through the Department of Fisheries and Oceans has authority for the water column and commercial fisheries.

The proposed deflection around ER67 increases the costs and engineering requirements relative to what would be required were the alignment to take a more direct route through the level soft bottom substrate more typically associated with the central part of Satellite Channel and ER67. This report briefly discusses the background history of ER67, reviews previous and current environmental studies in the area and considers the environmental consequences of going around ER67 relative to two alternative routes through ER67.

Contemporary information presented on benthic infaunal communities within ER67 was obtained through benthic grab sampling and conducted under Park Use Permit SV0010163 dated May 25, 2000 in cooperation with Mr. C. Kissinger of BC Ministry of Environment, Lands and Parks.



Legend

- Proposed Pipeline Route
- Kilometer Point
- ER67 Boundary
- Depth Contours
- Scuba Transect
- Jan. 24-Feb. 1, 2000 ROV Video Transect
- Benthic Grab Site
- Aug. 4-13, 2000 ROV Video Transect
- Sidescan and Sub-Bottom Survey Boundary

(All Locations Approximate)

FIGURE 1

ECOLOGICAL RESERVE 67 AND GSX SAMPLING SITES

SCALE: 1:25,000

0.5 0 0.5 km

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2.0 HISTORY OF ECOLOGICAL RESERVE 67

Baseline studies of the diversity and abundance of benthic infaunal communities in Satellite Channel and nearby waters, including the Strait of Georgia by Ellis (1967a, 1967b, 1968, 1970) eventually lead to the establishment of ER67. The general area of ER67 and adjacent Satellite Channel was noted to support a high diversity of benthic infauna and associated demersal species. In 1975, ER67 was proclaimed by Order in Council to "conserve rich benthic communities typical of fine-grained, level bottom environments in the southern Gulf of Georgia" (BC MELP 1993). Its boundaries were set at 1 nautical mile (1,852 m) square and encompass an area of 343 ha. While ER67 occurs in an area of high benthic infaunal diversity and abundance, its exact orientation and dimensions appear to have been based more on practical, cartographic criteria rather than being tied to a precise ecological boundary.

Despite the area's establishment as an ecological reserve, it has been subject to continuous fishing pressure, including both beam and otter trawling. Shrimp trawling and prawn trapping occurred in ER67 until 1999. Groundfish trawling was closed in 2000. During GSX PL's geophysical survey of ER67, it was apparent that its surface has been subject to considerable modification as a result of ongoing bottom trawl activity (Terra Remote Sensing Inc. 2000). This observation corroborates first hand reports of commercial fishermen active in the area. Side scan sonar images taken of the area reveal contemporary surficial scour marks indicative of bottom trawl activity (Figure 2).

2.1 Previous Studies (Pre-GSX PL)

ER67 and adjacent Satellite Channel were the subject of multi-year biological inventory and research by the University of Victoria in the late 1960s (Ellis 1967a, 1967b, 1968, 1970). Ellis observed that, "Extensive level-bottom plains occupying the Strait of Georgia and adjacent inlets at depths more than about 50 m bear fine-grained sediments of silty-clays, clayey-silts and sandy-silts, and have faunas falling within the complex of Amphiura and *Maldane* - *Ophiura* communities" (Ellis 1970). This complex appears to be broadly distributed in similar habitats which range through Puget Sound and the southern Strait of Georgia. Ellis (1970) also noted that the shallower communities within these level-bottom plains tended to have richer standing crop biomass. In collections taken from the length of Satellite Channel, Ellis (1970) observed that 17 species occurred in every replicate from 6 stations, including 9 species indicated as "ecologically significant" (*Lumbrinereis* sp., *Nepthys* sp., *Maldane glebifex*, *Sternaspis fossor*, *Prionospio* sp., *Compsomyax subdiaphana*, *Macoma eliminata*, *Yoldia ensifera*, and *Ophiura sarsi*). Ecological significance was based

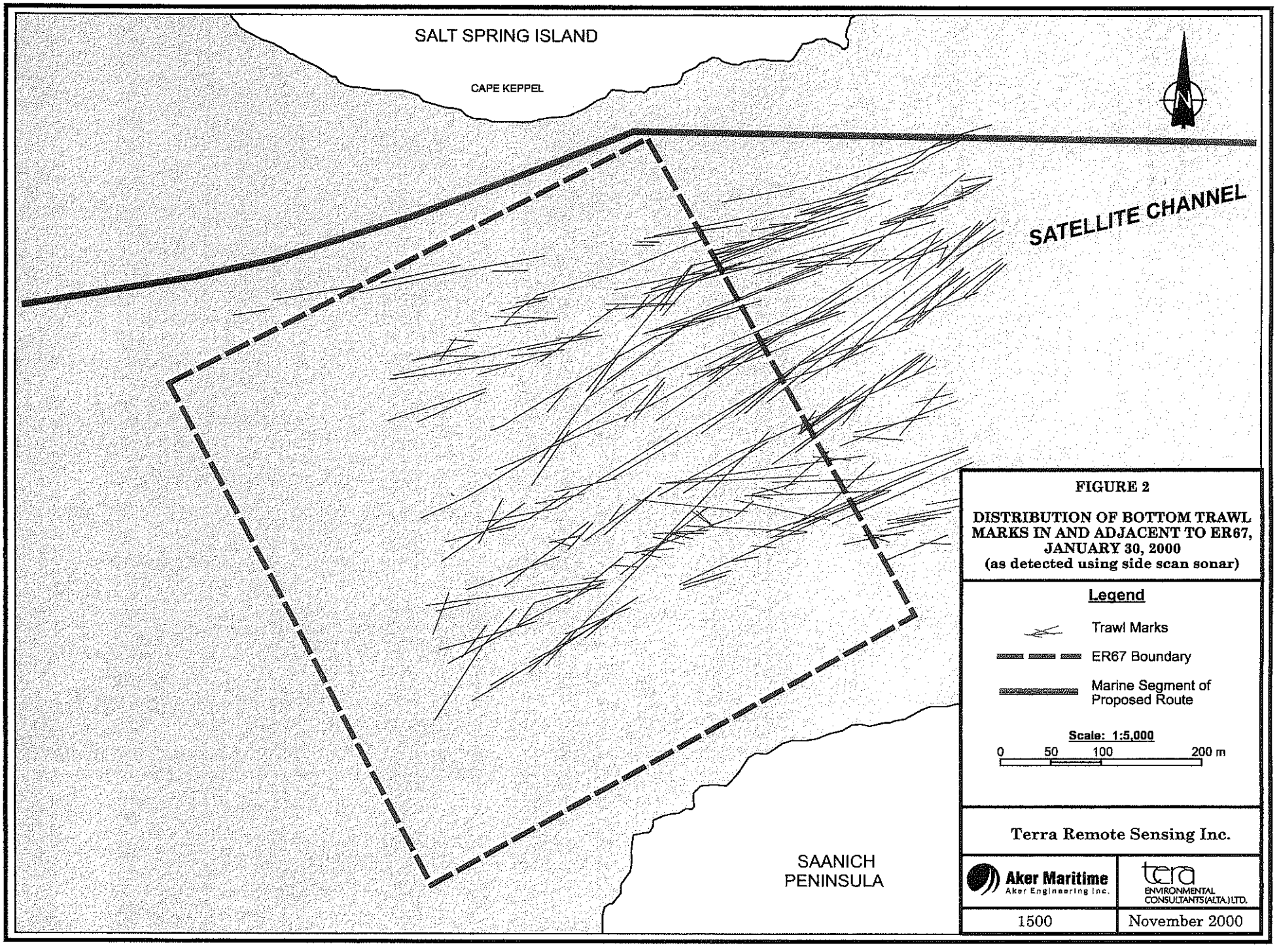


FIGURE 2

DISTRIBUTION OF BOTTOM TRAWL MARKS IN AND ADJACENT TO ER67, JANUARY 30, 2000
(as detected using side scan sonar)

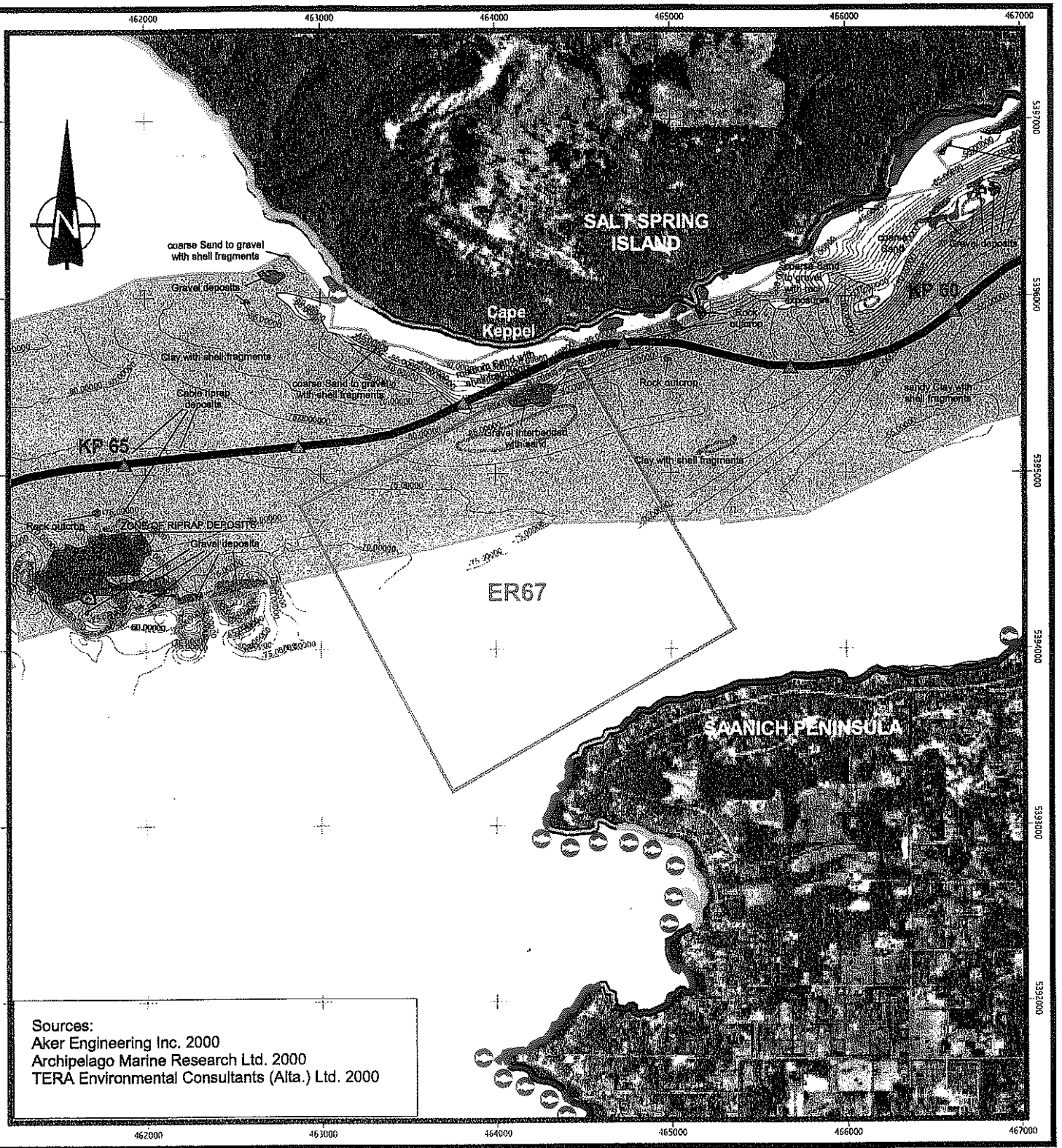
on their high frequency of occurrence in samples, high densities, high biomass and/or that they had a high index of dry weight biomass weighted by density. Slight differences were noted relating to the percentage of sand versus silt at a given site. Ellis (1970) also observed that the east end (off Isabella Point on Salt Spring Island) and west end (south of Separation Point) of Satellite Channel tended to have lower standing crop biomass than locations in the center of the channel (which would include ER67).

ER67 lies outside the area of primary focus during the Saanich Inlet studies (BC MELP 1996) but was included in the study area used for an environmental assessment of a Chevron fuel loading facility at Hatch Point (Debrocky Seatech Limited 1981). The adjacent shoreline in the vicinity of Cape Keppel was described as consisting of bedrock, boulder, and gravel on 10-45° slopes. Tidal movements were characterized by a flood tide travelling east to west up Satellite Channel and an ebb tide travelling west to east. The Debrocky Seatech Limited (1981) study identified the general area of ER67 and adjacent Satellite Channel as an area of flatfish spawning, salmon migration and as a place of flatfish and herring roe fisheries. Information on historic herring spawning in the area was recently documented by Hay and Carter (1999). In regard to Salt Spring Island, they noted one record of herring spawning off Cape Keppel in 1941 (Figure 3), one record off Isabella Point in 1953 and more frequent spawning in Fulford Harbour.

2.2 GSX Environmental Studies in and Adjacent to ER67

In the course of planning for the GSX PL more detailed data has been obtained on the occurrence and distribution of species and benthic habitats from the following surveys:

- Nearshore scuba reconnaissance, September 30, 1999 (TERA Environmental Consultants (Alta) Ltd.)
- Remotely Operated Vehicle (ROV) video survey, January 30, 2000 (Terra Remote Sensing Inc. 2000; biological interpretation by Archipelago Marine Research Ltd.)
- Side scan sonar and sub-bottom profiling, January 24 - February 1, 2000 (Terra Remote Sensing Inc., 2000)
- Reconnaissance-level benthic grab sampling program, June 4, 2000 (Burd *et al.* 2000) and particle size analysis (GeoSea 2000)
- Side scan sonar and sub-bottom profiling, August 4-13, 2000 (Aker Engineering Inc. and Williams Gas Pipeline)
- ROV video survey, August 4-13, 2000 (McDaniel and Glaholt 2000).



Legend

- Proposed Pipeline Route
- Kilometer Point
- ER67 Boundary
- Depth Contours
- Aker Engineering Inc. Sidescan and Sub-Bottom Survey Boundary

Subsea Habitat (Aker Engineering Inc.)

- Gravel - Predominant Sediment Type
- Rock Outcrop/Rock Exposure
- Sand - Predominant Sediment Type
- Silt/Clay - Predominant Sediment Type

Shoreline Type (Howes and Wainwright 1993)

- Rock Cliff
- Rock Platform
- Rock with Gravel Beach
- Rock with Sand & Gravel Beach
- Sand & Gravel Beach
- Sand & Gravel Flat
- Identified Bull Kelp Beds on southern Salt Spring Island (TERA, Sept. 2000)
- Herring Spawning Location (Hay and McCarter, DFO 1999)

(All Locations Approximate)

FIGURE 3

SUBSTRATE TYPE AND BULL KELP BEDS

SCALE: 1:25,000

0.5 0 0.5 km

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The locations of these sampling efforts are identified on Figure 1 and the results are briefly summarized in the sections which follow.

2.3 Benthic Habitat Types

2.3.1 Nearshore Salt Spring Island

From the south shore of Salt Spring Island in the vicinity of ER67, marine habitats grade from an inter-tidal zone dominated by coarse "hard-bottom" substrate to a broad channel flat dominated by very fine-textured "soft-bottom" substrate. This transition occurs through a variable distance though probably averages approximately 300-400 m. The intertidal zone is dominated by segments of coarse sand, gravel, cobble, boulder, and bedrock outcrop. Exposed bedrock ridges in places extend below the inter-tidal zone for variable lengths. The horizontal width of the inter-tidal zone is very narrow (typically <10 m) along the south coast of Salt Spring Island due to the steeply sloping topography in this area. Bull kelp forms a seasonal structural component of the marine habitat in places along the coast in this area including one stand north of the northeast corner of ER67 (Figure 3). Other bottom oriented green and brown algae are also present along a narrow depth range in this area. Below the intertidal zone, silt covered coarse sands, gravels and rock fragments rapidly give way to increasingly finer textured sediments which blanket the level sea bed.

2.3.2 ER67

Three broad sub-tidal morphological units (*Flat*, *Trench* and *Slope*) and five substrate types ("Clay with shell fragments", "Coarse sand to gravel with shell fragments", "medium sand with shell fragments", "gravel interbedded with sand", and "rock outcrop") are found in ER67 and adjacent Satellite Channel (Figure 3). All three are traversed by the proposed pipeline alignment around ER67 while only the *Flat* morphological unit would be traversed by either of two alternate routes through ER67 (Figure 4). As discussed in Section 1.1 above, ER67 was established to conserve the benthic communities associated with "fine-grained, level-bottom environments" and it is these environments that would most closely coincide with the *Flat* morphological unit identified in ER67. Approximately 85% (291 ha) of ER67 occurs on this level soft-bottom habitat type which is dominated by fine-grained substrates (sand, clay and shell fragments).

It is estimated that less than 5% (<17 ha) of ER67 consists of what has been characterized as a non-depositional, scour-formed *Trench* morphological unit comprised of coarse substrates (gravel and shell fragments) and believed subject to relatively high current velocities. It should be noted that the *Trench* unit has been described based on the

presence of what appears to be scoured, coarse substrates at approximately 85 m depth at the bottom of the *Slope* morphological unit rather than well defined bathymetric variation.

The *Slope* morphological unit also appears to occupy less than 5% (<17 ha) of ER67 and is comprised of a sloping shoulder of near surface coarse substrate (gravel, coarse sand and shell fragments) covered to varying degrees by a thin veneer of silts and organic deposits. At depth, the south shoulder of Saltspring Island is bedrock controlled, overlain to varying degree by larger rocky debris. *Trench* and *Slope* morphological units occur in the northeast quarter of ER67.

Particle size analysis for benthic grab samples taken along the toe of the *Slope* morphological unit and from within the *Flat* morphological unit of Satellite Channel in and adjacent to ER67 showed silt and clay content ranging from 38% to 41% and sand content ranging from 62% to 59% (GeoSea 2000). The most northerly benthic grab sample site occurred at the approximate toe of the *Slope* and had the highest coarse substrate content (66% sand) of any of the benthic grab samples taken. These samples suggest a relatively uniform substrate composition through this area, a factor which is mirrored in the benthic infaunal samples collected from these same sites (Section 2.5).

2.4 Species Habitat Associations

2.4.1 Nearshore Salt Spring Island

Species observed during diving reconnaissance along the south shore of Salt Spring Island on September 30, 1999, were typical of coarse substrate dominated nearshore environments in southern BC coastal waters. Species present included bull kelp, plumose anemone, grey brittle star, California sea cucumber, alabaster nudibranch, graceful crab, red rock crab, coonstripe shrimp, feather duster worms, sunflower sea star, short-spined sea star, red sea urchin, various hydroids and bryozoans, acorn barnacle, cup corals, quillback rockfish, China rockfish, copper rockfish, painted greenling, kelp perch, and speckled sanddab.

A shelf located north of ER67 and the proposed pipeline route near Cape Keppel, has also been identified by a local crab fisherman as an important local area for Dungeness crab (Lyttle pers. comm.)

2.4.2 Sub-tidal "Flat" Associated Benthic and Demersal Species

ROV video survey in January 30, 2000 involved deployment of a video equipped, remotely operated vehicle along three transects. Two transects went through ER67 while a third went around ER67 on a track roughly approximating the proposed pipeline alignment. This survey allowed viewing an approximate 0.5 - 1.0 m wide swath of seabed.

The August 4-13, 2000 ROV video survey provided video coverage of an approximately 0.5 - 1.0 m swath of seabed along the proposed pipeline alignment with a very high degree of positional accuracy.

The January 30, 2000 ROV survey identified 37 taxa of benthic and demersal species within the *Flat* type habitat dominating ER67 and most of Satellite Channel (Appendix 1) (Terra Remote Sensing Inc. 2000). The three most frequently occurring taxa were plumose anemone, vermilion star, and flatfish (English sole, Dover sole, flathead, slender or rex sole). During this survey, 21 taxa were uniquely associated with this morphological unit (white sea pen, brittle star, blood star, fat henricia, ochre sea star, spot prawn side striped shrimp, pink shrimp, unidentified brachyuran crab, octopus, stubby squid, striped nudibranch, unidentified worm, snail fish, Pacific sanddab, unidentified gadids, Pacific cod, walleye pollock, Pacific hake, spiny dogfish, copper rockfish). All of these taxa were confined to observations of from one to three individuals and their uniqueness may or may not be a function of sampling limitations.

The August 4-13, 2000 ROV transect through the same *Flat* morphological unit identified 17 taxa of invertebrate and fish (Appendix 2) (McDaniel and Glaholt 2000). Two species, plumose anemone, and a sea whip were considered "abundant" while all others were considered "few" in number. At least eleven taxa observed during the January 30, 2000 survey on the *Flat* morphological unit were also recorded during the August 4-13, 2000 ROV survey (orange sea pen, white sea pen, plumose anemone, swimming anemone, Dungeness crab, vermilion star, sunflower star, spiny mud star (sand star), English sole, eelpout, walleye Pollock). Dungeness crab were confirmed present on this and the *Slope* morphological unit during the August 4, 2000 ROV survey.

2.4.3 Sub-tidal "Slope" Associated Benthic and Demersal Species

During the January 30, 2000 ROV survey, species observed through the *Slope* morphological unit included relatively high density of plumose anemone and vermilion star, as well as relatively moderate densities of flatfish and spot prawn (Appendix 1). Rose star and mottled sea star, were the only species uniquely observed on the *Slope* unit. Species observed during the August 4-13, 2000 ROV survey on the *Slope* morphological unit also included plumose anemone and vermilion star, as well as orange sea pen, white sea pen, swimming anemone, sunflower star, leather star, Dungeness crab, longnose skate, plainfin midshipman, walleye pollock, English sole, and blackbelly eelpout (Appendix 2). All of these were described as being "few" in number as opposed to "common" or "abundant".

2.4.4 *Sub-tidal "Trench" Associated Benthic and Demersal Species*

The January 30, 2000 ROV survey identified 14 taxa within the *Trench* morphological unit (Appendix 1). Relatively high density of feather duster or parchment tube worms were observed in this unit compared with the *Flat* or *Slope* units (0.382 images/m compared with 0.001 and 0.061 images/m respectively). Similar patterns also occurred for red sea urchin, and certain species of flatfish. All species observed in the *Trench* unit, with the exception of the red urchin, also occurred in the *Flat* unit. The August 4-13, 2000 survey did not distinguish the *Trench* morphological unit which would have been to some extent encountered between KP 61 and KP 63.

2.4.5 *Comparison of Flat, Trench and Slope Associated Benthic and Demersal Species*

During the January 30, 2000 survey, a total of eight taxa were observed in all three habitat units (plumose anemone, swimming anemone, parchment or feather duster worms, sunflower star, vermilion star, spiny pink sea star, (Dungeness-type) crab, and unidentified sculpin). A total of 21 taxa were observed exclusively on the *Flat* morphological unit which forms the largest percentage of ER67, compared with 2 taxa for the *Slope* and 1 taxa for the *Trench* morphological unit. This apparent difference may be attributable to sampling intensity alone. During the August 4-13, 2000 surveys, 82% (14) of the benthic taxa and demersal species observed on the *Flat* morphological unit were also observed on the *Slope* morphological unit.

Considering the total number of taxa or species groupings alone (excluding benthic infauna) and adjusting for length of morphological unit surveyed, the *Trench* unit (0.206 taxa/m) had 29 times the density of taxa/m observed in the *Flat* morphological unit (0.007 taxa/m) and about 4 times the density as were noted on the *Slope* unit (0.057 taxa/m). It is likely that this is inversely the case where benthic infauna are considered.

2.4.6 *Benthic Infauna*

Seven replicate benthic grab samples were collected within and adjacent to ER67 (two samples in ER67, five samples adjacent) (Figure 1) (Burd *et al.* 2000). All seven were taken from habitat that would fall into the *Flat* morphological unit, though samples ER67-2 and SC-3 are at the toe of the *Slope* morphological unit. Sample SC-1 was approximately 1 km east of the east boundary of ER67. The total number of taxa per 0.1 m^2 grab ranged from 85 (site SC-2) to 118 (site SC-5) with abundance values (from 1.0 mm sieve sample) ranging from 4,754 individuals/m^2 (site SC-1) to 10,169 individuals/m^2 (site SC-3) and biomass

(excluding megafauna) ranging from 9.1 g/grab (site SC-5) to 16.5 g/grab (site SC-3) (Burd *et al.* 2000).

Data for benthic infaunal collection suggested a relatively homogenous set of samples (Appendix 3). While sampling was of a reconnaissance nature, cluster analysis of the samples obtained suggest there are no striking differences between samples collected in and adjacent to ER67 (Burd *et al.* 2000). Interestingly, no species of the polychaete genus *Maldane* was recovered from any of the GSX PL samples, in contrast to Ellis (1970) who reported *Maldane glebifex* in every sample. Eight of the other "ecologically significant" species reported by Ellis in the late 1960's appear to still be present in the area. It is possible that *Maldane glebifex* may be sensitive to trawling, however, it's absence may also be attributable to sampling variability and/or natural biophysical variation (Macdonald pers. comm.).

2.4.7 Comparison of Benthic Infaunal Species Assemblages between 1967 and 2000

Comparison of the results of contemporary benthic infaunal sampling conducted for GSX PL with samples obtained by the University of Victoria in the late 1960s is difficult due to differences in sampling effort, methodology, changes in taxonomy and taxonomic precision. Abundance and biomass dominants show a few similarities, particularly for larger bivalves and larger echinoderms. *Compsomyax subdiaphana*, *Macoma carlottensis, M. eliminata*, *Yoldia* spp., and *Brisaster latifrons* were predominant in both the samples obtained in the late 60s and in the year 2000 samples. Unlike the earlier studies, the current study did not show echinoderms to be abundant biomass dominants or important in terms of overall proportions (Burd *et al.* 2000).

While ER67 has had a long history of bottom trawling activity, the present study suggests at least benthic infaunal communities in and adjacent to ER67 remain similarly diverse and productive. While additional sampling would help confirm this, to the extent this is true, it may in part be attributable to removal of some percentage of demersal and benthic predators (*e.g.,* flatfish) by trawling. In this case, impacts to some species associated with trawling may have been partially offset by predator removal.

3.0 COMPARISON OF POTENTIAL IMPACT OF PIPELINE CONSTRUCTION FOR ALTERNATE ROUTES AROUND OR THROUGH ECOLOGICAL RESERVE 67

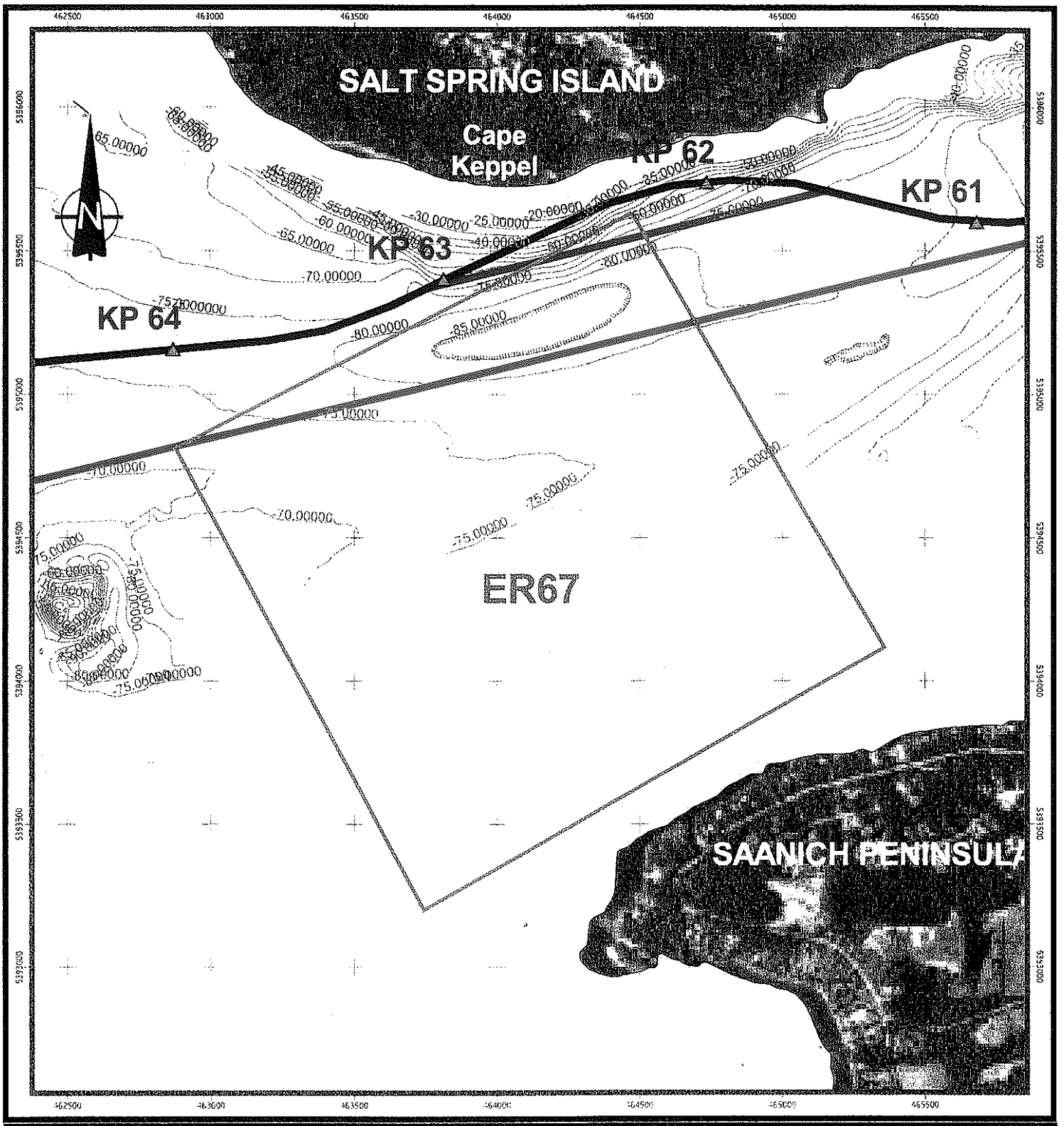
Consideration has been given to pipeline routing around ER67 (as proposed) or alternately through ER67 (Table 1 and Figure 4). The construction techniques for route alternatives A and B through ER67 would involve trenching of the pipe such that through time, the pipe will be buried by natural sediment transport. This operation would be routine and take perhaps 3-4 days for trenching and burial. Going around ER67 as proposed, whether by trenching or using surface laid pipe with some form of bracing (eg. clump weights) or a combination of the two will take perhaps two weeks longer owing to the more complex geometry of the alignment and installation procedures. For both the porposed and alternate routes, sediment will be translocated, have some potential to smother less mobile species and temporarily increase turbidity. In each case cases, the species most directly impacted will be associated with soft-bottom communities. This effect will be somewhat greater for the proposed route due to its greater length (*i.e.*, approximately 100-200 m longer). Austin *et al.* (1996) noted that most animals found on soft-bottom substrates (*e.g.*, sand, mud) have structures or behaviour to avoid smothering. Soft-bottom benthic communities, show relatively rapid recovery to short-term sediment burial and sediment disturbance (Essink 1999, Wulff *et al.* 1997, Levinton 1995). Essink (1999) reported that estuarine nematodes could survive burial by 10 cm (4 in) of dumped dredged sediment, mussels and oysters could "cope" with 1-2 cm (0.4-0.8 in) and that other macro-zoobenthos could survive sediment deposition of 20-30 cm (8-12 in). The proposed route does place the pipeline construction activity in closer proximity to fringing kelp beds and localized productive crab habitat found along the south coast of Salt Spring Island. Austin *et al.* (1996) suggested that high levels of sedimentation at critical periods could adversely affect settlement of macro-algae. Increasing turbidity and sedimentation toward the shoreward margin of Salt Spring Island could temporarily inhibit the successful re-establishment of macro-algae though east-west current flow through Satellite Channel, distance of the construction activity from the nearest macro-algae beds, temporary nature of the activity (4 weeks) and ability to partially direct sediment translocation suggests this effect should be of very limited to negligible extent.

Austin *et al.* (1996) identify purple (ochre) sea star (*Pisaster ochraceus*), geoduck (*Panopea abrupta*), butter clam (*Saxidomus gigantea*), Pacific (Nuttal's) cockle (*Clinocardium nuttallii*), horse clam (*Tresus capax*), mottled (painted) anemone (*Utricina crassicornis*) and tar spot algae (*Petrocelis middendorfii*; suggested by Kozloff (1993) to actually be a life stage of *Gigartina papilatta*) as potentially more sensitive species in nearby Saanich Inlet due to their long life expectancy, often slow recruitment and /or slow growth rate. Purple sea star was reported at low density (<0.001 images/m) within the *Flat* unit of ER67 during the January 30, 2000 survey. None of the "sensitive" bivalves were recovered during the

TABLE 1

COMPARISON OF ENVIRONMENTAL CONSEQUENCES OF PIPELINE ROUTING WITHIN AND ADJACENT TO ER67

Route	Environmental Comparison
Proposed Route (Adjacent to ER67)	• does not traverse ER67. • approximately 100 -200 m longer than Alternative A and B, resulting in proportionately more habitat disturbance. • long-term, small-scale alteration of habitat resulting in potential creation of new hard substrate and associated "reef" effect. • may disturb one localized, high diversity, hard-bottom substrate habitat area (*i.e.*, *Trench* unit) which will likely be slower to recover than other soft-bottom areas. • somewhat greater potential for impact to nearshore kelp communities (approximately 120 m south of nearest identified kelp bed). • will require approximately two weeks more to construct than Alternatives A or B and so result in somewhat more prolonged temporal disturbance of biota.
Alternate A (Within ER67)	• traverses toe of *Slope* unit in ER67 for approximately 0.5 km. • impacts similar benthic habitat as proposed route (*i.e.*, *Flat, Trench, Slope*). • may disturb one localized, high diversity, hard bottom substrate habitat area (*i.e.*, *Trench* unit) which will likely be slower to recover than other soft-bottom areas. • approximately 250 m south of nearest identified kelp bed.
Alternate B (Within ER67)	• traverses approximately 1.8 km of ER67. • impacts confined to *Flat* unit associated, soft-bottom benthic communities with anticipated rapid recovery. • approximately 675 m south of nearest identified kelp bed. • area has history of frequent disturbance by trawling.



Legend

- Proposed Pipeline Route
- Alternative A
- Alternative B
- Kilometer Point
- ER67 Boundary
- Depth Contours

(All Locations Approximate)

FIGURE 4

ROUTE ALTERNATIVES AND ASSOCIATED BATHYMETRY IN PROXIMITY TO ER67

SCALE: 1:15,000

0.2 0 0.2 0.4 km

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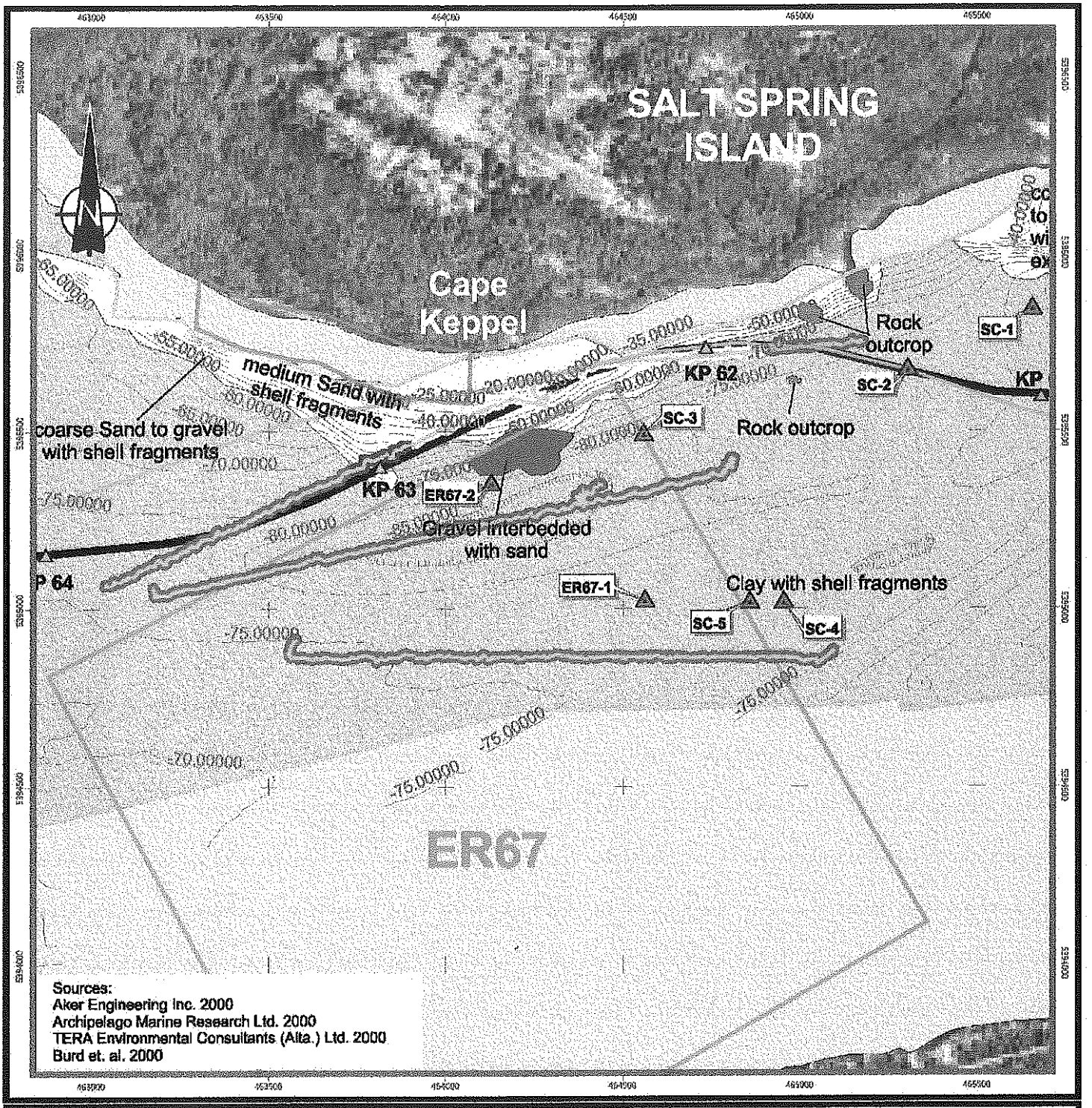
limited GSX sampling program (Appendix 3) nor were "siphon shows" observed during ROV surveys (though these could have been overlooked). Of the referenced sensitive species, Ellis (1967b, 1968) reported only *Clinocardium nuttallii* from his sampling efforts in Satellite Channel. His specimen was from Boatswain Bank. The "more sensitive species" identified by Austin (1996) were not identified during GSX surveys conducted in proximity to ER67. As discussed in Section 2.2.3 above, species composition along the proposed route north of ER67 and through the *Flat* unit of ER67 appear relatively similar. The *Trench* morphological unit traversed by the proposed route does, however, appear to support a disproportionately higher species richness than either the *Flat* or *Slope* units as well as being likely to include species that may be more sensitive to sedimentation and burial.

Trenching around ER67 will require more time to execute (approximately two weeks) and will result in some greater potential to turn up previously buried boulders, cobbles and rock fragments which may remain on the surface and have an enhanced "reef" effect. The potential use of bracing/clump weights (approximately 150) to anchor the pipe for its slope traverse north of ER67 will also add to the presence of hard-bottom substrate along the shoulder of Salt Spring Island. These two factors may increase the number of species typically associated with hard substrate already found in this area (*e.g.*, rockfish, anemones, hydroids, cup corals). Because the structures involved (if these are ultimately used) will occupy a small percentage of the area and are relatively simple, this effect is anticipated to be correspondingly reduced. The presence of other hard substrate in close proximity to the area traversed suggests the proposed action would not result in creation of profound alteration in habitat composition and species diversity in the area. The presence of debris flow areas along the slope traversed by the proposed route indicate communities in this area are subject to some periodic disturbance caused by this movement. To the extent there is any down-slope movement of sediments and small diameter substrate, it would tend to cover shallow profile hard exposures and reduce new "reef" effects. At the same time current induced scour occurring near the toe of slope of Cape Keppel should tend to mitigate the effects of sediment translocation on benthic communities most sensitive to this effect.

Potts and Hulbert (1994) noted that fish abundance was directly proportional to artificial reef structural volume and complexity. The long-term alterations proposed by GSX PL could be reasonably typified as less complex. In terms of potential effects on neighboring benthic and demersal communities, Ambrose and Anderson (1990) observed no evidence that foraging by reef-associated fishes caused a widespread reduction in infaunal densities near the reef. Overall, they observed decreases in the number of some species and increases in others. Research on artificial reefs in the Florida Keys demonstrated that, at least in some contexts, artificial reefs can result in a marked increase in the numbers of local resident reef fishes, without notable effects on fishes dwelling in nearby nonreef habitats (Alevizon and Gorham 1989). Polovina (1989) observed that artificial reefs are very good at attracting fish but that they do not effectively increase standing stock biomass

of fish and do raise concerns about potential to increase fishing mortality. This latter effect is assumed to be most problematic where management and enforcement are lacking.

Installation of the pipeline through ER67 on flat, soft-bottom substrate would not require any additional support structures and is also less likely to turn up or expose coarse substrates. The presence of soft substrates in this area will facilitate self burial and natural trench infilling. As with the proposed slope installation, trenching will still result in sediment translocation with some potential to smother less mobile species and temporarily increase turbidity within Satellite Channel. Particularly sensitive receptors (*e.g.*, eelgrass, cloud sponge) are not present. Species populations present in the area have already evolved in a relatively frequent disturbance regime associated with periodic bottom trawling in the area. No particularly sensitive or otherwise unique species or species populations are likely to be adversely impacted by the proposed activity.



Legend

- Proposed Pipeline Route
- Preliminary Marine Route
- Kilometer Point along Preliminary Marine Route
- ER67 Boundary
- UREP Boundary
- Depth Contours
- Aker Engineering Inc. Sidescan and Sub-Bottom Survey Boundary

Subsea Habitat (Aker Engineering Inc.)

- Gravel - Predominant Sediment Type
- Rock Outcrop/Rock Exposure
- Sand - Predominant Sediment Type
- Silt/Clay - Predominant Sediment Type

- Aug. 4-13, 2000 ROV Video Transect

Morphological Units Identified During ROV Video Survey

- Flat
- Slope
- Trench
- Benthic Infaunal Grab Sample Site (Burd et al. 2000)

(All Locations Approximate)

ECOLOGICAL RESERVE 67 AND SUB-TIDAL MORPHOLOGICAL UNITS (FLAT, TRENCH, SLOPE)

Supplement to TERA 2000, "Environmental Assessment of the Ecological Significance of Installing a Natural Gas Pipeline Around or Through ER67"

SCALE: 1:15,000

0.25 0 0.25 0.5 km

tera ENVIRONMENTAL CONSULTANTS (ALTA.) LTD.	1500	April 2001

4.0 CONCLUSION

While construction of either the proposed or alternate routes will result in relatively small scale, generally short-term environmental impacts, the data suggest that slightly less ecological disturbance and habitat modification would occur if the pipeline was constructed on more level portions of Satellite Channel within ER67, as opposed to the northern sloping margin of the Channel north of ER67 and south of Salt Spring Island. The currently proposed route around ER67 will result in slightly greater physical disturbance of benthic communities due to its extra length (approximately 100-200 m longer) and the requirement to trench and possibly brace on the associated slopes. Trenching through ER67 would result in deeper burial of the pipeline over time and likely minimize any potential for detectable change to the current benthic community structure. Some, likely small, incremental "reef" effect would be associated with the proposed slope traverse around ER67.

5.0 REFERENCES

5.1 Personal Communication

Lyttle, R. Commercial crab fisherman, Duncan, British Columbia

Macdonald, V. Biologica Environmental Services, Victoria, BC.

5.2 Literature Cited

Alevizon, W.S. and J.C. Gorham. 1989. Effects of artificial reef deployment on nearby resident fishes. Bulletin of Marine Science 44(2): 646-661.

Ambrose, R.F. and T.W. Anderson. 1990. Influence of an artificial reef on the surrounding infaunal community. Marine Biology 107: 41 - 52.

Austin, W.C., S.P. Leys, and C. Durance. 1996. Saanich inlet study: Sensitive habitats and biota. Water Quality Branch, Environmental Protection Department, BC Ministry of Environment, Lands and Parks.

BC Ministry of Environment, Lands and Parks. 1993. BC Ecological Reserves Program. Ministry of Environment, Lands and Parks, Victoria.

BC Ministry of Environment, Lands and Parks. 1996. Saanich Inlet Study Surface Circulation Studies. Water Quality Branch , Environmental Protection Department, BC Ministry of Lands and Parks.

Burd, B., V. Macdonald and R. Glaholt. 2000. Reconnaissance level baseline survey of benthic infaunal communities at Ecological Reserve 67 and Adjacent Satellite Channel June 4, 2000. Ecostat Research Ltd. Sydney BC, Biological Environmental Services Ltd. Victoria, BC and TERA Environmental Consultants (Alta) Ltd. Calgary, Alberta.

Debrocky Seatech Limited. 1981. Hatch Point Marine Environmental Assessment (Biological Oceanography, Physical Oceanography, Overview Vols.). Prepared for Chevron Canada Ltd. 3 Volumes.

Ellis, D.V. 1967a. Quantitative benthic investigations. I. Satellite Channel biomass summaries and major taxon rank orders. Fish. Res. Bd. Canada Tech. Rept. 25:51p. (not provided)

Ellis, D.V. 1967b. Quantitative benthic investigations. II. Satellite Channel Species data February 1965-May 1967. Fish. Res. Bd. Canada Tech. Rept. 35.

Ellis, D.V. 1968. Quantitative benthic investigations. III. Locality and environmental data for selected stations (Mainly from Satellite Channel, Straits of Georgia and adjacent inlets), February 1965-December 1967. Res. Bd. Canada Tech. Rept. 59.

Ellis, D.V. 1970. A review of marine infaunal community studies in the Strait of Georgia and adjacent inlets. Syesis.Vol.4. 9pp.

Essink, K. 1999. Ecological effects of dumping of dredged sediments; options for management. Journal of Coastal Conservation. 5:69-80.

GeoSea. 2000. TERA Environmental Particle Size Analysis. GeoSea Consulting (Canada) Ltd., Brentwood Bay, BC

Hay, D.E. and P.B. Carter. 1999. Herring Spawn Areas of British Columbia: a review, geographical analysis and classification. CD-ROM produced by the Pacific Biological Station, Nanaimo, Dept. of Fisheries and Oceans.

Howes, D.E. and P.E. Wainwright. 1993. Coastal oilspill response atlas, Southern Strait of Georgia. Prepared by Burrard Clean Operations Ltd. and BC Ministry of Environment, Lands and Parks.

Kozloff, E.N. 1993. Seashore life of the northern Pacific coast. University of Washington Press. 370pp.

Levinton, J.S. 1995. Marine Biology: Function, Biodiversity, Ecology. Oxford University Press, New York. 420 pp.

McDaniel, N. and R. Glaholt. 2000. Survey of subtidal benthic biodiversity and associated habitats along the proposed Georgia Strait Crossing Pipeline Route. Subsea Enterprises Inc., Vancouver, BC and TERA Environmental Consultants (Alta) Ltd., Calgary, Alberta.

Polovina, J.J. 1989. Artificial reefs: nothing more than benthic fish aggregators. CalCOFi Rep., Vol.30: 37-38.

Potts, T.A. and A.W. Hulbert. 1994. Structural influences of artificial and natural habitats on fish aggregations in Oslo Bay, North Carolina. Bull. Mar. Sci. Vol. 55(2-3):609-621.

Terra Remote Sensing Inc. 2000. Marine geophysical and bathymetric survey at Ecological Reserve 67. Prepared for Aker Engineering Inc. Houston, Texas.

Wulff, A., K. Sundback, C. Nilsson, L. Carlson, B. Jonsson. 1997. Effect of sediment load on the microbenthic community of a shallow-water sandy sediment. Estuaries. Vol. 20(3):547-558.

APPENDIX 1

SUMMARY OF INVERTEBRATE CLASSIFICATION BY VIDEO TRANSECT IN AND ADJACENT TO ER67, JANUARY 30, 2000[1,2]

Faunal Group	Common Name	Scientific Name	Taxa Images/m		
			Flat	Slope	Trench
Anemones	plumose anemone	*Metridium giganteum*	.048	.022	.029
	tube dwelling anemone	*Pachycerianthus fimbriatus*	.003	.004	-
	swimming anemone	*Stomphia* sp.	.006	.004	.029
Corals	orange sea pen	*Ptilosarus gurneyi*	.002	.048	-
	white sea pen	*Virgularia* sp.	.001	-	-
Tube Worms	Parchment tube worms		.001	.061	.382
Brittle Stars	brittle stars	Ophiuroids	<.001	-	
Sea Urchins	red sea urchin	*Strongylocentrotus franciscanus*	-	-	.103
Sea Stars	unidentified sea star		.002	.061	-
	sunflower star	*Pycnopodia helianthoides*	.004	.039	.004
	spiny mud star	*Luidia foliolata*	.006	-	.029
	blood star	*Henricia levisuscula*	<.001	-	-
	fat henricia	*Henricia sanguinolenta*	<.001	-	-
	vermilion star	*Mediaster aequalis*	.014	.031	.029
	rose star	*Crossaster papposus*	-	.004	-
	spiny pink sea star	*Pisaster brevispinus*	<.001	.031	.015
	Ochre sea star	*Pisaster ochraceus*	<.001	-	-
	mottled sea star	*Evasterias troschelii*	-	.004	-
Shrimp (Pandalid)	spot prawn	*Pandalus platyceros*	.008	-	-
	side-stripe shrimp	*Pandalopsis dispar*	<.001	-	-
	pink shrimp	*Pandalus jordani / borealis*	<.001	-	-
Crab	unidentified crab (box, tanner/snow/Dungeness)	*Brachyura* (various species).	<.002	.026	.015
Octopus	Octopus	*Octopus* spp.	<.001	-	-
Squid	stubby squid	*Rossia pacifica*	<.001	-	-
Nudibranch	striped nudibranch	*Armina californica*	<.001	-	-
Worm	unidentified worm		<.001	-	-
Fish					
Eelpout		Zoarcidae	.001	-	.015
Poacher	Sturgeon poacher	*Podothesus acipenserinus*	.003	-	-
Snailfish		*Cyclopteridae*	<.001	-	-
Goby		*Gobiidae*	<.001	-	.015

APPENDIX 1 Cont'd

Faunal Group	Common Name	Scientific Name	Taxa Images/m		
Flatfish	Pacific Sanddab	*Citharichthys sordidus*	<.001	-	-
	Dover, Flathead, Slender or Rex sole	*Microstomus pacificus, Hippoglossoides elassodon, Eopsetta exilis, Glyptocephlus zachirus*	.007	-	.044
	English Sole	*Pleuronectes vetulus*	.009	-	.015
Herring	Pacific Herring	*Clupea harengus*	.008	-	-
Gadidae	Pacific Cod	*Gadus macrocephalus*	<.001	-	-
	Walleye Pollock	*Theragra chalcogramma*	<.001	-	-
	Pacific Hake	*Merluccius productus*	<.001	-	-
Dogfish	Spiny Dogfish	*Squalus acanthias*	<.001	-	-
Rockfish	Copper Rockfish	*Sebates caurinus*	<.001	-	-
Sculpin	Unidentified Sculpin	*Cottidae*	.001	.004	.015
		Total Taxa	**37**	13	14
Infauna "Holes"	mounded infaunal holes		<.001	-	-
	small (<2 cm) unmounded (flat) infaunal holes		.026	-	-
	Large (>2 cm) unmounded (flat) infaunal holes		.001	.061	-

Note:

1. Source: Terra Remote Sensing Inc. 2000
2 Based on survey of 5284 m (Flat), 228 m (Slope) and 68 m (Trench)

APPENDIX 2

BIOLOGICAL OBSERVATIONS BY KP SEGMENTS[1]
(ROV Survey August 4-13, 2000)

Species Name	Species Name	Abundance[1]	
Route Segment		**KP 59-60 (*Flat*)**	**KP 60-61 (*Flat*)**
Video Tape Number		21	21
Survey Date (day/month/year)		9/8/00	9/8/00
ROV Depth (metres)		63-60	60-80
Substrate		mud	mud
INVERTEBRATES			
Ptilosarcus gurneyi	orange sea pen	+	
Virgularia sp.	white sea pen	++	+
Balticina septentrionalis	sea whip	+	+
Metridium giganteum	plumose anemone	+	+
Stomphia sp.	swimming anemone		+
Cancer magister	Dungeness crab	+	+
Pandalus platyceros	prawn		
Patinopecten caurinus	weathervane scallop		+
Tritonia diomedea	pink nudibranch	+	
Mediaster aequalis	vermilion star		+
Pycnopodia helianthoides	sunflower star	+	+
Luidia foliolata	sand star	+	+
FISH			
Hydrolagus colliei	spotted ratfish		
Porichthys notatus	plainfin midshipman	+	
Theragra chalcogramma	walleye pollock		
Lycodopsis pacifica	blackbelly eelpout	+	+
Lumpenus sagitta	snake prickleback	+	
Pleuronectes vetulus	english sole	+	+
Pleuronectidae	unidentified flatfish	+	+
Actinopterygii	unidentified fish	+	+

1. + = few, ++ = common, +++ = abundant
   Source: McNeil and Glaholt 2000

APPENDIX 2 - Cont'd

Species Name	Common Name	Abundance[1]		
Route Segment		**KP 61-62 (*Flat*)**	**KP 62-63 (*Flat*)**	**KP 63-64 (*Flat*)**
Video Tape Number		21	21	22
Survey Date (day/month/year)		9/8/00	9/8/00	9/8/00
ROV Depth (metres)		80-40	40-76	76-77
Substrate		mud	mud, some sand, cobble	mud
INVERTEBRATES				
Ptilosarcus gurneyi	orange sea pen	+	+	
Virgularia sp.	white sea pen		+	
Balticina septentrionalis	sea whip	+		
Metridium giganteum	plumose anemone	+	+	++
Stomphia sp.	swimming anemone	+	+	+
Cancer magister	Dungeness crab	+	+	+
Caridea	unidentified shrimp	+	+	+
Mediaster aequalis	vermilion star	+	+	+
Pycnopodia helianthoides	sunflower star	+	+	+
Luidia foliolata	sand star	+	+	+
Dermasterias imbricata	leather star		+	
FISH				
Raja rhina	longnose skate		+	
Hydrolagus colliei	spotted ratfish	+		+
Porichthys notatus	plainfin midshipman	+	+	
Theragra chalcogramma	walleye pollock		+	+
Lycodopsis pacifica	blackbelly eelpout	+	+	+
Lumpenus sagitta	snake prickleback	+	+	
Pleuronectes vetulus	english sole	+	+	+
Pleuronectidae	unidentified flatfish	+	+	+
Actinopterygii	unidentified fish	+	+	+

1. + = few, ++ = common, +++ = abundant
Source: McNeil and Glaholt 2000

APPENDIX 2 - Cont'd

Species Name	Common Name	Abundance[1]	
Route Segment		**KP 64-65 (*Flat*)**	**KP 65-66 (*Flat*)**
Video Tape Number		22	22/23
Survey Date (day/month/year)		9/8/00	10/8/00
ROV Depth (metres)		77-77	77-55
Substrate		mud	mud, some cobble
INVERTEBRATES			
Ptilosarcus gurneyi	orange sea pen		+
Virgularia sp.	white sea pen	+	+
Balticina septentrionalis	sea whip	++	++
Metridium giganteum	plumose anemone	++	+
Stomphia sp.	swimming anemone	+	+
Cribrinopsis fernaldi	crimson anemone		+
Cancer magister	Dungeness crab	+	+
Pandalus platyceros	prawn		
Caridea	unidentified shrimp	+	+
Patinopecten caurinus	weathervane scallop	+	
Tritonia diomedea	pink nudibranch		+
Mediaster aequalis	vermilion star	+	+
Pycnopodia helianthoides	sunflower star	+	+
Luidia foliolata	sand star	+	+
FISH			
Raja rhina	longnose skate	+	
Hydrolagus colliei	spotted ratfish	+	+
Porichthys notatus	plainfin midshipman		
Theragra chalcogramma	walleye pollock	+	
Lycodopsis pacifica	blackbelly eelpout		++
Lumpenus sagitta	snake prickleback		
Pleuronectes vetulus	english sole	+	+
Pleuronectidae	unidentified flatfish	+	++
Actinopterygii	unidentified fish	+	

1. + = few, ++ = common, +++ = abundant
   Source: McNeil and Glaholt 2000

APPENDIX 3

BENTHIC INFAUNAL SPECIES DIVERSITY AND ABUNDANCE IN AND ADJACENT TO ER67 AND ADJACENT SATELLITE CHANNEL, JUNE 4, 2000 [1]

	GSX ER67-1				GSX ER67-2				GSX SC-1				GSX SC-2				GSX SC-3				GSX SC-4				GSX SC-5			
	1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm	
TAXON [2]	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A
CNIDARIA																												
Hydrozoa																												
Clytia sp.													34	0			4	0			34	0						
Lafoea sp.	37	0			23	0											113	0									2	0
Monobrachium parasitum	169	0	43	0	250	15			28	0			108	0	104	0	272	0	114	0	272	0	34	0			35	0
Obelia sp.																	6	0							100	0	10	0
Tubularia marina									1	0													0	1				
Anthozoa																												
Edwardsia sipunculoides																									1	0		
Pachycerianthus fimbriatus					1	0																						
PLATYHELMINTHES																												
Leptoplana sp.					1	0																						
NEMERTEA																												
Cerebratulus californiensis					0	1			0	2	0	1					1	0			1	0						
Nemertea indet.																									0	1		
Tubulanus polymorphus									0	1	0	1																
NEMATODA																												
Nematoda indet.			3				3		6		4				4		1										5	
ANNELIDA																												
Polychaeta Errantia																												
Antinoella macrolepida									2	1							1	3										
Diopatra ornata									2	0							1	0							1	0		
Drilonereis falcata minor											1	0			1	0									2	0	0	1
Errano bicirrata																	1	0			1	0			1	0		
Eteone californica																									1	0		
Eteone longa complex	0	1																							1	1		
Eteone spilotus																											2	0
Eumida longicornuta																					1	0						

Appendix 3 Cont'd

	GSX ER67-1				GSX ER67-2				GSX SC-1				GSX SC-2				GSX SC-3				GSX SC-4				GSX SC-5			
	1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm	
TAXON[2]	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A
Eunoe sp.	0	1																										
Exogone dwisula																											0	1
Exogone molesta					1	0									1	0			1	0								
Gattyana cirrosa											1	2													4	3	0	1
Glycera americana	1	0							1	0							1	0										
Glycera nana	2	0			3	0			1	1			2	0	0	1	2	1			5	0			2	1		
Glycera tesselata													1	0														
Glycinde armigera							1	1			0	2									1	0	0	1				
Goniada brunnea									1	0							1	1			3	0						
Hesperonoe complanata																							0	3				
Lumbrineris cruzensis	3	2	0	2									2	0	0	1	3	1			5	0	4	0	15	2	2	1
Lumbrineris latreilli									3	0	6	1																
Malmgreniella scriptoria	1	2	0	3					1	0																		
Micropthalmus sp.																	0	1										
Nephtys cornuta			4	4	4	0	15	3	1	0	17	3			4	5	14	3	3	10	2	0	4	2			5	14
Nephtys ferruginea	0	1	0	1	1	0	1	1	2	0	0	1	0	1	0	2	0	4			1	2			2	0		
Nephtys sp.							0	1																				
Nereis procera																											0	1
Onuphis iridescens	0	2	0	1					1	1							1	2			1	0			1	0	1	1
Pholoe glabra	2	0	7	0	2	1	2	7	3	0	18	1	3	0	6	2	2	11	0	5	4	0	7	1	2	0	4	0
Phyllodoce groenlandica	1	2											1	0			1	1							2	0	1	0
Phyllodoce sp.							0	1																				
Pilargis berkeleyae							1	1									0	1										
Podarkeopsis glabra	1	0	1	0													1	0			1	0			1	0		
Polynoidae indet.									0	1																		
Scoletoma luti	1	2			7	0			7	0			1	0			4	2	0	1	4	0			5	0		
Sphaerodoropsis sphaerulifer									0	1																	1	3
Sphaerosyllis sp.																											0	2
Polychaeta Sedentaria																												
Ampharete acutifrons	0	1																			1	0			1	1	0	1
Aphelochaeta monilaris	1	1			1	1											1	0			1	0	0	1	1	0		
Aphelochaeta multifilis									0	1	0	1	1	0			1	0							0	2		
Aphelochaeta sp.																							0	2				
Aricidea catherinae	4	0	1	1	3	0	4	3	1	0	6	0	3	0	2	2	4	0			2	0	0	5	1	0	1	1
Aricidea ramosa	1	0	0	1							1	0					1	0					3	0			1	0
Artacama conifera	1	0																							1	0		
Asabellides sibirica			0	1																								

Appendix 3 Cont'd

TAXON[2]	GSX ER67-1				GSX ER67-2				GSX SC-1				GSX SC-2				GSX SC-3				GSX SC-4				GSX SC-5			
	1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm	
	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A
Barantolla americana					1	2							2	1			6	3			0	2						
Boccardia basilaria																					1	0						
Brada villosa	2	0			0	1	0	1	1	0	0	2	2	0	1	0	2	3			4	0						
Capitella capitata complex																	0	2										
Chaetozone acuta	1	0	0	1	6	2	2	1			0	6	0	4	2	0	0	6	0	1			4	0	1	0	0	1
Chone mollis	3	0									1	0	1	0	0	1	0	1							1	0	0	1
Chone sp.																							0	1				
Cossura modica			1	0																								
Cossura pygodactylata					7	1	1	4	3	0	4	1	1	0	3	0	1	0	0	3			1	0			2	0
Decamastus gracilis					1	1	0	1																				
Dipolydora socialis	3	0																			1	0	0	1	1	0		
Euclymeninae indet.	0	1	0	1																								
Galathowenia oculata	3	4	0	3	11	2	0	7	13	2	0	2	6	0			22	1							6	11	0	2
Heteromastus filobranchus							0	1	3	2	1	1	3	0											3	1		
Laonice cirrata																									1	0		
Levinsenia gracilis	18	0	1	27	11	7	29	5	6	3	62	19	1	1	14	20	9	3	8	10	7	4	0	5			11	18
Leitoscolopos pugettensis	0	3			4	1	0	1	1	0	0	2	2	0	0	4	7	6			7	1			0	1	2	3
Magelona longicornis	0	1											1	0											1	0		
Mediomastus ambiseta	6	3	0	1	4	0	2	9	1	0	5	6					3	6	2	13			17	1	16	7	1	4
Mediomastus sp.													0	1	0	2												
Melinna elisabethae	2	0											1	0														
Mesochaetopterus taylori																									2	0		
Notomastus tenuis	17	8			3	0			3	3	0	1	3	4	0	1	16	3			5	2			1	1		
Ophelina acuminata											0	1																
Owenia fusiformis					3	0																						
Paraprionospio pinnata	4	0			3	0			1	1											3	0	0	1			1	0
Pectinaria granulata	1	0			9	1	0	1	3	0			5	1			3	0			7	0			2	0		
Pectinaria sp.																											0	1
Polycirrus californica													1	0											1	1		
Polycirrus sp. complex																	0	1										
Polydora brachycephala																									1	0		
Praxillella pacifica	2	2			0	2			0	3			3	1			4	7	0	2	5	5						
Praxillella praetermissa	3	2							0	1			0	2											0	5		
Praxillella sp.	0	1											0	1											1	2		
Prionospio lighti	4	0	6	1	6	5	15	4	3	2	20	3	4	0	15	16	6	1	3	2	8	2	0	2	3	0	12	1
Prionospio steenstrupi			0	2	1	0	0	2	1	0			3	0	0	1	1	1					3	0	1	0		
Pseudopolydora kempi japonica																							0	5				

Appendix 3 Cont'd

	GSX ER67-1				GSX ER67-2				GSX SC-1				GSX SC-2				GSX SC-3				GSX SC-4				GSX SC-5			
	1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm	
TAXON[2]	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A
Spio cirrifera							0	1																			0	1
Spiochaetopterus costarum																	1	0			1	0						
Spionidae indet.							0	3																				
Spiophanes berkeleycrum	0	244	0	31	0	7	0	8	0	23	0	15	0	1	0	10	0	8	0	10	0	4	0	143	0	295	0	18
Sternaspis fossor	9	5	0	3	0	10			2	1			2	13	0	1	4	16	0	2	1	11	0	7	5	6		
Terebellides californica																	1	1					0	1			0	2
Terebellides reishi			0	1									1	0	0	2	0	1										
Travisia pupa																					1	0						
Oligochaeta																												
Tubificidae indet.					0	1	0	1																				
Hirudinea																												
Piscicolidae indet.									1	0																		
SIPUNCULA																												
Gollingia pugettensis					0	2							1	0	0	1	1	0							1	0		
Phascolosoma agassizii																	1	0										
MOLLUSCA																												
Aplacophora																												
Chaetoderma argenteum									1	0													0	1				
Gastropoda																												
Alvania compacta					2	0							1	0	1	0	1	0							1	0	1	1
Bittium attenuatum	4	0	0	1	7	0			1	0			6	2	0	3	3	2			9	0						
Bullidae indet.							0	1																				
Cylichna attonsa	0	1							0	1			1	0														
Euspira pallida																					1	0						
Haminoea vesicula					1	0									0	1					1	0						
Nitidella gouldii	3	0															1	0			9	0						
Odostomia quadrae					1	1																						
Odostomia sp.	0	1	0	1																	0	1					0	1
Ophiodermella cancellata																					1	0						
Philine sp.	1	0																										
Turbonilla sp.	2	0					0	1					1	0							1	0						
Bivalvia																												
Acila castrensis	0	7	0	3	2	8	0	12	1	20	0	26	2	8	0	22	0	9	0	16	1	4	0	8	3	14	0	16
Axinopsida serricata	35	152	0	17	25	97	0	2	44	107	0	3	50	205	0	15	57	197	0	15	49	219	0	9	16	35	0	13
Bankia setacea	1	0																										

Appendix 3 Cont'd

TAXON[2]	GSX ER67-1				GSX ER67-2				GSX SC-1				GSX SC-2				GSX SC-3				GSX SC-4				GSX SC-5			
	1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm	
	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A
Compsomyax subdiaphana	0	9	0	1	1	2			0	2			1	7			1	8			1	2	0	2			0	2
Crenella decussata																							0	1				
Cyclocardia ventricosa																					0	1	0	1			0	5
Eunnucula tenuis	1	1	0	3	22	22	0	14	10	15	0	7	16	32	0	18	14	20	0	5	8	13	0	2	1	2	0	11
Hiatella arctica									0	2													0	17	2	9		
Lucinoma annulatum	0	1			0	2					0	2	0	2	0	4	0	1	0	1	0	4					0	2
Lyonsia bracteata	1	0			1	1											1	1			0	3						
Macoma brota																	0	2							0	1		
Macoma calcarea					0	1			0	4			0	3														
Macoma carlottensis	9	14			3	7			24	19			15	7			10	11			14	25			7	11		
Macoma elimata	3	2			2	8			2	0			1	2			1	11			0	6			2	3		
Macoma sp.	0	6	0	16	0	12	0	5	0	27	0	22	0	20	0	26	0	13	0	11	0	3	0	4			0	18
Megacrenella columbiana																									1	0		
Musculus niger	0	2											1	0			0	1			0	1						
Mysella turmida			0	5	1	0	0	3	1	1	0	10	2	2	0	2	1	3	4	2			0	2	2	0	0	2
Mytilidae indet.																							0	1			0	1
Nemocardium centifilosum																					1	0						
Nuculana minuta					1	1							0	6	0	2	1	0	0	1	3	1					0	3
Pandora filosa																					1	0						
Parvilucina tenuisculpta	0	9	0	1	1	17	0	26	0	16	0	2	0	30	0	9	6	24	0	3	2	45	0	1	0	9	0	5
Psephidia lordi	1	1																										
Thyasira gouldii			0	1					0	1																		
Yoldia ensifera																					0	1			0	1		
Yoldia martyria					0	1							0	1							0	1						
Yoldia scissurata	0	1			0	1			1	0			0	1	0	1											0	1
Yoldia sp.	0	1	0	16	0	8	0	11	0	7	0	38	1	2	0	26	0	6	0	23	0	3	0	13	0	4	0	28
Scaphopoda																												
Rhabdus rectius	2	18	0	1	7	14	0	4	0	2	0	1	0	30	1	9	9	23			20	22	0	1	0	2	0	9
ARTHROPODA																												
CRUSTACEA																												
Cirripedia																												
Balanus glandula																	1	0										
Copepoda																												
Harpacticoida indet.			1	1																								
Ostracoda																												
Acanthocythereis sp.							1	0																				

Appendix 3 Cont'd

TAXON[2]	GSX ER67-1				GSX ER67-2				GSX SC-1				GSX SC-2				GSX SC-3				GSX SC-4				GSX SC-5			
	1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm	
	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A
Euphilomedes producta	38	0	11	55	30	1	4	34	49	0	16	65	29	1	24	102	38	0	8	74	25	1	6	3	1	0	13	74
Ostracoda indet.											0	1																
Postasterope sp.			2	0			2	0			2	0			1	1			6	0							1	5
Rutiderma lomae							0	1			1	1							0	1			1	0				
Leptostraca																												
Nebalia pugettensis															0	1												
Cumacea																												
Campylaspis biplicata			1	0																								
Diastylis bidentata	1	0							2	0																		
Diastylis dalli					1	0							1	0														
Diastylis paraspinulosa																									1	0		
Diastylis sp.																											0	1
Eudorella pacifica	5	0	14	9	3	1	0	4	4	4	17	11	2	0	9	2	0	1	5	3	3	0	1	4	1	0	7	8
Eudorellopsis longirostris									1	0	0	1			1	0	0	1	0	1			1	0	1	0		
Leucon subnasica			5	0			1	0			17	0			5	0			5	1			5	1			5	0
Tanaidacea																												
Leptochelia savignyi																							0	1			0	1
Leptognathia gracilis			39	2	1	0	0	3			19	6			18	8	3	0	18	8			64	9			11	14
Isopoda																												
Haliophasma geminatum											0	1									1	0						
Munnogonium cf. *tillerae*			5	0							2	2											3	0				
Pleurogonium rubicundum							2	0											2	0							2	1
Amphipoda																												
Americhelidium shoemakeri	1	0	3	0			1	0	1	0	10	3			2	1	0	1	1	1			2	4			9	0
Ampelisca unsocalae	2	6	0	5	2	4	0	1	2	4	0	2	1	0							1	1	0	2	3	0	0	2
Amplelisca sp.																			0	1								
Aoroides intermedius																									2	1	0	2
Aoroides sp.															0	1							0	4				
Bathymedon pumilus																			1	0								
Bathymedon sp.									1	0	2	0																
Caprella laeviuscula																	1	0										
Cheirimedela zotea																							0	5				
Dyopedos sp.	2	0	5	0			2	0	3	0	1	3			1	0							2	0			1	0
Foxiphalus similis																	1	0										
Gammaridea indet.									0	1															1	0	1	0
Guernea reduncans			10	0			1	0			1	1							1	1			9	2			1	2
Heterophoxus affinis					1	1	0	1	1	0	2	6	1	0			1	0					5	3				

Appendix 3 Cont'd

TAXON[2]	GSX ER67-1				GSX ER67-2				GSX SC-1				GSX SC-2				GSX SC-3				GSX SC-4				GSX SC-5			
	1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm	
	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A
Heterophoxus ellisi																									1	0		
Heterophoxus sp.			0	2															0	2					0	4	0	3
Lepidepecreum garthi																			0	1							0	1
Metaphoxis frequens																											1	0
Microjassa sp.																											1	0
Orchomene cf. *pinguis*											1	0																
Pachynus cf. *barnardi*			7	4	1	0	6	0			10	0			6	0			4	1			1	0			5	0
Parametopella sp.											1	0																
Photis brevipes											20	7																
Photis parvidons	9	2	29	42			4	1	4	0			2	0	13	2	11	0	8	23					1	0	2	5
Photis sp.																			0	1	3	0	0	10			0	5
Phoxocephalidae indet.			1	0																								
Pleustidae indet.			0	1																								
Prachynella lobo																											1	0
Protomedeia grandimana	5	3	0	4																								
Protomedeia sp.									1	0	0	1							0	1								
Rhepoxynius barnardi	2	0	0	2	3	0			2	0	1	1			2	0	2	0	0	8	7	0	0	2	1	0	0	6
Westwoodilla caecula	1	0							0	1	0	1									0	1			0	1		
Decapoda																												
Crangon dalli					1	0																						
Pinnixa occidentalis																					1	0						
PHORONIDA																												
Phoronis sp.	0	2			4	0													0	1					1	0		
ENTOPROCTA																												
Barentsia sp.																	4											
BRYOZOA																												
Bowerbankia gracilis																	47											
ECHINODERMATA																												
Ophiuroidea																												
Amphiodia periercta	3	22			2	3			3	12			1	5			2	18			3	3			8	16		
Amphiodia urtica	9	2							0	1							3	1							5	2		
Amphiodia sp.																			0	1	0	2						
Ophiura sarsia	0	2							0	1																		

Appendix 3 Cont'd

	GSX ER67-1				GSX ER67-2				GSX SC-1				GSX SC-2				GSX SC-3				GSX SC-4				GSX SC-5			
	1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm	
TAXON[2]	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A
Ophiuroidea indet.	0	1	0	3			0	4	0	1	0	13			0	6							0	10	0	1	0	2
Echinoidea																												
Brisaster latifrons	1	0																										
UROCHORDATA																												
Ascidiacea																												
Ascidiacea indet.			0	4											0	1												
HEMICHORDATA																												
Saccoglossus sp.																					1	0						
Total Number of Adults and Juveniles	445	555	200	285	493	276	100	196	262	299	270	309	334	397	241	335	745	455	194	266	558	396	177	306	255	457	161	329
Total Number of Organisms		1000		485		769		296		561		579		731		576		1200		460		954		483		712		490
Total Number of Taxa		72		55		63		49		70		58		60		52		82		42		67		55		68		69
Organisms per m²		8475		4110		6517		2508		4754		4907		6195		4881		10169		3898		8085		4093		6034		4153
MEMO																												
Amphipoda indet. (larval)																			1									
Aranae indet. (Spider)			1																									
Autolytus fasciatus																									2			
Balanus sp. nauplius					1																							
Brachyura indet. zoea	1						1		1								1				1							
Calanoida indet.			1				1										1						1					
Calanoida indet. copepodite							1																					
Calanoida indet. nauplius							2																					
Caridea indet. zoea																							1					
Cirripedia indet. cypris larvae									1																			
Corycaeus sp.							3																					
Crinoidea indet. (fragment)			1																									
Cumacea indet. (larval)			6												1													
Eucalanus bungii					1																							
Euphausia pacifica					1																							
Euphausiacea indet. furcilia																			2									
Euphausiacea indet. nauplius							1																					
Fish egg													2															
Gammaridae indet. (larval)	1																											
Gastropod egg case	17				6		1		17				1														1	

Appendix 3 Cont'd

TAXON[2]	GSX ER67-1				GSX ER67-2				GSX SC-1				GSX SC-2				GSX SC-3				GSX SC-4				GSX SC-5			
	1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm		1.0 mm		0.5 mm	
	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A
Gastropteron pacificum	1																											
Hydroida indet. medusae																											1	
Invertebrate egg			95		1		34		6		27				30				1								17	
Invertebrate egg case																											1	
Invertebrate egg sac																			1									
Mollusca egg case					1																7							
Mysidacea indet.	1								1								1											
Neocalanus sp.					1																							
Ostracoda indet. (larval)															2													
Parathemisto pacifica					1																							
Tanaidacea indet. (larval)			1																									
Thysannoessa raschii					3																							

NOTES

1. Source: Burd *et al.* 2000a
2. GSXER67-1: Some gravid *Photis parvidons.*
   GSXER67-1: Phoxocephalidae indet. - head only.
   GSXER67-2: Spionidae indet. are larvae
   GSXER67-2: Gravid *Leptognathia gracilis*