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# A Comparative Analysis of Submarine Cable Installation Methods in Northern Puget Sound, Washington

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**In this study we analyze environmental impact associated with installation of submarine power cables and telecommunication lines between the islands and mainland of the North Puget Sound region. Using information from permit applications, routing plans, and biological assessments, installation techniques were evaluated for their degree of nearshore habitat disturbance. Nearly 25% of the cable projects approved between 1990 and 2000 had a negative impact to nearshore habitat with over 70% having unknown impacts. The extent of disturbances ranged from geomorphic alterations with complete loss of seagrass (*Zostera marina L.*) cover to no apparent damage. Large hydraulic trenching devices caused the most severe nearshore damage. Directional drilling and the use of existing conduit produced the least amount of impact while the technique of laying the cable on the sea bottom resulted in unknown environmental impacts. Each installation method described in this study had unique environmental concerns with implications that need further examination.**

*Keywords:* Seagrass, Submarine Cable, Disturbance, North Puget Sound

## INTRODUCTION

North Puget Sound, including the San Juan Islands, is located in the northwest section of Washington State. The North Puget Sound region is a fjord estuary carved by retreating glaciers approximately 10,000 to 20,000 years ago. These glaciers formed deep valleys and depressions creating an array of protected bays and inlets that host a large variety of marine vegetation. Kelp, macroalgae, and seagrasses are found on the shorelines throughout this region (WDNR, 2001). North Puget Sound's marine environment has a continuous shoreline with an estimated 80% unaltered by human activities (Bailey et al., 1998), however this may change.

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In the past decade, the North Puget Sound area has experienced a large increase in human population, particularly in the island community of San Juan County. A recent survey estimated a population increase of 40.3% in San Juan County from 1990 to 2000, which was nearly double the rate experienced by Washington State during the same period (US Census Bureau, 2000). Included in this study are two other counties, Whatcom and Skagit County, which experienced increases of 30.5% and 29.5% respectively within this period (US Census Bureau, 2000).

The global loss of seagrass resources has largely been attributed to human activities that reduce water clarity, change shoreline processes or directly remove plants (Short and Wyllie-Echeverria, 1996). While these same activities threaten all six seagrass species in Washington State (Wyllie-Echeverria and Ackerman 2003), particular attention is focused on impacts that endanger one species, *Zostera marina* L. (eelgrass) because the meadows formed by the vegetative growth of these plants are valuable habitat for fish, shellfish, invertebrates and waterbirds throughout Puget Sound (Phillips 1984; Fresh 1994; Simenstad 1994). In addition to activities associated with industrial and commercial development, dock and pier construction and shoreline armoring impact *Z. marina* populations in this region (Broadhurst, 1998; Williams and Thom, 2001; Fresh *et al.* , 2001). However, a less explored disturbance is the impact caused by the installation of submarine cables.

The process of installing submarine cable can potentially damage nearshore marine habitat. *Z. marina*, which grows on submerged land along the shore of Northern Puget Sound (Gayaldo et al. in review; Berry et al., 2003), is the primary habitat of concern that may be adversely impacted by these projects. Meadows formed by the clonal expansion of this marine macrophyte are an essential nursing ground for juvenile anadromous fish, such as chinook (*Oncorhynchus tshawytscha)* and chum (*Oncorhynchus keta)* salmon, and a critical spawning habitat for Pacific herring (*Clupea pallasii)* (Phillips, 1984; Simenstad, 1994). Since the listing of chinook and chum salmon as threatened in the Puget Sound, activities which can fragment the distribution of *Z. marina* such as cable installation, are scrutinized by natural resource agencies in Washington State (MOA, 1999).

The degree of disturbance caused by a cable installation project varies depending on the scale of the project and the particular technique or combination of techniques used. Recognizing the potential ecological damage caused by cable projects, marine resource managers have adopted policies aimed at preserving the continuity of patch configuration within a particular *Z. marina* population and if these plants are present at a proposed cable site, installers are required to perform a biological assessment or a dive survey and submit the results on the appropriate state application (refer to the Permit Process section). Following submittal, the Washington State Department of Fish and Wildlife area biologist will determine if an application is approved based on the assessment and installation method. If a significant impact is anticipated, the application may be denied or amended depending on the circumstances for applying. Therefore, the criteria used by resource managers to predict whether a particular method will result in nearshore disturbances is limited to a small percentage of projects

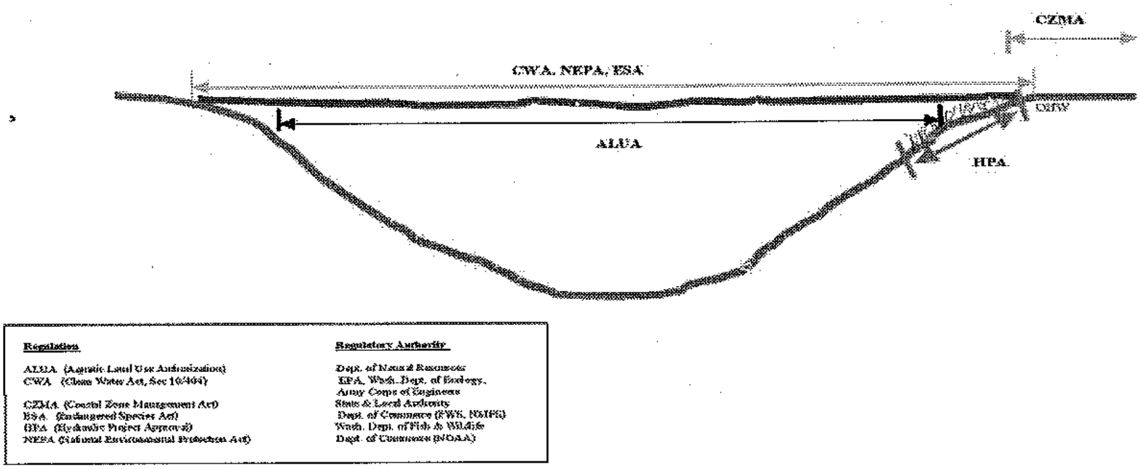


FIGURE 1
Regulations governing the waterways and nearshore environments in Puget Sound, Washington. Seagrass habitat is found within the HPA permit jurisdiction.

that were required to perform post-project assessments or monitoring. Our objective is to discuss the lack of quantitative information that is reviewed in the process of evaluating impacts to *Z. marina* populations caused by the installation of submarine cables.

## PERMIT PROCESS

Washington Department of Fish and Wildlife (WDFW) has the responsibility to protect endangered and threatened species as well as documented forage fish and spawning habitat (critical habitat) along the state's shorelines as according to the Hydraulic Code Rules (WAC 220-110). The rules described in the hydraulic code are designed to guide WDFW area biologists in the decision-making process on whether to grant a hydraulic permit. In addition to the hydraulic permit issued by WDFW, other federal, state and local authorities, with overlapping jurisdictions, may require supplementary permits to perform nearshore and onshore activities (Fig. 1).

Acquiring the proper permits and approval for a submarine cable installation can vary depending on the scope of the project. Any construction activity in or near Washington State waters must receive a Hydraulic Project Approval (HPA) permit issued by the Washington Department of Fish and Wildlife (WDFW) before work can commence. The HPA can be applied for by either completing a HPA application or submitting a Joint Aquatic Resource Permit Application (JARPA) form. The JARPA is a permit consolidation form designed to streamline the permitting process and provide consistent information to permitting agencies. In conjunction with the JARPA, the applicant must perform a State Environmental Protection Act (SEPA) checklist, which determines whether an Environmental Assessment or, a more in-depth, Environmental Impact statement will be required.

TABLE 1
Permits covered by the JARPA application and their appropriate regulatory agencies.

| Regulatory Agency | Permits | Protection |
| --- | --- | --- |
| Local Government | Shoreline permits: Conditional Use, Variance, or Exemption | Manage activities above high water |
| Washington Department of Fish and Wildlife water | Hydraulic Project Approval | Protection of marine life and habitat below ordinary high water |
| Washington Department of Ecology | 401 Water Quality Certification Nationwide Permits | Implements water quality standards to ensure protection of marine life |
| Washington Department of Natural Resources | Aquatic Resources Use Authorization Notification | Manages state owned aquatic lands for social & economic benefits of the public while mini mizing adverse impacts to marine ecosystems. |
| U.S. Corps of Engineers | Section 404 and Section 10 permits | Regulates activities occurring within U.S. navigable waters |
| U.S. Fish and Wildlife Service or National Marine Fisheries Service | Endangered Species Act consultation | Ensure activities do not adversely impact listed threatened or endangered species |

The JARPA form consolidates seven permits from federal, state, and local authorities into one overall application (Table 1). The Shoreline Substantial Development permit is issued by local government under the Shoreline Management Act. Local governments have the option to issue "Conditional Use" or "Variance" permits, which allows flexibility for special circumstances, such as emergency repair of utility service. The permits issued by local government are reviewed by the Washington State Department of Ecology. A 401 Water Quality Certification under the Clean Water Act is required when activities may involve discharges to navigable waters (Hershman and Lind 1994). The Section 10 and Section 404 permits are issued by the U.S. Army Corps of Engineers for any work in or affecting navigable waters of the United States, which includes wetlands. Projects crossing or impacting bedlands, tidelands, or shorelands of navigable waters must apply for an Aquatic Resources Use Authorization Notification from the Washington State Department of Natural Resources (Hershman and Lind 1994).

## METHODS OF RESEARCH

We searched the HPA database for marine construction projects within the study area from 1990 to 2000 and selected applications related to submarine cable installation. Ninety-three marine projects were identified and of these twenty-five were selected that involved submarine cable installation or replacement within the study area. All data was categorized chronologically. Within each year, the data were coded using specifics contained in the HPA (Strauss and Corbin 1990). Site visits occurred at four cable project locations where personal observations were conducted either by SCUBA or skiff.

## TECHNIQUES

In order to understand how installers can avoid adverse impacts from cable installation projects, there must first be an understanding of how the various installation techniques operate. In North Puget Sound, there were four basic submarine cable installation techniques used: embedment machine, directional drilling, existing conduit, and laying the cable on the bottom. The following descriptions were excerpted from the text in the application and describe the techniques used in our study area.

An embedment machine is an underwater excavating device that buries small diameter submarine cable into the sea bottom. There are variations of these units, but each share similar cable burying processes. Remotely operated, the device creates a trench and lays the cable simultaneously. Trenches are either created by a plow blade or a blade equipped with water nozzles that hydraulically disperses the sediment. Cables can be buried up to depths of three meters and adjusted during installation as the substrate profile changes. Some of these units are not self-propelled and require towing by either a vessel or land-based winch. On the towed version, rubber tires are partially filled with air and water, which acts as a buoyancy compensator preventing the weight of the device from making depression scars on the bottom. The self-propelled model moves along the bottom using high-pressure water jets for propulsion and is directionally guided by the deployed cable.

Directional drilling involves using a land-based drilling machine, producing a subsurface tunnel underneath the area to be avoided. The boring operation begins by drilling a pilot hole horizontally with a cutting head attached to a drill string. As drilling progresses, a mixture of water and bentonite (a non-toxic, natural clay) is injected through slurry jets located at the front of the cutting heads. The bentonite mixture lubricates the drill head to reduce frictional temperatures and helps emulsify the sediment. Once the drilling is complete, the cable conduit is attached to the boring head and retracted toward the land. This method has geophysical constraints, which may restrict its use to soft substrate. Principally, directional drilling is used at locations where the substrate is easily penetrable and absent of large bedrock deposits that may deflect the drilling head in an undesired direction.

Laying the cable on the seafloor has been used at various depths ranging from ordinary high water line to deep open ocean. The cable is deployed from a barge offshore and suspended by floats over the desired route through the nearshore region. Once positioned, divers deflate the floats and guide the cable into place while attempting to avoid marine vegetation, if possible. A steel casing was installed over the cable before it was lowered to the seafloor at one location in the study area. The cable casing provided additional protection from vessel traffic and reduced cable movement. The desired outcome from this method is for the cable to which may affect available food resources for some migratory fish species (Frost et al., 1999; Hovel, 2003). Bell et al. (2001) reviewed 14 published studies and work in Tampa Bay, FL, and found that responses to fragmentation of seagrass beds were variable, with details of each case (including the cause of fragmentation, faunal community composition, and fishing activities) likely influencing outcomes of each study. More extensive damage to seagrass beds caused by intensive propeller scarring was more likely to result in negative impacts to fauna, probably because such impacts included damage to the substrate, not only to the configuration of the seagrass beds (Bell et al., 2001). Thus, although the exact consequences of fragmentation of seagrass beds during cable installations is unpredictable, because certain installation methods (e.g. embedment machine) can involve extensive damage to the substrate, cable installation impacts are more likely to be negative than neutral.

Power lines in terrestrial habitats may also cause detrimental fragmentation effects. The installation of the power lines and support roads fragmented landscapes in Norway, reducing suitable foraging habitat and disrupting migration routes of indigenous reindeer (Nellemann et al., 2001). Consequently, the remaining population became subdivided into several small groups with limited or no breeding contact. Although, foraging resources were available within the fragmented areas, the reindeer herds avoided the open spaces causing overgrazing in other areas undisturbed by humans. The behavioral changes in the reindeer were not anticipated or immediately evident, but observed after long-term monitoring. The difficulty of predicting species behavioral responses to landscape changes supports the need to conduct post-project monitoring on all submarine cable projects that may alter or damage existing marine habitat.

The results of this study indicate that embedment machine causes disturbances to *Z. marina* populations that are unavoidable. This device, which is capable of carving a trench up to 3 meters wide (personal observation), can create a corridor within a contiguous patch or further fragment discontinuous patches by means of plant removal. While the impact on organisms caused by this transformation of the vegetated landscape has been studied in other regions (e.g., Hovel 2003), similar investigations are lacking in the Northern Puget Sound. When compared to the other installation methods, the embedment machine and the imminent environmental impacts it causes should receive the most scrutiny among resource managers. Since, damages can be anticipated before installation commences, unlike laying cable on the bottom, expected *Z. marina* loss should be calculated and mitigation measures implemented prior to installation activities.

A majority of the projects examined in this study had unidentified impacts due to the assumption by permitting authorities that no or minimal disturbance would occur from a particular method. For example, directional drilling and the use of existing conduit are expected to cause the least amount of disturbance to intertidal and subtidal regions. Directional drilling avoids impacts by tunneling under the *Z. marina* zone and surfacing at an established depth beyond the subtidal zone. However, if un-penetrable substrate is encountered while drilling, the boring head may be deflected upward, surfacing within the region designated for protection, however this was not reported to have occurred with the projects reviewed in this study.

Laying cable directly on the seafloor is considered to cause minimal impact to

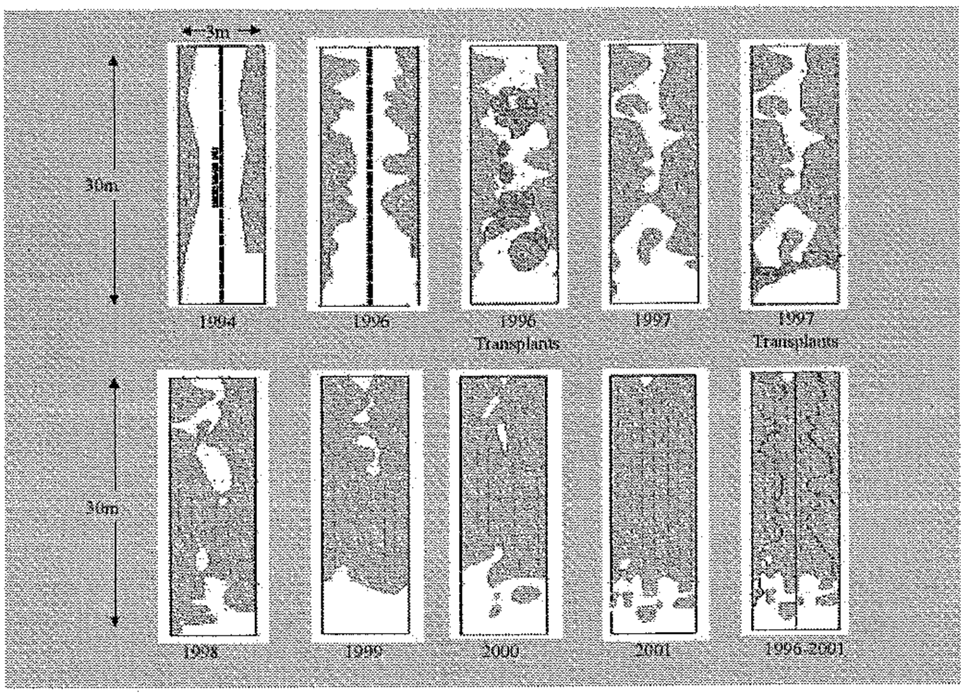


Figure 3.
A time-series regrowth of *Z. marina* in a section of the disturbance corridor at Picnic Cove, Shaw Island, Washington.

nearshore habitat. All the projects with one exception that chose this installation technique were not required to perform post-project monitoring, which raises some concerns as to whether this method may have an impact on *Z. marina* populations. Since cable diameters typically do not exceed twenty centimeters, the cable resting undisturbed on the sea bottom is not expected to cause significant damage to *Z. marina*. However, a closer examination is needed to determine whether tidal changes or currents causes cable movement or scouring. Also, macroalgal attachment on exposed cable may shade *Z. marina* growing adjacent to cables, possibly creating a larger disturbance corridor.

The actual impact to *Z. marina* from the installation of submarine cables is largely unknown, however, data from our time series investigation at one site illustrates that recovery can take several years. Cable was installed at this site, a small semi protected cove on the south side of Shaw Island, in the San Juan Islands (Fig. 3), in the fall of 1993 using the embedment machine. Landscape analysis following the installation indicated a linear scar with an approximate area of 0.09 ha was cut through the *Z. marina* meadow at the site. Over the next two years using the sampling techniques of diver surveys and towed underwater video (Norris et al., 1997), damage assessment revealed that while this only represented a loss of 2.3% of the 3.9 ha meadow, the connectivity of the near shore distribution was severed and the redox environment remaining trench was not habitable for *Z. marina* (Wyllie- Echeverria et al. unpublished data; Gayaldo et al. in review). Because this break in continuous cover could hinder fish passage, WDFW required remedial action be taken. Starting in the summer of 1996 the anoxic sediment in the trench was blended with beach sand and a whole plant *Z. marina* transplant was initiated. A second transplant was undertaken in the summer of 1997. No further transplants occurred, however re-growth across the shallow subtidal region of the scar was monitored until connectivity was achieved; a process that took six years (Fig. 3).

Whereas insufficient data exists on the cumulative impact to the nearshore environment associated with such activities, when combined with other human-induced disturbances, such as float construction (Fresh *et al.*, 2001) and dredging (Phillips, 1984), cable installation projects may significantly contribute to the loss of *Z. marina* in Northern Puget Sound and once impacted scars may take several years to heal. The bays and coves supporting submarine cables are designated sites that are subject to future cable installation projects. Many of these locations have multiple cable lines running parallel and adjacent to each other, which depending on the installation technique chosen, can result in a recurring disturbance. With established cable corridors becoming congested, efforts are needed to utilize space more efficiently (e.g. reusable cable conduit) to prevent further damage to nearshore environments.

Seasonal restrictions of in-water construction or installation activities have provided protection for migratory fish species, but greater efforts are needed. Regulations do not specify which installation technique must be used by the installer, however, it is assumed that the method chosen should not adversely affect critical marine habitat or cause fish mortality. A high percentage of projects reviewed in our study had unknown impacts following completion. This coupled with the fact that project applicants were not required to perform post-project monitoring is troubling. The limited data on the biological consequences of fragmentation within an extant *Z. marina* population or landscape alterations in the near shore in the Northern Puget Sound supports the need for policy changes to incorporate increased monitoring requirements as a permit condition.

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