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16. ABSTRACT

An experimental structure for controlling shoreline erosion was built by District 05. The structure, a combination of groins and sills, was built of 5 by 10 foot plastic coated nylon sandbags that were filled in place. The bags and the material from which they are made were generally satisfactory. Several problems with the design of the structure and with the construction technique were encountered and are described. These problems prevented satisfactory completion of the structure, and for that reason, no evaluation of the sand trapping and energy dissipating characteristics of the structure could be made. The environmental impact of this installation was evaluated and was found to be insignificant in the time frame represented by this project. The methods used to accomplish the impact study are described and the results reported.

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
TRANSPORTATION LABORATORY

December 1973

FHWA No. F-5-8
TL No. 632125

Mr. R. J. Datel
State Highway Engineer

Dear Sir:

I have reviewed and now submit for your information this interim research project report titled:

EVALUATION

OF A

SHORELINE EROSION CONTROL

PROJECT

Study made by.....Foundation Section

Under the Supervision of.....Raymond A. Forsyth
and
Marvin L. McCauley, E.G.

Principal Investigator.....Ronald Mearns, E.G.

Report Prepared by.....Ronald Mearns, E.G.

Very truly yours,

JOHN L. BEATON
Chief Engineer, Transportation Laboratory

Attachment

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ACKNOWLEDGEMENTS

This project was conducted in cooperation with the U. S. Department of Transportation, Federal Highway Administration, under agreement number F-5-8.

The author would like to thank Mr. Roy Alderman, District 05 Maintenance Engineer, and his staff for their invaluable assistance in performing this study. Mr. Joe Mori of the Division of Highways Photogrammetry section and Mr. Bob Freer of the Transportation Laboratory also contributed greatly to the project by completing various contracts under very tight time limitations.

The contents of this report reflect the views of the Transportation Laboratory which is responsible for the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California or the Federal Highway Administration. This report does not constitute a standard, specification or regulation.

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INTRODUCTION

The California coastline is in a state of continual change as a result of erosion that results from the interaction of the land and the sea. This erosion frequently results in damage to man made projects adjacent to the shore.

This report covers work performed on Road 05-Mon-1-PM 60.05. Figure 1 shows the location of the area while Plate 1 is an airphoto mosaic of the site with several features labeled. Plate 2 shows an overall view of the area.

On March 14, 1970, the south approach to the Rocky Creek Bridge cracked and settled. Repairs were required to assure the safe passage of vehicles. The damage had occurred because the bluff adjacent to the bridge had collapsed as a result of undercutting by the ocean. Detailed investigation of the bridge and its foundation revealed that the bridge had not been damaged and that the bluff had stabilized.

In order to prevent reactivation of the landslide by further undercutting of the bluff, the District constructed a seawall. This seawall has performed satisfactorily, to date, although it has sustained major damage requiring considerable maintenance and repair.

The coastline in this area, which trends north and south, is highly irregular with many offshore rocks. The winds normally blow from the northwest and storms generally come from the southwest. In spite of the offshore rocks, this location is subject to almost continuous severe wave attack. A primary reason for the initiation of this project is that this location represents an extremely severe condition.

Because of the irregularity of the coastline and the presence of offshore rocks, currents along the shore are weak and tend to be local. The absence of strong long duration currents precludes the movement of large amounts of sand. In the vicinity of the seawall, however, strong local currents have been observed moving sand both north and south. These sand losses resulted in undercutting the sea wall and extensive damage. Plate 3 shows this damage. Note that all sand is scoured away from the foundation. Plate 4 shows a collapse of seawall backfill material as a result of scour. The wall under severe wave attack is shown by Plate 5.

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In the spring of 1971, there was concern that the seawall might fail and major corrective action would be required to protect the Rocky Creek Bridge. At that time the District, acting on the recommendation of the Transportation Laboratory (Formerly the Materials and Research Department), decided to construct an experimental groin and sill sand trap using very large nylon sandbags that would be filled in-place.

The reasons for the selection of this type of installation were:

1. To keep the local currents away from the seawall;

2. To raise the base grade of the beach sufficiently to assure that sand remained permanently under the seawall;

3. To establish a permanent beach which would cause the waves to break thereby dissipating their energy; and

4. To accomplish these goals with minimum capital investment and environmental impact.

The first contractor on the construction project suggested the treatment shown on page 16. Because of inadequate equipment and inexperienced personnel, numerous problems and delays occurred which resulted in failure to complete the proposed structure. A subcontractor was then brought in to build the structure shown on page 19. The reduced size of the project was made necessary because the remaining funds were insufficient to complete the original plans. The scaled down structure was felt to be adequate to permit evaluation of the sand trapping capabilities of the sandbag structure.

Since the structure to be built, the materials incorporated in the structure and the construction technique were all new and untried, it was decided that a research project to evaluate them would be valuable. This report presents the results of that evaluation.

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CONCLUSIONS

The material of which the sandbags are made has proven durable enough to withstand at least 2-1/2 years of exposure in this location. In those locations where the bags can be damaged by vandals or natural sharp objects, they should be filled with concrete instead of sand. Sandbags cost about $30 each. Labor and equipment costs required to fill the bags with sand run another $60. Costs to purchase and pump concrete are estimated to add another $100 per bag.

The ties at the corners of the bags are totally inadequate. Special treatments are required to hold the bag in place. Ropes tied onto the corners of the bag and vicegrip pliers clamped onto the corners have both worked satisfactorily.

Either a trash type pump or a suction dredge type pump can be used for filling the bags. Adequate water and sand supplies must be available. Pump output must be carefully regulated to prevent splitting the seams of the bags.

An anchoring system is required to hold the bag in place during the initial stage of the filling process. Anchors and lines, stakes and special spades were all tried with the spades working best.

The sill and groin sand trap could not be properly evaluated on this project. The sill was built in three stages covering a 9 month period. Because of sand movements and bag settlement, there was a variation of elevation of several feet along the top of the sill. The low spots provided a convenient exit for water and sand so that the sand never really accumulated. For the same reason it was not possible to evaluate the permanence of the beach or its effectiveness in dissipating energy.

No disturbance of the bluff or shoreline was required for construction, nor was any special access required. As placed on this project, the bags are exposed only at the lowest tides so the visual impact is minimal. Sea life is using the stable sandbags as a new habitat which further reduces the visual impact.

There has been no observable depletion of sand either up or down the coast in the two years since this project was started. This may be due to the failure of the structure to trap sand. There has been no significant change in the shoreline configuration during the life of this project. Bottom conditions in the sub-tidal zone do not appear to have changed.

There have been no detectable disappearances or appearances of plants or animals since construction of the sill. Some changes in numbers of plants and animals have been observed in the intertidal zone which is where the sill is located. The changes are believed to be seasonal and not related to the presence of the sandbags.

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RECOMMENDATIONS

Further research in the use of sandbags is recommended. Use should be based on a need for reduced costs or minimal environmental impact. For permanent installations, where damage by vandals or severe abrasion by sharp objects is anticipated, the bags should be filled with concrete.

Work on this research project was suspended pending a decision by the District on the feasibility of repairing the sill and groin structure. This work was done during the months of May, June and July, 1974. Now that it has been completed, it is recommended that the research be re-scheduled and re-financed to complete the objectives of evaluating the sand trapping capabilities of the sill and groins, the energy dissipating characteristics of a beach within the sand trap and any environmental effects of the operating sand traps.

Since the groin and sill are feasible and the materials and construction techniques have proven successful, we recommend a more detailed and scientific environmental impact assessment be made. The more detailed study should include but not be limited to quantitative estimates of sand accumulations and losses, subtidal zone biologic census to determine the impact of near shore current displacement, and periodic aerial photo coverage to monitor the extent, configuration and density of kelp beds in the vicinity of the construction as well as changes in beaches and bluffs.

If the installation is only partially effective in trapping sand and this appears to be the result of insufficient design, it is recommended this subject be investigated. Bag configuration, interlocking capabilities, placement and structure of sills and groins should be included in the study.

Construction of a new installation in an area having more placid surf conditions should be considered to test the sand trapping qualities of a new design.

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IMPLEMENTATION

The findings of this project will be distributed throughout the State by means of this report.

Transportation Laboratory personnel involved with this research will use their expertise in making recommendations on future shoreline erosion control projects. They will also be available to the Districts for consultation and training purposes.

The findings of this report will also be presented to the Bank and Shore Protection Committee, to be considered for problems they are working on and for publication in any memoranda or manuals that they might issue.

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RESULTS

The concept of the sill and groin sand trap and the use of the large sand bags were first presented early in 1971 by representatives of Erosion Control West, Inc. This company was a subsidiary of Erosion Control, a Florida based company specializing in shoreline erosion control and correction. Erosion Control West, Inc. is no longer in business.

Sand Bags

The system proposed by both companies was based on the use of five by ten foot nylon bags which could be filled in place and would therefore, have low material and installation costs. The bags are made by Burlington Industries and include a patented opening which permits filling but prevents later sand loss. The fabric is covered either with an acrylic plastic or with polyvinyl chloride depending on the job requirements. The acrylic covered bags are black and cost $23.40 while the PVC covered bags are white and cost $31.20. These prices were in effect in December, 1973.

The bags were found to have sufficient strength for the intended purpose. Two strength problems were noted and deserve mention. A canvas strap is sewn into each corner, ostensibly for the purpose of tying the bag in-place while it is being filled. If these ties are used in this way, they frequently rip out of the bag, leaving a hole through which sand can escape. The second problem involves the rate at which the bags can be filled. Since the sand is pumped in as a water-sand slurry it is necessary for water to escape. Water can, and does, escape through the fabric and also out of the fill opening. It was found that too high a pumping rate did not permit the water to escape in sufficient quantity to prevent rupture of a seam.

Vandalism and damage by objects (shells, rocks, boards, etc.) which are propelled by wave action have resulted in the loss of some bags. In areas subject to this problem, only concrete filled bags should be used. Several bags were purchased by the District 05 Maintenance Department and were used to make repairs on the sea wall by filling them with concrete. Their performance for this application was excellent. Plate 6 shows concrete filled bags used to repair damage to the seawall.

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DESIGN

Because of their previous experience, Erosion Control West was invited to inspect the site and, if the proposed sill and groin sandtrap appeared feasible, submit a proposed design. Representatives of Erosion Control West and Erosion Control, along with a private coastal engineering consultant did conduct a field review. They concluded that the proposed project was feasible and submitted the design shown in Figures 2, 3 and 4.

As a result of experience gained on this project, it is apparent that several factors must be considered when designing a system of this nature. The principle axis of the bags must be oriented parallel to the direction of maximum wave forces. Bags oriented at right angles are easily rolled out of position. The sill and groins must be so located and designed that their top will establish and maintain a constant elevation. The development of low spots will result in heavy sand losses from within the sand trap. If bags are to be piled on top of each other they must have some support to hold them in place. Presumably the filling of the sand trap will perform this function satisfactorily, however, bags may be displaced before such filling has occurred. Displacement of bags will result in low spots which in turn will prevent successful functioning of the sand trap.

The bags are made by folding the material and sewing the edges closed. This results in a flat object with dimensions of five feet by ten feet. As a bag is filled, it draws in resulting in filled dimensions of four feet by nine feet when measured across centerline in each direction. This reduction of dimensions must be provided for when designing a sand bag structure. Failure to consider these factors will affect the integrity of the structure and will result in significant cost underestimation.

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CONSTRUCTION

Because of the size of the bags and the necessity of holding them in place in the surf, several special steps must be taken. It is necessary to attach strong ropes at each corner and to provide a moveable anchoring system to which the ropes can be tied.

Various anchoring systems were tried. The most successful was a specially constructed spade which would become more firmly planted the greater the force applied. Plate 7 shows one of these anchor spades. The bags must be held firmly in place in order to achieve a uniform and constant elevation for the top of the sill and groins. Because the bags draw in from the original five feet by ten feet size as they are filled it is necessary to place them carefully and hold them securely so that no gaps occur to permit a loss of sand.

The bags were filled by use of a suction pump which drew in a slurry of water and sand and delivered it through a nozzle into the bag. For this project, the pump used three inch diameter hoses which appear about right for the filling rate of the bags. The rate for filling bags varied from 16 to 48 minutes and was dependent on such diverse problems as debris in the sand which would plug up the intake nozzle, availability and accessibility of sand, sufficient water, roughness of the surf conditions, and the skill and diligence of the operator of the intake nozzle. The pump was powered by a two cylinder Wisconsin gasoline engine which was adequate for the job but was subject to mechanical failure in the cold and wet conditions encountered at this site. Although the pump was adequate, the passage of the abrasive sand grains through the impeller blades rapidly wore them out thereby requiring frequent replacement to maintain pump efficiency.

Several problems were encountered in the bag filling operation. The intake hose could not be longer than about 50 feet. This was necessary to maintain sufficient flow to prevent plugging of the hose. Because of this requirement, the pump had to be located close to the sand and water supply. In order to hand move the pump which weighs over 200 pounds, a carrying rack was constructed. Elevated legs were built to keep the pump dry. To provide stability in the surf, a wide based platform was also used. The necessity for keeping the pump dry has resulted in shortening the work day during days with rough surf action. Plates 8-11 show the pump and engine, the carrying rack, working platform, the operator working the intake nozzle, and the output nozzle in place during the filling operation.

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Because the proposed structure was in the surf zone it was found that work had to be scheduled for periods of low tide. Because of the tendency for winds to increase in the afternoons, mornings provided best working conditions. The most favorable tides were those lower than -.5 foot. Minus tides at this location occur in the mornings during spring and early summer. In scheduling work on any project employing a sand bag installation, consideration must be given to tide and wind information.

The health and safety of the workers under the conditions at this site are also factors of major importance. High seas and extreme turbulence are the rule. Therefore, work could not be attempted at less than ideal conditions. The water temperature seldom, if ever, exceeds 50°F so that all personnel required wet suits. To provide sure footing and facilitate the work, quick release type weight belts were also needed. Personnel were not permitted to work alone in the surf. An observer was maintained on shore to oversee the entire job. The need for these precautions were readily apparent on this project. Because of the unique nature of this type of work, these observations are included for future consideration.

Work was started in September 1971 and completed in August 1972. A total of 43 working days were used to place 385 bags. The reason for this extended construction period were:

1. The unexpectedly rough surf conditions.

2. Equipment problems.

3. Difficulty in developing a satisfactory construction technique.

4. The infrequent occurrence of satisfactory low tides.

5. Labor problems.

The effect of these problems can be greatly alleviated through application of the lessons learned on this project. It is estimated that an equal number of bags could be placed in 16 to 20 working days, if the work is properly planned.

Plate 12 is a view of the sill looking toward the south taken five months after the sill was completed. Several of the bags can be seen to have been displaced. It can also be seen that the south end of the sill is lower in elevation than the north end. The groin is not visible because it is even lower. It is believed that the absence of sand behind the bags permitted the wave action to displace them. Observations during low tides indicate that waves break over the sill and the water in running

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back to the sea must run south across the groin. The velocity of this runoff is great enough to carry away the sand so that the bags never had any support. Control of the elevation of the top of the sill and groin would eliminate this problem and permit the entrapment of sand.

In spite of this problem, it is estimated that only about 10% of the bags on the sill have been displaced. The displacements are nearly all in the direction of the beach, and in a few cases, have not resulted in a total loss of effectiveness. Although the sand bag structure has not been observed in an exposed condition since November of 1972, it has been seen through the water. It appears to be basically still intact after 15 months. Except for the bags at the extreme surf line, they are all covered by a solid and apparently permanent growth of marine algae. Bags in the surf line are expected to fail as a result of severe abrasion. This failure will probably occur between 3 and 5 years depending on the severity of the exposure.

Following completion of the sill, the local shoreline current was observed to have been displaced to the ocean side of the sill. This was a necessary accomplishment if a permanent sand beach was to be created. This observation suggests that a properly constructed sill and groin structure would be a successful sand trap.

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ENVIRONMENTAL IMPACT

The rocks exposed in the bluff in the vicinity of the seawall are primarily a highly fractured and faulted moderately weathered metamorphosed diorite. They are vulnerable to erosion by the sea, particularly in the fault zones. The bluffs were carefully observed for about 1/4 mile north and south of the seawall to determine the kinds of changes and the rates at which they might be expected to occur. During the relatively short life of this project, there were no significant changes in the bluff. There was some local spalling of rocks from fractures and fault zones.

No significant permanent change in the height, width, or shape of the beach occurred during the life of this project. There have been significant seasonal changes in beach height and slope with the highest sand elevations reached in the spring and early summer and the lowest in the late winter. This loss of sand appears to be the result of storm action. The sand appears to move into deeper water, from which it is gradually washed up on the beach by less turbulent water. There is some evidence that a small amount of sand may be lost to the south as a result of local currents.

Offshore Rocks

A photographic record of offshore rocks was kept, and again no significant changes were observed.

Underwater Conditions

The Transportation Laboratory Scientific Dive Team made underwater inspections of the bottom conditions in the vicinities of rocks A, D, E, F, G, H, I, J, K, L, M, N, and O shown in Plate 1. These rocks are encrusted with sponges, corals and algae. No changes were ever noted in any of them. The nature of the bottom between E, F, G and N, O, P out as far as H did change. At times this bottom was entirely buried in sand while at other times there were numerous rock outcrops exposed on the bottom as well as extensive areas covered with gravels and shells. No accurate measurement of the depth of the sand was obtained. However, the absence of heavy developments of marine life at the base of rock I suggest as much as four feet of sand build up. Rock H is about 1000 feet from shore. The water depth at a zero tide is approximately 28 feet. There is some sand on the bottom at this location but it is local and appears to be relatively thin and probably stable.

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Biology

Numerous birds and mammals have been observed in the vicinity of the seawall. No detailed study of the numbers of types was made. Observations made during the two years since the start of this project suggest that no species have left the area, nor is there any noticeable change in the numbers of either birds or mammals.

Observations of the kelp bed which exists to the west and south of rocks E, F, and G indicate that the areal limits have not changed during the life of this project. These observations were made from a study of aerial photographs, and from observations from the bluff. Subsurface observations indicate that the density of the kelp is extremely variable and is related to storm activity. Discussions with marine biologists from the Department of Fish and Game and from the U. S. Naval Post Graduate School in Monterey indicate that this variation in kelp density is seasonal and not related to the presence of the seawall or the groin and sill structure.

Since the sill and groin were to be placed in the intertidal zone, it was decided to make a detailed study of the life in that zone. A consulting marine biologist was employed to take a periodic biologic census. It was decided that the rocks on which Bench Marks 1 and 2 were placed (see Plate 1) would be most likely to be affected by the construction of the groin and sill.

The census was taken along permanently established transect lines that extend in various directions from the top of the rock to its base. The census is obtained by stretching a rope along the transect line and centering a 1 square meter frame along the rope. The frame was divided into 100 squares and the types and numbers of the plants in each square were recorded. Plate 13 shows the frame and grid. The frame is moved down the rope one meter at a time, thus, providing a complete census. The census was taken at extreme low tide to permit access to the base of the transect line.

By reestablishing the transect line with the rope it becomes possible to exactly reproduce the census areas and thereby obtain comparable information whenever desired. Four transect lines were used on the rock at Bench Mark 1 and three transect lines were used on the rock at Bench Mark 2. A complete census on each transect line was obtained during November and December of 1971 and follow-up data was obtained twice each calender year since. The plants and animals identified on each transect line are

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listed in the Appendix. There was found to be a zonal distribution of species between the lowest and highest points on each transect line. There was also found to be a seasonal variation in the population along the transect line. There was not found to be any disappearance or introduction of species during the life of this project. It is believed that this type of structure has had no effect on the biological environment of this site, except that certain plants have started growing on the relatively stable bags (see Plate 14). The presence of this growth is expected to increase the life of the bag by protecting it from sand abrasion. It also tends to obscure the bag thereby decreasing its visual impact.

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Figure 1

LOCATION MAP

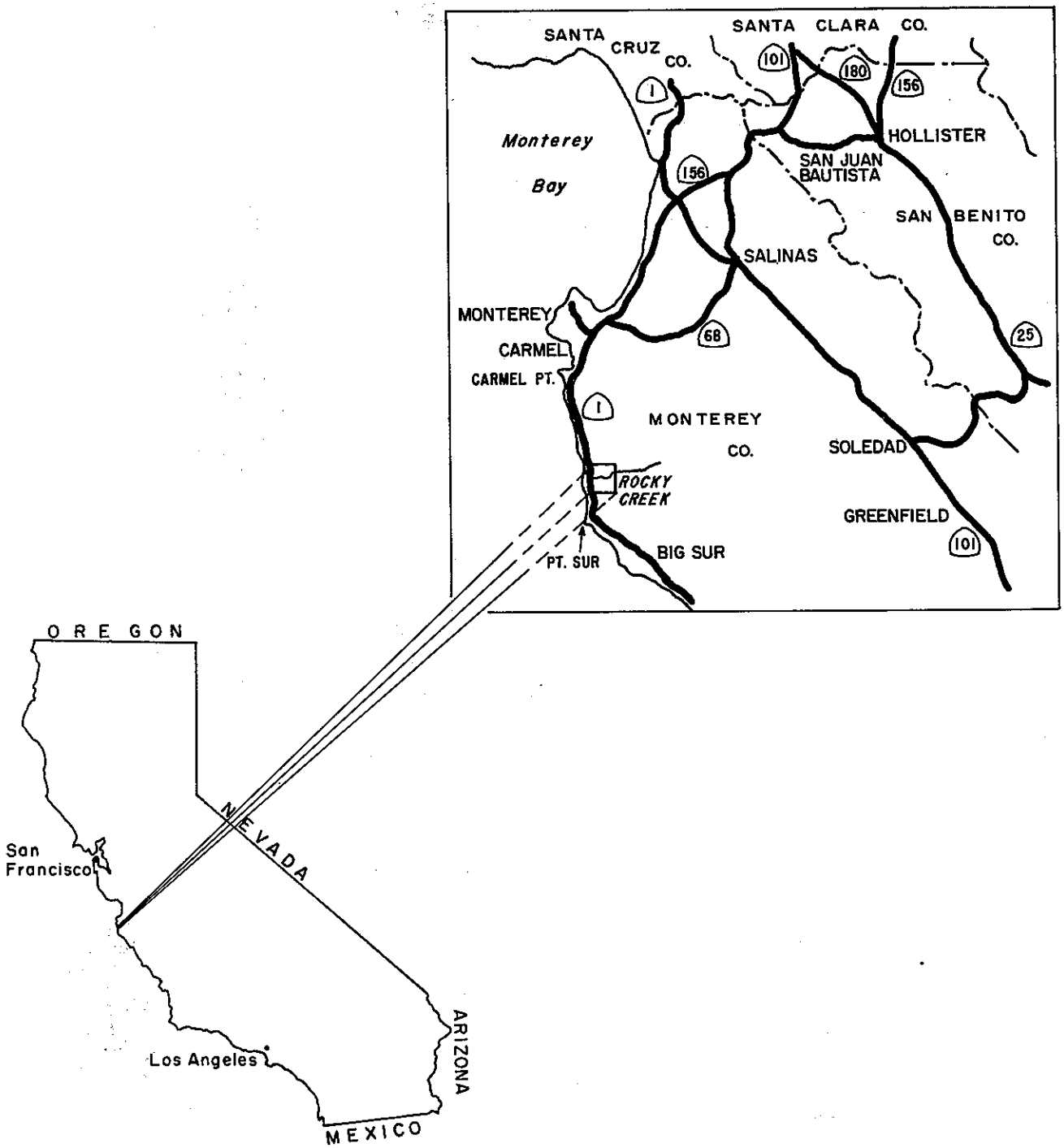

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Figure 2

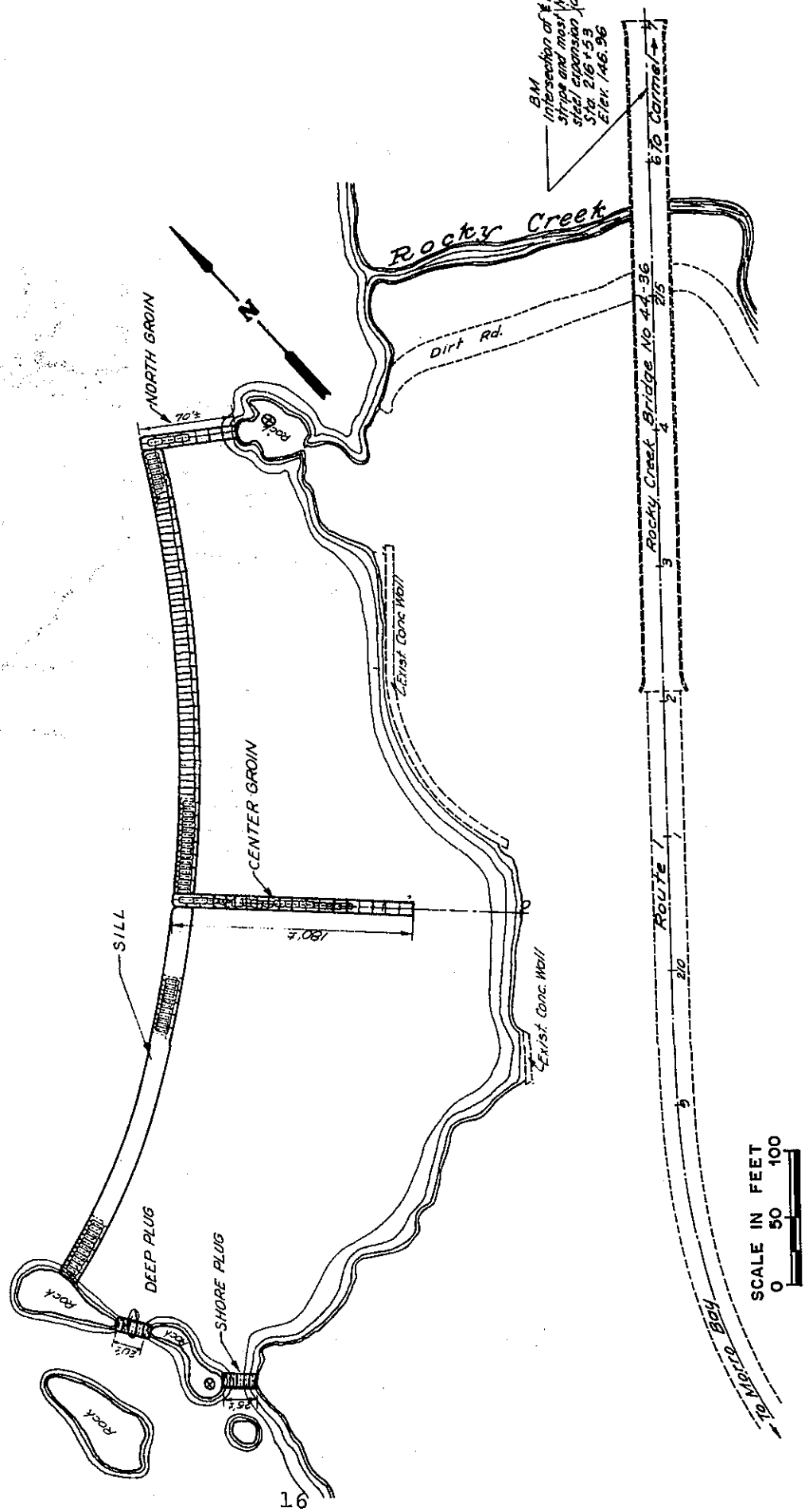

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Figure 3

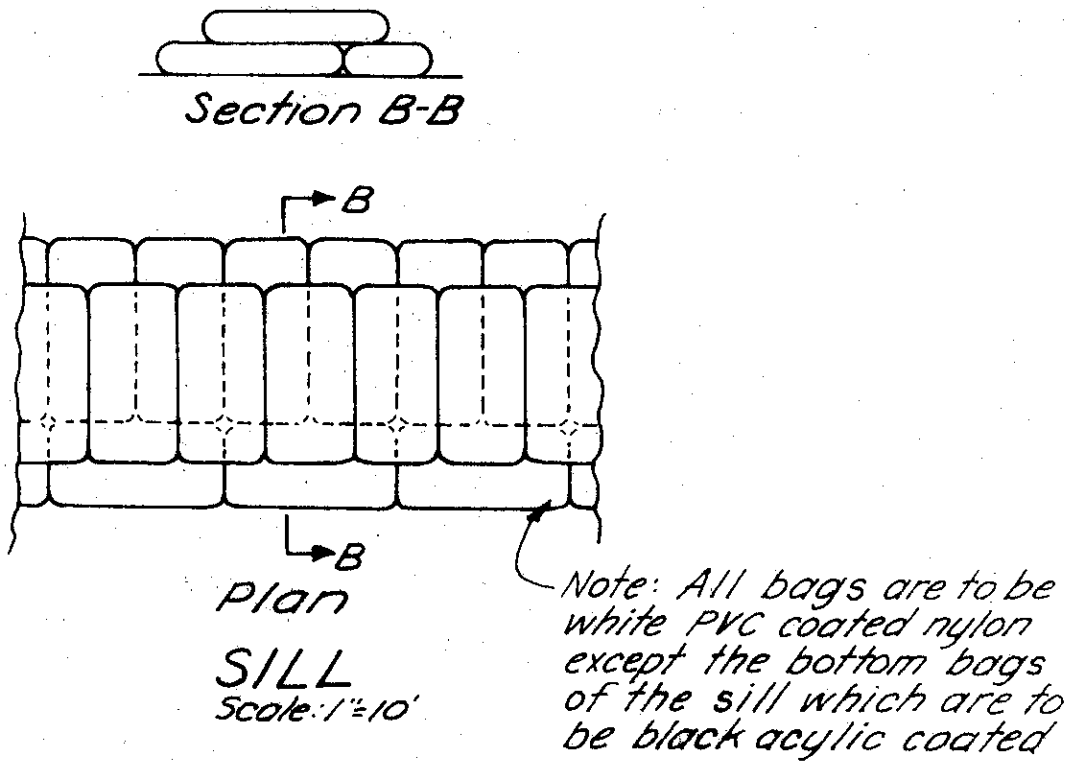

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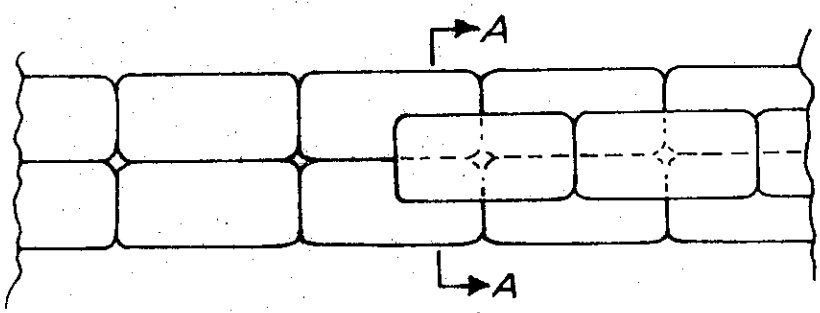
Figure 4

Section A-A



Plan

CENTER GROIN
Scale: 1"=10'

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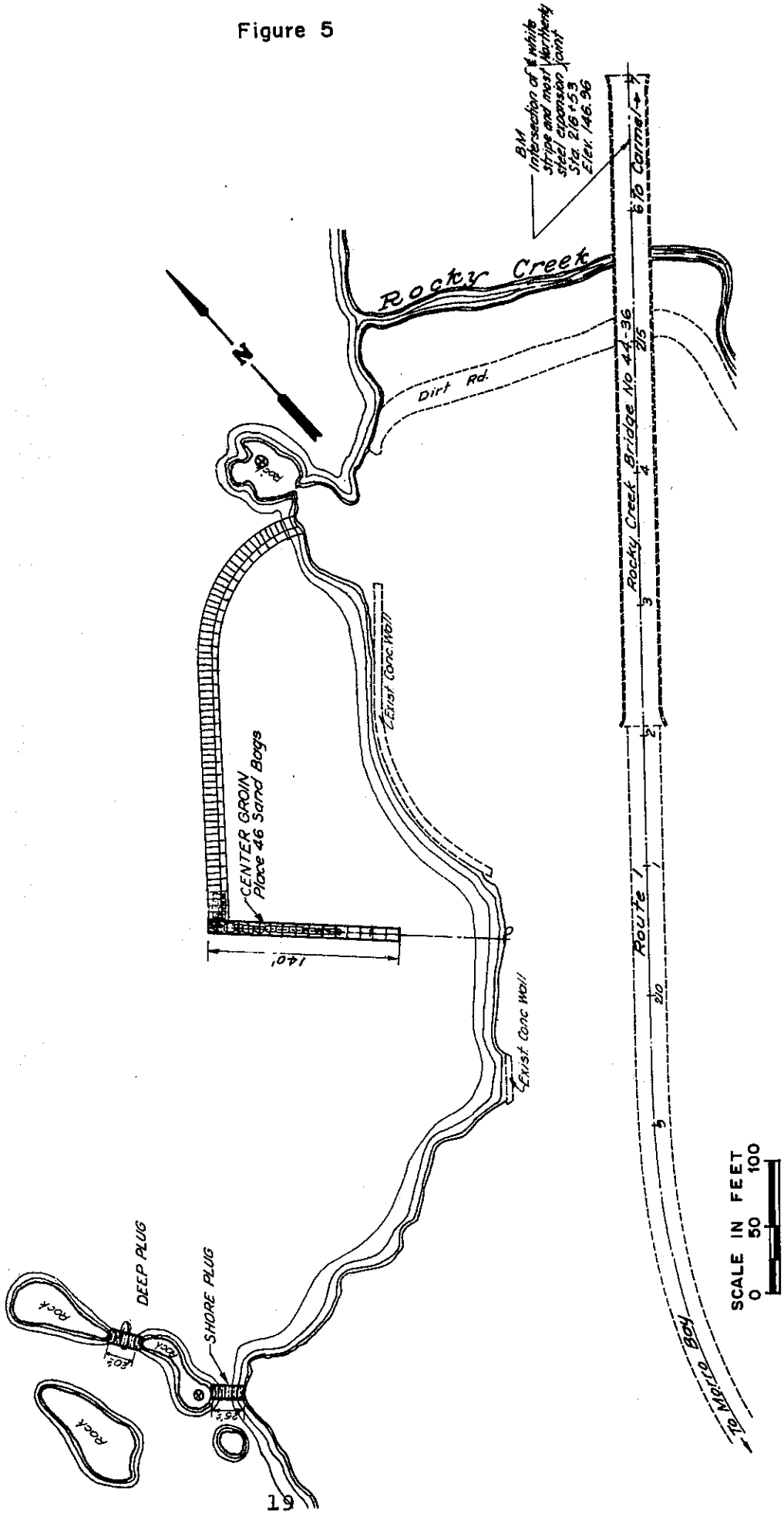
Figure 5



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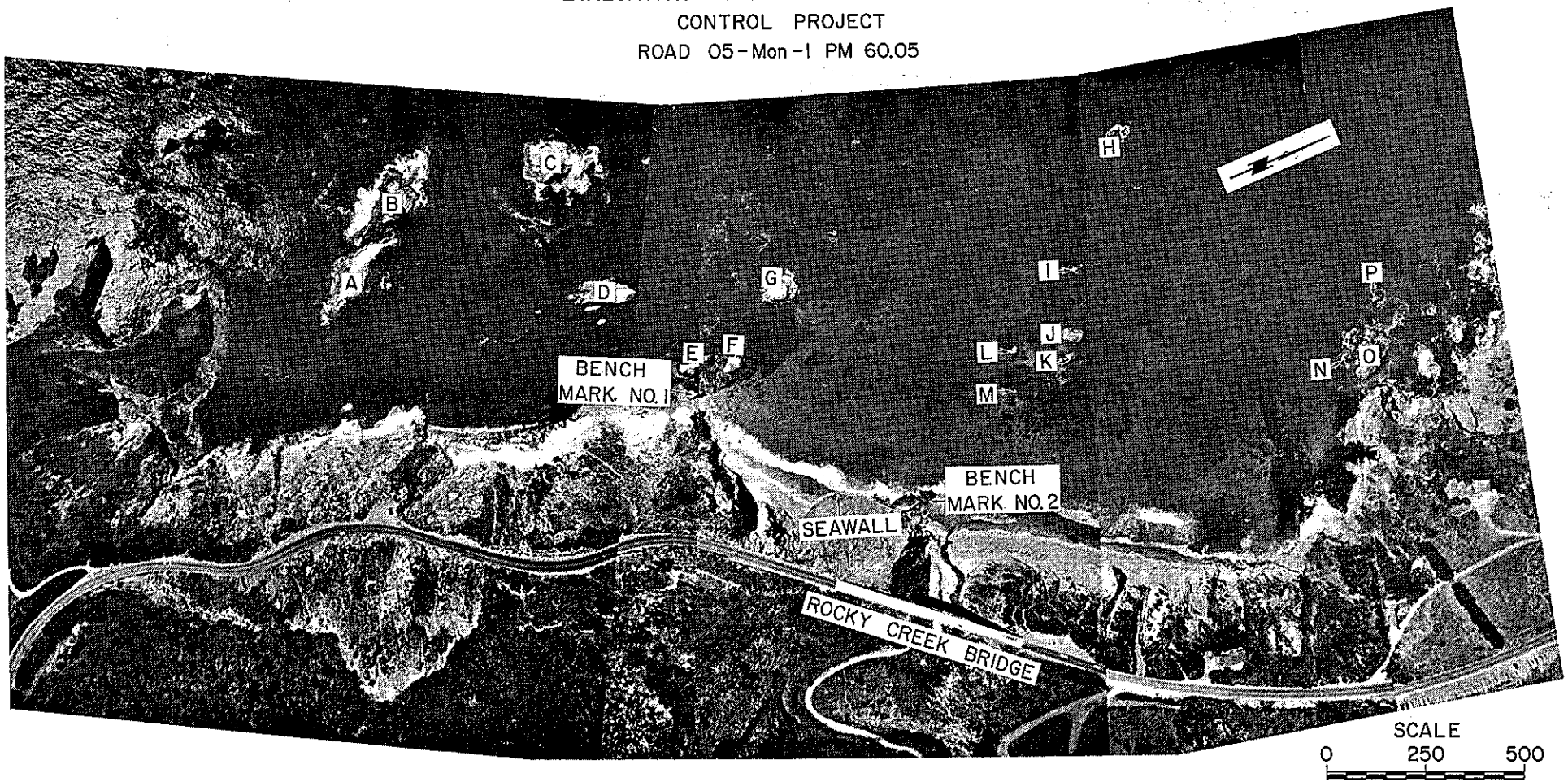
EVALUATION OF A SHORELINE EROSION
CONTROL PROJECT
ROAD 05-Mon-1 PM 60.05



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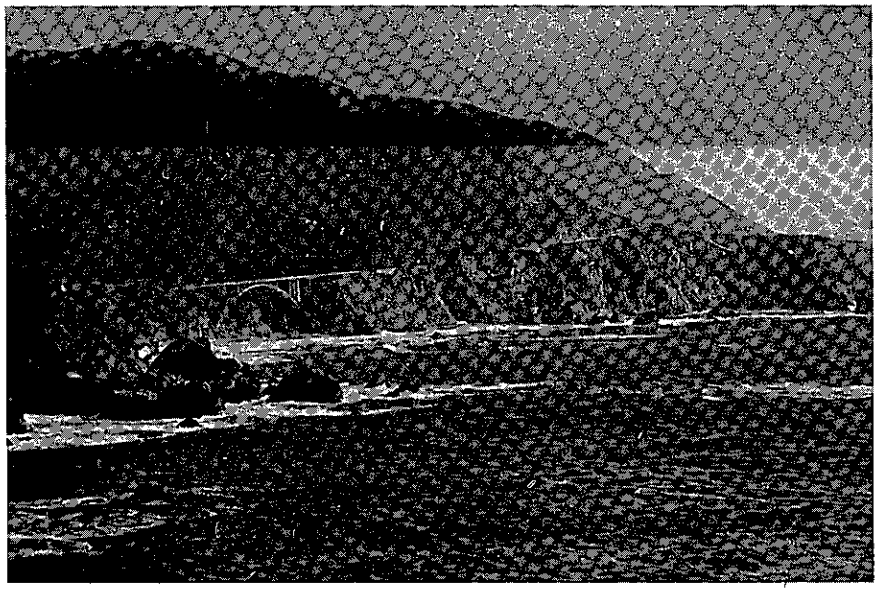

Plate 2 - Overall View of Area

Plate 3 - Damaged Seawall

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Plate 4 - Loss of Seawall Backfill Material

Plate 5 - Wave Action on Wall

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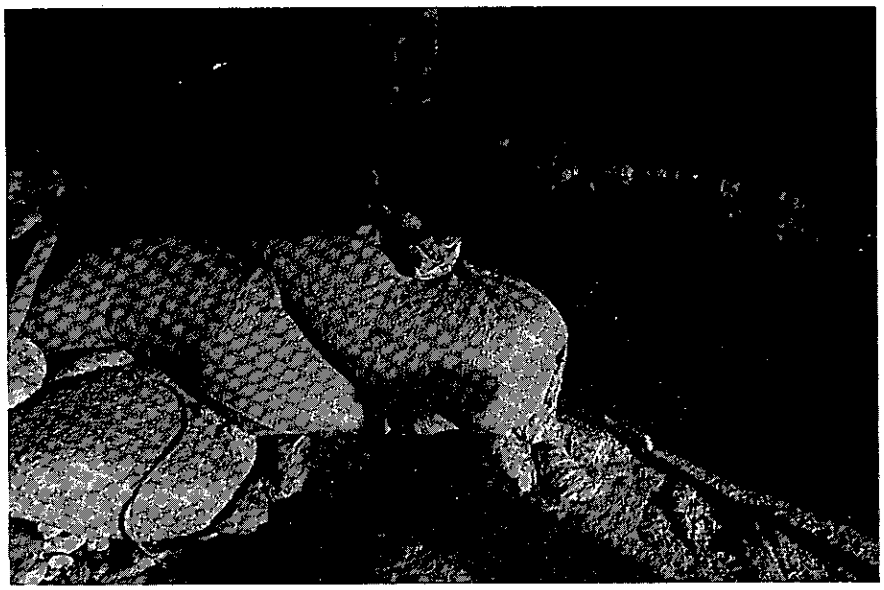

Plate 6 - Concrete Filled Sandbag

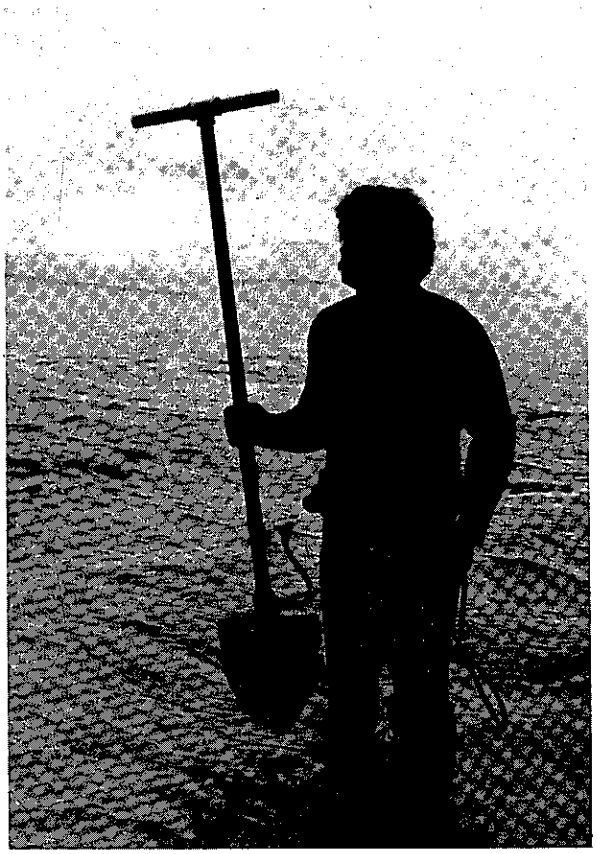

Plate 7 - Anchor Spade

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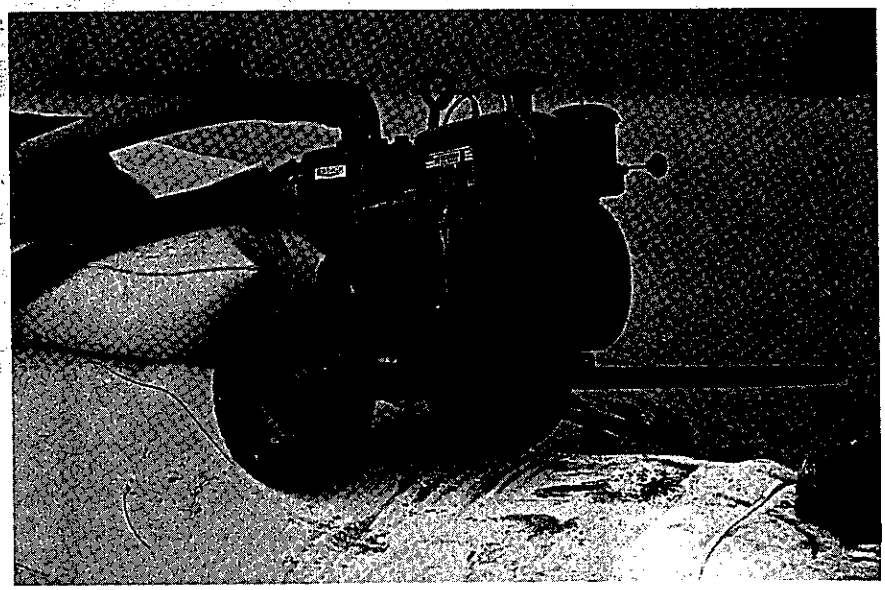

Plate 8 - Typical Pump

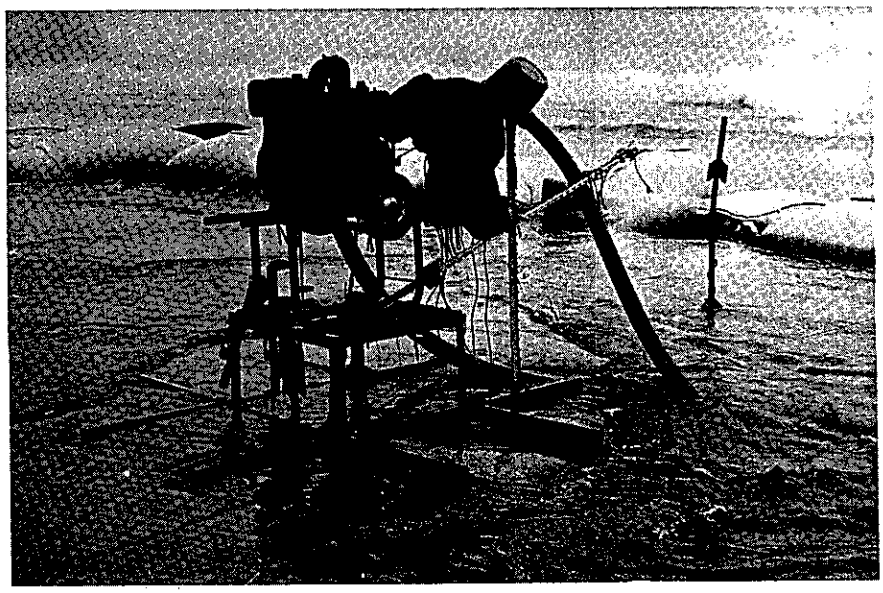

Plate 9 - Pump in Operation

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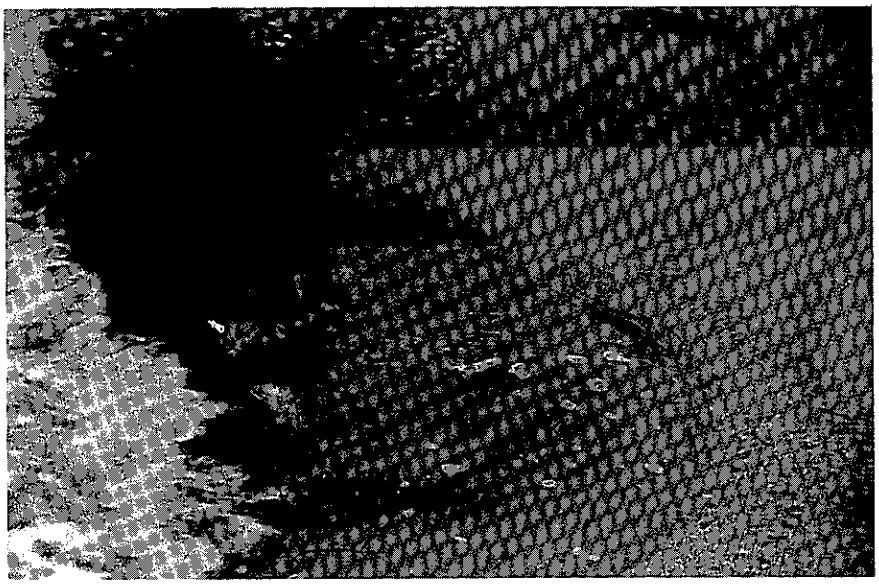

Plate 10 - Operator with Intake Nozzle

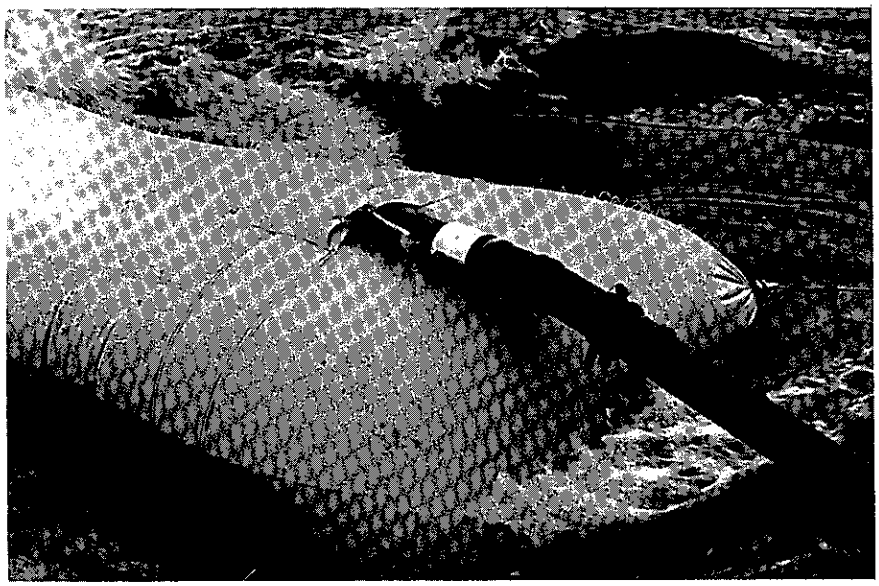

Plate 11 - Output Nozzle During Filling Operation

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Plate 12 - Sill - Five Months After Completion

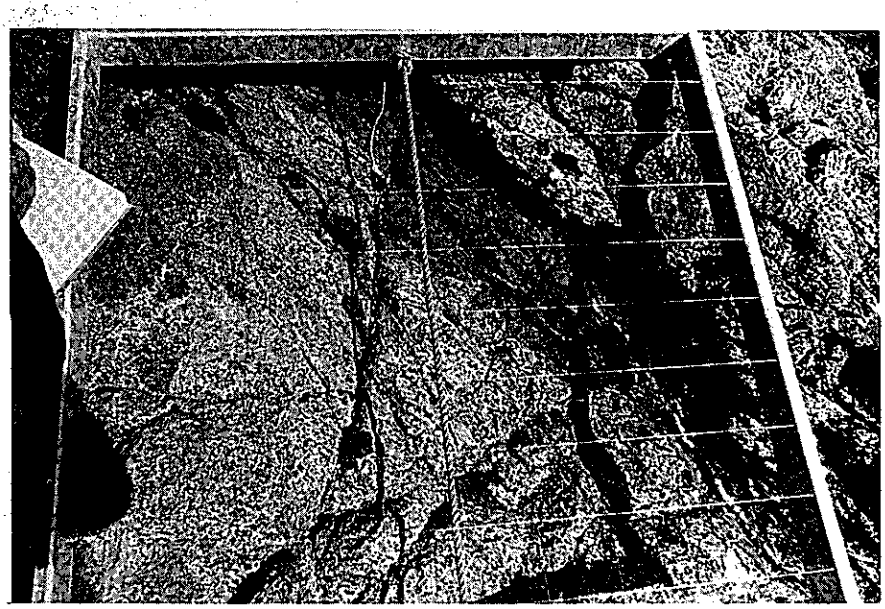

Plate 13 - 1 Meter Frame with Grid for Taking Biologic Census

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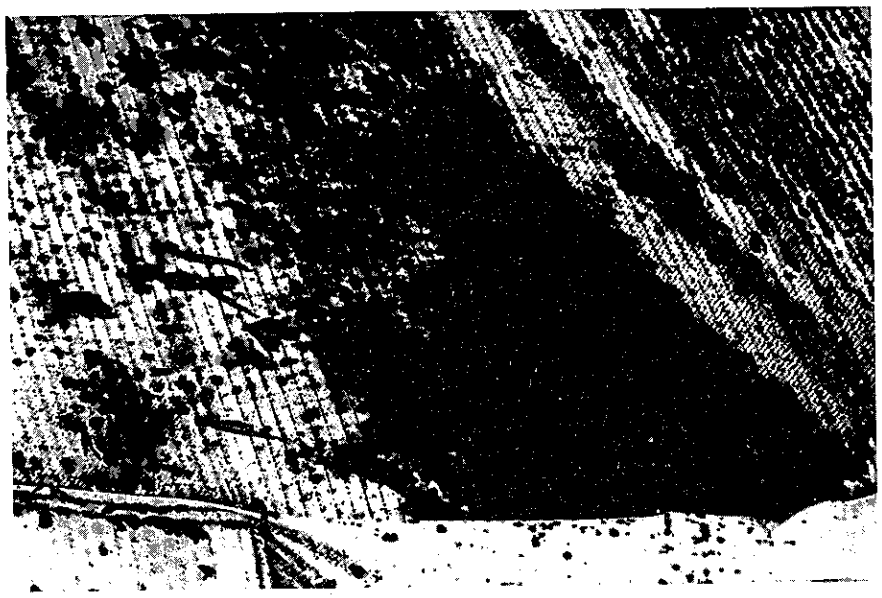

Plate 14 - Plant Grown on Sandbags

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APPENDIX

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List of Animals and Plants in Census

Transect N-1

Plants	Animals
Pelvetiopsis arborescens	Balanus glandula
Pelvetiopsis limitata	Mytilus californianus
Lithothamnium sp.	Acmaea digitalis
Endocladia muricata	Anthopleura elegantissima
Cladophora trichotoma	Pollicipes polymerus
Gigartina agardhii	Tetraclita squamosa
Corallina vancouverensis	Mopalia sp.
Hildenbrandia sp.	

Transect N-2

Pelvetia arborescens	Balanus glandula
Endocladia muricata	Acmaea digitalis
Cladophora trichotoma	Mytilus californianus
Lithothamnium sp.	Pollicipes polymerus
Hildenbrandia sp.	Tetraclita squamosa
Postelsia palmaeformis	Nutallina californica
Gigartina agardhii	Anthopleura elegantisima
Corallina vancouverensis	Thais emarginata
Petrocelis sp.	
Prionitis lanceolata	

Transect N-3

Endocladia muricata	Acmaea digitalis
Pelvetiopsis arborescens	Littorina planaxis
Cladophora trichotoma	Littorina scutulata
Hildenbrandia sp.	Balanus glandula
Lithothamnium sp.	Mytilus californianus
Gigartina agardhii	Pollicipes polymerus
Corallina vancouverensis	Anthopleura elegantissima
Egregia menziesii	Nuttalina californica
Prionitis lanceolata	
Prionitis linearis	
Iridoophycus coriaceum	

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List of Animals and Plants in Census (cont).

Transect S-1

Plants	Animals
Pelvetiopsis arboreseens	Mytilus californianus
Cladophora trichotoma	Littorina planaxis
Endocladia muricata	Acmaea digitalis
Pelvetiopsis limitata	Balanus glandula
Gigartina agardhii	Tetraclita squamosa
Porphyra sp.	Pollicipes polymerus
Lithothamnium sp.	Anthopleura elegantissima
Codium fragile	Plocamia karykina
Hildenbrandia sp.	
Codium setchellii	

Transect S-2

Pelvetiopsis arborescens	Littorina planaxis
Gigartina agardhii	Acmaea digitalis
Lithothamnium sp.	Balanus glandula
Hildenbrandia sp.	Mytilus californianus
Pelvetiopsis limitata	Tetraclita squamosa
Endocladia muricata	Anthopleura elegantissima
Porphyra sp.	
Petrocelis sp.	
Codium setchellii	
Corallina vancouverensis	
Gymnogongus linearis	
Codium fragile	
Pelvetia sp.	
Egregia menziessii	

Transect S-3

Endocladia muricata	Balanus glandula
Pelvetiopsis arborescens	Pollicipes polymerus
Lithothamnium sp.	Acmaea digitalis
Hildenbrandia sp.	Tetraclita squamosa
Pelvetia fastigata	Anthopleura elegantissima
Cladophora trichotoma	Mytilus californianus
Gigartina agardhii	Haliotis cracarodii
Postelsia palmaeformis	Cliona celata
Porphyra sp.	Katharina tunicata
Pelvetiopsis limitata	
Codium detchellii	
Egregia menziesii	
Phylospadix scouleri	
Prionitis lanceolata	
Odontothalia floccosa	
Plocamium pacifica	

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List of Animals and Plants in Census (cont)

Transect S-4

Plants

Pelvetiopsis arborescens
Endocladia muricata
Lithothamnium sp.
Cladophora trichotoma
Pelvetiopsis limitata
Porphyra sp.
Gigartina agardhii
Hildenbrandia sp.
Egregia menziesii
Corallina vancouverensis
Petrocelis sp.
Prionitis lanceolata
Codium setchellii
Odentothalia floccosa
Hymenena flabelligera
Ulva sp.

Animals

Balanus glandula
Pollicipes polymerus
Acmaea digitalis
Mytilus californianus
Tetraclita squamosa
Anthopleura elegantissima
Thais emarginata
Nutallina californica
Katharina tunicata
Cliona celata
Acmaea pelta

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