FRI-UW-8817
September 1988

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FISHERIES MITIGATION PLAN FOR EXPANSION OF MOORAGE AT BLAINE MARINA, BLAINE, WASHINGTON

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WETLAND ECOSYSTEM TEAM

FINAL REPORT

to

Port of Bellingham

Approved

Submitted 9-24-88 R. C. Francis.

Director

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INTRODUCTION

The Port of Bellingham has proposed to expand existing facilities in Blaine Marina. The project would include dredging of an existing intertidal mudflat down to depths of approximately -12 ft MLLW. Concerns raised by state and federal agencies regarding the impact to fisheries resources prompted a series of biological baseline studies in the area. Of primary concern was the loss of potentially important feeding habitat for juvenile salmon (*Oncorhynchus* spp.) and Dungeness crabs (*Cancer magister*). Investigators from the Wetland Ecosystem Team (WET), Fisheries Research Institute, conducted studies to document the occurrence of these and related (e.g., prey) resources in the vicinity of the area to be developed and to evaluate potential mitigation alternatives. Earlier work by WET (Thom et al. 1986a) indicated that: (1) on-site, in-kind mitigation was not feasible because of space constraints; and (2) off-site, in-kind mitigation was not recommended because of the relatively undisturbed nature of the surrounding environment. Therefore, we focused on developing an understanding of the system in order to propose on-site construction of marshes and/or eelgrass meadows that might serve as compensatory mitigation for removal of high intertidal mudflat. Owing to the space constraint, we sampled the biological components in such a way as to establish value for value ratios based on the sampled parameters. The baseline biological sampling was, therefore, conducted at sites in a marsh and eelgrass meadow located near the marina. Results from mudflat, marsh and eelgrass habitat sampling were used to contrast the relative and absolute abundances of fisheries resources and, in particular, epibenthic prey resources for juvenile salmon. Marsh and eelgrass habitats have been constructed with variable success in mitigation efforts and are naturally occurring in the immediate vicinity of the marina flat. On the basis of early findings (i.e., spring-early summer) from the present study, it became evident that eelgrass was the habitat type to investigate further for use in the mitigation plan. To evaluate the potential for constructing an eelgrass meadow as mitigation, we conducted an eelgrass transplant experiment in the marina.

The studies that were conducted are fully treated in a separate report (Thom et al. 1988). Following the recommendations of Cooper (1987), we herein present a mitigation plan that summarizes the results of the biological studies, outlines environmental goals for the mitigation, proposes the location and design of the mitigation, details performance standards for the mitigation, and provides a monitoring plan and a contingency plan.

Briefly, the primary goal of the proposed mitigation is to provide juvenile salmon with early season feeding and rearing habitat, which will be lost as a result of dredging the mudflat. A secondary goal is to enhance productivity (primary, secondary and tertiary) along the southerly breakwater to offset losses due to removal of the mudflat. Because an eelgrass (*Zostera marina* L.) bed is proposed to accomplish mitigation goals, the plan is not in-kind mitigation. However, eelgrass is expected to provide food resources at least equivalent in total to that presently supplied by the mudflat. In addition, the eelgrass meadow is expected to form refuge habitat superior to that of the mudflat.

SETTING

Blaine Marina is located on the eastern shoreline of the southern Strait of Georgia in a narrow passage separating Drayton Harbor to the south from Semiahmoo Bay to the north (Figure 1). Drayton Harbor covers approximately 2,727 a (1,104 ha). It is a shallow embayment with approximately 67% of the area at intertidal and shallow subtidal depths (Table 1). Much of this area (33%) is eelgrass meadow (*Zostera marina, Zostera japonica*, Aschers. & Graebn.). Semiahmoo Bay habitats are similar to Drayton Harbor. However, Semiahmoo Bay is much more exposed to the open waters of the Strait of Georgia as compared to Drayton Harbor. Fisheries resources including Dungeness crab, Pacific herring (*Clupea harengus pallasi*) and salmon are abundant in these areas (Evans-Hamilton and D.R. Systems 1987). The eelgrass in the bays has been identified as important spawning habitat for herring. Shorebirds and water fowl, abundant much of the year, are probably utilizing invertebrate food resources on the flats and in the channels. Salinity in Drayton Harbor was relatively high (>25 ppt) during our studies. Water temperature varied from a low in March of 8°C to a high of 24°C in July. Winds were predominantly from the south in spring and early summer. Hence, the study sites in Drayton Harbor experienced wind generated turbulence as compared to the flat located in the marina. This fact is believed by us to explain much of the difference in biological conditions in the marina as compared with the reference mudflat site in Drayton Harbor.

BASELINE STUDY

Methods

Our studies were conducted during 12 field trips made between 4 March and 20 October 1987. The study sites were located in habitats as follows: (1) a small (0.8 a; 0.3 ha) salt marsh located at the extreme eastern end of the marina; (2) the top of the marina flat; (3) the slope at the seaward edge of the marina flat; (4) on the mudflat immediately adjacent to the marina in Drayton Harbor; and (5) in the eelgrass bed 200 m south of the entrance to

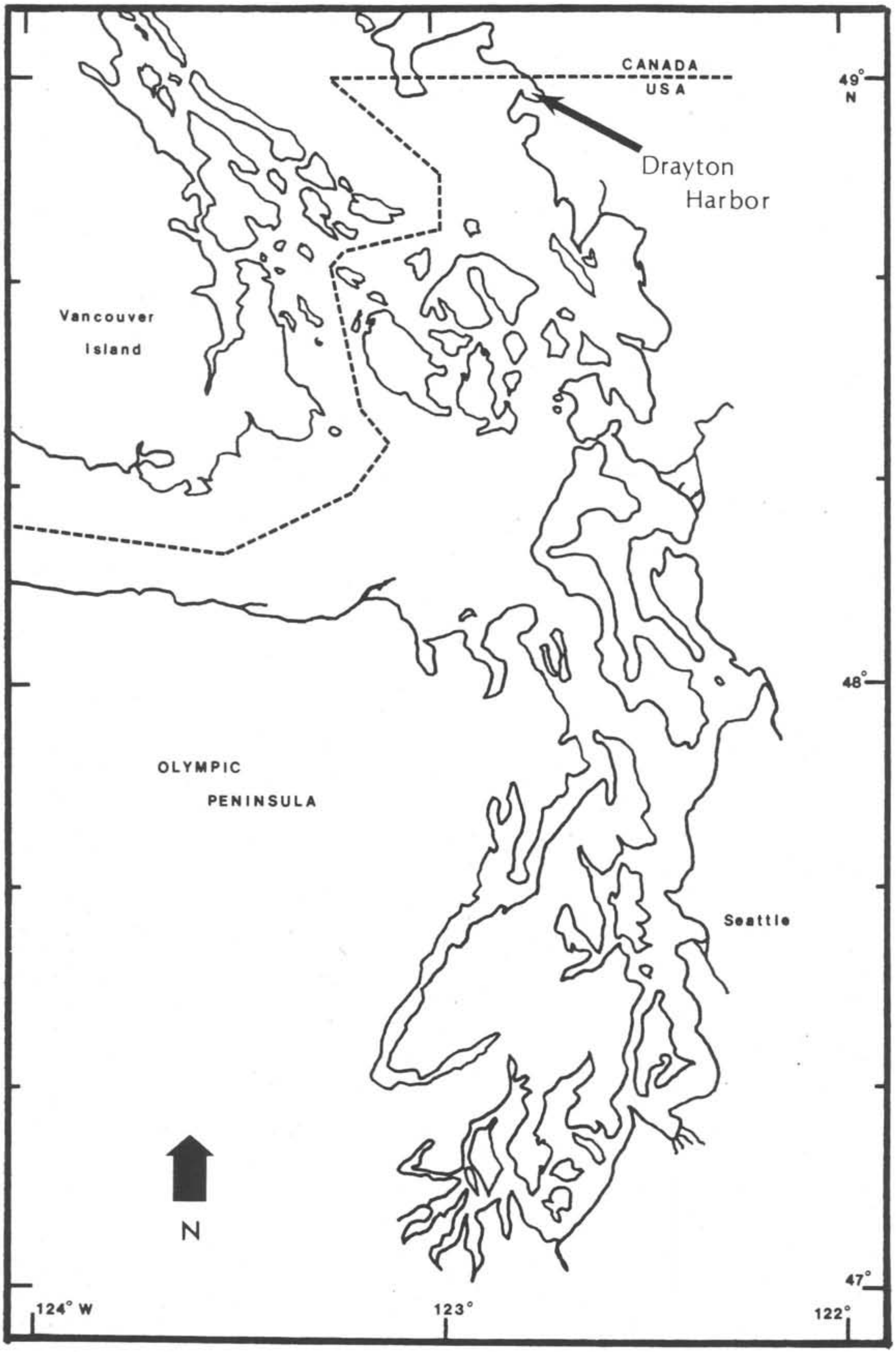


Figure 1. Location of Drayton Harbor.

Table 1. Areas of various habitats and the project area in Drayton Harbor.

Habitat	Area	
	Acres	Hectares
Drayton Harbor	2727	1104
Intertidal/Shallow subtidal	1818	736
Eelgrass	606	245
Mudflat	1212	491
Mudflat above +6 ft MLLW	404	163
Project area	14	6

the marina (Figure 2; Table 2). The mudflat site in Drayton Harbor served as a control for the marina flat. Substrata and elevation range were observed to be very similar between the two sites. The marsh, slope and eelgrass sites allowed us to gather information on potential mitigation habitats.

We sampled plant biomass, eelgrass density, epibenthic zooplankton species density and total density; and fish and crab density and biomass (Table 2). Ten replicate random samples for vegetation and epibenthic zooplankton were collected from each flat site, and five samples each were collected from the marsh, slope and eelgrass sites. Both the marina flat and the control (Drayton) flat were found to have two distinct surface sediment textures. Hence, each of these were sampled as separate strata and were sampled with five replicate samples within each strata. Three replicate beach seine collections were made on the flats at high tide and in the eelgrass site at low tide. Epibenthos sampling was carried out only during seven field trips made in March-June, the period of peak salmonid occurrence in the system. Epibenthos sampling could not be carried out in the marsh site during many of the sampling trips because the water level at high tide was too low for the epibenthic suction pump sampler, which required ca. 15-cm water depth to function. All other parameters were sampled on each of the 12 visits.

We conducted experimental planting in the marina in July 1987 in which 10.2-cm (4-in) diameter plugs were placed at elevations between 0.0 and +1 ft MLLW. A total of 110 plugs containing an average of 8.5 shoots/plug (s.d. = 3.60) were transplanted onto four plots. Two of the plots were located along the steep (approximately 3:1 slope) mud habitat located along the southern base of the riprap breakwater. Additional plots were located on the marina flat slope and on the northern boundary of the marina near the marina flat. Observations of the transplants were made during August-October 1987 and again in March-April 1988. During the observations, we made notes on the survival of shoots and root production.

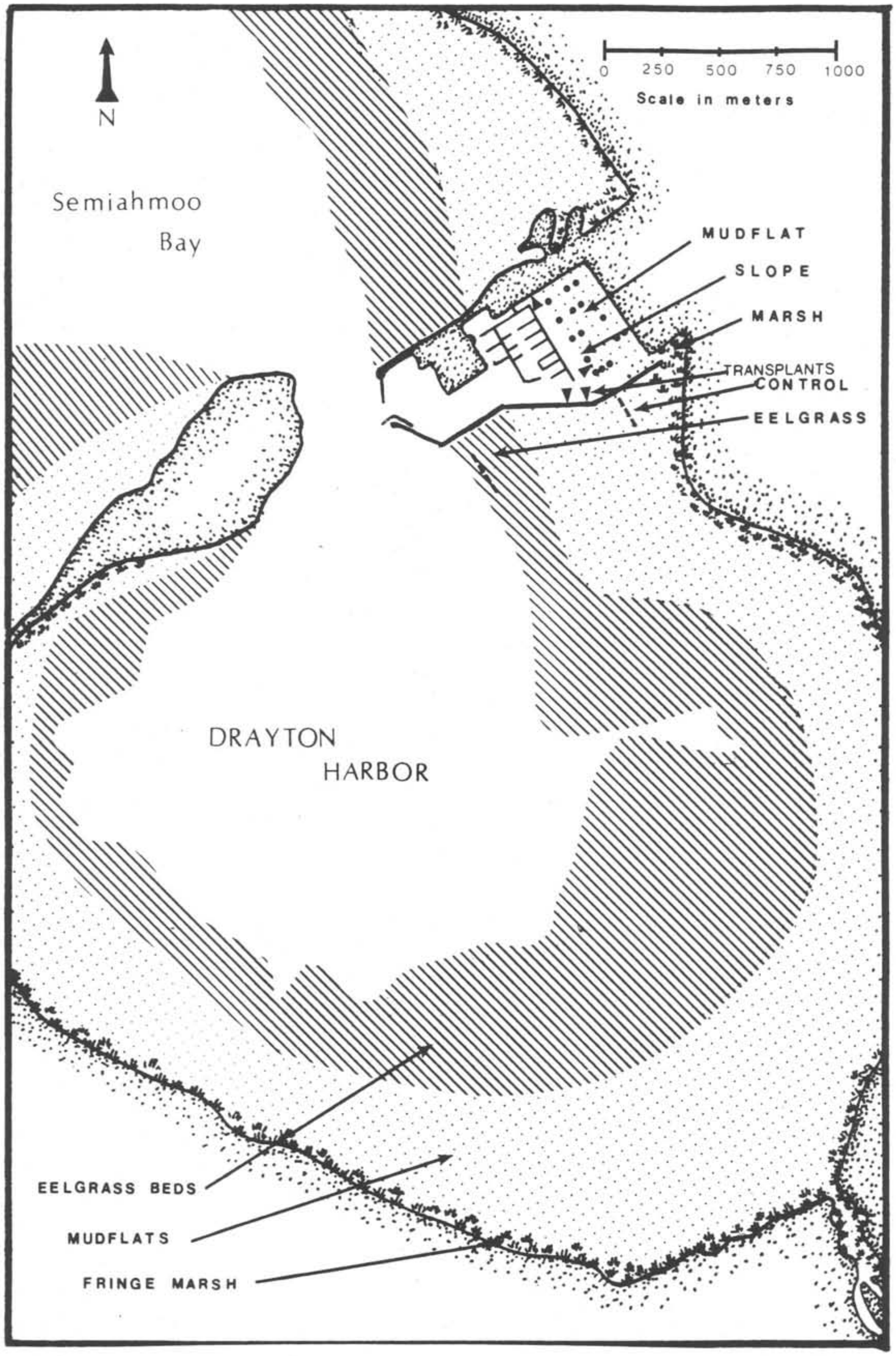


Figure 2. Location of study sites in Blaine Marina and in Drayton Harbor.

Table 2. Number of replicate samples collected during each of twelve field trips, and the total thereof, in Blaine Marina and Drayton Harbor, March-October 1987; Habitat elevation (ft, MLLW) in parentheses.

Study Site	Sediment pigments	Marsh flora	Eelgrass flora	Epibenthos assemblage	Fish & crab assemblage
Marina Flat (+6 to +7)	10	-	-	10	3
Marina Slope (+3)	5	-	-	5	-
Marina Marsh (+9)	-	5	-	5	-
Drayton Flat (+6 to +7)	10	-	-	10	3
Drayton eelgrass (+2)	-	-	5	5	3
Total samples/Trip	25	5	5	35	9
Total for study	300	60	60	370	104

Summary of Results

Vegetation

The salt marsh consisted primarily of *Scirpus maritimus*, *Triglochin maritimum*, *Distichlis spicata* and *Salicornia virginica*. *S. maritimus* consistently had the highest mean standing stock, with the maximum live standing stock of 460 g dry wt/m^2 in July.

The flats contained a sediment-associated flora consisting of microalgae (i.e., diatoms). Green algae, primarily *Enteromorpha* spp., were abundant during much of the spring and summer. The marina flat contained extensive patches of the yellow-green alga *Vaucheria* spp. that were located on the tops of broad low-lying ridges. The eelgrass (*Z. marina*) site contained some seaweed taxa, including the red algae *Ceramium pacificum* and *Chondria dasyphylla*, and the green alga *Ulva* sp. Total standing stock was remarkably similar among all the sites during March-April (Figure 3). This is in view of the fact that very little macroscopic vegetation occurred on the flats during this period. The biomass in the eel-grass bed increased rapidly between April and August. *Zostera marina* comprised >99% of the total biomass in August. Seasonal changes were not evident in the standing stock of plants on the flats (Figure 3). Standing stock was greater on the marina flat as compared to

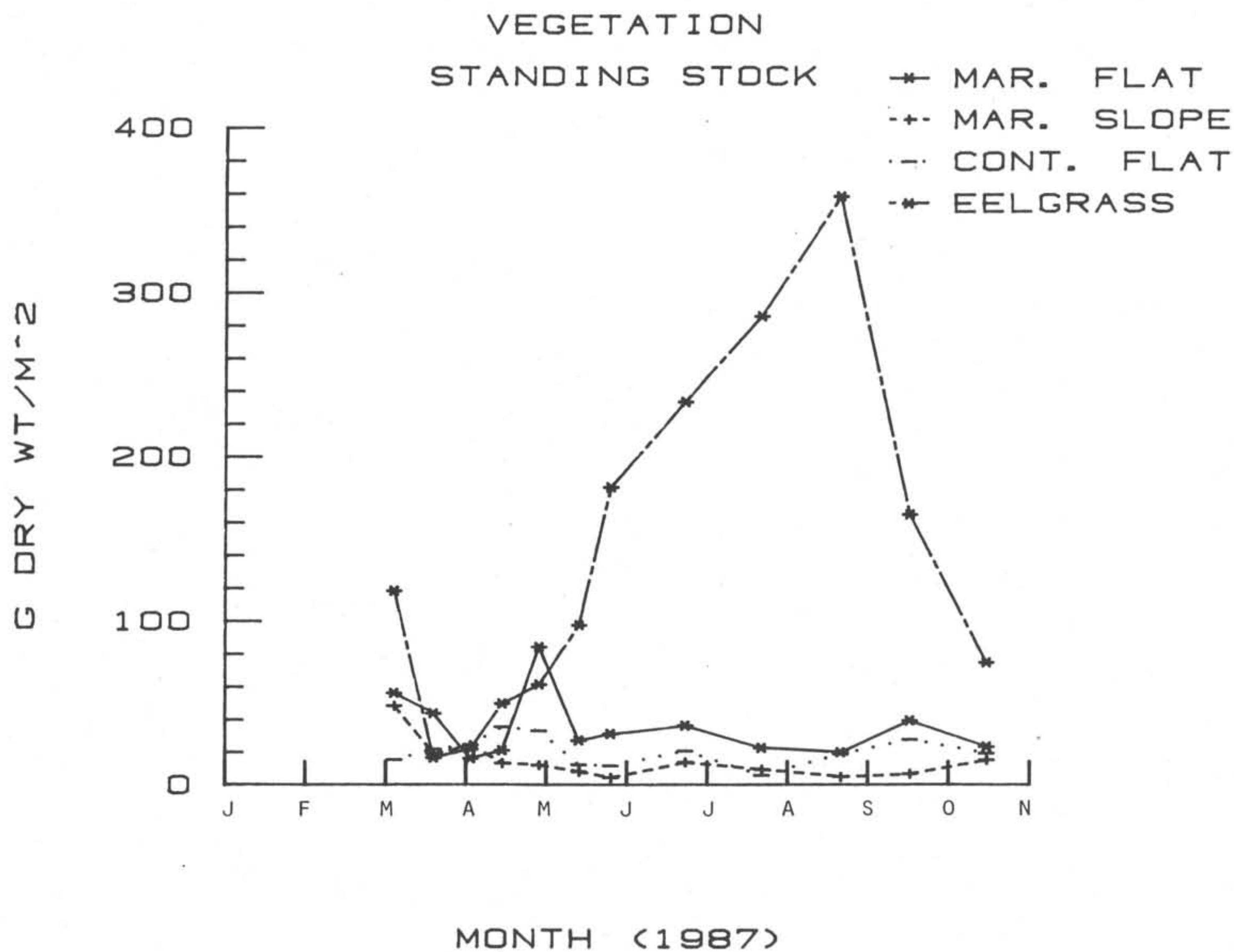


Figure 3. Mean total vegetation standing stock at the study sites. The vegetation on the marina flat, slope and control flat is primarily sediment associated algae. The vegetation in the eelgrass site is primarily *Zostera marina* and seaweeds.

the control flat in 11 of the 12 samplings. Standing stock of plants was greater on the marina flat as compared to the marina slope during 9 of 12 samplings.

Epibenthic Zooplankton

The marina flat contained the greatest density of epibenthos in early March among all sites and remained relatively high through April (Figure 4). In mid-April, epibenthic populations in the eelgrass meadow increased dramatically. This latter site held the highest mean densities among all sites for the remainder of study. The marina slope site showed peak densities in late March and mid-May. The control flat densities followed a seasonal pattern similar to that of the marina flat.

Densities of selected taxa known to be preferred by juvenile salmon exhibited a major peak in March on the marina flat and marina slope sites (Figure 5). Densities of these taxa were low within the eelgrass until mid-April, when densities increased dramatically. Prey densities in the eelgrass remained high during the period of peak salmonid densities (Figure 6). The control flat contained very low densities of these taxa throughout the study period. The data from the marsh are not presented here because taxa in the samples are rarely found in the stomachs of juvenile salmon utilizing the estuaries of Washington State. We concluded that the marsh was of relatively low importance for juvenile salmonid feeding in this system because of the non-preferred epibenthic prey and because the tide was only intermittently high enough (above approximately +10 ft MLLW) for the fish to enter and feed for an extended period of time.

Fish and Crabs

Fish densities were relatively low (i.e., below 100/100 m^2) at all sites through mid-April (Figure 6). Densities increased at all sites in late April, with the most dramatic increase occurring in the eelgrass meadow. The marina flat had more fish on average than the control flat in 7 of the 12 visits. The numerically dominant taxa on the marina and control flats were surf smelt. Shiner perch was the most abundant fish taxon in the eelgrass meadow.

Juvenile salmonid densities were relatively high in the marina in early April and again in mid-May (Figure 7). Chum salmon was the only species caught from March to mid-April at the sites. In May and June, chinook salmon occurred in the samples from the sites along with chum salmon. Chinook salmon were the most abundant salmonid caught in June. Coho salmon were caught in low numbers between late April and July. Salmonids were present in the eelgrass in April-May, and showed a peak in late-April. Salmon caught in summer (July-August) were generally larger fish.

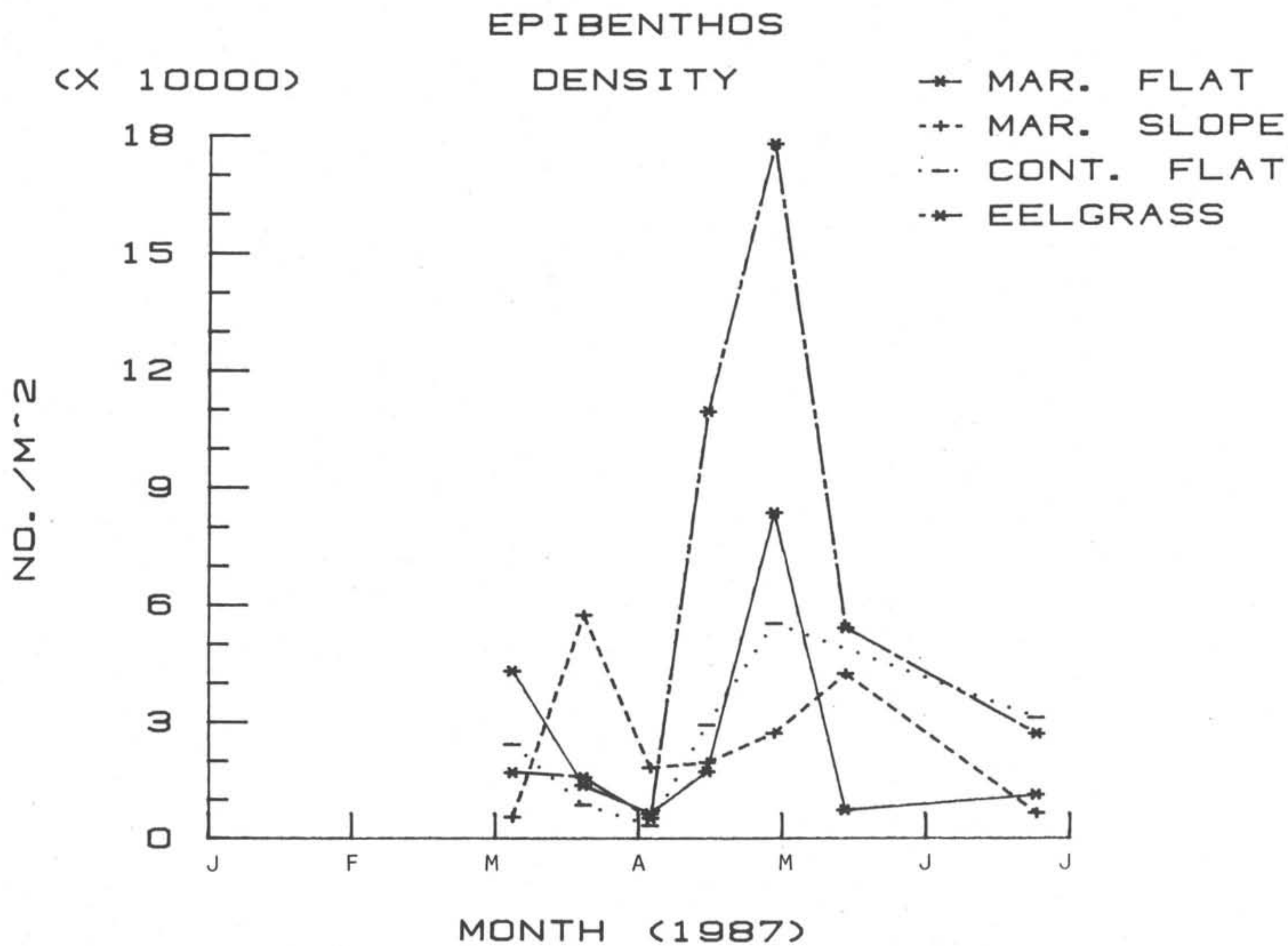


Figure 4. Mean epibenthic zooplankton density at the study sites.

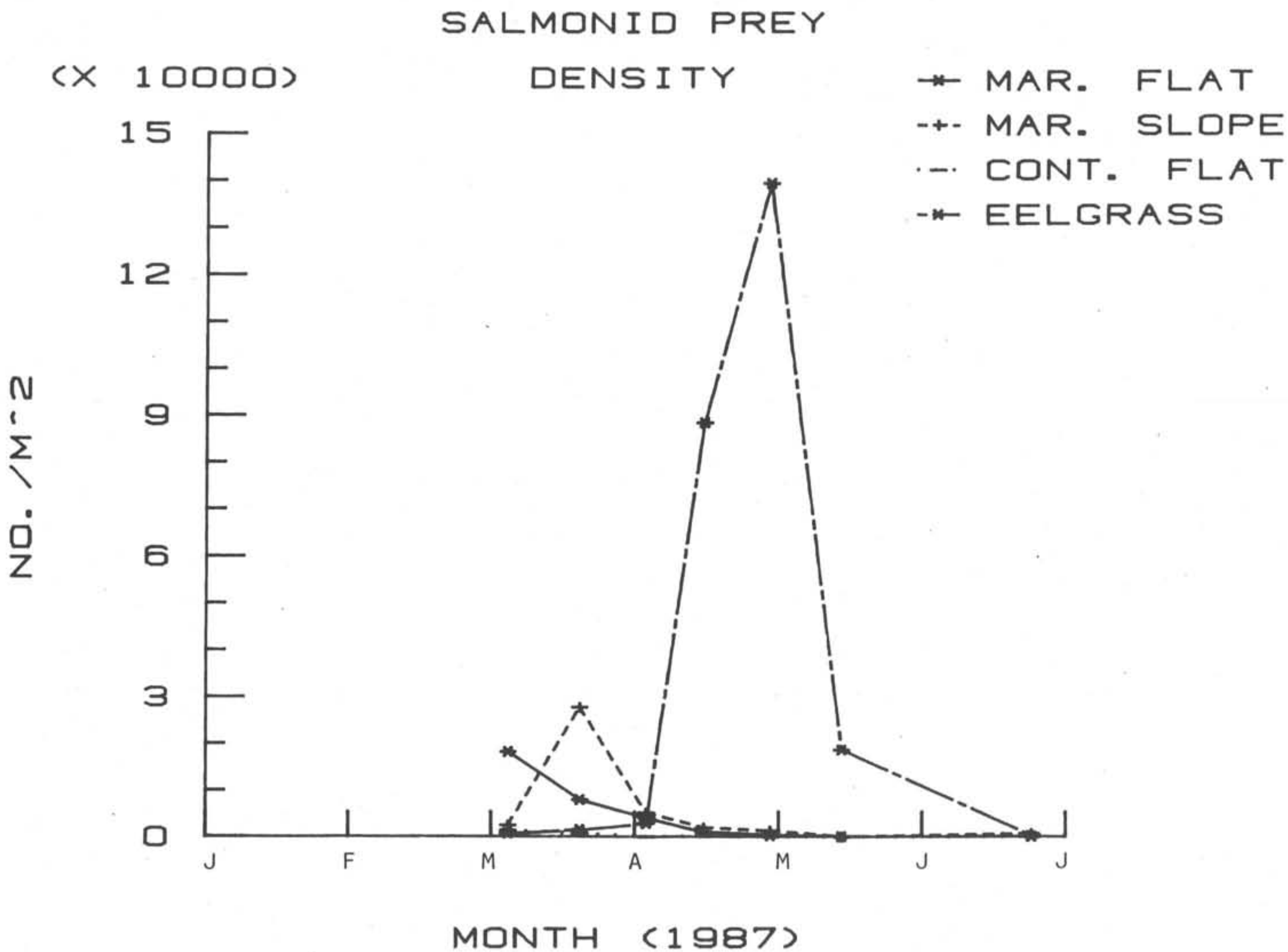


Figure 5. Mean density of epibenthic zooplankton known to be preferred as prey by juvenile salmon at the study sites.

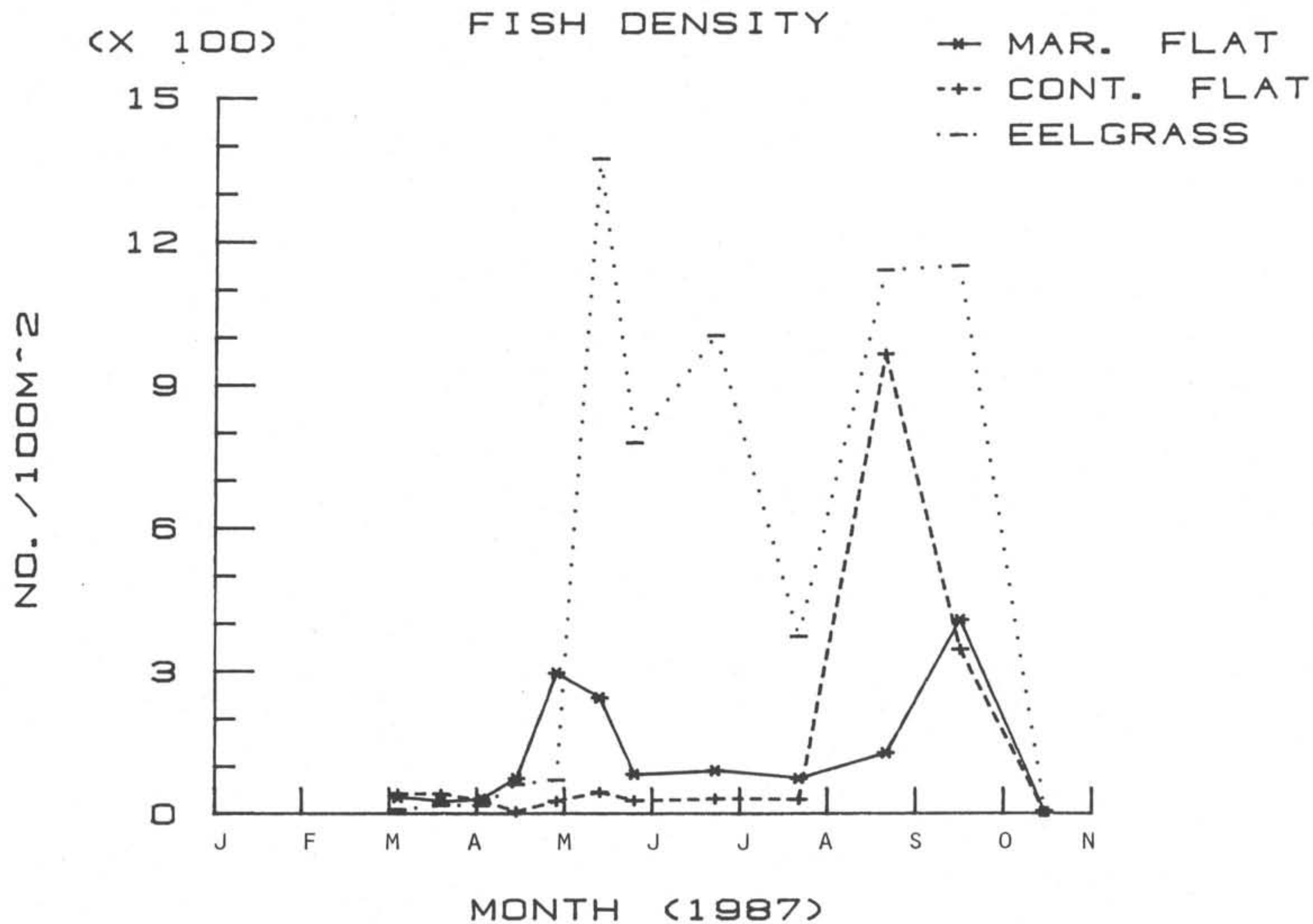


Figure 6. Mean fish density at the study sites.

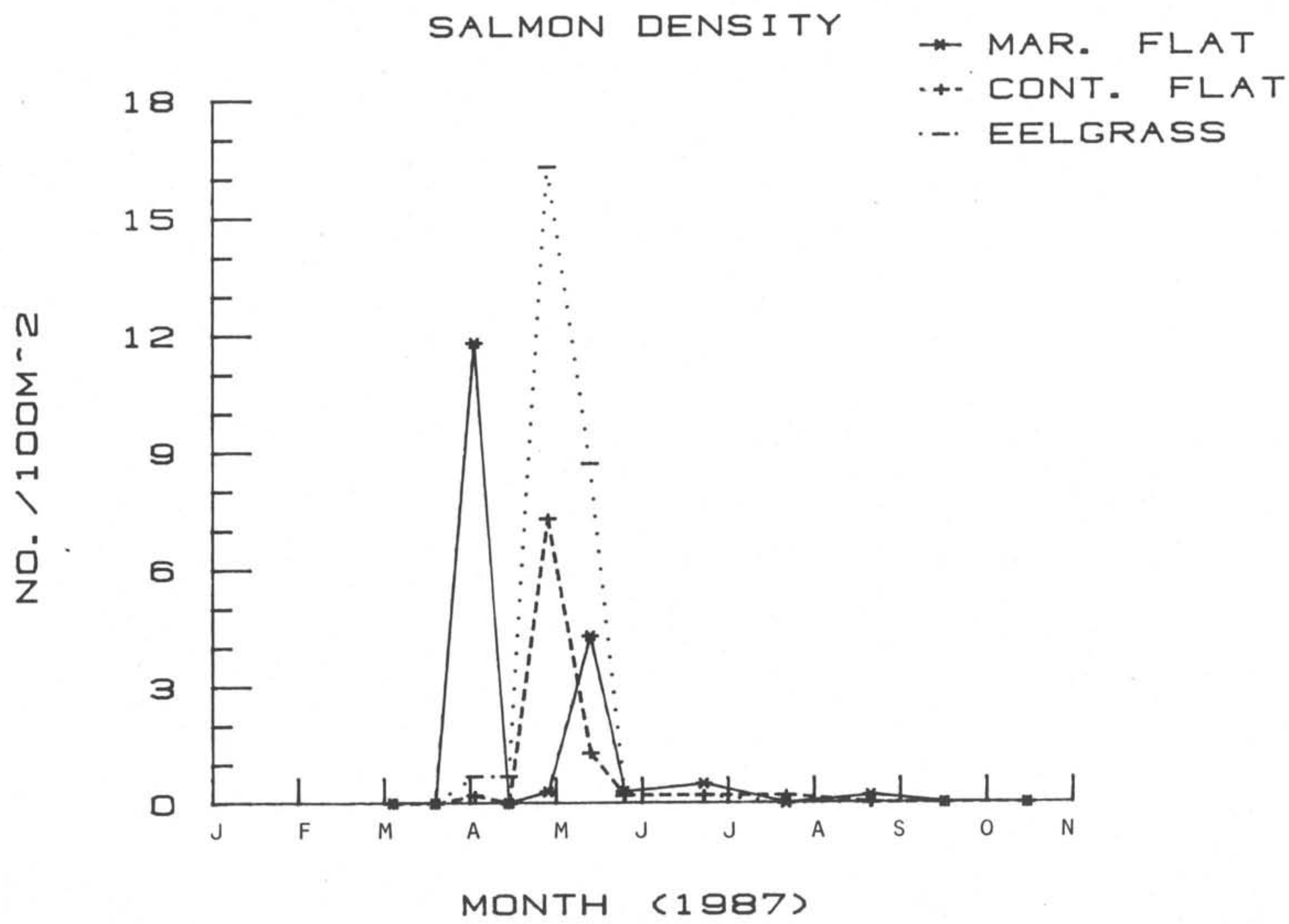


Figure 7. Mean density of juvenile salmon at the study sites.

Mean fish species richness varied between 2 and 8 species/seine at the marina and control flat sites, with a peak indicated in May and June (Figure 8). The eelgrass site consistently held the greatest mean number of fish species, and was 2-3 times as species rich as compared to the high intertidal flat sites, except for the first sampling in March.

Dungeness crab densities peaked in April-August in the eelgrass meadow (Figure 9). No Dungeness crabs were caught on the marina flat over the study period, and very few were caught on the control flat. Mating pairs were common in mid-late April in the eelgrass meadow.

Eelgrass Transplant Experiment

Although only 8% of the plugs that were planted in July 1987 were evident in April 1988 (Table 3), the plants that did survive over winter were generally healthy as judged by green leaves and robust below ground root systems. The greatest survival was noted in the south breakwater sites (I, III; see Figure 2). We did note natural small patches of *Zostera japonica* along the south breakwater and on the marina flat. In addition, a small (~0.1 m^2) natural patch of *Z. marina* occurred near one of the south breakwater plots. The plugs that survived were those transplanted at the lowest elevations (i.e., -1 ft MLLW), and the natural *Z. marina* patch was located at approximately -2 ft MLLW. These latter observations indicated that most of the experimental plots were located at too high an elevation. Although eelgrass is very dense on Drayton Harbor flats between +3 and -6 ft MLLW (Thom et al. 1988), the beach slope (i.e., 3:1) of the transplant plots may have affected the survival of transplants in the marina. It is known that eelgrass is generally confined to areas with low slope gradients, and in areas of standing water at low tide, such as occur on the flats in Drayton Harbor. The fact that natural patches of eelgrass occur on steeply sloping areas inside the marina, and that transplants did survive over winter, suggests that eelgrass transplanting for mitigation is a viable alternative. The experiment did result in valuable information regarding possible alternative design criteria of an eelgrass mitigation plan.

Conclusions

We conclude that, among the habitats sampled, the marina flat was relatively important in providing preferred food resources for juvenile chum salmon during the early period of migration through Drayton Harbor. High densities of salmon epibenthic prey occurred on the flat and slope habitats within the marina, and fish were present during this period. Stomach content analyses, although not a major component of the sampling design, confirmed that the salmon were feeding on the types of epibenthic organisms that occurred on

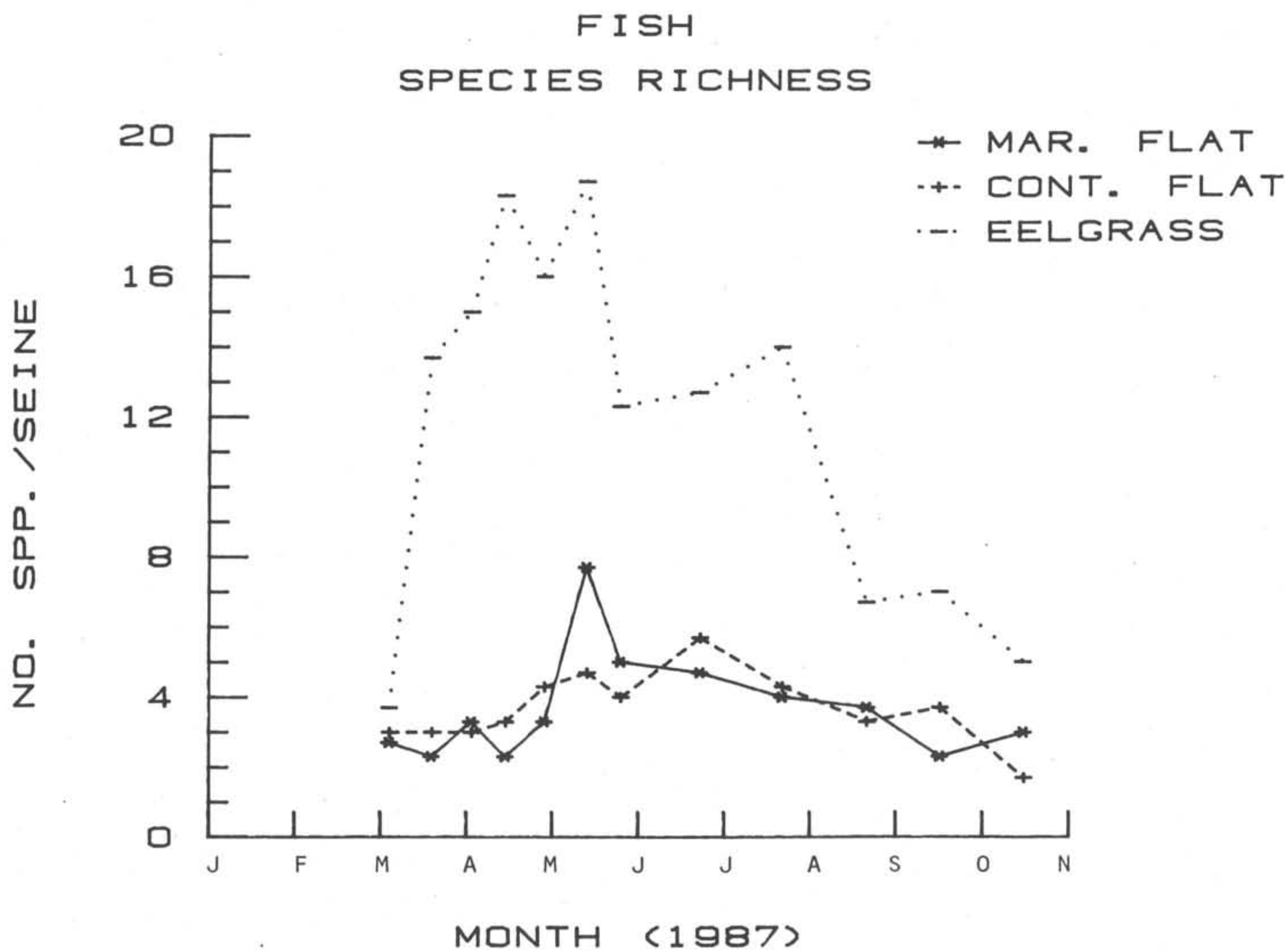


Figure 8. Mean number of fish species at the study sites. The area sampled by the beach seine is 520 m^2.

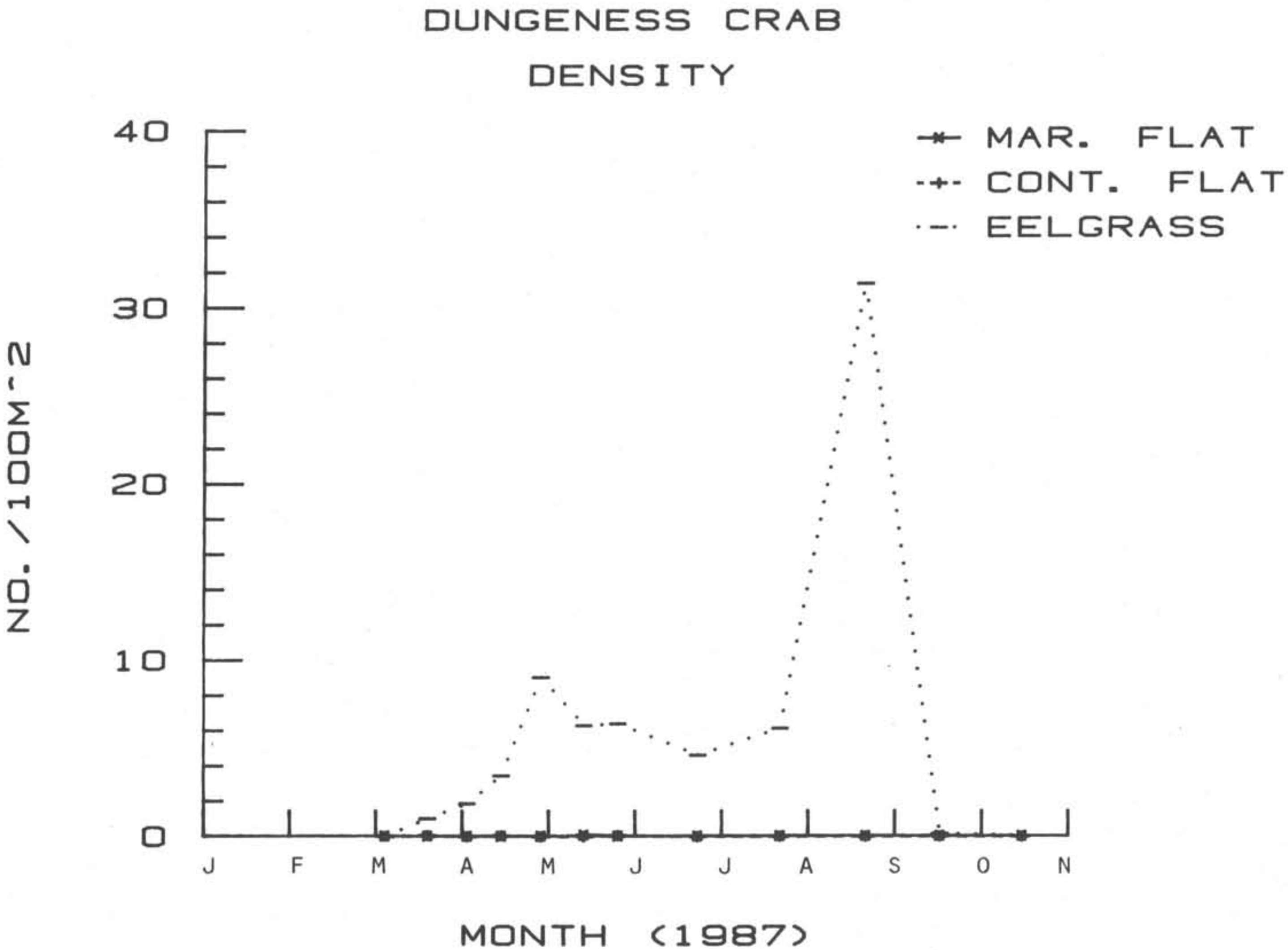


Figure 9. Mean density of Dungeness crabs at the study sites.

Table 3. Results of eelgrass transplant experiment (see Figure 2). Data are numbers of plugs of eelgrass. (nd = no data)

Plot no.	Location	1987 July	1987 Aug	1987 Sep	1987 Oct	1988 March	1988 April
I	S. breakwater (inner)	30	18	13	11	12	5
II	Marina slope	30	20	2	nd	1	1
III	S. breakwater (outer)	30	20	20	18	9	3
IV	N. breakwater	30	12	3	nd	1	1
Mean No. Shoots/Plug		8.5	nd	nd	nd	3-5	1-3
Percent of plugs remaining		100	58	32	-	19	8

the flat. The salt marsh habitat appeared to be relatively less important with regard to fisheries resource support.

Among all habitats, the eelgrass meadow provided superior support for fish and crabs beginning in April. The eelgrass site contained salmonid prey densities from 2 to 14 x $10^4/m^2$ as compared to $<2 \times 10^3/m^2$ on the marina flat during the period of peak salmonid densities. The mean salmonid prey density for the sampling period on the marina flat was $4{,}480/m^2$ as compared to $36{,}053/m^2$ in the eelgrass bed. This converts to a ratio of 8.0:1 for eelgrass:marina flat prey densities. Ratios for eelgrass vs. marina slope and eelgrass vs. control flat were 6.4:1 and 105.4:1, respectively. In addition, samples in the eelgrass bed far exceeded those at the other sites in terms of fish densities and number of fish species and crab density during most of the study period.

The lag in population increases of epibenthic prey organisms in the eelgrass meadow as compared to the flats may be related to physical factors. First, the marina flat and the control flat sites are at substantially (5-7 ft) higher elevations than the meadow. This suggests that light energy and heating will have a greater effect on the benthos earlier in the year (i.e., early spring) as extreme low tides shift from night- to day-time hours. Second, the marina flat and slope are protected from most winds, which would tend to disturb the development of benthic microalgal and filamentous macroalgal growth that typically occurs in early spring. Vegetation biomass (consisting of small, highly productive species) was greater on the marina flat in March as compared to the control flat. Hence, the marina flat represents a somewhat unique situation in Drayton Harbor with regard to early support of salmonids, perhaps due to protection offered by the presence of the breakwater.

Of all the habitats with the potential to support selected fisheries resources, eelgrass appears to be the most important in the Drayton Harbor system. The three-dimensional structure (i.e., shoots) and high vegetation biomass and high primary productivity all contribute to high epibenthos densities, high crab abundances, dramatically high fish species richness and abundances as compared to the mudflat habitat.

ENVIRONMENTAL GOALS

The marina expansion would include removal of a maximum of approximately 14 acres of high intertidal mudflat. This would include slope habitat as defined by us that borders the flats. In addition, steeply sloping mud habitat along the southern breakwater would be converted into a gently sloping eelgrass flat. The impact to fish would be from removal of habitat that provides significant food resources early during the outmigration period. Dungeness crab populations apparently do not use the flat. Therefore, the goal of the mitigation plan for fisheries is to maintain or exceed present (i.e., 1987) abundances (i.e., the total amount of epibenthic prey) of preferred salmonid epibenthic prey in the marina system, especially during the early spring salmonid outmigration period.

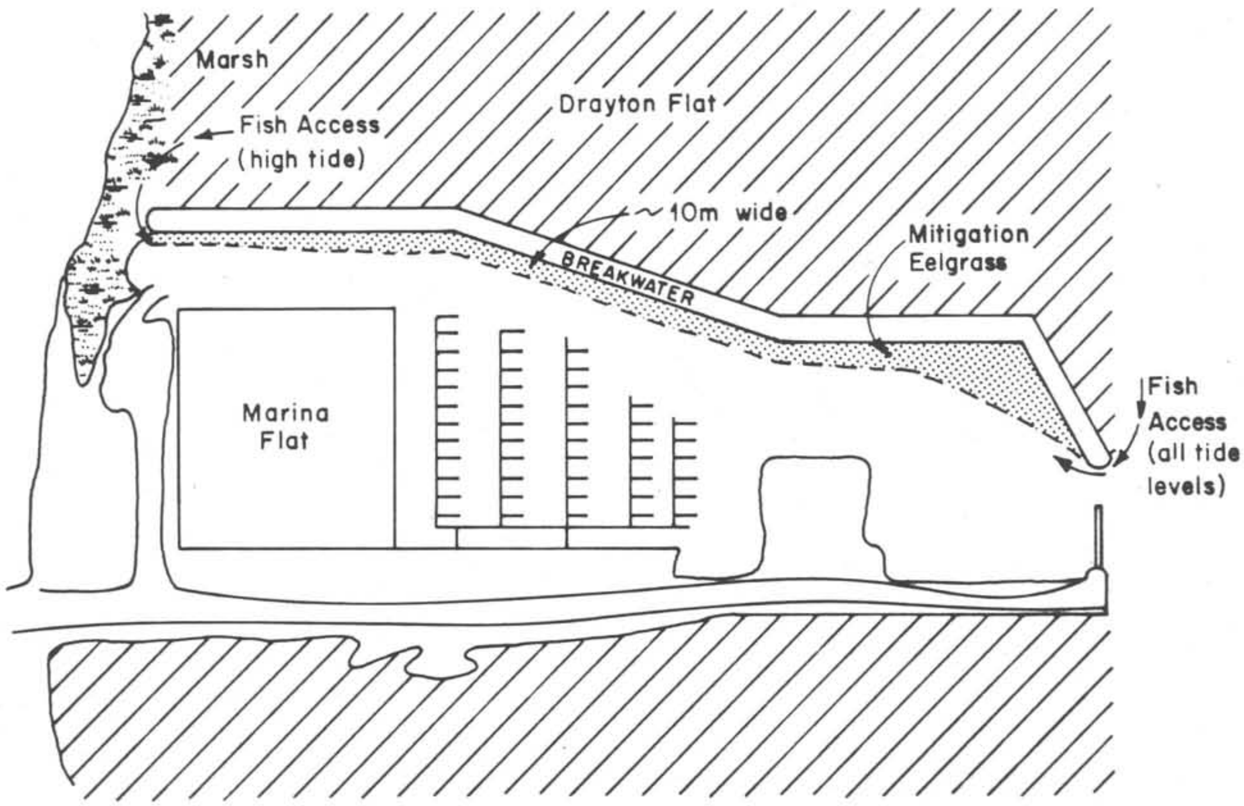
The goal, as stated in the Introduction, can only be accomplished through mitigation that enhances epibenthic prey densities above those occurring on the marina flat at present. This means that higher epibenthic prey abundance must be produced per unit area, if less area can be used to offset the impacts of the expansion. In addition, the early population increase of epibenthic prey in the marina may be important to the fish.

The proposed mitigation plan consists of developing a corridor of eelgrass meadow approximately 1.2 ha (3 acres) in size located at a depth of +0 ft MLLW along the northern (marina) side of the southern breakwater (Figure 10). The low elevation, flat elevation gradient and standing water created by the bench profile was designed to mimic the most suitable physical conditions for eelgrass establishment and growth.

The concept applied in the proposed plan involves replacement of lost habitat values rather than area for area replacement. The justification for this plan is as follows.

1. Space is limited within the marina for mitigation activities. We felt it is better to accomplish the mitigation on-site rather than off-site. Furthermore, the general area in Drayton Harbor is relatively undisturbed, and it appeared not appropriate to perturb a well functioning and productive natural system.

A) Plan View



B) Profile

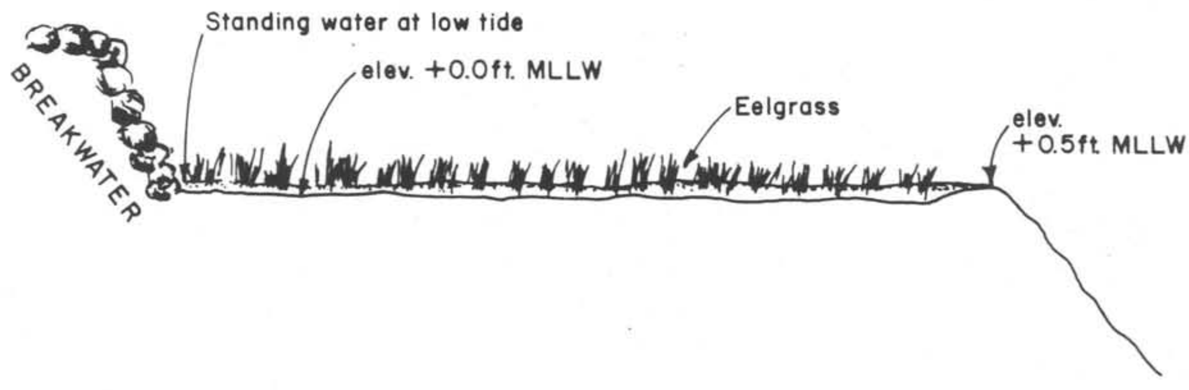


Figure 10. The mitigation plan: (A) plan view; (B) profile.

2. Our data show that the eelgrass meadow accommodates greater numbers, for a longer period of time, of epibenthic prey and fish species as compared to the high intertidal mudflats in the region. Over the study period, the mean and peak salmonid prey densities in eelgrass were 8 and 518 times greater, respectively, than those occurring on the marina flat.
3. Organic matter production by plants is greater in the eelgrass meadow as compared to the high mud flats; this would result in greater sustained food web support in the marina and adjacent areas.
4. By constructing the eelgrass meadow within the confines of the marina, an earlier population increase (in March as opposed to April-May) of salmonid epibenthic prey is predicted.
5. Eelgrass occurs in very sporadic and small patches in the marina at present, and transplants showed low but measurable survival over winter.
6. The lower elevation of the bed as compared to the existing high flat would increase the time fish and crabs could utilize the habitat.
7. The shape of the mitigation area is important also. In general, foraging success in a habitat is increased by maximizing connectivity among important habitats (Forman and Godron 1986). The corridor bed would allow direct connection and movement of fish along the breakwater from either the landward or seaward end of the marina. The fish would be exposed to a contiguous food-rich refuge habitat.
8. The technology of transplanting eelgrass for habitat establishment is relatively well developed in comparison to other types of vegetated habitats.
9. On the basis of salmonid density ratios, refuge values and other factors, construction of 3 acres of eelgrass is conservative compensation for loss of 14 acres of high intertidal mudflat.

WORK PLAN

Details of the engineering feasibility are presented elsewhere in the permit application. We will establish the eelgrass bed using the following procedures. The methodology for transplanting eelgrass will follow that developed and extensively tested by Fonseca et al. (1982a, 1982b, 1984, 1985). In addition, the results of transplanting experiments carried out in the Northwest by Phillips (1980) were reviewed. In general, Phillips' experiments showed that several methods, including individual shoots and plugs, resulted in establishment of eelgrass patches.

Following slope preparation, a sand-silt sediment will be placed on top of the fill (if necessary) to form suitable soil for eelgrass transplanting. Transplant material will be gathered from Drayton Harbor. Shoots and roots will be rinsed free of sediment and planting units will be prepared. A planting unit will consist of 10-15 shoots, with attached roots and rhizomes, bound to thin rods. The planting units will be transported from the donor site to the transplant site in buckets. The units, with the aid of the rod, will then be inserted into the sediment at the transplant site. Care will be taken to assure that plants are in good condition when transplanted. Planting density will be 1 unit every 1 m which results in an average of 1.44 units/m^2. The total number of units required to fill the entire 3 acre (12,141 m^2) area would be 17,483. The total number of shoots transplanted would range between 174,830 and 262,246. The previous studies (Fonseca et al. 1979) have shown that this transplant density would yield 70% cover of the substrata by leaves in approximately 250 days. However, these types of studies have been carried out only on a limited basis in the Pacific Northwest, and no prediction regarding expected percent cover after a certain period of time can be made at present.

PERFORMANCE STANDARDS

The performance standards for evaluating the mitigation project will include parameters quantified in 1987 and used as a basis for designing the mitigation. The performance of the mitigation area will be judged both on the baseline data and on comparisons with the control areas. Control sites located on the high flat and in the eelgrass meadow outside the marina will be monitored to provide an indication of natural fluctuations in the system that may affect how we evaluate the performance of the mitigation area.

Owing to the inherent spatial variability of these types of systems, year-to-year variations and stochastic processes, it is very difficult to predict exactly how the mitigation will perform. If control sites show significant differences from 1987, resource managers would jointly determine the meaning of the differences relative to the performance goals. The studies conducted in 1987 provided a good indication of the relative levels of performance of the various habitats, and we expect that these relative levels should be maintained within reasonable bounds.

The performance standards for the proposed mitigation plan are as follows.

1. We have designed the mitigation to produce densities of salmonid epibenthic prey of, on average, approximately eight times that occurring on the marina flat in March-June. The ratio of area lost to dredging vs. area of mitigation is 5:1. On the basis of the field studies, eelgrass potentially would yield average densities of

salmonid prey eight times greater as compared to the marina flat. Therefore, a ratio of 5:1 for prey densities in the mitigation site would compensate on a 1:1 basis for the prey resources lost. Owing to the expected enhancement of prey densities (i.e., 8:1) in the eelgrass bed, the 3 acres of mitigation is conservative with regard to production of salmonid prey.

2. On the basis of our data, we expect that the mitigation area should contain greater numbers of fish species and crabs, and greater mean annual biomass of benthic plants as compared to the existing marina flat. Owing to lack of empirical data from Northwest systems, we recommend that the performance standards with regard to these latter parameters be that the mitigation area shows unspecified but enhanced levels for all of these parameters. The presence of juvenile salmon and other fisheries resources (e.g., Dungeness crabs, herring) will be evaluated quantitatively in terms of presence, duration of occurrence and abundance. Utilization of the mitigation habitat by fish will be further verified by sampling fish stomach contents in comparison with the epibenthic prey spectra in the eelgrass bed.
3. Developing the eelgrass meadow within the protected confines of the marina would predictably result in, based on our observations, a population increase in epibenthic prey earlier in the year (March as opposed to April) as compared to the Drayton Harbor eelgrass meadow. This increase would compensate for the March population increase of epibenthic prey we documented on the marina flat.
4. Finally, a goal of the transplanting work is to have eelgrass establish a functioning bed within 1 year following transplanting. The goal for eelgrass would be to have standing stock and density of the bed not significantly different from the control site within 5 years following transplanting. Eelgrass cover, density and above- and below-ground standing stock, along with epiphyte standing stock, will be used to evaluate bed establishment.

MONITORING PROGRAM

The monitoring program will evaluate the progress of the mitigation area with respect to the performance standards. The monitoring will be conducted for a period of 5 years following construction. At the end of 5 years, a determination will be made by discussions with resource and regulatory agencies and the Port of Bellingham as to the need for continued monitoring and the scope of the monitoring program. The initial program will begin during the first spring following completion of construction of the marina and mitigation area (Table 4). Including floral, prey resource and fisheries resource components

Table 4. Monitoring program parameters and sampling intensity. The program would commence in the first spring following construction and be conducted for five consecutive years.

Parameter	Months sampled	Intensity
Vegetation:		
Cover	March-August	1/month
Density	March-August	1/month
Biomass	March-August	1/month
Epibenthic prey:		
Density	March-June	1/month
Biomass	March-June	1/month
Fish and Crab:		
Density	March-August	1/month
Biomass	March-August	1/month
Stomach contents[a]	March-June	1/month

[a]Juvenile salmonids only

into the monitoring program is required (1) to fully evaluate the performance of the constructed mitigation system, (2) to help explain why performance standards are not being met, and (3) to design possible remedial action.

Sampling methodology employed during the baseline studies (Thom et al. 1988) will be used for the monitoring program. Random, replicate samples for benthic plants and animals will be collected in each of three sites. The sites are (1) the mitigation area, (2) the high flat control outside the marina, and (3) the eelgrass control. The control sites will provide a measure of the natural conditions concordant in time with the mitigation eelgrass bed, which allows an analysis of the effect of interannual variations in the performance of the mitigation habitat.

By constructing the mitigation site in conjunction, as much as is feasible, with dredging, the time lag between marina flat dredging and mitigation site construction will be minimized . Transplanting will be carried out as soon as possible following site preparation. We anticipate that colonization of the mitigation area by small, short-lived animals (e.g., harpacticoid copepods) will begin immediately. Establishment of the bed will take at least 1 year following transplanting. Establishment is defined as growth of transplants and colonization of unplanted areas via vegetative and reproductive production.

CONTINGENCY PLAN

The following contingency plan is proposed in the event that performance standards are not met by the eelgrass mitigation project. In conjunction with resource agencies, the Port of Bellingham will determine the possible reasons why the eelgrass bed did not meet or exceed performance standards based on monitoring data and other pertinent information. Failure of the eelgrass system to support epibenthic prey resources and serve as habitat for fisheries organisms may be either due to failure of the eelgrass plants to grow and fill unplanted areas, or failure of the bed to be colonized by epibenthic salmon prey populations. Analysis of the data from the monitoring program should provide an indication of the reasons for the failure.

Contingency plans are as follows.

1. If eelgrass does not survive and spread, substrata/habitat modifications will be employed. It may be that eelgrass will colonize well in some areas and not survive in others. In these cases, remedial action of habitat enhancement by substrata modification coupled with replanting of areas showing poor survival will be carried out as needed to meet performance standards for the entire mitigation site.
2. If epibenthic prey resource abundances do not meet performance standards on the unvegetated substrata, gravel will be placed on the top of the fill. Gravel has been shown to support salmon epibenthic prey resources in some situations. In particular, a gravel beach established in Commencement Bay did show extremely high epibenthic prey densities shortly following construction (Thom et al. 1986b). Sampling of gravel substrata in the Duwamish River estuary in 1988 has also shown high epibenthic prey abundances in that habitat (Simenstad, unpublished data).

SUMMARY

It is proposed that loss of 14 acres of high intertidal mudflat used for feeding by juvenile salmonids will be compensated through construction of 3 acres of habitat (eelgrass) of demonstrated higher value. The mitigation plan calls for establishing an eelgrass bed very near the area to be dredged and was designed to enhance fish access, refuge, food availability and passage through the system. Monitoring of the performance of the bed will be carried out, and review of monitoring results in conjunction with close coordination with resource agencies will be used to evaluate this performance. Contingency plans will be carried out in the event that the mitigation does not meet performance standards.

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