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THE GOG-LE-HI-TE WETLAND SYSTEM IN THE PUYALLUP RIVER ESTUARY, WASHINGTON

Phase V Report: Year Five Monitoring, January-December 1990

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FINAL REPORT
to
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KEY WORDS

estuarine wetland, juvenile salmon, mitigation, sedimentation, wetland monitoring

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EXECUTIVE SUMMARY

In 1990, the fifth and final year of the U.S. Army Corps of Engineers permit-required monitoring program for the Gog-Le-Hi-Te wetland system (formerly the Lincoln Avenue Wetland system) included sampling of sediment characteristics, vegetation, fish, and birds. This report discusses and compares the findings over the 5 years of monitoring.

We conclude the following:

- The system continues to serve the target resources for which it was designed, and that the scope of use is highly dynamic.
- The system continues to undergo rapid and dramatic physical, chemical, and biological changes.
- Shifts in the composition of emergent vegetation continue in the upper intertidal.
- Transplanted *Carex lyngbyei* habitat has decreased >50% from its original (planted) area.
- Naturally-recruited *Typha* and other estuarine wetland taxa (*Scirpus*), as well as woody riparian vegetation (e.g., *Salix*), have increased their areal representation in the system.
- Fish utilization appears to have increased since 1988 in terms of maximum density.

INTRODUCTION

As mitigation for filling a 9.6-acre parcel of land (Parcel 5; Fig. 1) containing wetland and upland habitats, the Port of Tacoma constructed a similarly sized wetland system. Construction included establishment of a sedge (*Carex lyngbyei*) marsh through initial transplantings. The new wetland system, located at the intersection of the Lincoln Avenue bridge and the Puyallup River (Fig. 1), was connected to the Puyallup River estuary via a breach in the river dike in February, 1986. Earlier reports (Thom et al. 1987, 1990; Shreffler et al. 1990) on the project detail the construction and monitoring results through 1989. This monitoring work has shown that transplanted sedge continues to dominate the vegetation in the system and that other species, especially cattails, have vigorously colonized the system. In addition, target resources including juvenile salmonids, shorebirds, and waterfowl occupied and utilized the system. On the basis of these findings, it was concluded that the wetland system satisfied ecological performance criteria established as part of the mitigation agreement (Thom et al. 1987, 1990; Shreffler et al. 1990). However, the system was in an early stage of development and, similar to any new ecological system, changes were expected in subsequent years.

The work in 1990, which was the fifth and final year of U.S. Army Corps of Engineers permit-required monitoring, included continued systematic sampling of sedimentation, vegetation, fish, and birds. In contrast to previous years, infauna and epibenthic zooplankton were not sampled in 1990. Very little change in the taxa composition of these assemblages was seen following the initial dramatic changes that occurred during the first year following construction. Thom et al. (1990) concluded that, although the density of infauna and epibenthic zooplankton probably will exhibit large fluctuations over time, the species in this assemblage appear to have stabilized very shortly after construction. In addition, infauna and epibenthic zooplankton were not a major part of the diet of juvenile salmonids in the system (Shreffler et al. 1990). Insects that either emerged from the marsh or were imported from the river were found to be much more important to the diet of the young salmon.

STUDY SITES

The wetland system contains an upland area with a grassland, cattail marsh, and swamp, and an intertidal area consisting of mudflats and channels (Fig. 2). In 1990, sampling of vegetation and fish was carried out in the intertidal area. Birds were sampled in all habitats. All flats except flat 5 were planted in 1986-1987 with *Carex*, and flat 5 served as an unplanted reference area.

MATERIALS AND METHODS

GROSS HABITAT COMPOSITION

Standard-elevation vertical color aerial photographs taken in July of each year since Gog-Le-Hi-Te was constructed (1986-1990) were used to digitize habitat area for 10 habitat categories: (1) upland grass, (2) upland tree, (3) palustrine *Typha* marsh, (4) willow (*Salix* spp.), (5) intertidal *Typha*, (6) *Carex*, (7) high intertidal mudflat, (8) low intertidal mudflat, (9) tidal channel, and (10) the debris-drift zone. A Jandel Scientific digitizing board and Sigma-Scan software were used to trace habitat polygons from the 9 x 9 in (1 in = 200 ft) photographs. The measurements for each photograph were standardized by a known dimension—the distance between two telephone poles visible in each—and the area calculated automatically.

SEDIMENTATION

Sedimentation was measured at two sites on flat 4. The sites consisted of two wooden stakes, spaced 1 m apart, driven into the sediment such that the tops of the stakes were 20 cm above the sediment surface. Measurements were made between a meter stick, which spanned between the tops of the stakes, to the surface of the sediment at 25-, 50- and 75-cm points along the meter stick. Heavy sedimentation in previous years, especially 1988-1989, buried the sediment monitoring stakes originally established in 1987. The stakes were driven into place, and initial measurements were taken on 14 May 1990. Subsequent measurements were taken on 13 June and 26 July.

VEGETATION

Chlorophyll *a* and phaeopigment concentrations were determined as a measure of important sediment-associated microalgal biomass from sediment cores (1 cm diameter x 1 cm deep) taken at five sites (12, 28, 44, 60, 76 m) along the flat 4 transect. Samples were collected on 14 May 1990. Sample processing followed the methodology of Thom et al. (1987).

During 1987 and 1988, emergent macrophyte (i.e., rooted plants) percent cover, density and aboveground biomass were sampled at the 29 intertidal sites located on flats 1-8 (Fig. 3); the lowest site on flat 5 was not included. Macrophyte percent cover was estimated from photographs taken from directly above the center of each 1-m^2 area within a quadrat positioned at each site. The four corners of each 1-m^2 area were permanently marked with wooden stakes to facilitate repositioning of the quadrat during subsequent samplings. The number of shoots of *Carex* and *Typha* occurring within each quadrat was counted in the field. In 1989, we modified the emergent plant sampling method because the cattails were too tall (i.e., over 2 m) to fit within the photographic sampling frame used in 1987-88. In addition, the high density of the vegetation and burial of most stakes from sedimentation prevented the relocation of the site markers. Therefore, in 1989 and 1990, we estimated the cover of each major emergent plant species using aerial photographs and groundtruthing.

The vertical color aerial photograph taken on 21 July 1990 was also used to assess vegetation cover. During the 14 September visit, the distribution of major plant taxa was outlined on clear plastic sheets, which overlayed the photograph. The taxa were relatively easily distinguished by color on the photograph. In the laboratory, a clear plastic sheet containing grid of squares (i.e., pixels) with a scale area of 9.2 m^2 was laid over the photograph. The number of pixels in which a plant species covered at least 50% of the area of the pixel was recorded for each species. The number of pixels was multiplied by 9.2 m^2 $pixel^{-1}$ to yield an estimate of area covered by each emergent plant species. This procedure was repeated for aerial photographs taken in 1986-1990. Groundtruthing conducted on 24 July 1990 greatly aided the identification of plants in the photographs. Groundtruthing consisted of recording the location of plant taxa along 54 transects spaced 10 m apart, which ran from the base of the berm (or dike) across the intertidal zone toward the midbay of the wetland system. We felt that this procedure provided a reliable estimate of vegetation cover and that data were of comparable accuracy among years. Information was available for all years on species distribution and cover, and aerial photographs were consistent in scale, season, and quality.

Carex and *Typha* shoot density was estimated from within a 0.1-m^2 quadrat non-selectively placed into the stands of each of these species on each flat during the 26 July visit. Three quadrats were sampled on each flat for each species. Belowground biomass of *Carex* was estimated from core samples (0.06-m^2 area x 30-cm deep) taken within stands of this species on flats 1, 2 and 7. One core was collected from each flat by excavation. The roots and rhizomes were cleaned of sediments by careful rinsing over a 2-mm mesh screen. In the laboratory, the material retained on the screen was dried and weighed to the nearest mg. Measurements of total shoot (i.e., length of the longest leaf) length were made on 50 plants collected non-selectively from the stands of *Carex*.

We developed a comprehensive, although probably not complete, list of angiosperm species occurring in the intertidal portion of the system. On 26 July, a plant taxonomist, Sara Cooke, collected and identified plants along the 54 transects we used for groundtruthing surveys.

FISH

Fish residing in the wetland during low tide were sampled in tidal channels, as in previous years' sampling. Fish sampling was targeted at estuarine-dependent outmigrating juvenile chum salmon (*Oncorhynchus keta*) and chinook salmon (*O. tshawytscha*), but data were obtained on all fish that were captured. Sampling occurred monthly, March 15, April 17, May 14, and June 13, during the strong spring tide series.

Two tidal channels (3, 4) were sampled on each occasion using a 9.7-m, two-pole seine with a 6-mm mesh bag (Thom et al. 1988, 1989, 1990; Shreffler et al 1990). The seine was equipped with a solid core lead line that kept the net on the bottom while the float line kept the top of the net at the surface. Prior to sampling each channel, the surface water temperature, salinity, wind speed and direction, visibility, percent cloud cover, amount of precipitation, air temperature, and time of day were recorded. At each channel, the seine was stretched across the width of the channel at its mouth (to the basin) and then pulled up the the length of the channel to the upland end, where the net was drawn completely out of the water. Mud clogging the bag of the seine was washed through the mesh with water before the sample was sorted.

Captured fish were then placed in buckets of water, rinsed to remove most of the mud, and sorted to species. In the laboratory, fish were identified, enumerated, measured (nearest 1-mm fork length or total length), weighed (damp weight to nearest 0.01 g), and checked for reproductive status. Species identifications followed Hart (1973) and Wydoski and Whitney (1979); differentiation between the various salmon species was made with the aid of several references (McConnell and Snyder n.d., Trautman 1973, Phillips 1977). If necessary, they were verified using the University of Washington synoptic fish collection.

Fish data were recorded on NODC[1] format #100, type 3 (catch summary) and type 4 (individual fish examination) data recording forms. These data were then entered and stored on a microcomputer for tabulation and statistical analysis. All fish density and standing stock data were reported as based on the total area estimated for the two channels, i.e., 1,398 m^2 and 1,682 m^2 for channels 3 and 4, respectively (Thom et al. 1987).

BIRDS

Observations of bird presence were made at least weekly during 1990 by Jon R. Jensen. The data sheets, kindly supplied by Thais Bock of the Tahoma Audubon Society, included records of species observed in the wetland during each visit. Ms. Bock also provided her list of bird species observed in the system on frequent trips to the site.

Quantitative surveys of numbers of individual birds, their species, and their location within the system were made at monthly intervals from 17 April through 17 September by a biologist from the Puyallup Indian Fisheries Office. Bird counts were stratified by areas in the wetland (cattail

[1]NOAA National Oceanographic Data Center.

border, cattail marsh, water, dike, mudflat aerial, upland). This type of sampling was carried out in 1986 and 1987 (Thom et al. 1986, 1988).

RESULTS AND DISCUSSION

GROSS HABITAT COMPOSITION

Upland habitats comprised a relatively consistent proportion of the system through the 5 years since initiation of the wetland, while intertidal wetland habitats fluctuated dynamically (Fig. 4). Upland grassland fluctuated 5% to 6%, between 14,200 to 16,700 m^2; upland trees have increased slightly, from 725 m^2 in 1986 to between 1,600 m^2 and 1,400 m^2 in 1988 and 1990, respectively; and the freshwater *Typha* (cattail) marsh remained constant at between 1,900 m^2 and 2,300 m^2.

The transitional zone between the intertidal wetland habitats and the upland habitats was rapidly colonized by willow (*Salix*) and alder (*Alnus rubra*), which increased from 0.4% (160 m^2) in 1986 to between 4.5% and 4.0% (1,700–1,600 m^2) of the total system area in 1989 and 1990.

Intertidal *Typha* increased rapidly from occupying 0 m^2 in 1986 to approximately 1% (450 m^2) in 1987, and between 4% and 5% (1,600–2,700 m^2) in the last 2 years. The area occupied by debris-drift material accumulating in the *Typha* zone has increased; cover of this material increased from 0 m^2 in 1986 to 3.6% of the system (1,400 m^2) in 1990. The transplanted and vegetatively recruited *Carex* has declined from a maximum of 16.5% of the system (7,000 m^2) in 1987 after 2 years of transplanting to between 7% and 7.4% (2,700-3,000 m^2) in 1989 and 1990. Intertidal mudflat area has varied between 31.9% (12,300 m^2) and 38.4% (14,700 m^2) in the first 4 years, but it decreased to 24.0% (9,600 m^2) in 1990. The tidal channels originally occupied 12.5% (4,800 m^2) of the area in 1986 but decreased rapidly to between 2.6% to 5.5% in the intervening years until increasing to 6.7% (2,700 m^2) in 1990.

Declines in habitat area were offset by increases in debris-drift coverage and in coverage of the midbay.

SEDIMENT CHARACTERISTICS

Since dike breaching in February 1986, sediments from the Puyallup River have been deposited in the wetland, which has resulted in changes in sediment grain size and bottom contours. The net result has been to decrease the depth of these areas and reduce the area that contains water during all stages of the tide. We estimated that in 1989 (Thom et al. 1990), on average, 1-3 ft of sediment has been deposited in the channels and mid-bay. This deposition has occurred largely along the edges of the channels and immediately inside the mouth of the system.

Thom et al. (1990) found that sedimentation between 1988 and 1989 was heavy due to periods of heavy rainfall and runoff; in particular, the flats received the most sediment recorded.

The sedimentation stake monitors we set up in 1990 showed that measurable sedimentation did not occur on the flats during spring and summer (Fig. 5). That vegetation appeared to be increasing in areal extent between 1989 and 1990 (see below) suggests that plants on the flats were not being lost because of heavy sedimentation. This means that sedimentation on the flats was probably less for 1990 than that which occurred in previous years.

VEGETATION

Our single sampling of sediment pigments showed that chlorophyll was undetectable and that phaeopigments were high during May (Fig. 6). This condition is not atypical for the system, as indicated by previous samplings, and it indicates that the surface sediments were dominated by the degradation products of photosynthesis. Heaviest degradation appears to occur immediately following the spring (i.e., April) bloom of algae in the system (Thom et al. 1988).

The survey of plant species within the intertidal portion of the system resulted in a list of 57 species (Table 1). Among these species were several species of sedge, rush, and willow, which are typical of wetland systems. Flat area corresponded strongly with the number of species found on the flat (Fig. 7). This suggests that by increasing the flat area, an increase in number of species would be predicted. Of note is that the flats were planted with one species only in 1986. The system has been colonized by at least 56 other species since 1986. The full report on the plant taxonomic survey is in Appendix A.

The total area covered by macrophytes increased by about 67% between 1989 and 1990 (Fig 8). This increase was largely attributable to the increase in cover of low growing and juvenile flowering plants at the seaward edge of the marsh. This ground cover consisted primarily of immature *Juncus bufonius* (toad rush). Between 1989 and 1990, the ground cover had become much more predominant and was readily detected on the aerial photographs. *Typha* increased in cover (43%) also, as did *Scirpus acutus* (195%).

The changes in *Carex lyngbyei* parameters are perhaps indicative of a maturing assemblage. *Carex* density continued to increase dramatically between 1989 and 1990, in a manner similar to the increase between 1988 and 1989 (Fig. 9). This increase in density is in spite of the the general decline in area covered by this species following transplantation. We felt that the small increase in area of cover by *Carex* in 1990 as compared with 1989 was real and may indicate a prograding of this species onto the flats. The increase in density coupled with the slight increase in area resulted in a dramatic rise in total shoot abundance in the system (Fig. 9). In total, shoot abundance has risen from an initial transplanting of about 48,000 shoots in 1986-1987 to over 420,000 shoots by

1990. Shoot lengths in 1990 were very similar to lengths in 1986 at Gog-Le-Hi-Te (Fig. 10). Shoot density, as shown above, was much greater in 1990 as compared with 1986 (Fig. 10). Aboveground biomass was greater in 1990 than 1986 (Fig. 10). Perhaps of most importance to the establishment of a stable system is the development of the roots and rhizomes. Belowground biomass increased fourfold between 1986 and 1990 (Fig. 10).

Very rough estimates of the rate of development of the transplanted *Carex* stand can be made based on the mean values for density for above- and belowground biomass. Using a straight line regression between the 2 years, shoot density, aboveground biomass, and belowground biomass have increased at rates of 38 shoots m^{-2} $year^{-1}$, 53 g m^{-2} $year^{-1}$ and 160 g m^{-2} $year^{-1}$, respectively. Although knowledge of these rates is very important to the understanding regarding development of wetlands for mitigation and other purposes, the rates must be viewed with caution. First, error bars around mean aboveground parameter values are large. Second, a straight-line relationship may not be the most appropriate model. We have seen that density increased at a much more rapid rate in the last 2 years as compared with the first 2 years. It may be that this rate is maintained or increased as the stand becomes more mature and established. Hutchinson (1986) presented data on *Carex* aboveground biomass from 17 stands along the West Coast and showed that the mean biomass ranged from about 300 to 1,700 g m^{-2} (mean about 1,100 g m^{-2}). The value for Gog-Le-Hi-Te was 415 g m^{-2}, which was within this range. The full range of values for density and belowground biomass in *Carex* stands is not known.

FISH

A total of nine species of fishes were found to occupy the wetland's tidal channels between early March and early July, with a maximum of eight species captured in mid-April (Fig. 11). No new species were encountered during the 1990 sampling. Maximum mean total fish density (0.66 fish m^{-2}) occurred in mid-June. This pattern in maximum fish density was influenced predominantly by the largest catch ($\bar{x} = 0.562$ fish m^{-2}) of juvenile chinook salmon ever encountered in the wetland. All other fish densities were below 0.1 fish m^{-2} and were numerically dominated by largescale suckers (*Catostomus macrocheilus*), threespine stickleback (*Gasterosteus aculeatus*), and prickly sculpin (*Cottus asper*) (Fig. 12).

The mean total fish density over the four sampling periods was 0.2 fish m^{-2}, which was comparable to the mean total fish density sampled by seine between April and June 1989 and which continued the higher densities evident since 1988 (Fig. 13a). In 1990, total fish species richness (9; Fig. 13b) was slightly lower than in either 1988 (10) or 1989 (12), comparable to earlier years (1986-1987). Sampling intensity has been reduced to a monthly basis since 1988. The less frequent sampling in 1988 and 1989 still indicated increasing fish utilization as compared with 1986-87. Sampling in 1990 indicated either a leveling off or a decrease in fish utilization. While there is no direct evidence of causal mechanisms, we interpret the potential limitation in fish utilization to be associated with decreased habitat space during periods of low tides and potentially more limiting thermal and other water quality conditions associated with decreasing channel depth and subtidal refugia. As has been described in prior reports (Shreffler et al. 1988; Thom et al. 1987, 1989), the absence of data on fish assemblage composition and standing stock from natural wetland habitats comparable to Gog-Le-Hi-Te (e.g., reference sites) limits our ability to interpret these trends.

In terms of mean total density, juvenile salmon utilization appears to have increased since 1987 (Fig. 14). It is noted that this is affected by the high chinook salmon catch in June.

BIRDS

Between 1986 and 1990, 118 bird species have been noted in the system (Table 2). In 1990, 22 species were added by the joint observations of Thais Bock and Jon Jensen. A plot of the cumulative number of species observed in the system continued to climb rapidly, as was the case in previous years (Fig. 15). On the basis of the quantitative observations, there has been little change in the total number of species that occupy the system during the spring-summer. Total numbers of species observed in the system were 34, 39, and 36 in 1986, 1987, and 1990, respectively. These data suggest that the system continues to attract large numbers of bird species and that the system is at carrying capacity in terms of number of species in any one year.

The quantitative bird counts showed that waterfowl use of the system was higher in 1990 as compared to 1986 (Fig. 16). Waterfowl comprised over 80% of the total abundance of birds during some months. Shorebird use appears to be more prevalent in 1990 compared with 1986. In 1986, shorebirds comprised approximately 20-30% of the individuals, whereas in 1990 shore birds comprised 5-40% of the observed individuals. This result is difficult to explain. Changes in the mix of habitats in the system may account for the observed difference.

In excess of 500 individuals occupied the system on some days in 1990 (Fig. 17). The increased presence of waterfowl is reflected in the increased numbers of birds observed in water (Fig. 18). The tidal flats continued to be an important area for birds as indicated by the number of observations in that habitat.

CONCLUSIONS

The system continues to function in support of juvenile salmon, shorebirds, and waterfowl—the target taxa for which the system was built. The area occupied by tidal marsh appears to be increasing after 3 years of decline. We noted a heavy cover of low-growing species at the prograding edge of the marsh, and colonization of longer-lived plant taxa within this edge. It appeared also that the elevation at the edge of the marsh was increasing owing to sediment trapping. Sediment trapping could partially be due to the plants establishing at the edge. *Carex* data, and data on the number of species in the system, strongly suggest that the system is maturing. The total number of plant species in the system (ca. 57) indicates that species recruitment to the system is occurring (i.e., via river input or birds). Owing to lack of available surveys, whether this large number of species is representative of natural systems in the Northwest is unknown. Possibly the number of plant species in the system is due to the system being new, and the total number of plant species may decline over time as the system becomes dominated by longer-lived perennial taxa.

Mean fish density in 1990 was similar to 1988 and 1989. It remains to be seen whether the high chinook catch on only one sampling date is illustrative of increased utilization by that species or whether it represents an extreme event in variable use of the wetland. Shreffler et al. (1990) documented that juvenile chinook have a mean residence time of between 5.06±8.09 days (volitional) and 38.33±6.60 days (mark-release), and they may remain in the wetland as long as 43 days. This suggests a tendency for juvenile chinook to remain and forage (Shreffler et al., in review) in the wetland as long as temperature, salinity, and other factors potentially limiting their residence do not exceed threshold levels. With decreasing tidal channel habitat, however, these factors may be becoming more limiting to fish utilization.

The system is probably still threatened by stochastic events (e.g., floods, droughts, freezes). Root-rhizome biomass showed a dramatic increase since 1986. The belowground system is the part of the plant that is most resistant to stochastic events, and it would be the source of new shoot material in the event that the aboveground material (i.e., shoots) is destroyed. The stability of the system depends upon the development of the root-rhizome complex. There is simply no available data for *Carex* that we could use to evaluate whether the rate of increase in belowground biomass at Gog-Le-Hi-Te is normal or not.

The primary concerns regarding the fate of the system include sedimentation and trash. There is now a maintenance program in place, funded by the Port of Tacoma to remove trash from the system. The program is jointly implemented by the Port and Metropolitan Park. The main effects of sediment accumulation have been to decrease bottom depths in the mid-bay and reduce channel widths. These changes did not exclude salmonids from the system in spring because of high river flows during periods of extreme low tides. The intertidal portion of the system appeared to contain adequate water depths for fish during all tidal stages in late winter and spring. During late spring and summer, especially during the major drought in 1987, water remained only in channels 3 and 4 during neap series low tides. This probably excluded all but small, more thermally tolerant fish from the system during summer low tides. In 1990, sedimentation was minimal on the flats. At Gog-Le-Hi-Te, sedimentation was expected to be substantial immediately after dike breaching, and this was the case in 1986-1989. When natural systems are newly exposed to sediment sources, sedimentation is typically rapid for a period of time, after which the rate of sediment accrual declines. We expect that sediment accrual rate will ultimately decrease at Gog-Le-Hi-Te. Therefore, at this time it is premature to conduct remedial action to remove sediments or reduce sedimentation.

SUMMARY AND RECOMMENDATIONS

In terms of fish utilization, and especially relative to the mandated 50% use factor for juvenile salmon, the Gog-Le-Hi-Te system may be entering a limiting phase associated with filling of subtidal habitat. Sedimentation of the subtidal, and thus conversion of subtidal to intertidal habitat is expected to continue. If sedimentation rates continue such that the subtidal areas continue to be converted to intertidal, it may be necessary to consider artificially deepening the channels to increase subtidal habitat for fish. Such action may need to be considered over the long term as a temporary measure, and one that must likely be implemented repeatedly in the future to maintain continual availability of the system for juvenile salmon. Again, this is dependent upon the long-term sedimentation rates. Other methods to maintain the system's availability for juvenile salmon may exist, such as modifying the wetland's configuration to increase tidal velocities and thus maintain channel scouring. Alternatively, serious consideration should be given to withholding these modifications in favor of letting the wetland system naturally stabilize at a topographic/ bathymetric equilibrium because such modifications will substantially disturb the biotic community that has become established over the past 5 years. Over the long term, Gog-Le-Hi-Te should achieve a comparatively natural community state that includes support, to one degree or another, of all the target resources.

Monitoring to date indicates that the system continues to function in support of juvenile salmon, shorebirds, and waterfowl, and thus satisfies federal permit requirements. Since many of the parameters measured during the first 5 years indicate that the system is young in terms of stability and continued use by target resources, it may be appropriate to consider some level of monitoring to be conducted over time for the future.

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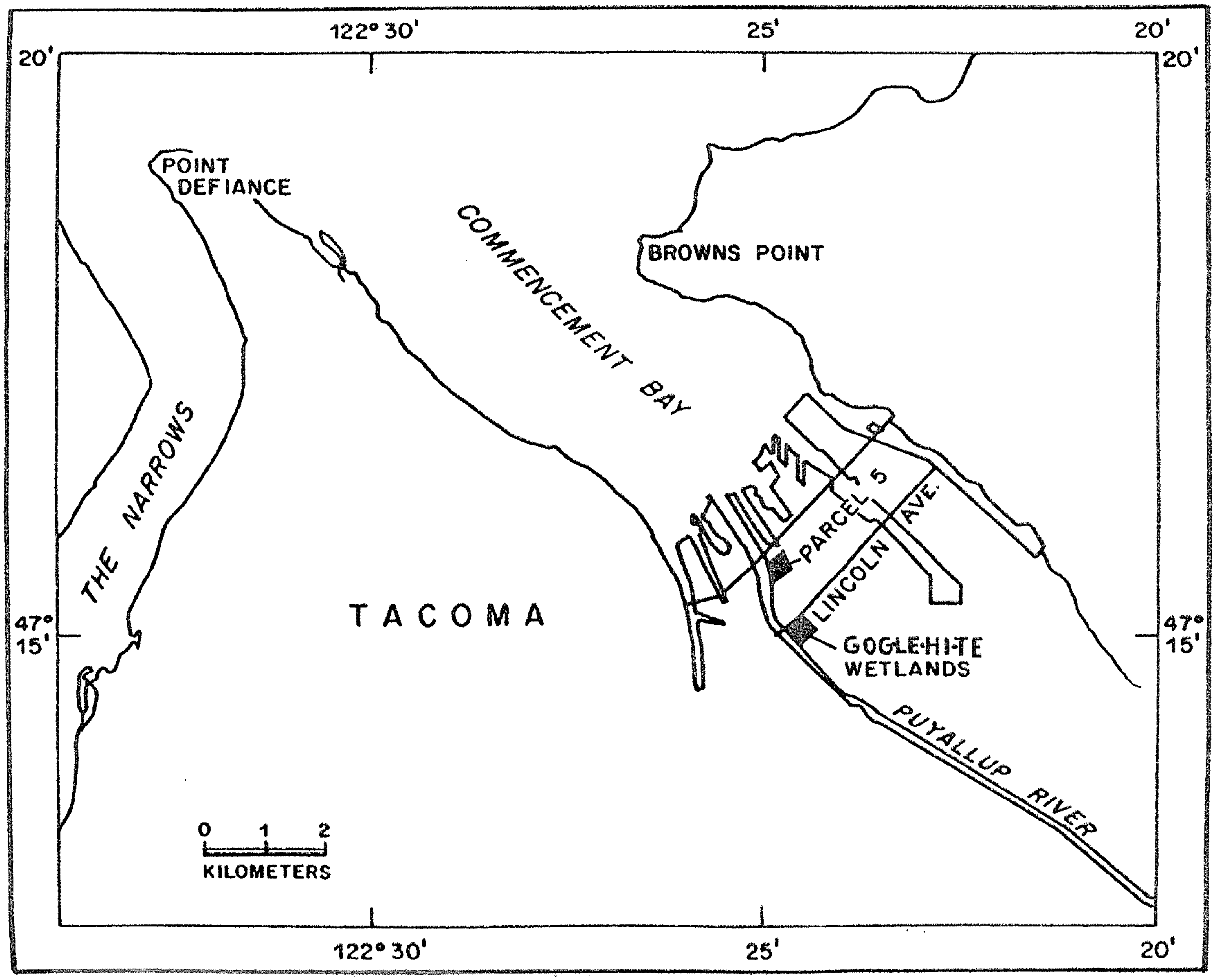

Figure 1. Diagram of Go-Le-Hi-Te wetland system.

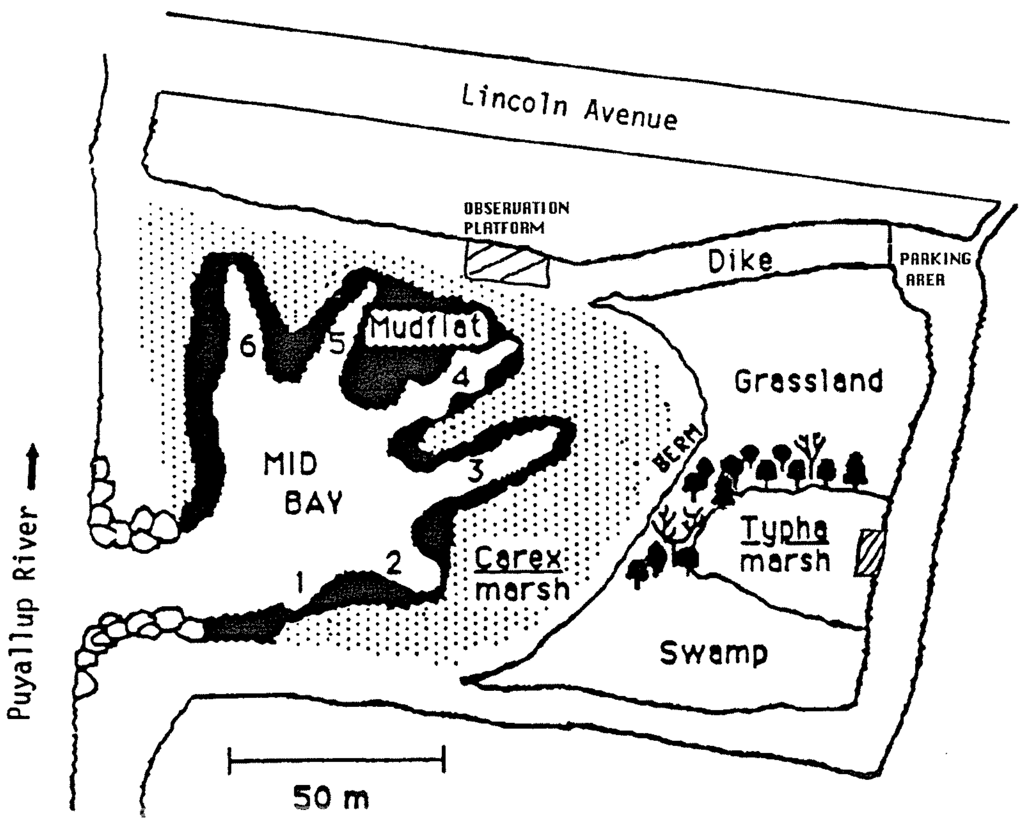

Figure 2. Present (July 1990) distribution of habitat types in Gog-Le-Hi-Te wetland system.

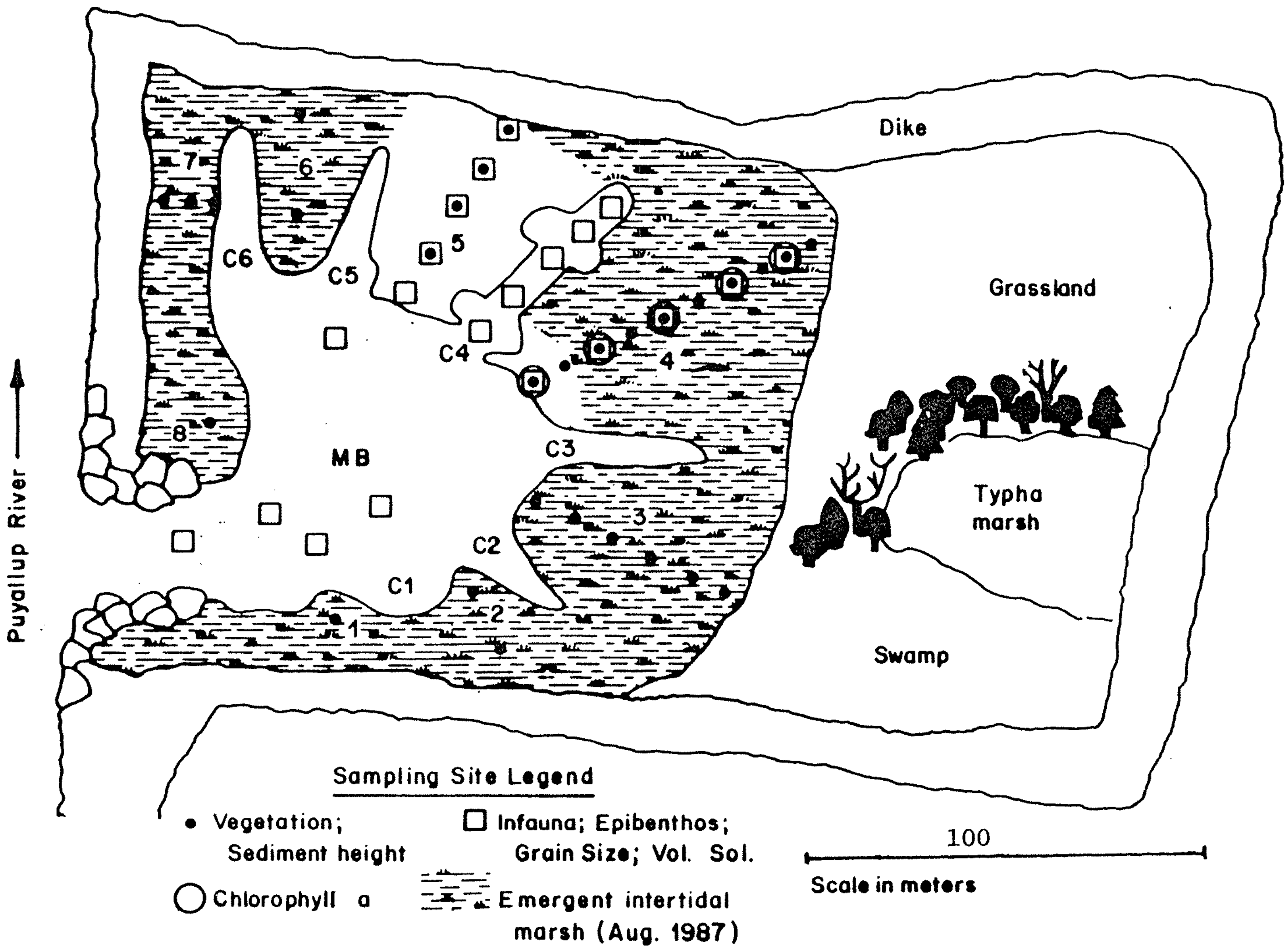

Figure 3. Intertidal sampling sites of Go-Le-Hi-Te wetland system.

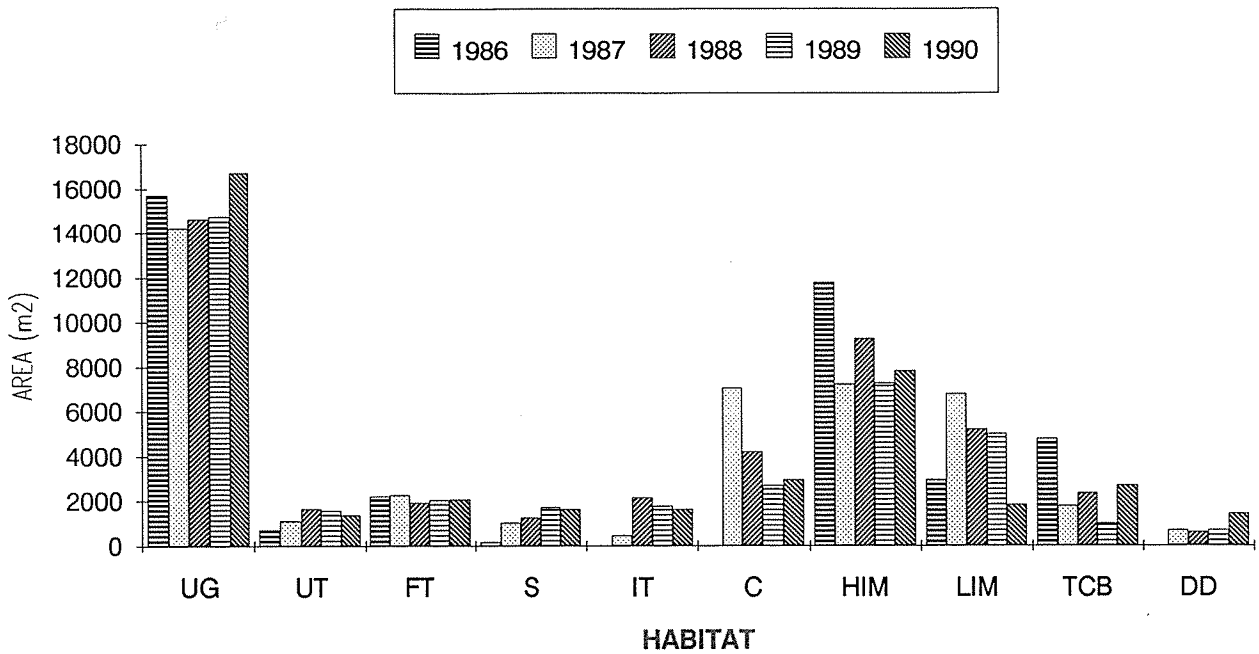

Figure 4. Changes (%) in habitat composition of Gog-Le-Hi-Te system over first 5 years (1986–1990): UG = upland grass, UT = upland trees, FT = freshwater *Typha* (cattail) marsh, S = *Salix* (willow, alder), IT = intertidal *Typha*, C = *Carex* (sedge), HIM = high intertidal mudflat, LIM = low intertidal mudflat, TCB = tidal channel, and DD = debris and drift material.

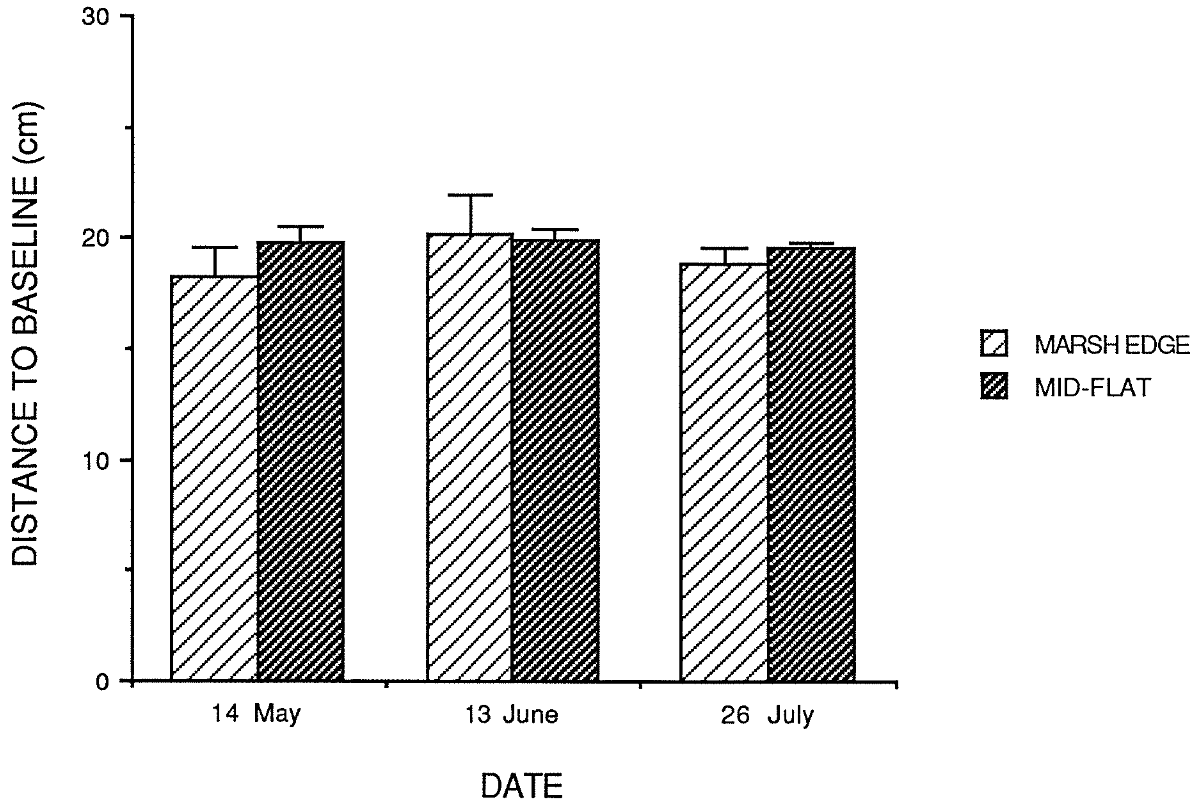

Figure 5. Mean (±SE) distance from the surface of the sediment and the baseline (initially approximately 20 cm above the sediment surface) at three sampling dates in two habitats.

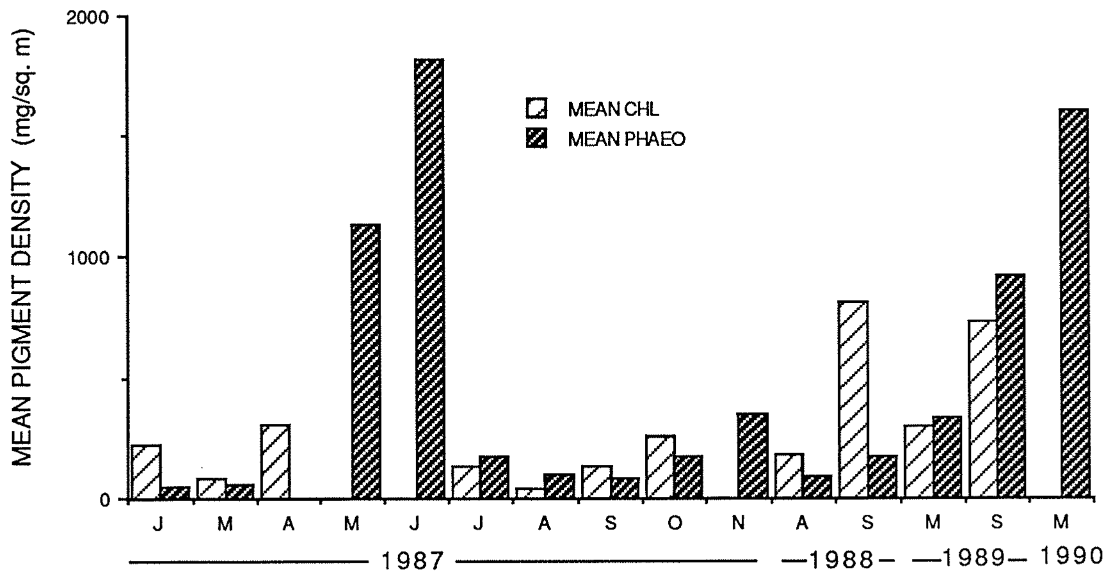

Figure 6. Mean pigment density on the flats for all years sampled.

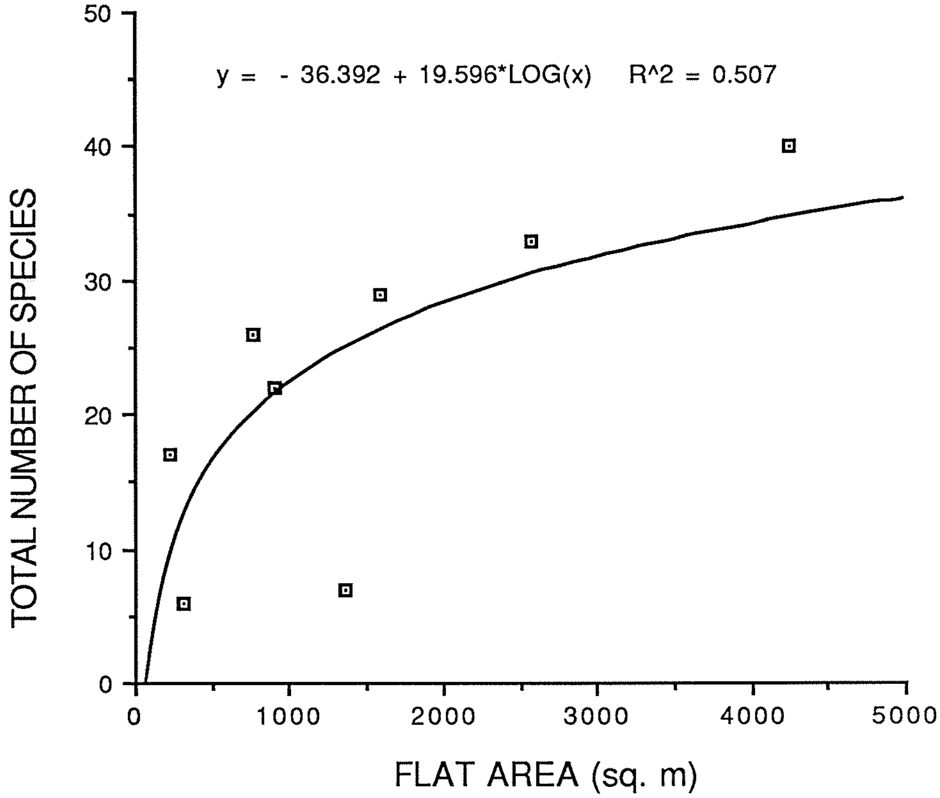

Figure 7. Relationship between the area of the flats and the number of wetland species noted on the flat.

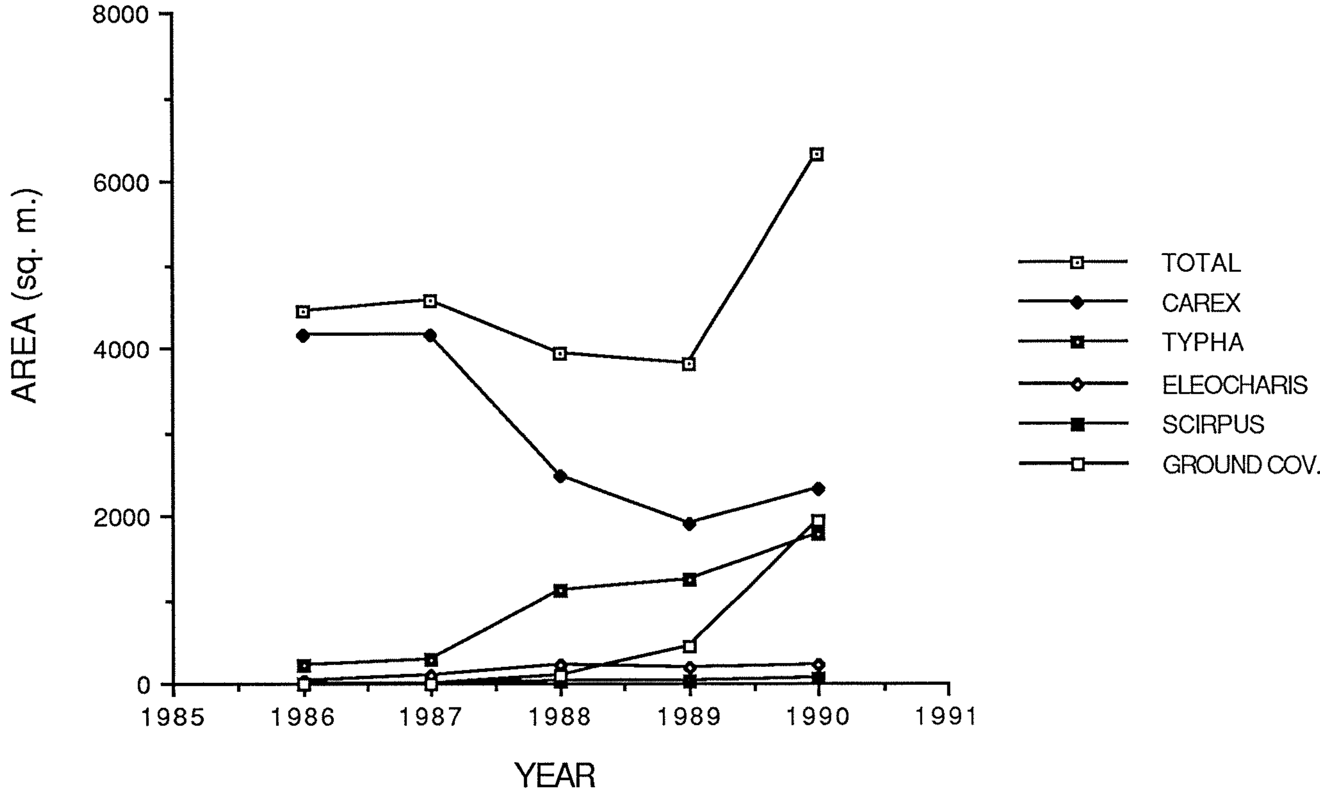

Figure 8. The area of the tidal portion of the system occupied by the major plant taxa.

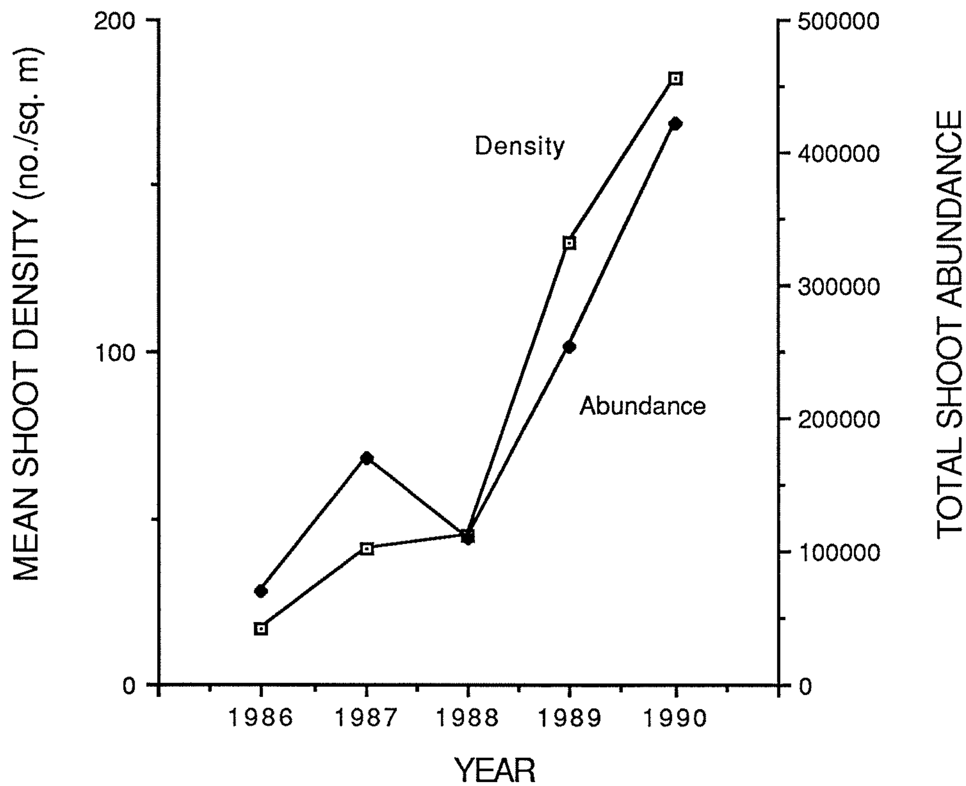

Figure 9. Changes in the area covered and mean shoot density of *Carex* in the system between 1986 and 1990.

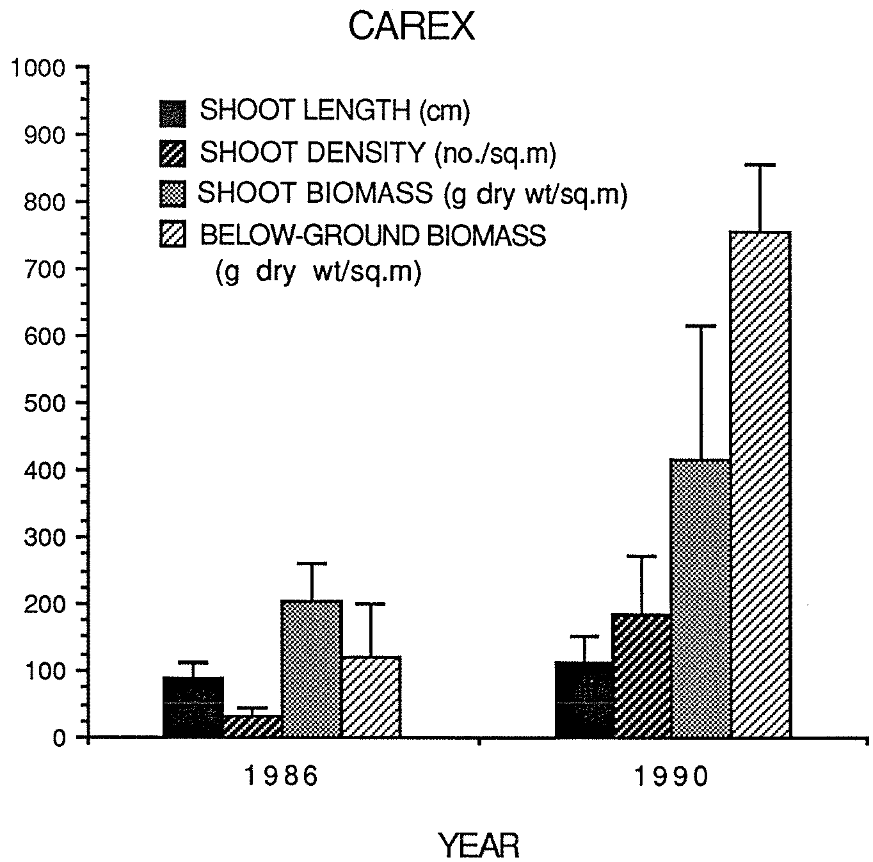

Figure 10. Changes in mean (±1 SE) of shoot length, density, and biomass of belowground biomass *Carex* in the system between 1986 and 1990.

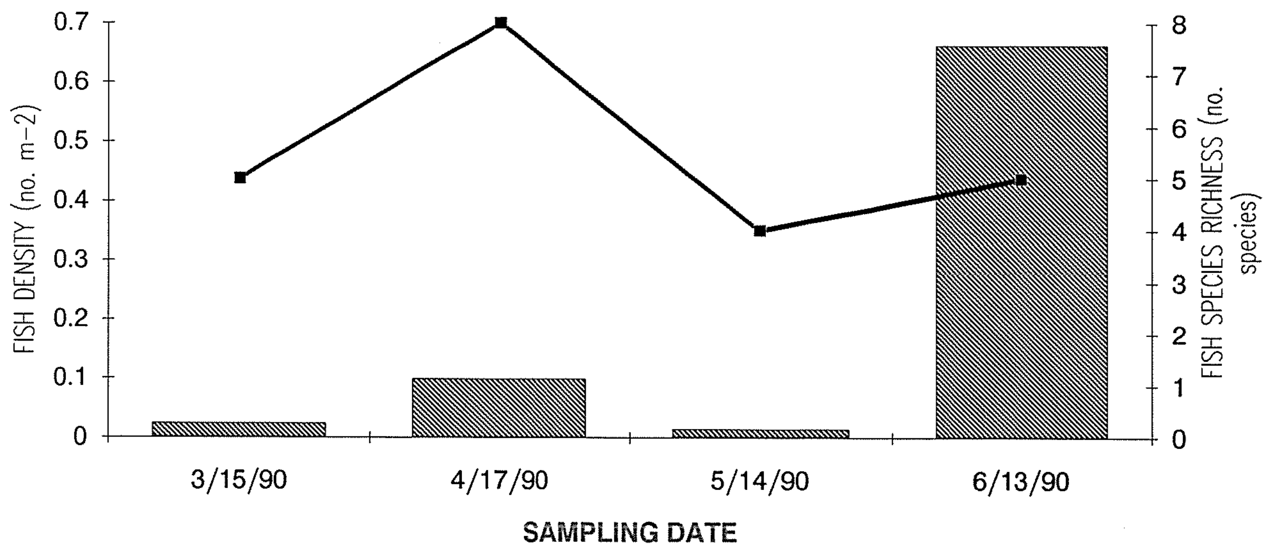

Figure 11. Mean density (no. fish m^{-2}; vertical bars) and species richness (no. species; line) of fish occupying two tidal channels in Gog-Le-Hi-Te wetland sampled monthly by seine between mid-March and mid-June, 1990.

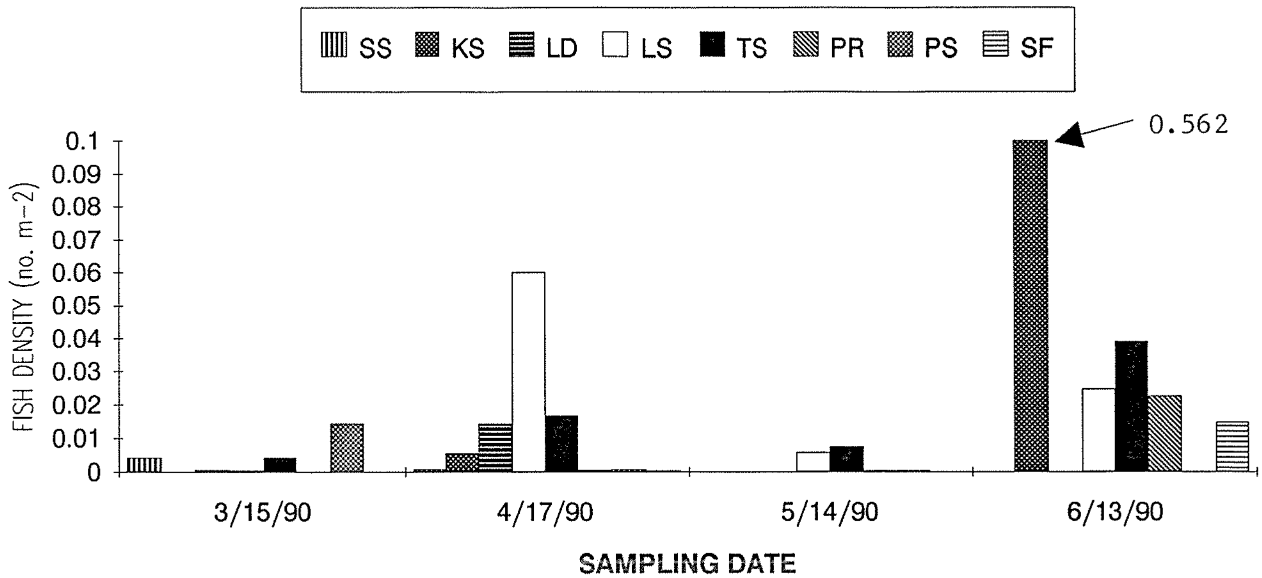

Figure 12. Mean density (no. fish m^{-2}) of fish occupying two tidal channels in Gog-Le-Hi-Te wetland system sampled monthly by seine between mid-March and mid-June, 1990. Fish species in order of appearance (left to right) on chart: SS = coho salmon, KS = chinook salmon, LD = longnose dace, LS = largescale sucker, TS = threespine stickleback, PR = prickly sculpin, PS = Pacific staghorn sculpin, and SF = starry flounder.

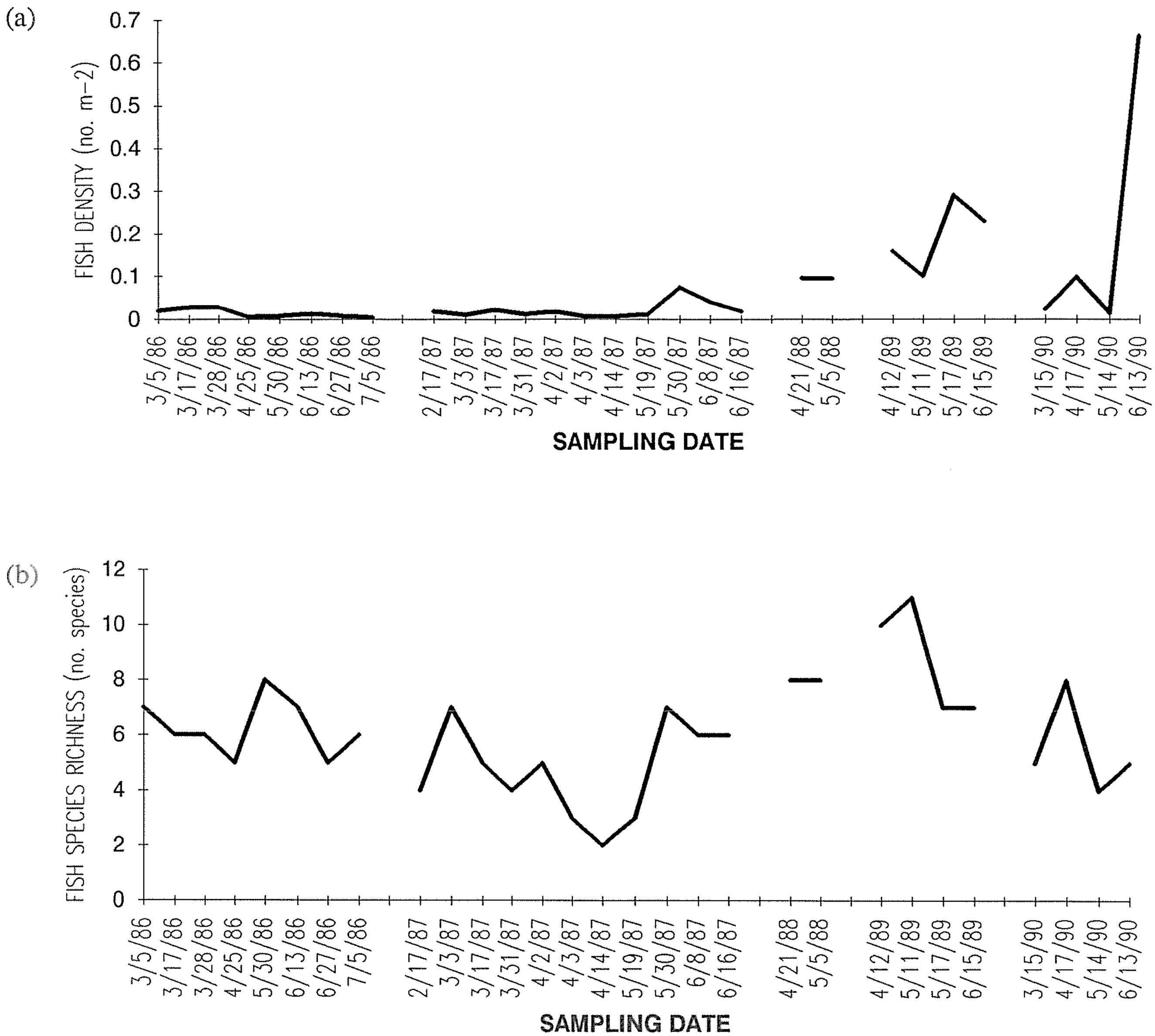

Figure 13. Mean total density (a—no. fish m^{-2}) and species richness (b—number of species) of fish occupying tidal channels in Gog-Le-Hi-Te wetland system sampled by seine over the 5-year period following construction, 1986-1990.

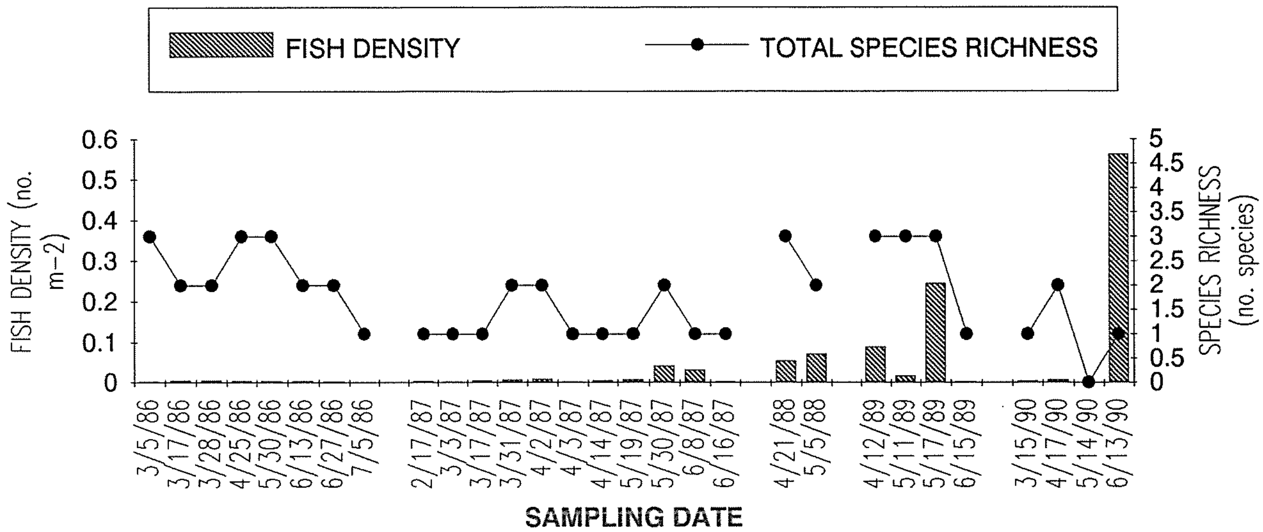

Figure 14. Mean total density (no. fish m^{-2}) and species richness (number of species) of juvenile salmon occupying tidal channels in Gog-Le-Hi-Te wetland system sampled by seine over the 5-year period following construction, 1986-1990.

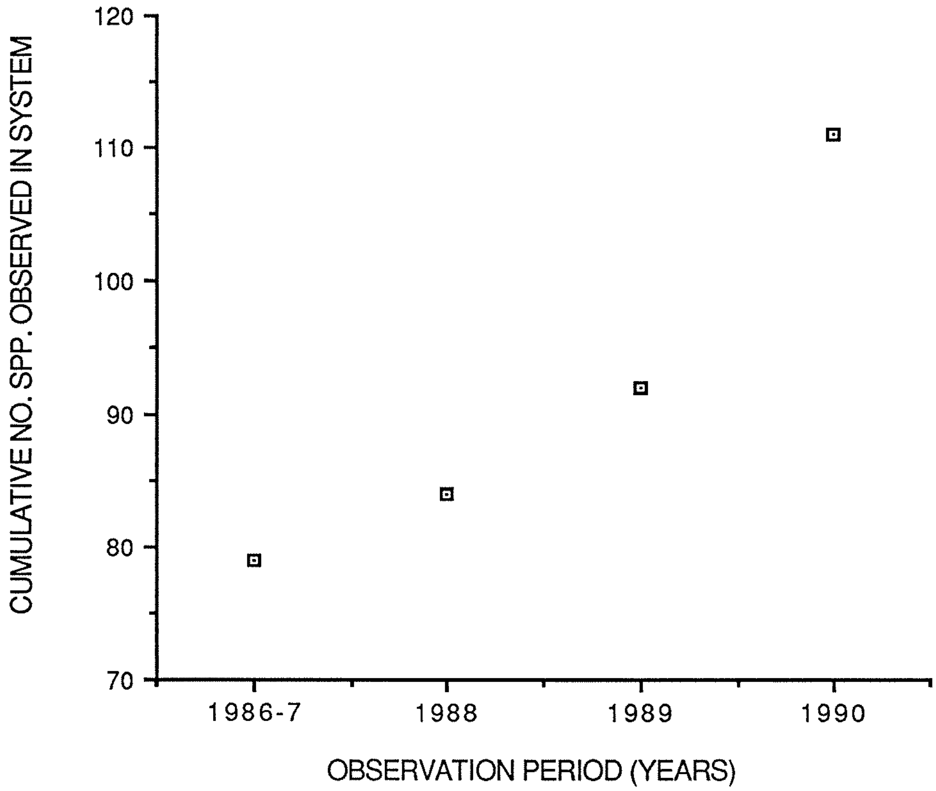

Figure 15. Cumulative number of bird species observed in Gog-Le-Hi-Te wetland system by Jon Jensen and Thais Bock.

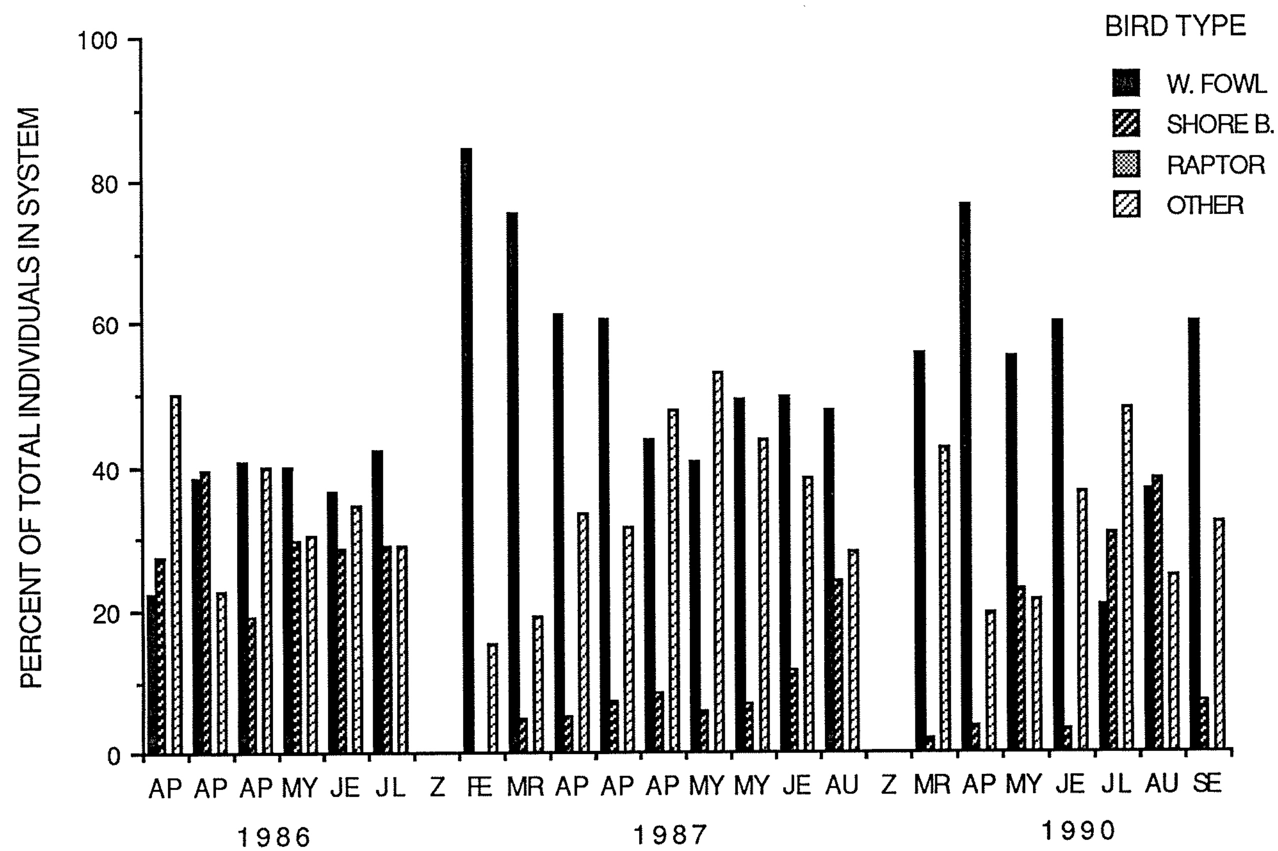

Figure 16. Percent of total number of birds observed in Go-Le-Hi-Te wetland system by bird type, 1986, 1987, and 1990 quantitative bird surveys.

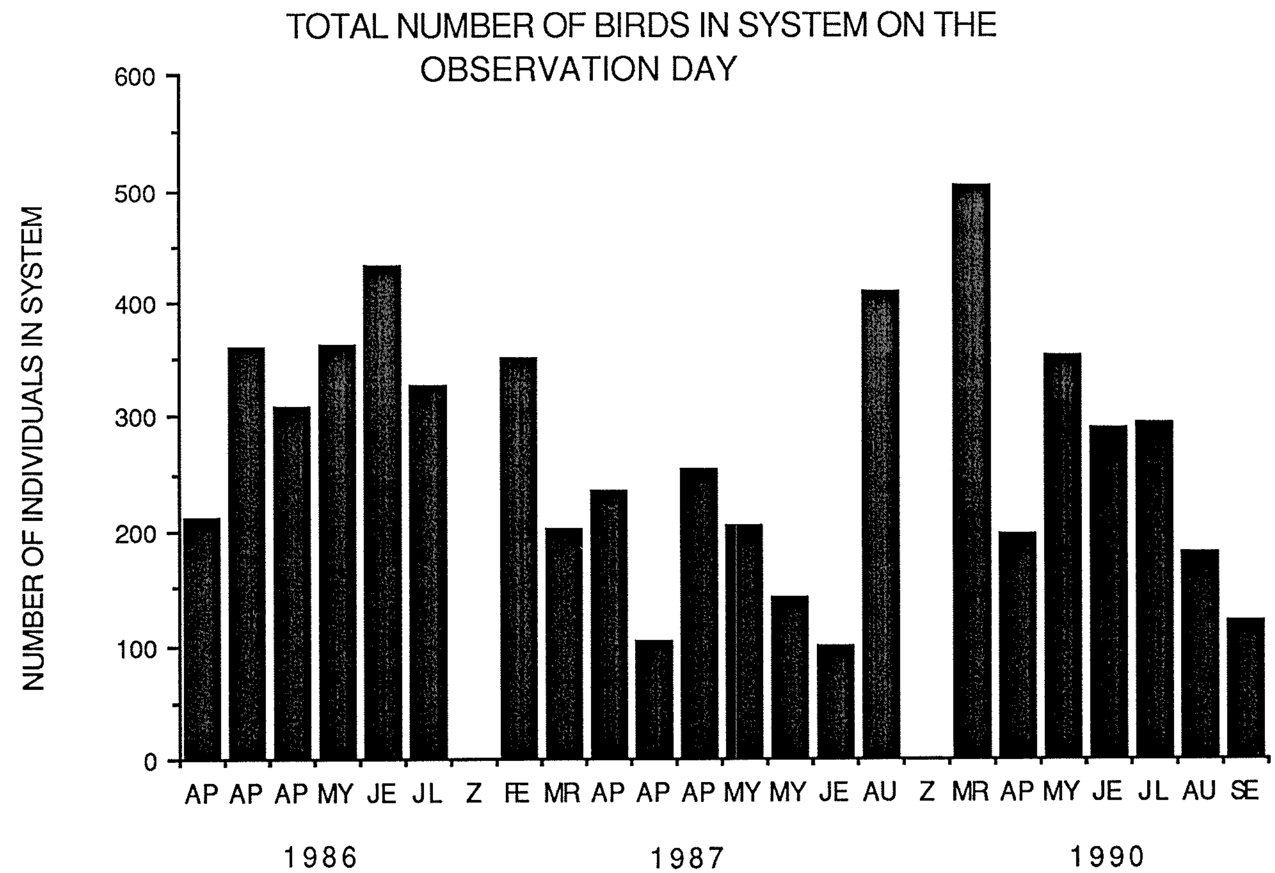

Figure 17. Total number of birds observed in Go-Le-Hi-Te wetland system during each quantitative bird survey in 1986, 1987, and 1990.

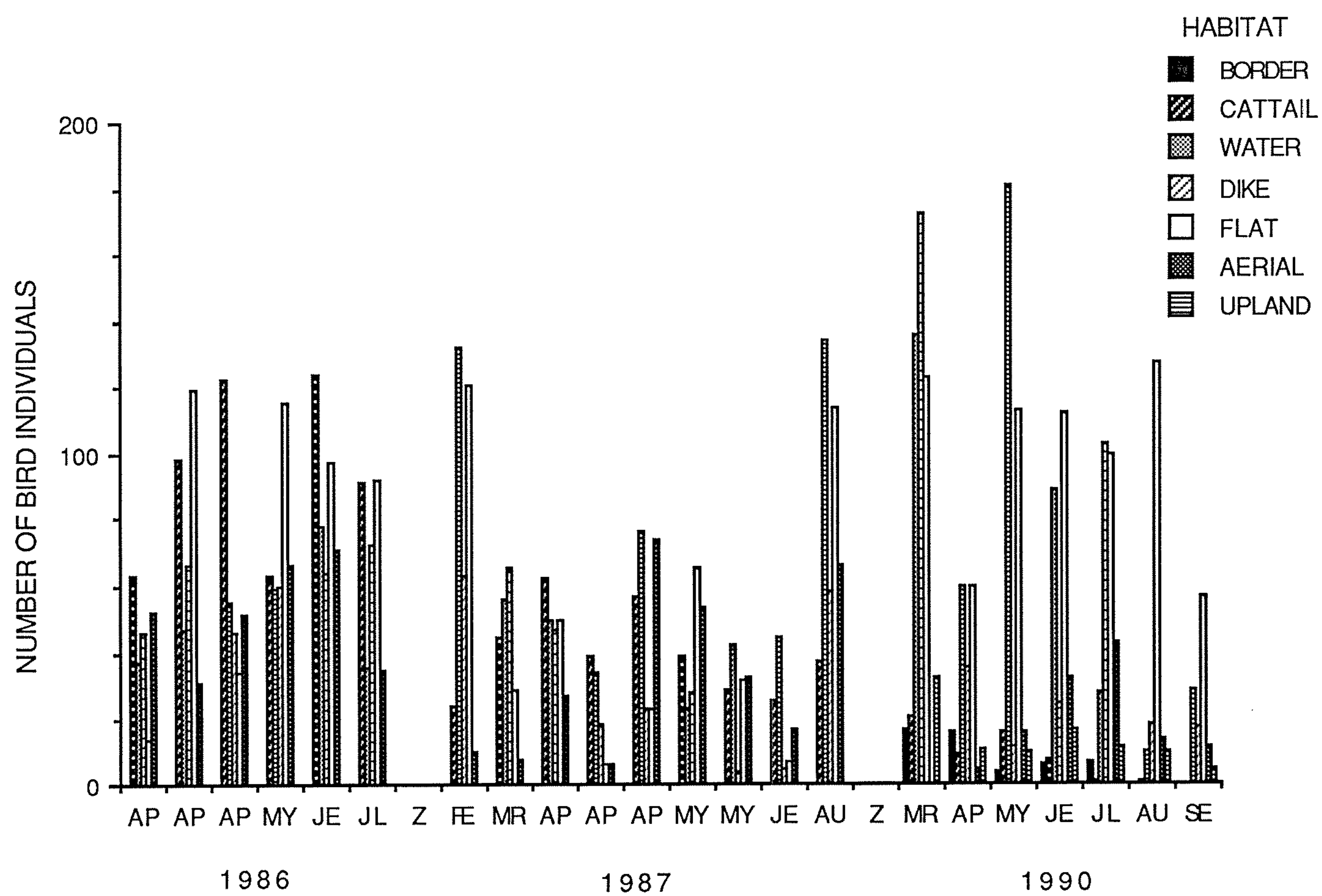

Figure 18. Number of individual birds observed in Gog-Le-Hi-Te wetland habitats, 1986-1990.

Table 1. Plant species found in the wetland system on 26 July 1990.

Species	Common name	Flat 1	Flat 2	Flat 3	Flat 4	Flat 5	Flat 6	Flat 7	Flat 8
Agrostis alba	Creeping bentgrass		x		x				
Alisma plantago-aquatica	American waterplantain		x		x	x	x		
Alnus rubra	Red alder			x		x	x	x	
Anaphalis margaritaceae	Pearly everlasting			x	x				
Bidens cernua	Nodding beggar-tick	x	x	x	x	x			x
Callitriche stagnalis	Pond waterstarwort	x							x
Carex deweyana	Dewey's sedge			x	x				
Carex lyngbyei	Lyngby's sedge	x	x	x	x	x	x	x	x
Carex stipata	Awlfruit sedge		x	x	x	x			
Cirsium arvense	Creeping thistle		x						
Cytisus scoparius	Scot's broom				x		x		
Dipsacus sylvestris	Teasle		x		x				
Eleocharis palustris	Creeping spikerush	x	x	x	x	x	x	x	
Elodea nuttallii	Nuttall's waterweed			x	x				
Epilobium angustifolium	Fireweed			x					
Epilobium watsonii	Watson's willow-herb	x			x		x		
Equisetum arvense	Common horsetail		x	x	x				
Galium parisiense	Wall bedstraw			x	x	x			
Ghapnalium uligonosum	Marsh cudweed	x							x
Holcus lanatus	Common velvet-grass			x	x	x			
Hydrocotyle ranunculoides	Marsh pennywort	x		x		x	x		
Iris pseudocorus	Yellowflag				x				
Juncus accuminatus	Tapered rush	x	x	x	x	x	x		
Juncus balticus	Baltic rush					x	x		
Juncus bufonius	Toad rush	x	x	x	x	x	x	x	x
Juncus effusus	Soft rush		x			x	x		
Lathrys spp.	Sweetpea		x	x	x				
Lotus corniculatus	Birdsfoot-trefoil	x			x	x	x		x
Lycopus uniflorus	Northern waterhorehound			x	x	x			
Melilotus alba	White sweet-clover		x	x	x				
Mimulus guttatus	Yellow monkey-flower				x	x			
Myosotis laxa	Small flowered forget-me-not	x		x	x		x		
Myosotis scorpioides	Common forget-me-not			x	x				
Phalaris arundinaceae	Reed canarygrass	x	x	x	x	x	x		

Table 1–cont.

Species	Common name	Flat 1	Flat 2	Flat 3	Flat 4	Flat 5	Flat 6	Flat 7	Flat 8
Plantago lanceolata	English plantain						x		
Plantago major	Common plantain	x	x	x	x				
Polygonum hydropiper	Marshpepper		x					x	
Populus tricocarpa	Black cottonwood	x		x	x	x			
Potentilla palustris	Marsh cinquefoil				x				
Ranunculus repens	Creeping buttercup				x	x			
Rubus discolor	Himalayan blackberry				x	x	x		
Rumex crispus	Curly dock		x	x		x	x		
Rumex spp.	Dock		x	x					
Salix hookeriana	Hooker willow						x		
Salix lasiandra	Red willow		x	x	x	x	x		
Salix scouleriana	Scouler willow	x	x	x	x	x			
Scirpus acutus	Hardstem bullrush		x	x		x			
Scirpus cyperinus	Woolgrass bullrush		x	x	x	x	x		
Scutellaria lateriflora	Hoodwort	x		x	x				
Solanum dulcamara	Bittersweet nightshade				x	x			
Suaeda maritima	Herbaceous seabite					x			
Tanacetum vulgare	Common tansy	x		x	x		x	x	
Trifolium pratense	Red clover		x		x				
Typha latifolia	Cattail		x	x	x	x	x		
Vicia spp.	Vetch		x	x					
Veronica americana	American brooklime				x				
Zannichellia palustris	Horned pondweed					x		x	

Table 2. Presence of birds noted at Gog-Le-Hi-Te wetland system. 1 = present.

	Species	UW 1986	UW 1987	UW 1990	Bock and Jensen cumulative list 1986-7	1988	1989	1990
1	Common Loon	1						
2	Western Grebe	1	1		1	1	1	1
3	Horned Grebe	1	1		1	1	1	1
4	Pied-billed Grebe	1						1
5	Double-crested Cormorant	1	1		1	1	1	1
6	Canada Goose	1	1		1	1	1	1
7	Domestic Goose				1	1	1	1
8	Bar-headed Goose							1
9	Snow Goose				1	1	1	1
10	Wood Duck				1	1	1	1
11	Northern Pintail							1
12	Eurasian Widgeon				1	1	1	1
13	American Widgeon	1	1	1	1	1	1	1
14	Common Merganser	1			1	1	1	1
15	Red-breasted Merganser		1	1	1	1	1	1
16	Hooded Merganser		1		1	1	1	1
17	Mallard	1	1	1	1	1	1	1
18	Gadwall	1	1	1	1	1	1	1
19	Green-winged Teal	1	1	1	1	1	1	1
20	Blue-winged Teal		1			1		1
21	Cinnamon Teal		1	1	1	1	1	1
22	Canvasback					1		1
23	Common Goldeneye							1
24	Barrow's Goldeneye							1
25	Bufflehead				1	1	1	1
26	American Coot	1	1	1	1	1	1	1
27	Western Gull	1	1					
28	Herring Gull	1	1	1				1
29	Bonaparte's Gull	1	1		1	1	1	1
30	Glaucous-winged Gull			1	1	1	1	1
31	Mew Gull				1	1	1	1
32	California Gull				1	1	1	1
33	Thayer's Gull				1	1	1	1
34	Ring-billed Gull							
35	Greater Scaup			1		1		1
36	Northern Shovelor		1		1	1	1	1
37	Great Blue Heron	1	1	1	1	1	1	1
38	Green-backed Heron	1	1	1	1	1	1	1

Table 2—cont.

Species	UW 1986	UW 1987	UW 1990	Bock and Jensen cumulative list 1986-7	1988	1989	1990
39 Killdeer	1	1	1	1	1	1	1
40 Least Sandpiper	1	1	1	1	1	1	1
41 Western Sandpiper	1	1	1	1	1	1	1
42 Spotted Sandpiper			1	1	1	1	1
43 Stilt Sandpiper					1		1
44 Common Snipe	1	1					1
45 Greater Yellowlegs				1	1	1	1
46 Lesser Yellowlegs				1	1	1	1
47 Bar-tailed Godwit				1	1	1	1
48 Long-billed Dowitcher		1	1	1	1	1	1
49 Short-billed Dowitcher				1	1	1	1
50 Common Yellowthroat		1	1	1	1	1	1
51 Lesser Golden-Plover				1	1	1	1
52 Semi-palmated plover						1	1
53 Virginia Rail						1	1
54 Dunlin						1	1
55 Sora				1	1	1	1
56 Red-tailed Hawk	1		1	1	1	1	1
57 Sharp-shinned Hawk							1
58 Cooper's Hawk				1	1	1	1
59 American Kestrel				1	1	1	1
60 Merlin				1	1	1	1
61 Rock Dove	1	1	1	1	1	1	1
62 Morning Dove				1	1	1	1
63 Barn Swallow	1	1	1	1	1	1	1
64 Cliff Swallow	1	1	1	1	1	1	1
65 Rough-winged Swallow	1						
66 Violet-green Swallow		1	1	1	1	1	1
67 Tree Swallow				1	1	1	1
68 Savannah Sparrow	1	1	1	1	1	1	1
69 Song Sparrow		1	1	1	1	1	1
70 Fox Sparrow				1	1	1	1
71 Lincoln's Sparrow				1	1	1	1
72 Golden-crowned Sparrow				1	1	1	1
73 White-crowned Sparrow				1	1	1	1
74 House Sparrow	1		1			1	1
75 European Starling	1	1	1	1	1	1	1
76 American Crow	1	1	1	1	1	1	1
77 American Robin	1	1	1	1	1	1	1
78 American Goldfinch	1	1	1	1	1	1	1
79 California Quail	1			1	1	1	1

Table 2—cont.

		UW	UW	UW	Bock and Jensen cumulative list			
	Species	1986	1987	1990	1986-7	1988	1989	1990
80	Red-necked Pheasant		1	1	1	1	1	1
81	Red-winged Blackbird	1	1	1	1	1	1	1
82	Black-capped Chickadee		1	1	1	1	1	1
83	Brown-headed Cowbird		1		1	1	1	1
84	Marsh Wren			1	1	1	1	1
85	Bewick's Wren				1	1	1	1
86	Winter Wren				1	1	1	1
87	Rufous Hummingbird			1				
88	Belted Kingfisher			1	1	1	1	1
89	Northern Flicker				1	1	1	1
90	Willow Flycatcher				1	1	1	1
91	Stellar's Jay				1	1	1	1
92	Bushtit				1	1	1	1
93	Ruby-crowned Kinglet				1	1	1	1
94	Cedar Waxwing				1	1	1	1
95	Northern Shrike				1	1	1	1
96	Orange-crowned Warbler				1	1	1	1
97	Yellow-rumped Warbler						1	1
98	Yellow Warbler						1	1
99	Wilson's Warbler						1	1
100	Western Tanager					1		1
101	Black-headed Grosbeak				1	1	1	1
102	Rufous-sided Towhee							1
103	House Finch				1	1	1	1
104	Pine Siskin						1	1
105	Band-tailed Pigeon						1	1
106	Purple Martin						1	1
107	American Pipet						1	
108	Dark-eyed Junco						1	1
109	Pectoral Sandpiper				1	1	1	1
110	Western Meadowlark							1
111	Western Wood-pewee							1
112	Ring Necked Duck							1
113	Pelagic Cormorant							1
114	American White Pelican							1
115	Northern Harrier							1
116	Ring-billed Gull							1
117	Water Pipit							1
118	Black-throated Gray Warbler							1
	TOTAL	34	39	36	78	83	90	112

APPENDIX:

VEGETATION SURVEY OF THE GOG-LE-HI-TE ESTUARY

SARA COOKE

August 23 1990

Table 1. Plant species found in the Gog-Le-Hi-Te estuary.

Species	common name	flat 1	flat 2	flat 3	flat 4	flat 5	flat 6	flat 7	flat 8
Agrostis alba	creeping bentgrass		x		x				
Alisma plantago-aquatica	American waterplantain		x		x	x	x		
Alnus rubra	red alder			x		x	x	x	
Anaphalis margaritaceae	pearly everlasting			x	x				
Bidens cernua	nodding beggar-tick	x	x	x	x	x			x
Callitriche stagnalis	pond waterstarwort	x							x
Carex deweyana	Dewey's sedge			x	x				
Carex lyngbyei	Lyngby's sedge	x	x	x	x	x	x	x	x
Carex stipata	awlfruit sedge		x	x	x	x			
Cirsium arvense	creeping thistle		x						
Cytisus scoparius	scot's broom				x		x		
Dipsacus sylvestris	teasle		x		x				
Eleocharis palustris	creeping spikerush	x	x	x	x	x	x	x	
Elodea nuttallii	Nuttall's waterweed			x	x				
Epilobium angustifolium	fireweed			x					
Epilobium watsonii	Watson's willow-herb	x			x		x		
Equisetum arvense	common horsetail		x	x	x				
Galium parisiense	wall bedstraw			x	x	x			
Gnaphalium uligonosum	marsh cudweed	x							x
Holcus lanatus	common velvet-grass			x	x	x			
Hydrocotyle ranunculoides	marsh pennywort	x		x		x	x		
Iris pseudocorus	yellowflag				x				
Juncus accuminatus	tapered rush	x	x	x	x	x	x		
Juncus balticus	Baltic rush					x	x		
Juncus bufonius	toad rush	x	x	x	x	x	x	x	x
Juncus effusus	soft rush		x			x	x		
Lathrys spp	sweetpea		x	x	x				
Lotus corniculatus	birdsfoot-trefoil	x			x	x	x		x
Lycopus uniflorus	northern waterhorehound			x	x	x			
Melilotus alba	white sweet-clover		x	x	x				
Mimulus guttatus	yellow monkey-flower				x	x			

TABLE 1. continued

Species	common name	flat 1	flat 2	flat 3	flat 4	flat 5	flat 6	flat 7	flat 8
Myosotis laxa	small flowered foreget-me-not	x		x	x		x		
Myosotis scorpioides	common forget-me-not			x	x				
Phalaris arundinaceae	reed canarygrass	x	x	x	x	x	x		
Plantago lanceolata	English plantain						x		
Plantago major	common plantain	x	x	x	x				
Polygonum hydropiper	marshpepper		x					x	
Populus tricocarpa	black cottonwood	x		x	x	x			
Potentilla palustris	marsh cinquefoil				x				
Ranunculus repens	creeping buttercup				x	x			
Rubus discolor	Himalayan blackberry				x	x	x		
Rumex crispus	curly dock		x	x		x	x		
Rumex spp.	dock		x	x					
Salix hookeriana	Hooker willow						x		
Salix lasiandra	red willow		x	x	x	x	x		
Salix scouleriana	Scouler willow	x	x	x	x	x			
Scirpus acutus	hardstem bulrush		x	x		x			
Scirpus cyperinus	woolgrass bullrush		x	x	x	x	x		
Scutellaria lateriflora	hoodwort	x		x	x				
Solanum dulcamara	bittersweet nightshade				x	x			
Suaeda maritima	herbaceous seabite					x			
Tanacetum vulgare	common tansy	x		x	x		x	x	
Trifolium pratense	red clover		x		x				
Typha latifolia	cattail		x	x	x	x	x		
Vicia spp.	vetch		x	x					
Veronica americana	american brooklime				x				
Zannichellia palustris	horned pondweed					x		x	

Methods

An on-site evaluation was conducted in one day in mid July, 1990 at the Gogli*hi*ti site located in Tacoma, Pierce County, Washington. Only the estuary zone was examined. This was accomplished by segregating the estuary area into eight regions called "flats" (see figure 1), delineated by the dredged canals, and walking a transect out from a pre-measured stake from the edge of the wetland/upland boundary into the mud-flat region. The vegetation zonation was measured from the stake and the dominant species recorded to characterize each zone. The general species found in each flat were also recorded. Unknown specimens were collected and identified using C.L. Hitchcock and A. Cronquist Flora of the Pacific Northwest (1973). Fifty-seven different species were found, from the adjacent upland zone out to the mud flats, in the estuary area. No percent cover estimates were made. This is by no means an exhaustive list as only one on-site evaluation was performed.

Vegetation

* *For a general list of species found in each plot please refer to Table 1. Common names are listed there.*
* *For the locations of each flat and stake please refer to Figure 1. This is an acetate to overlay on the air photo.*
* *All measurements are in meters (M) with the origin at the stake, extending out to the mud zone.*
* *Each zone is named after the dominant species found in the zone*

Flat 1: This area is composed of a thin strip of mud flat adjacent to the dredged water canal that enters the mouth of the wetland. There is a thin strip of Eleocharis palustris along the upland edge.

Stake 1 :	upland edge zone:	Lotus corniculatus, Populus tricocarpa, Salix scouleriana, Epilobium watsonii, Phalaris arundinaceae, Myosotis laxa
	Spike rush zone: 0-4M	Eleocharis palustris, Tanacetum vulgare, Juncus bufonius, Plantago major, Carex lyngbyei, Juncus accuminatus
	Mud flat Zone: 4-9M	Gnaphalium uligonosum, Bidens cernua, Callitriche stagnalis, Hydrocotyle ranunculoides, Scutellaria lateriflora

Flat 2: The upland slope of this area is dominated by Salix spp. and Phalaris arundinaceae. The cattail/sedge zone is present here although the plants are quite small. Below this is the spike rush zone, and finally the mud flat zone.

Stake 2 :	upland edge zone:	Vicia spp., Rumex crispus, Rumex spp., Cirsium arvense, Equisetum arvense, Dipsacus sylvestris, Lathrys spp.
	willow/reed : canary grass zone 0-4M	Carex stipata, Carex lyngbyei, Juncus bufonius, Eleocharis palustris, Alisma plantago-aquatica, Bidens cernua, Scirpus cyperinus, Typha latifolia, Salix lasiandra, Salix scouleriana, Juncus effusus, Scirpus acutus
	cattail/sedge zone: 4-6M	Typha latifolia, Carex lyngbyei
	sedge zone: 6-10M	Carex lyngbyei
	spike rush zone: 10-12M	Eleocharis palustris
	mud flat zone: 12-23M	Juncus bufonius
Stake 3 :	upland edge zone:	Vicia spp., Rumex crispus, Cirsium arvense, Equisetum arvense, Dipsacus sylvestris, Lathrys spp., Populus tricocarpa, Salix Lasiandra, Tanacetum vulgare, Holcus lanatus, Rubus discolor, Melilotus alba
	cattail/sedge zone: 0-5M	Typha latifolia, Carex lyngbyei, Scirpus cyperinus, Scirpus acutus
	sedge zone: 5-11M	Carex lyngbyei, Eleocharis palustris, Scirpus cyperinus
	spike rush zone: 11-13M	Eleocharis palustris
	mud flat zone: 13-17M	Juncus bufonius, Callitriche stagnalis, Polygonum hydropiper

Flat 3 : The upland edge of this area is dominated by Alnus rubra and Phalaris arundinaceae. The cattail/sedge zone is also present here and some of the plants are quite robust. Below this is the spike rush zone, and finally the mud flat zone, which extends 45 Meters to the channel.

Stake 4 :	upland edge zone:	Alnus rubra, Rumex crispus, Phalaris arundinaceae, Epilobium angustifolium, Anaphalis margaritaceae, Equisetum arvense, Galium parisiense, Holcus lanatus, Myosotis laxa, Myosotis scorpioides, Plantago major, Populus tricocarpa, Salix lasiandra, S.scouleriana, Tanacetum vulgare
	cattail/sedge zone: 0-12M	Typha latifolia, Scirpus cyperinus, Carex lyngbyei, Carex stipata, Juncus accuminatus, Scirpus acutus, Scutellaria lateriflora
	sedge zone: 12-14M	Carex lyngbyei, Typha latifolia
	spike rush zone: 14-18M	Eleocharis palustris, Alisma plantago-aquatica, Carex deweyana, Tanacetum vulgare
	mud flat zone: 18-45M	Juncus bufonius, Bidens cernua, Hydrocotyle ranunculoides, Lycopus uniflorus, Melilotus alba

Flat 4 : This area is the largest of the wetland. The Typha zone was measured at 18 Meters, and all the plants were healthy and robust. The upland edge of this area is dominated by Rubus discolor, Lotus corniculatus, and Cytisus scoparius, with minor amounts of Populus tricocarpa, Salix lasiandra, Salix scouleriana, Trifolium pratense, Dipsacus sylvestris, Tanacetum vulgare, Anaphalis margaritaceae, Holcus lanatus Equisetum arvense, and Phalaris arundinaceae. There is a flooded area between the upland slope and the start of the Typha zone that contained Potentilla palustris, Myosotis laxa, Myosotis scorpioides, Solanum dulcamara, Bidens cernua, Solanum dulcamara, Veronica americanum, Iris pseudocorus, Agrostis alba, Ranunculus repens, Epilobium watsonii, Alisma plantago-aquatica, Carex deweyana, Carex stipata, Galium parisiense, Gnaphalium uligonosum, Iris pseudocorus, Juncus accuminatus, Juncus effusus, Lycopus uniflorus, Mimulus guttatus, and Veronica americana. The spike rush zone is greatly reduced here, with only a few meters of Eleocharis palustris mixed with a few plants of Scirpus cyperinus. The mud flat region was the longest at 32 Meters. The mud flat zone was continuously carpeted with young sprouts of Juncus bufonius, with a few plants of Elodea nuttallii, & Suaeda maritima.

Flat 5 : The upland edge of this area is dominated by Alnus rubra, and Rubus discolor. The cattail zone is very small and dissapears completely in this flat. The sedge zone is very narrow and the plants are very small. The spike rush zone is greatly expanded, as is the mud flat zone, which extends 40 Meters to the channel.

Stake 5 :	upland edge zone:	Alnus rubra, Rubus discolor, Populus tricocarpa, Salix lasiandra, Salix scouleriana, Phalaris arundinaceae, Carex stipata, Scirpus cyperinus, Rumex crispus, Tanacetum vulgare, Juncus effusus, Anaphalis margaritaceae, Carex stipata, Galium parisiense, Holcus lanatus, Lotus corniculatus, Ranunculus repens,
	cattail zone: 0-4.5M	Typha latifolia, Eleocharis palustris Carex lyngbyei, Juncus acuminatus
	debris zone: 4.5-15M	wood debris, Bidens cernua, Lycopus uniflorus, Mimulus guttatus, Salix scouleriana, Alisma plantago-aquatica, Juncus balticus, Juncus bufonius, Scirpus acutus, Hydrocotyle ranunculoides, Callitriche stagnalis, Potentilla palustris, Solanum dulcamara, Suaeda maritma, Zannichellia palustris
Stake 6 :	upland edge zone:	Alnus rubra, Salix lasiandra, Phalaris arundinaceae, Epilobium watsonii, Rumex crispus, Plantago lanceolata, Juncus effusus, Rubus discolor, Tanacetum vulgare
	sedge zone: 0-18M	Carex lyngbyei, Eleocharis palustris, Typha latifolia, Alisma plantago-aquatica, Juncus acuminatus, Juncus balticus, Myosotis laxa, Scirpus cyperinus
	mud flat zone: 18-23M	Juncus bufonius, Callitriche stagnalis, Hydrocotyle ranunculoides

Flat 6 : The upland area of this zone is dominated by Alnus rubra and Salix lasiandra. The cattail zone is no longer present, while the Carex lyngbyei zone has greatly expanded, and appears to be expanding further. The spike rush zone is restricted to a narrow band .5 meters wide.

Flat 7 : The upland area of this zone is dominated by Alnus rubra and Salix lasiandra. The Carex lyngbyei zone is quite large and appears to be expanding further into the mud flat zone. The spike rush zone is almost absent.

Stake 7 :	upland edge zone:	Alnus rubra, Salix lasiandra, Myosotis laxa Rumex crispus, Phalaris arundinaceae
	spike rush zone: 0-4M	Eleocharis palustris, Typha latifolia, Alisma plantago-aquatica, Carex lyngbyei
	sedge zone: 4-9M	Carex lyngbyei
	mud flat zone	Polygonum hydropiper, Tanacetum vulgare
	9-14M	Juncus bufonius, Zannichellia palustris

Flat 8 : This area is very similar to Flat 1. The upland is steep and very narrow. It is dominated by Lotus corniculatus, Rubus discolor, and Alnus rubra. There is no Typha zone, and a very small Carex lyngbyei zone. The Juncus bufonius zone is predominantly adult plants in flower, not the young sprouts that are common in Flats 3-7. There were a few scattered individuals of Gnaphalium uligonosum, Bidens cernua, Callitriche stagnalis, Ploygonum hydropiper, Zannichellia palustris, and Hydrocotyle ranunculoides.

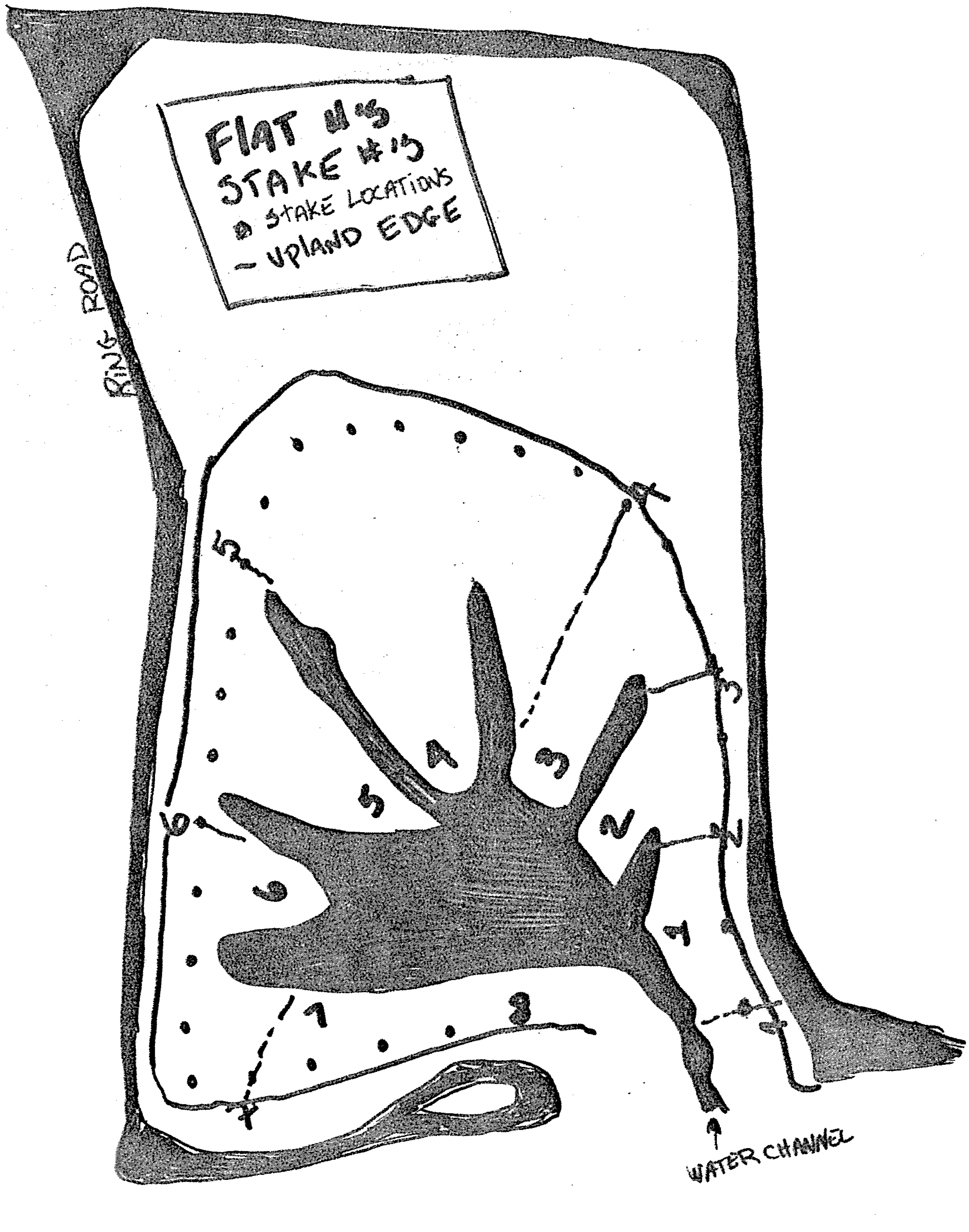

Figure 1. Gog-Le-Hi-Te wetland.