ABSTRACT

Title of Dissertation: ALTERNATE STATE THEORY AND TIDAL FRESHWATER MUDFLAT EXPERIMENTAL ECOLOGY ON ANACOSTIA RIVER, WASHINGTON, D.C.

Peter Ian May, Doctor of Philosophy, 2007

Dissertation directed by: Patrick Kangas
Marine Estuarine Environmental Sciences

The concept that multiple community states may alternately exist for some ecosystems has been the subject of controversy for decades. This theory is tested and applied to the mudflats of the low/middle marsh intertidal zone of two restored freshwater tidal marshes on the Anacostia River. It is believed that experimental exclosures exposed strong species interactions and provided a window with which to view the potential alternate existence of two structurally different systems, intertidal mudflat and emergent marsh. The occurrence, persistence and community composition of the two ecosystem states are examined through experimental exclosures at the two marsh restoration study areas.

The power of large grazers to deflect the goals of wetland restoration practitioners is studied in the context of alternate state theory. Initially unvegetated mudflat, native marsh vegetation emerged within exclosure study areas at two restoration sites. Resident Canada geese (*Branta canadensis maxima*) decimated planted areas of restored marsh left open to grazing, returning marsh to unvegetated mudflats. Data from exclosures are presented on macrophyte community composition, sediment elevation, bird, fish, invertebrate and algae associations from two separate sets of Anacostia River experimental exclosure sites, one covering 588 m^2, the other covering 2,700 m^2. Results support the hypothesized alternate existence of the two system states in the same space and relative time, each dependant upon the access of a critical mass of large grazers. A description of the mudflat biotic community and its interconnectivity is discussed as an important feature of the Anacostia River system.

An emergy analysis of each state and an accounting of fisheries energy flow is conducted. Information collected relating to the pre-restoration (tidal mudflat) and post-restoration (emergent marsh) physical and biological conditions are detailed and analyzed. A determination of the emergy inputs for a large-scale marsh restoration project are calculated and as a final analysis, economic (emdollar) equivalents are developed to compare the yield of fisheries production supplied by mudflats vs. a restored and mature emergent freshwater tidal marsh. Through these studies support is given to valuing mudflats as important system components of Anacostia River.

ALTERNATE STATE THEORY AND TIDAL FRESHWATER MUDFLAT EXPERIMENTAL ECOLOGY ON ANACOSTIA RIVER, WASHINGTON, D.C.

By

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2007

Dedication

To all my family

To the Anacostia River

Acknowledgements

This dissertation would not have been possible without the lifelong love and support of my family. Thank you Mom, Dad, Chris, Klaus, Omi, Myra, Sarah, all the cousins, Mays and Spangenbergs.

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The final push to complete this dissertation was supported immensely by Erin Leone for her help with statistics. My lifelong friend Tom Juhasz gave me a long weekend to remember in helping me organize my final draft. Chris Streb, a friend from the early grad school days of “GEES” gave me 24 hours of his life to finalize the frustrations of formatting. Friends Bryon Salladin and Jeremy Thomas helped me out of tight spots. Biohabitats gave me the time and support to complete the work. Ginger Chapman cheered me on at all the right times. 19-Q and Old Greenbelt gave me solitude as my refugia from the distractions of life.

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Chapter 1: Introduction

Restoration is the ultimate test of ecological theory.

J.J. Ewel, 1987

1.1 Background and Significance

The mudflats of the tidal freshwater Anacostia River in Washington, D.C. are the focus of complimentary studies that may provide evidence of two alternate community states, intertidal mudflat and emergent marsh, existing within the same space and relative time (Figure 1.1). The theory of alternate or multiple stable community states (detailed in the following literature review) may be an appropriate framework for attempting to explain, in part, the resilience of mudflats on the Anacostia River for over half a century and the tendency of recent emergent marsh restoration projects to be altered or confounded.

The purpose of this study is to define several of the basic ecological elements and forcing functions of the mudflat system, and determine the potential for the low-middle marsh elevation zones on mudflats of Anacostia River to support two alternate states, one emergent marsh and the other unvegetated intertidal mudflat. The experimental use of exclosures as an artificial switching function between the two states is key to determining this potential. The mudflats of the low-middle marsh zone have the potential to support emergent marsh vegetation under certain conditions and are here after referred to as biogenic mudflats. Biogenic mudflats are a part of the greater mudflat system on the Anacostia River, in addition to those intertidal mudflats existing below the low-marsh elevation gradient which due to physical conditions lack the ability to support emergent marsh vegetation, and from here after are referred to physical mudflats. Where both types are considered together, mudflats or mudflat system will be used.

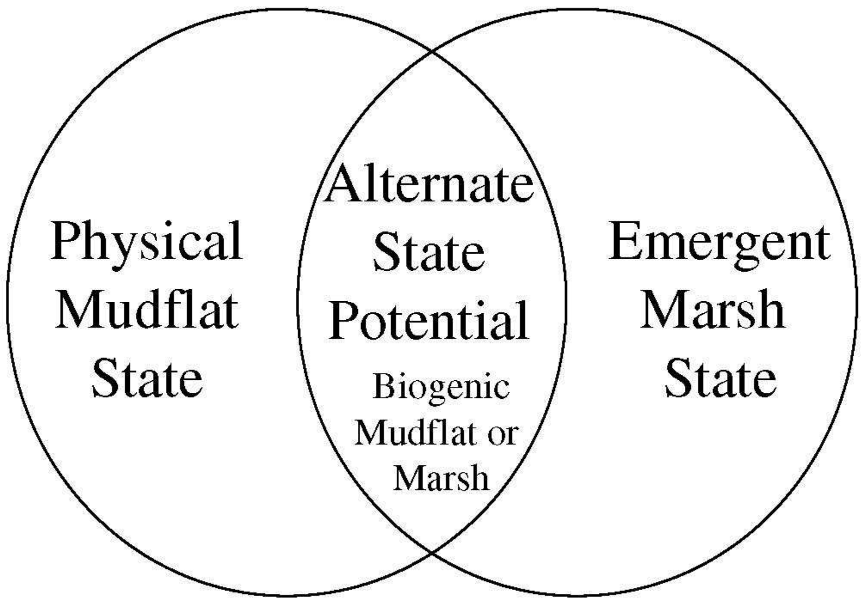

Figure 1.1 Venn diagram of the two dominant intertidal system states on Anacostia River with the alternate potential for either state to occur.

The results of biogenic mudflat exclosure field experiments implemented between 1997-1998 and 2001-2004 at two Anacostia marsh restoration sites are used to examine: (1) the basic ecological interactions that characterize the entire mudflat system; (2) the applicability of the alternate community state model to the Anacostia biogenic mudflat and restored marsh systems; (3) the switching mechanisms of change between the two community types; and (4) the patterns of development of emergent marsh plant communities under strong herbivory pressure with and without exclosures.

Additionally, an emergy analysis (detailed in Chapter 5) of the resource flows and forcing functions of the two community states, mudflat and restored emergent marsh, is employed with a conversion of restoration emergy to its economic equivalent in emdollars (Odum, 1996). Based on the significant investment of resources from the economy into converting tidal mudflats into emergent marsh, an emergy analysis of the two alternate states is applied to one of the large-scale marsh restoration efforts completed on Anacostia River mudflats.

1.2 History of Tidal Freshwater Emergent Marshes and Mudflats on Anacostia River

The Anacostia River has been changed significantly by direct and indirect human involvement over the last 400 years (Table 1.1). Historically, the Kenilworth and Kingman marshes supported expansive areas of emergent freshwater tidal wetlands dominated by *Zizania aquatica* (Coues and Prentiss, 1883; Biohabitats, 1990; Syphax and Hammerschlag, 1995). These wild rice stands were the keystone of a thriving sora and carolina rail hunting enterprise at the turn of the 19th Century which was renowned as the finest in the region (Coues and Prentiss, 1883). From the 1920's through the 1940's, the U.S. Army Corps of Engineers (USACE) was directed to dredge and fill these marshes on the Anacostia River as they were considered a health threat as a vector for mosquitos and malaria (Biohabitats, 1992; Syphax and Hammerschlag, 1995). The dredging and straightening of the river effectively eliminated the emergent marshes, and in their place shallow water boating and recreational "tidal lakes" were envisioned (USACE, 1913).

Table 1.1 Anacostia River timeline of human involvement in changes to the ecosystem.

17^{th}-18^{th} Century	19^{th} Century	1920-1940s	1940-2000	1993, 2000, 2003
Anacostia early Native and European settlements Deep water river system Fringing marshes Tobacco farming increases sediment load River begins to shallow	Washington, D.C. founded Agriculture high sediment loads helps create more expansive marshes River silts in and looses deepwater Wild rice marshes support rail hunting	Marshes dredged and filled by Army Corps of Engineers River straightened and deepened, river edges walled with stone bulkheads Kenilworth & Kingman areas created as recreation lakes	Watershed development increases sediment load River silts in to shallower depths and intertidal mudflats develop as a dominant river feature	Mudflats converted to emergent marsh restoration sites by Army Corps of Engineers Kenilworth Marsh restoration Kingman Marsh restoration River Fringe Marsh restoration

The Kingman and Kenilworth tidal lakes quickly filled with sediment derived from a rapidly developing watershed, in the process creating persistent, expansive areas of intertidal mudflats. These mudflats were a defining characteristic of the Anacostia River ecosystem for over half a century until the implementation of large-scale wetland restoration projects at Kenilworth in 1993 and Kingman Lake in 2000 converted large areas of mudflats to emergent marsh (USACE, 1993; personal observation, 2000).

The pre-restoration Kenilworth and Kingman mudflats were identified by the

U.S. National Park Service (NPS) and the U.S. Army Corps of Engineers for restoration to emergent marsh utilizing dredged river sediments and extensive emergent macrophyte plantings (USACE, 1993). Prior to the Kenilworth restoration in 1993, the reasons for a lack of volunteer recruitment of emergent macrophytes to the mudflats were first investigated. Independent field experiments were undertaken to determine the conditions that emergent plant species required to successfully colonize and vegetate the mudflats (Athanas et al., 1991; Bowers, 1993; Stevenson et al., 1995). Along mainstem Anacostia River mudflats, planting success / survival was determined to be influenced by river flow shearing energies, deposition of floatable wrack, sediment toxicity and anoxia, and substrate elevation (Stevenson et al., 1995), whereas at Kenilworth adjacent to the river channel, sufficient substrate elevation was determined to be the primary controlling factor for planting success (Bowers, 1993).

After what was considered a successful marsh restoration effort at Kenilworth in 1993 (Syphax and Hammerschlag, 1995), plans were made by USACE to continue the restoration work on the extensive mudflats of Kingman Lake in 2000. While the Kingman project was being planted in the summer of 2000, resident Canada goose (*Branta canadensis maxima)* grazer damage to the plantngs required that fences be erected around and within the planting areas to allow the plants time to root and take hold. Excluding the geese with perimeter and interior fencing at the recommendation of the planting contractor, Ecological Restoration and Management, the project areas became green with the installation of 700,000 individual plants comprised of six species (Hammerschlag et al., 2001). The following spring of 2001 saw the removal of the fencing which had collapsed in many places over the winter.

1.3 *The Use of Exclosures as a Method of Exposing Alternate States in Intertidal Habitat*

An experimental exclosure design was first developed at the restored Kenilworth Marsh in 1997. Initially intended to support a study of shorebird and fish invertebrate predation and algal grazing and disturbance on mudflats (May, 2000), the exclosures revealed the unforseen pressures of larger scale herbivory. The emergent macrophyte *Pontederia cordata* unexpectedly volunteered within the experimental biogenic mudflat exclosures which had previously not supported broad-leaved emergent plants. In 1998, the direction of the research moved to address the question of herbivory on biogenic mudflats, which appeared to suppress the emergence, survivorship and growth of marsh macrophytes, maintaining an unvegetated biogenic mudflat system state while suppressing the emergent marsh system state.

A further investigation of this effect was undertaken at the Kingman Marsh restoration site in the spring of 2001 following the previous years marsh construction and restoration planting. An exclosure design and emergent macrophyte assessment regime was developed and implemented with the intention of experimentally determining the level of goose herbivory pressure the restoration area was experiencing as well as determining the effectiveness of two different exclosure sizes.

Data are presented on marsh plant survivorship, biomass, cover and biogenic mudflat community structure from the two Anacostia River study areas, Kenilworth Marsh (1997-1998) and Kingman Marsh (2001-2004) (Figure 1.2). The exclosure data appears to support the theory that alternate community states (biogenic mudflat and emergent marsh) exist on an elevational gradient of 1.5-2.0 ft above NGVD '29 (National Geodetic Vertical Datum 1929) within the intertidal zone of Anacostia mudflats in the presence of strong herbivory pressure.

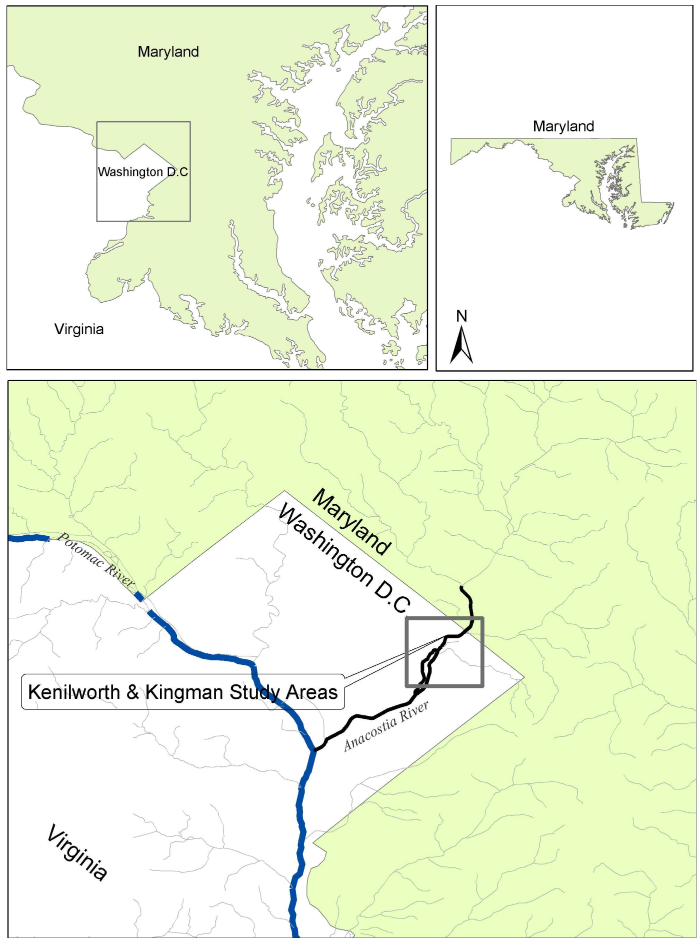

Figure 1.2 Vicinity map of exclosure study areas on Anacostia River.

The greater potential of exclosure fencing uses for emergent marsh restoration became apparent as early as the Kenilworth exclosure study in 1998, but was not fully appreciated until the Kingman Marsh restoration witnessed goose herbivory on a massive scale (Syphax personal communication, 2001; Hammerschlag et al., 2001). These experiments verify that there is a distinct correlation between the planting "success" of tidal marsh restoration projects in this low-middle marsh zone and the exclusion of resident Canada geese (*Branta canadensis maxima*) from some restoration areas. This condition is considered an indication that alternate system states do exist with goose herbivory being a primary driver toward the biogenic mudflat state while confounding emergent marsh state development being advanced by the USACE and NPS.

1.4 Research Questions and Hypotheses

Given the power that resident Canada geese have shown in controlling biogenic mudflat / emergent macrophyte community dynamics, and the marsh restoration process driven by the Army Corps of Engineers, several research questions and hypotheses were developed:

Question: Do alternate system states exist on Anacostia River tidal mudflats?

Hypothesis: The evidence of significant differences in vegetation between excluded and unexcluded plots on the biogenic mudflats in the low-middle (1.5-2.0 ft. NGVD '29) marsh zone suggest alternate system states.

Question: Of what significance is the role of resident Canada geese in marsh restoration and alternate state theory?

Hypothesis: Resident geese are an attractor to the biogenic mudflat state and will drive marsh restoration efforts toward the biogenic mudflat state on

Anacostia River.

Question: Are exclosures revealing temporary or persistent alternate states on Anacostia mudflats?

Hypothesis: Exclosures reveal the potential for persistent alternate states on Anacostia biogenic mudflats depending upon goose herbivory.

Question: At what elevations are exclosures most successful in facilitating emergent vegetation establishment?

Hypothesis: Exclosures promote successful vegetation establishment within a defined zone of elevation.

Question: What are emergent plant community organizing dynamics within exclosures over time?

Hypothesis: Plant community dynamics within exclosures may not be generally predicted.

Question: What are the economic and ecological costs and benefits of emergent marsh restoration to the environment and society?

Hypothesis: The ecological and socioeconomic benefits of emergent marsh restoration are worth the economic investment.

1.5 Organization of the Thesis

The work in this thesis is organized by research area, each with its own introduction, site conditions, methods, results and discussions sections. A literature review chapter of alternate state theory, mudflats, aquatic community interconnections, and exclosures is followed by separate chapters on Kenilworth Marsh, Kingman Lake/Marsh, and a chapter detailing an emergy analysis of the Kingman Marsh restoration. A discussion and summary chapter concludes the thesis with recommendations for the application of the research conducted here to future restoration work and thoughts on the restoration of marshes at the expense of mudflat habitat.

Chapter 2: Literature Review

2.1 Alternate Stable State Theory

The view that some ecosystems have the potential of existing and persisting as different stable community types within the same physical space and time, or along some trajectory has been referred to as alternate stable states or multiple stable states (Tansley, 1935; Sutherland 1974, 1990; May, 1977; Peterson, 1984; Knowlton, 1992; Brinson et al., 1995; Lockwood, 1997; Scheffer and Jeppesen, 1998; Petraitis and Latham, 1999; van de Koppel et al., 2001; Young et al., 2001). This theory has been forwarded as a way to describe the parallel potential, yet alternate emergence, of different stable communities within a single environmental condition.

There has been debate as to whether the condition actually exists in the natural world as it has been shown in mathematical models and theory (Noy-Meir, 1975; May, 1977; Sutherland, 1974, 1981, 1990; Connell and Sousa, 1983; Sousa and Connell, 1985; Rietkerk and van de Koppel, 1997). Often the controversy focuses on how stability is defined and even determined for a natural community (Lewontin, 1969; Noy-Meir, 1975; May, 1977; Sutherland, 1974, 1981, 1990; Connell and Sousa, 1983; Sousa and Connell. 1985; Knowlton, 1992). Alternate stable state theory assumes that if a system is sufficiently disturbed or altered so that it reaches some threshold past which it is difficult to return to its original state, then it has essentially flipped into a new stable state of existence.

In a review article 30 years ago, May (1977), acknowledged and agreed with a growing body of empirical evidence supporting multiple stable states. In the same article May also stated that "Unfortunately, the complications inherent in multi-species systems almost invariably preclude any quantitative confrontation between theory and data, … for multi-species communities, the empirical observations remain largely anecdotal, and the theory remains largely metaphorical." Notwithstanding Connell and Sousa's (1983; Sousa and Connell,1985) contrary position on the evidence for multiple stable states, others argue that the use of manipulative field experiments can effectively demonstrate the existence of multiple states (Sutherland, 1974, 1981, 1990; Peterson, 1984; Hik et al., 1992; Knowlton, 1992; Petraitis and Latham, 1999; van de Koppel et al., 2001).

In an effort to avoid the complications inherent in the stability debate with respect to alternate states (Knowlton, 1992), the use of the term alternate community states (Petraitis and Latham, 1999) or simply alternate states is employed. The recognition of the power of switching forces that trigger changes between alternate states and the point at which a community breaks from one state to the other is crucial to the understanding of multiple state theory (May, 1977; Knowlton, 1992; Rietkerk and van de Koppel, 1997; Petraitis and Latham, 1999; Kangas, 2004a). Under some conditions an alternate state can be achieved very quickly, although stability implies that it would be difficult to switch a system state back again. Without the ties of the stability debate, it is believed that in the case of Anacostia River biogenic mudflats and restored marshes a rapid change in state can be achieved under the right conditions. The simple trigger of erecting a fence on a biogenic mudflat to induce a marsh system state, and then taking it down again to return to a biogenic mudflat system state is all that is needed and is investigated in this study.

2.2 *Tidal Freshwater Mudflats*

One system that is under represented in the ecological literature is the freshwater tidal mudflat. Extensive marine tidal flat experimental investigations have been undertaken encompassing years of accumulated data and observations (Reise ,1985, 2001). The unseen complexity and diversity of the marine intertidal flat system, as well as its global ubiquity, has long made these areas a natural choice for ecological study (Reise, 1985, 2001; Nordstrom and Roman, 1996). By contrast, the freshwater tidal mudflats are not diverse in benthic assemblages (Brittingham and Hammerschlag, 2006) and can easily be overlooked by ecologists who study the diverse flora and fauna associated with the emergent marshes (Diaz, 1977, W.E. Odum et al., 1984, 1988; Lopez, 1988; Findlay et al., 1989; Sacco et al., 1994).

The ecological role of freshwater tidal mudflats may be more complex than a casual observation may suggest (Peterson, 1981). W.E. Odum and associates (1984), some of the first to extensively study tidal fresh marshes from a whole systems perspective, believed at the time that "the knowledge of energy flow in tidal freshwater wetlands is almost totally speculative." However, Diaz and Boesch (1977) mentioned that freshwater tidal flat benthic fauna appeared to be a significant contributor to the diets of benthic feeding fishes. Wading birds and migratory shorebirds are also a major predatory force in the tidal flat feeding on invertebrates in the upper few centimeters of the exposed sediment surface (Baker and Baker, 1973; Schneider, 1978; Quammen, 1984).

Further investigations into the positive role that freshwater tidal mudflats play in migratory bird feeding grounds is warranted. Tidal marsh restoration efforts in the District of Columbia between 1993 and 2003 has converted or attempted to convert almost all expansive mudflat areas to emergent marsh utilizing dredge spoil deposited on the mudflats to raise sediment elevations to a point suitable for emergent macrophyte growth (USACOE, 1993). While the ecological benefits of emergent marshes are generally recognized (Odum et al., 1984; Mitsch and Gosselink, 2000), one potential consequence of converting mudflats to emergent marsh is the elimination of valuable feeding areas for shorebirds and some waterfowl during their long migrations (Recher, 1966; Hayman et al., 1986; Evans, 1987; Perry and Deller, 1996). Reducing this significant habitat type from the District could have hidden costs which have not yet been accounted for. The mudflat system in the District is not well studied and there may be some species, energy flow pathways, nutrient processing or other functions and values that have not been uncovered. The question must be asked, are mudflats important and in what ways?

2.3 Tidal Freshwater Aquatic Community Interconnectedness

The study of food webs and trophic level interactions have been the source of significant research since Elton's landmark work Animal Ecology in 1927 and Lindeman's work in the trophic dynamic aspect of ecology (1942). The later work of MacArthur (1955), Paine (1966), May (1973), Pimm and Lawton (1977), Reise (1985), Power (1992), and others solidified the importance of experimental and model investigations into the very basic levels of biotic interrelationships to gain a greater understanding of the structure of ecosystems.

Aquatic community interconnectedness with the biotic and physical environment have been experimentally studied extensively in rivers (Power 1984, 1988, 1990), marine systems (Paine, 1966, 1969, 1974; Reise, 1985, 2001) and estuarine systems (Teal, 1976; Diaz, 1992; Everett and Ruiz, 1993). These investigations have often revealed interesting relationships that were only discovered after extensive observation and field experimentation. The comparatively less extensive tidal freshwater marsh ecosystems have much wider gaps in the experimentally derived knowledge of basic functional relationships (Diaz and Boesch, 1977; Good et al., 1978; Odum et al., 1984; W.E Odum, 1988; Keddy, 2000; Mitsch and Gosselink, 2000). The pivotal compilation of Good, Whigham and Simpson (1978) assembled several papers on freshwater wetlands, many of which were works on the tidal marshes. The summary combined works of Simpson, Good, Leck and Whigham (1983) and Odum et al. (1984) stated the importance of and need for further work into the study of these systems. Numerous studies on these systems have been completed (McVay et al., 1980; Doumlele, 1981; Simpson et al., 1983a; Bowden, 1984; Rozas and Odum, 1987; Rozas et al., 1988; Hussey and Odum, 1992; Leck and Simpson, 1987, 1994; Khan and Brush, 1994; Diaz, 1994; Pasternack and Brush, 1998; Perry and Hershner, 1999; Otto et al., 1999; Pasternack et al., 2000; Baldwin et al., 2001; Pasternack and Brush, 2001; Seybold et al., 2002; Tanner et al., 2002; Capers, 2003) adding significantly to the tidal freshwater marsh literature base. While many of these works were arguably important, it still appears that Simpson et al., (1983) and Odum et al., (1984, W.E.,1988) were alone in looking at tidal freshwater marshes from a whole systems perspective.

2.4 *Exclosures, Tidal Flats and Emergent Marsh Herbivory*

The roles of exclosures in experimental ecology and restoration have followed a parallel evolution for many years. Exclosures as experiments are widely used to quantitatively reveal the effects of predation, herbivory or disturbance on the community structure of a studied ecosystem (Paine, 1969, 1974; Power, 1984, 1988; Quammen, 1984; Reise, 1985, 2001; Bazely and Jeffries, 1989; Belanger and Bedard, 1994; Taylor and Grace, 1995; Grace and Ford, 1996; Evers et al., 1998; Gough and Grace, 1998; Rachich and Reader 1999; Baldwin and Pendleton 2003). By establishing some sort of barrier to suspected predators, herbivores or bioturbators, an exclosure plot paired with an unexclosed control plot releases the excluded study plot from whatever known (or unknown) agents that are acting on the site, and with some time the change in biological or physical character of the site is revealed when compared to the control site (Figure 2.1). Restoration work has often made use of some type of exclosure to prevent suspected herbivores from disturbing a restored system and even as a method of restoration in and of itself (Keller and Burnham, 1982; Platts and Wagstaff, 1984; Opperman and Merenlender, 2000; Haramis and Kearns, 2007).

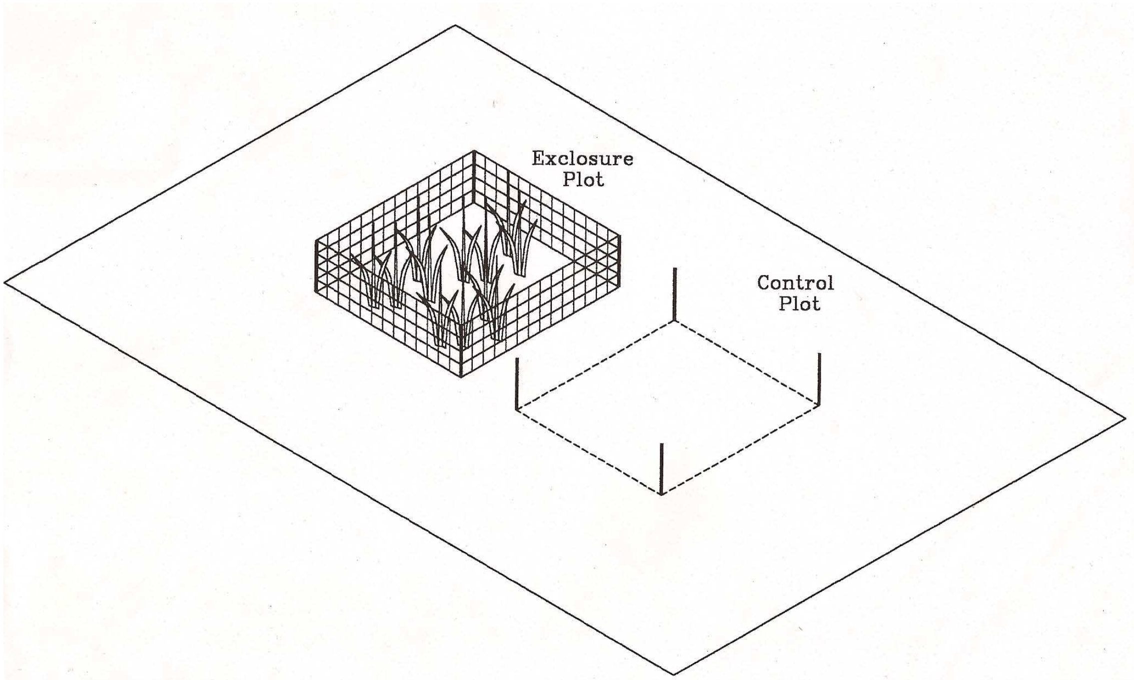

Figure 2.1 Schematic of a typical exclosure experimental arrangement.

In exclosure studies of goose herbivory in salt marshes, Bazely and Jeffries (1986, 1989) determined that changes in plant community structure due to grazing are often abrupt and can be followed by periods of relative stasis. However, their studies also found that the plant community changes within exclosures do not necessarily predict the structure of the marsh as a whole under ungrazed conditions. Bazely and Jeffries (1986, 1989) observed that the plant community within their exclosures was not found elsewhere in their study area and that this represented a "cul-de-sac in community development." Although exclosures can arrest the effects of grazing within them, unanticipated changes in plant community structure can still occur seasonally and yearly as the interactive effects of competitive exclusion become evident.

Self-organization is typical for newly emerging systems after a significant disturbance (Odum, 1989, McKee and Baldwin, 1999) such as a massive restoration effort (Kangas, 2004a; Mitsch and Jorgensen, 2004). Although ironically, what organizes in exclosures, while reflecting what the community might be like without a stressor, should still not be considered "natural" in the sense that it would undoubtedly change significantly once the fencing was removed.

The large scale fencing effort that was initially employed in the Kingman Marsh restoration may be considered to have been maintaining an artificial and unrealistic version of a restored marsh given the reality of heavy grazer activity. Utilizing the unintended disturbances caused by the geese as a signal for a reevaluation of marsh restoration design can only help to move the discipline of restoration ecology forward (Zedler, 2001), instead the traditional engineering tendency toward complete control may only set the stage for future disappointments (Mitsch and Jorgensen, 2004).

Chapter 3: Kenilworth Marsh Experimental Ecology

3.1 Introduction

Kenilworth Marsh was once a part of hundreds of hectares of tidal freshwater emergent and forested wetlands that fringed the Anacostia River (Figure 3.1). Since the early part of the 20th Century, plans were made to significantly alter the Anacostia shoreline (U.S. Army Corps of Engineers, 1913). From the 1920s-40's the Anacostia was dredged by the Army Corps of Engineers to deepen and straighten the river for improved navigation (Syphax and Hammerschlag, 1995). Dredged river material was used to fill fringing wetlands to create upland for what was to become Anacostia Park in 1923 (Hutchinson, 1977). In the 1940s the Kenilworth Marshes were dredged to create a recreational lake, although sedimentation soon filled the shallow tidal area and it became dominated by unvegetated intertidal mudflats considered to be of minimal habitat value (Syphax and Hammerschlag, 1995).

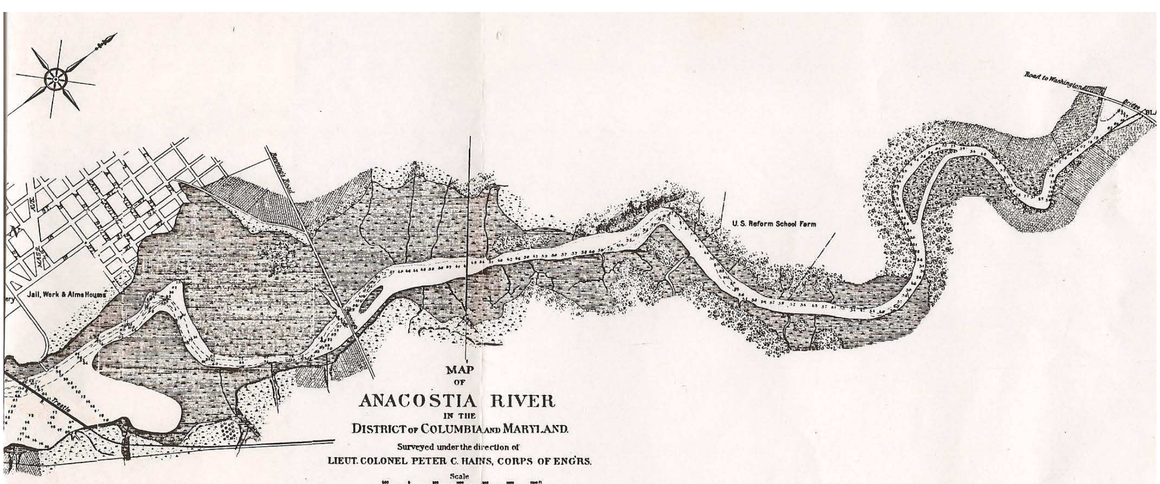

Figure 3.1 United States Army Corps of Engineers 1891 Map of Anacostia River Marshes.

The National Park Service personnel had a longstanding planning concept to restore portions of the area to its pre-existing emergent marsh state. Previously there was a concern that sediment contamination may have been prohibiting vegetative growth (Syphax and Hammerschlag, 1995). In 1991, to test the hypothesis that sediment elevation was a limiting factor to emergent plant growth, a study was conducted by constructing several cells, filling them with adjacent sediment to different elevations, then planting 10 species of emergent plants (Bowers, 1993,1995; Syphax and Hammerschlag, 1995). Sediment elevations in the replicated cells ranged from 0.5-3.0 feet above mean sea level (MSL). Results of the field testing found that approximately 2.0-2.1 feet above MSL was the optimal sediment surface elevation for emergent plant growth (Bowers, 1993; Syphax and Hammerschlag, 1995). An unexpected factor that influenced plant growth in the study cells was grazing of the plants by Canada geese *Branta canadensis* (Bowers, 1993).

In 1992 the National Park Service, collaborated with the Baltimore District Army Corps of Engineers to perform dredging operations in the tidal Anacostia River and utilize the dredged sediment to raise the surface elevations of Kenilworth Marsh to levels that were determined to be suitable for marsh vegetation to survive (Syphax and Hammerschlag, 1995). A massive planting effort was undertaken in the spring of 1993 involving over 290,000 plants of 16 species. Channels or “guts” were cut into the planted restoration areas to enhance tidal river water access to the planted areas to mimic prior wetland hydrology. At the end of the first growing season, emergent marsh plant coverage of the restoration area was considered successful with over 90% coverage of a majority of the target sites (Syphax and Hammerschlag, 1995).

The restoration areas were defined as Mass Fill 1 (MF1) 4 ha, Mass Fill 2 (MF2) 6 ha, and smaller dispersed fringe areas, Mass Fill 3 (MF3) of less than 3 ha (Figure 3.2).

Figure 3.2 Kenilworth Marsh and Dueling Creek study areas.

Sediment surface elevations were targeted at 2.5 feet above MSL (0.495 ft.) for the high marsh zone of MF1 and 2.1 feet above MSL for the middle marsh zone of MF2. Mass Fill 3 was intended to be a middle marsh zone, although after planting it was determined that these areas were lower in elevation and likely at less than 2.0 feet above MSL making it a low marsh zone inundated to a greater depth and for a greater duration than the areas with higher sediment surface elevations. Average tidal ranges on the Anacostia River are approximately 2.9 feet (Figure 3.3). By early September of 1993 the marsh vegetation was dominated by *Leersia oryzoides* in Mass Fill 1 while *Sagittaria latifolia* and *Leersia oryzoides* were co-dominants in Mass Fill 2 (Hammerschlag, unpublished data). Mass Fill 3 fringe areas were slow to vegetate with mudflats dominating. This was determined to be a result of lower final sediment elevations within the MF3 sites (Syphax and Hammerschlag, 1995).

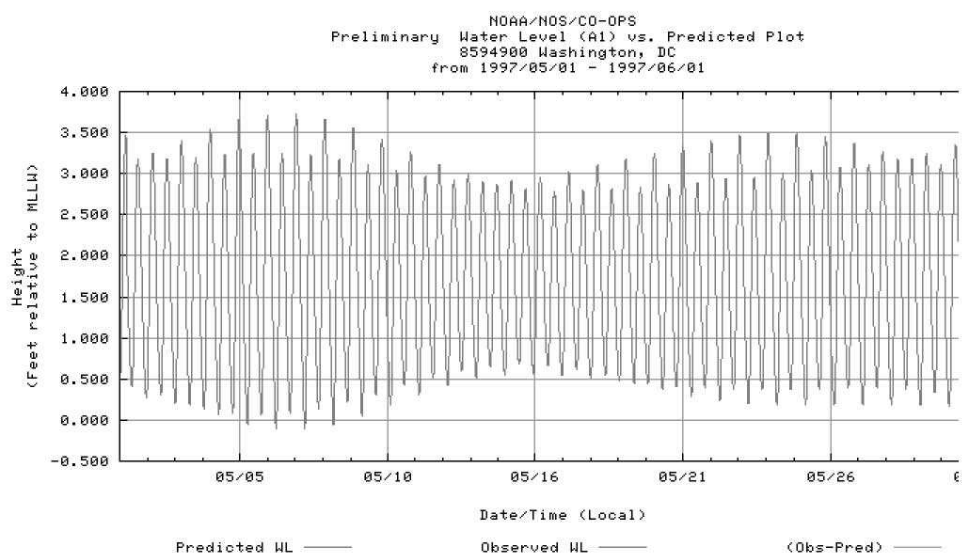

Figure 3.3 Anacostia River typical tidal hydrograph.

One approximately 4,060 m^2 (0.4 ha) area of MF3, was situated just 25 m east of the Anacostia River inlet to Kenilworth Marsh. This site was planted twice in 1993 and completely denuded each time, presumably by Canada geese. This area, maintained as an intertidal mudflat with an average surface elevation of just 1.1 ft (0.4 ft min to 2.0 ft max) NGVD above mean sea level (1995 Army Corps of Engineers Survey), was used for studying the ecology of the mudflat system state.

In 1996 a preliminary plan for investigating the ecology of intertidal mudflats was developed. The interrelationship between mudflat benthic macroinvertebrates and shorebird predation was the initial focus, with the added effects of fish predation on invertebrates and algae coverage also of interest. In January of 1997, initial investigations of invertebrate, bird and fish utilization of the Kenilworth MF3 mudflat began. Following the exclosure experiments of Paine in the rocky marine intertidal (Paine, 1969; 1974), Power in riverine systems (Power, 1984; 1988; 1990) and Riese in marine tidal flats (Reise, 1985; 2001), in March of 1997 a fenced exclosure experimentation scheme was begun to determine the relative influence of shorebird vs. fish predation on mudflat benthic macroinvertebrates. Grazing and disturbance effects on algae coverage of the mudflat was also of interest as it is the only form of primary production at the base of the mudflat food web.

In July of 1997, two species of macrophytes volunteered within the biogenic mudflat exclosures, *Pontederia cordata* (17 clonal groups), and *Polygonum* sp. (38 clonal groups). These plants did not emerge anywhere else on the biogenic mudflat and had not since initial attempts at planting in 1993 had failed. The unexpected effects of the exclosure fencing in stimulating biogenic mudflats to allow the emergence of macrophytes, changed the nature and direction of the study toward the role of grazers as strong top-down forces in controlling emergent macrophyte emergence, survivorship and growth.

Eventually, results of the study led to the discussion of the potential for mudflats on the Anacostia River to be models of the rationale behind alternate state theory. As stated earlier, this theory has been put forward as a way to describe the parallel potential, yet alternate emergence, of different stable communities within a single environmental condition. This concept, and its application to the results of the Kenilworth mudflat research, would have unrealized implications for future emergent marsh restoration on Anacostia River.

3.2 Study Area Location Description

The Kenilworth study area is located on the Anacostia River in Washington, D.C. (38° 54' 37"N, 76° 56' 54"W). The river is completely freshwater and tidal with an estimated tidal amplitude of approximately 1.0m. The marsh and mudflat study areas for birds and fish, exclosure invertebrates, algae and plants are situated immediately south and east of the mainstem Anacostia River (Figure 3.2) approximately 11 km upriver of its confluence with the Potomac River. Soil variables for Kenilworth surface sediments range from 20-57% sand, 31-48% silt and 12-32% clay with 6-11% organic matter and an average pH of 6.41 (Neff, 2002). Dueling Creek Marsh, a 1.2 ha site used as a local reference condition for fish surveys, is located approximately 0.8 km upriver of the Kenilworth Marsh inlet, just past the D.C. / Maryland line entering from the west side of the Anacostia River.

3.3 Research Methods and Materials

3.3.1 Birds

In an effort to understand the ecological association of avifauna to mudflats, birds were observed twice monthly at the Kenilworth Mass Fill 3 mudflat beginning in 1997, continuing through 1999 (Appendix A, Table 3.1). Observations were made from the edge of a wooded area that is adjacent to the mudflat at low tide. Low tide counts are considered representative of average waterbird usage (Burton et al., 2004). A count of all birds within the field of view of the mudflat study area was conducted over a period of 30 minutes, with notes taken differentiating if the birds were physically in the mudflat zone or outside the mudflat in the open water, trees or adjacent shoreline. Only birds with a water connection were identified, with all primarily terrestrial bird species not counted in the survey aside from the two species of hawk that conspicuously circled the mudflat area while scores of killdeer fed at low tide. After an initial count over 15 minutes, the remainder of time was spent observing the behaviors of the birds on the mudflat and counts made for new visitors to the area. All counts of large numbers of birds were double-checked during this time period and the lesser of the two numbers used as the official count.

3.3.2 Fish

To define the system components of fish to mudflat and emergent marsh, surveys were conducted within the tidal channels of Kenilworth and Dueling (Figure 3.2) using a Smith-Root fish electrofishing boat operated by the D.C. Government Fisheries Division.

Surveys were conducted on a flooding high to slack spring tide during each shocking run to allow for shocker boat access. A total of 25 electrofishing surveys were completed covering spring, summer and fall seasons intermittently between 1993 and 1998 (Appendix A, Tables 3.2 to 3.6). Shocking levels were set at 240-500 volts at 3-5 amps, 60 pulses/sec, adjusted for conductivity (D.C. Fisheries standard operating procedures). Approximately 1000 seconds of shocking time was conducted within each of the tidal channels in Mass Fill areas 1 & 2, as well as the open water adjacent to the Mass Fill 3 area experimental mudflat. Each survey was completed through two, 100m passes over the same area, once in and once out of survey line. All fish collected were kept in live wells on the boat and identified to species, counted, measured for length and released after shocking was completed. Game fish and larger fish species were also weighed to the nearest gram.

A bag seine survey of the fishes leaving the mudflat on an ebb tide was also conducted in January and February of 1997, and October of 1998 (Appendix A, Table 3.6). A 30m weighted bag seine with surface edge floats was deployed across a tidal gut draining the study mudflat on a flood/slack tide and retrieved on the ebb/slack low tide. All fish in the bag sein survey were collected, identified to species, counted and released.

Electrofishing surveys were also conducted at Dueling Creek, a 1.2 ha mature emergent tidal marsh just upriver of the Kenilworth Marsh inlet above the District line in Maryland. Dueling Creek had not been physically altered for over 50 years since the original straightening of the Anacostia River. This system was used as a reference condition for the Kenilworth Marsh restoration and was surveyed with the same level of effort encompassing approximately the same total shocking area as was surveyed in

Kenilworth, often on the same date and tide. Abundance, numbers of species, frequency and relative importance of each species found during the observation period were calculated, as well as the percent similarity of the numbers of species to each survey site.

3.3.3 Exclosures

In late March of 1997 field exclosure experimentation at Kenilworth Marsh began on the mudflat within the Mass Fill 3 restoration area. Four, 7m x 7m treatment plots in the experiment included: mudflat control plots of fish and bird accessible areas (AA, all accessible, no exclosure); fish accessible/bird exclosure (FA, partial exclosure); bird accessible/fish exclosure (BA); and fish/bird exclosure (TX, total exclosure) (Figure 3.4).

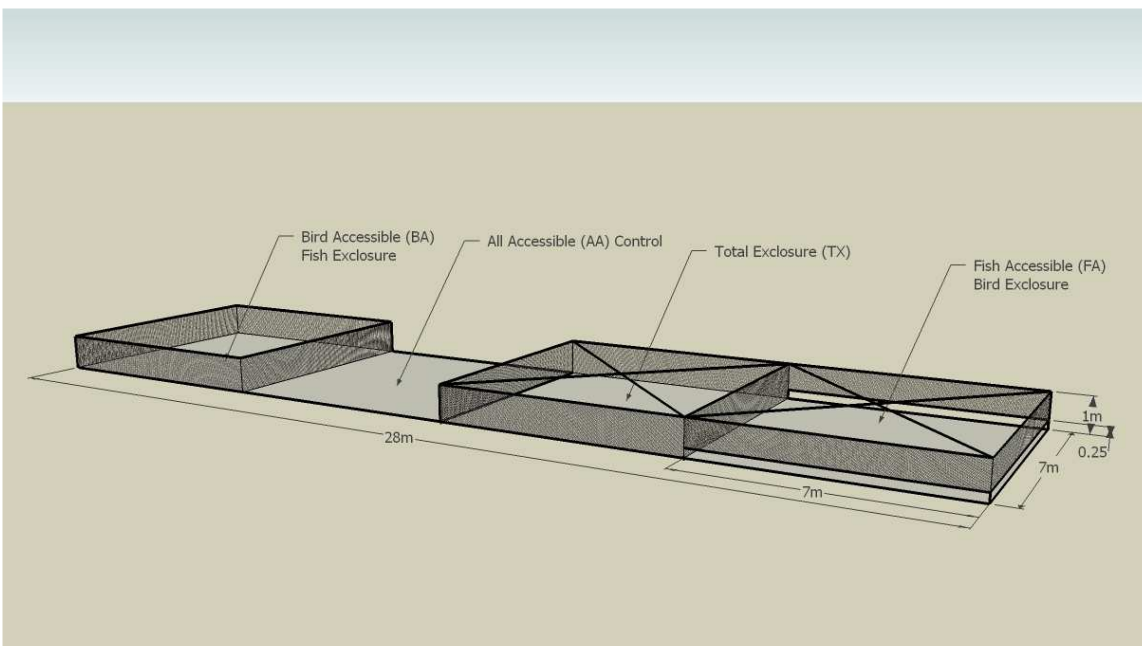

Figure 3.4 Schematic of Kenilworth MF3 mudflat exclosure treatment types.

Three blocks (A-C) with each of the four treatments were established for a total of 12 treatment plots on the mudflat (Figure 3.5). All plot areas were randomly assigned treatments within each block, with blocks stratified for approximately equal elevation as determined by arrangement of the blocks parallel to the incoming tide with flood facing fence sides positioned at the edge of low tide.

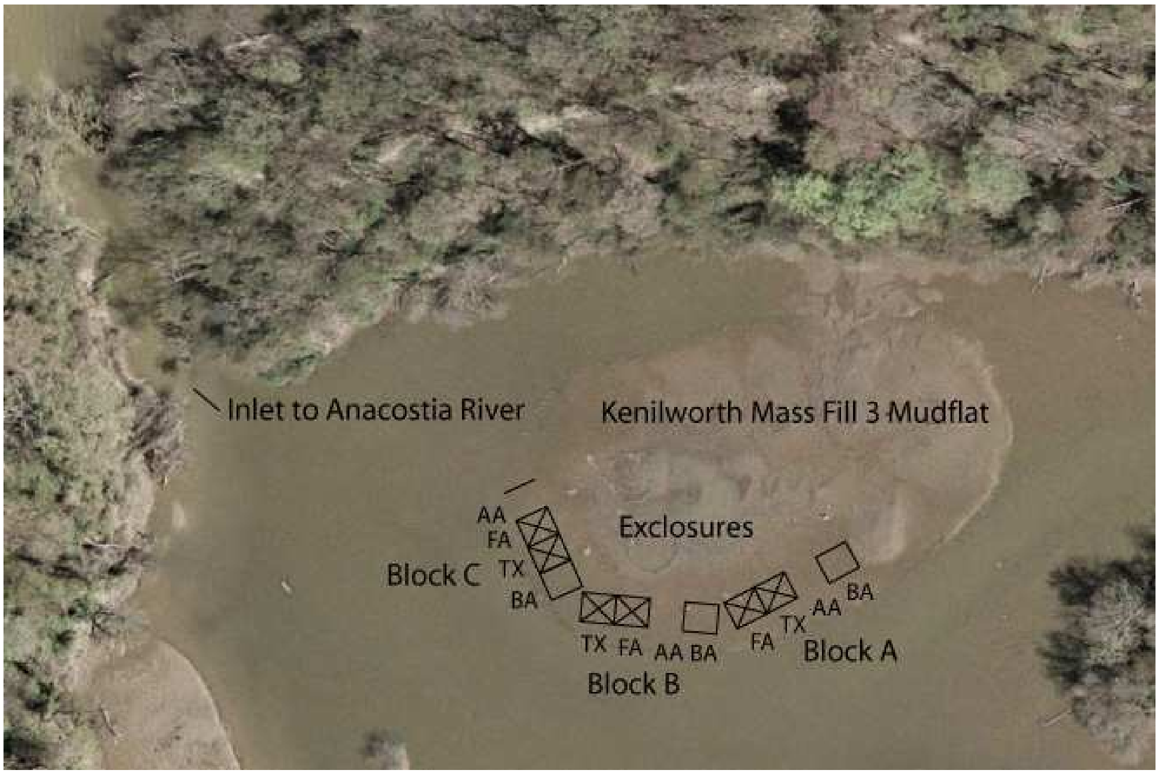

Figure 3.5. Arrangement of Kenilworth MF3 mudflat exclosure treatment blocks.

The perimeter fencing type used for the exclosures consisted of aquaculture grade nylon netting with 1cm mesh diameter and 1.0m fence height wrapped around 5cm by 5cm, 2m long hardwood stakes sunk approximately 1m into the mudflat at the corners of each exclosure. Total exclosure and bird accessible/fish exclosure plots had fencing flush with the mudflat while only total exclosure and fish accessible/bird exclosure treatments had lines crossing above the plots to prevent bird landings within the plots. The bird accessible treatment was intended to allow for the landing of shorebirds within the plot to permit invertebrate predation while excluding fish access. The 7mx7m exclosure sizing for this study was among the largest found to be used for experimental tidal flat research at the time (Quammen, 1984; Riese, 1985). Fish accessible/bird exclosure treatment plots had 25cm of fencing trimmed on two sides of each plot from the mud up to exclude birds but allow fish entering the mudflat area on the incoming tide. Non-excluded control plots had no fencing on at least two sides of each plot and no overplot bird exclusion lines.

In 1997 the BA, bird accessible/fish exclosure treatment was observationally found to not allow for shorebird access with the treatment effectively acting as a total exclosure to fish and birds. In 1998 these exclosure treatment plots were dismantled as they were functioning as a total exclosure and removed from the experiment while the other treatments plots were maintained.

3.3.3.1 Invertebrates

Shorebird and fish predation impacts on benthic macroinvertebrate populations within the different exclosure treatment types were evaluated. Samples were collected from the mudflat substrate with a manual coring device to evaluate macroinvertebrate species composition and densities (Vorberg, 1993). The corer had a diameter of 6.5 cm and was sunk into the mudflat to a depth of approximately 10cm. Five core samples were collected from within each treatment (166 cm^2), with each core sample site located using a random numbers table and values applied to a coordinate grid across each plot. Core samples were only taken from locations at least 1m from any fence line to avoid edge effects. The 1m band around the inside perimeter of each treatment plot was used as a movement corridor when samples were collected to avoid disturbing the mudflat as much as possible. In 1997, sediment core samples were taken from each of the four mudflat exclosure treatments on a low tide in March, May, July, September, and November. In 1998, invertebrate cores were collected monthly from each of three treatments from April through November. Mudflat sediment samples were immediately rinsed through a U.S. Standard #30 sieve, (0.595 mm^2 openings), and the remaining material preserved in site labeled jars of 70% ethanol and stained with several grams of rose bengal. In a lab, the contents of each jar was rinsed of preservative and spread over a light table in a glass tray with all stained invertebrates identified, counted and removed from the tray.

3.3.3.2 Algae

Effects of fish and bird grazing and disturbance on algae percent coverage of the mudflat were evaluated through the exclosure treatments. The mudflat exclosure algae coverage was determined at low tide once monthly beginning in April throughout 1997 and once every month in 1998, but for March, which was flooded due to spring storm flooding events at several attempted field collection dates. Algae percent coverage was determined through the use of a 1m x 1m square wooden frame with a fishing line grid overlay at 10cm intervals. The frame was placed at three randomly generated coordinate positions on the mudflat within each treatment plot. Algal cover measurements were only taken from locations at least 1m from any fence line to avoid edge effects. The 1m band around the inside perimeter of each treatment plot was used as a movement corridor when samples were collected to avoid disturbing the mudflat as much as possible. Percent algae coverage was determined by counting points under grid line intersections where algae were visually evident on the mudflat.

3.3.3.3 Emergent Macrophytes

During the course of invertebrate and algae data collection, the emergent macrophytes, *Pontederia cordata and Polygonum* sp., were observed to volunteer in the in several of the exclosures beginning in July of 1997 and their presence in each exclosure treatment noted throughout the growing season. Exclosure plots were visited and maintained throughout the winter. In the second year (1998), active experimentation was employed as intentional plantings were used to more fully understand the interactions between exclosures and macrophyte survival and growth under different levels of fish and bird accessibility as potential grazer or disturbance factors. Five, 50cm average stem height, actively growing bare root *Pontederia* plants were grouped in the middle of each treatment plot on one meter centers in an “X” configuration in early June of 1998. Plant presence and evidence of grazing was recorded through the growing season for each plot. At the peak of the growing season, individual plant clonal clusters were measured for area coverage. All above-ground plant biomass was collected from each of the treatment plots by cutting at the mudflat surface, bagged, plot coded, and weighed. Fresh plant matter was later rinsed of mud and sorted by treatment plot and plant number. Biomass was initially air dried for several days and then oven dried at 80° C for at least 48 hours and weighed to the nearest 0.01g.

3.4 Data Analysis Methods

Absolute and relative abundance, average numbers of individuals observed/survey, frequency and importance values of each species recorded during the observation periods were calculated for all bird and fish data.

A Chi-Square analysis was conducted on invertebrate data collected within the experimental exclosure treatment plots during years 1997 and 1998. Repeated sampling of each treatment type within each block repetition revealed strong differences in invertebrate numbers between similar treatments between blocks, which is often expected with populations of invertebrates in tidal flats (Riese, 1985). These block differences were removed by converting invertebrate raw numbers, or counts, into percentages (%) of the total invertebrates of each species (group) per sample from each treatment, which would transform the effect of the natural variability of invertebrate populations between repetitions to one that could be more validly compared between exclosure types with the Chi-Square analysis.

A two-way ANOVA using the SAS mixed model procedure (PROC MIXED) was applied to each years invertebrate data converted to densities (#individuals/m^2), incorporating the blocking structure of the replicated plots as a randomized variable (SAS, 2006). The model was exclosure type as an independent descriptor variable and invertebrate density (#/m^2) as the dependant response variable. The variances between exclosure types were heterogeneous so the data were log transformed. Tukey test adjustments were made to identify significantly different means, with the overall family-wise experimental error rate not to exceed $\alpha = 0.05$ and the standard error of the mean presented as the measure of variation.

The SAS mixed model procedure was also used to analyze the algae data. The algae data were first averaged across both years and by block repetition and exclusion type as well as by season. Seasons were divided into Spring (March-May), Summer (June-August), Fall (September-November), and Winter (December-February). As with the invertebrate density data, Tukey test adjustments were made to identify significantly different means, with the overall family-wise experimental error rate not to exceed $\alpha = 0.05$ and the standard error of the mean presented as the measure of variation.

A two-way ANOVA using the SAS mixed model procedure (PROC MIXED) was applied to the macrophyte biomass data incorporating the blocking structure of the replicated plots as a randomized variable (SAS, 2006). The model was exclosure type as an independent descriptor variable and dry weight as the dependant response variable. The variances between exclosure types were heterogeneous so the data were log transformed. Because there was no dry weight biomass within each of the three all accessible control (AA) treatment plots, there was no variance between each of the treatment plots. Tukey test adjustments were made to identify significantly different means, with the overall family-wise experimental error rate not to exceed $\alpha = 0.05$ and the standard error of the mean presented as the measure of variation.

3.5 Results

3.5.1 Birds

Bird observations at the Kenilworth MF3 mudflat study area were conducted over 87 separate site visits at low tide between January 1997 and August 1999 (Appendix A, Table 3.1). Of 33 species of birds representing 8 families, ten species had a frequency of occurance of 10% or greater and nine species had a relative abundance of greater than 1% (Figure 3.6), with 24 species having a relative abundance of less than 1% (Table 3.1). In terms of total numbers of birds counted over the span of the survey the Canada goose, *Branta canadensis*, were most numerous (666 individuals) with the killdeer *Charadruis vociferous,* next with 460 individuals counted, followed by mallards *Anas platyrhynchos* (354) and ring-billed gulls *Larus delawarensi* (204).

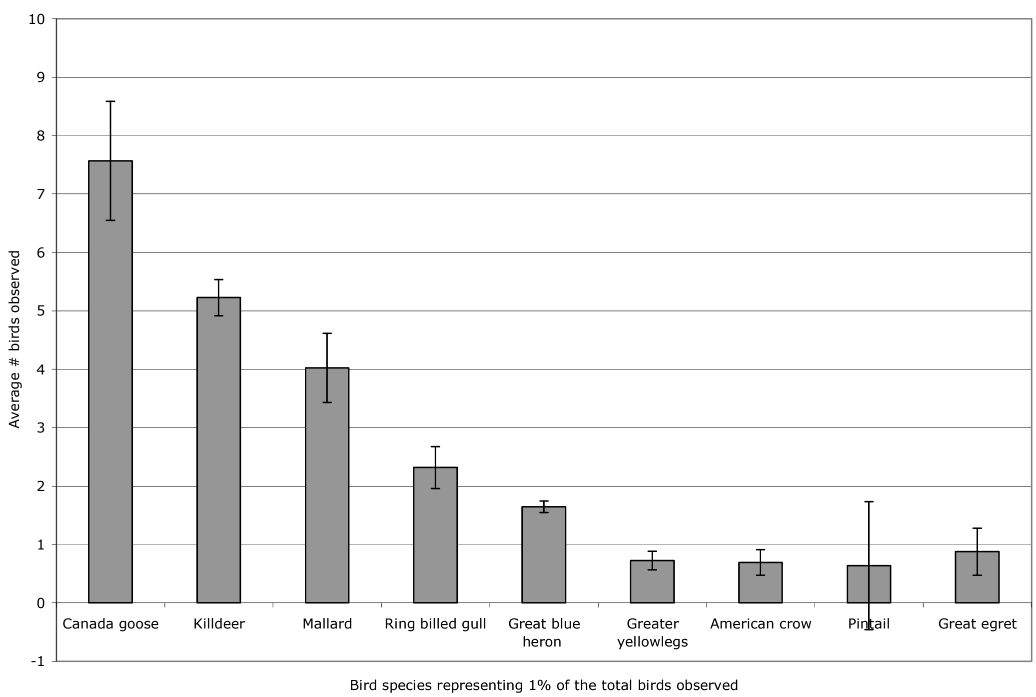

Figure 3.6 Kenilworth MF3 mudflat bird observations 1997-1999.

The majority of these birds were identified on or very near the exclosure mudflat. The great blue heron, *Ardea herodias*, was most frequently observed (77% of the time) on or around the mudflat area with killdeer following in frequency at 67% and geese at 46%. The top five species in terms of relative abundance included: Canada goose (22%), killdeer (15%), mallard (12%), ring-billed gull (7%), and great blue heron (5%).

The calculation of an importance value (% relative abundance + % frequency / 2) gave the relative significance of each species of bird to the mudflat observation area. This value integrates the percent relative abundance of numbers of each species to the total number of birds counted with the percent frequency, or likelihood of each species to be seen at the site during a site visit. Table 3.1 is ranked in order of importance value. The killdeer ranked highest in importance with the great blue heron ranked close behind. Canada goose, ring-billed gull and mallard rounded out the top five species of importance to the mudflat observation area.

Of the 8 families of birds that were observed in the mudflat study area, 6 guilds were represented (Table 3.2). The feeding group representing the greatest number of species was the shorebirds followed by the dabbling ducks/geese. In terms of the average numbers of birds within these groups, the ranking was reversed, due to the numbers of geese and mallards representing more than twice the average numbers of shorebirds. Essentially these feeding groups were almost entirely represented by the numbers of killdeer, geese and mallards. Lesser numbers of individuals of the other species within each of these groups made up the shorebird and dabbling waterfowl feeding groups.

Scavengers and diving birds were the next feeding groups found in the mudflat area that comprised a total of 5 species of birds each. In terms of average numbers of

Table 3.1 Kenilworth MF3 mudflat bird surveys 1997-1999 listed in order of importance value (relative abundance + frequency / 2). Functional feeding groups are: SB, Shorebirds; WB, Wading birds; DDG, Dabling ducks/geese; SC, Scavengers; R, Raptors.

33 Species	87 Observations	Feeding Group	Absolute Abundance	Average # / Survey	Relative Abundance	Frequency	Importance Value
Charadrius vociferus	Killdeer	SB	460	5.29	15.4%	67%	41.0
Ardea herodias	Great blue heron	WB	145	1.67	4.8%	77%	40.9
Branta canadensis	Canada goose	DDG	666	7.66	22.3%	46%	34.1
Larus delawarensis	Ring billed gull	SC	204	2.34	6.8%	41%	24.1
Anas platyrhynchos	Mallard	DDG	354	4.07	11.8%	31%	21.4
Tringa melanoleuca	Greater yellowlegs	SB	64	0.74	2.1%	31%	16.6
Ceryle alcyon	Belted kingfisher	DB	28	0.32	0.9%	31%	16.0
Corvus ossifragus	Fish crow	SC	61	0.70	2.0%	29%	15.4
Casmerodius albus	Great egret	WB	77	0.89	2.6%	23%	12.8
Phalacrocorax auritus	Double crested cormorant	DB	15	0.17	0.5%	10%	5.4
Larus argentatus	Herring gull	SC	28	0.32	0.9%	8%	4.5
Anas acuta	Northern pintail	DDG	56	0.64	1.9%	6%	3.8
Anas rubripes	American black duck	DDG	15	0.17	0.5%	6%	3.1
Butorides virescens	Green heron	WB	7	0.08	0.2%	6%	3.0
Lophodytes cucullatus	Hooded merganser	DB	13	0.15	0.4%	5%	2.5
Mergus merganser	Common merganser	DB	11	0.13	0.4%	5%	2.5
Aix sponsa	Wood duck	DDG	9	0.10	0.3%	5%	2.4
Actitus macularia	Spotted sandpiper	SB	7	0.08	0.2%	5%	2.4
Pandion haliaetus	Osprey	R	6	0.07	0.2%	5%	2.4
Larus philadelphia	Bonaparts gull	SC	10	0.11	0.3%	3%	1.9
Haliaeetus leucocephalu	Bald eagle	R	3	0.03	0.1%	3%	1.8
Buteo jamaicensis	Red-tailed hawk	R	3	0.03	0.1%	3%	1.8
Bucephala albeola	Bufflehead	DDG	20	0.23	0.7%	2%	1.5
Tringa solitaria	Solitary sandpiper	SB	5	0.06	0.2%	2%	1.2
Calidris pusilla	Semipalmated plover	SB	4	0.05	0.1%	2%	1.2
Sterna hirundo	Common tern	DB	3	0.03	0.1%	2%	1.2
Egretta thula	Snowy egret	WB	3	0.03	0.1%	2%	1.2
Calidris alba	Sanderling	SB	2	0.02	0.1%	2%	1.2
Aythya americana	Redhead	DDG	7	0.08	0.2%	1%	0.7
Gallinago gallinago	Common snipe	SB	1	0.01	0.0%	1%	0.6
Tringa flavipes	Lesser yellowlegs	SB	1	0.01	0.0%	1%	0.6
Larus marinus	Great black backed gull	SC	1	0.01	0.0%	1%	0.6
Buteo lineatus	Red-shouldered hawk	R	1	0.01	0.0%	1%	0.6
		Total	2290	19.37			

Table 3.2 Kenilworth MF3 mudflat study area bird functional feeding groups.

Functional Feeding Group	FFG Code	# Species	Avg # birds /survey
Shorebirds	SB	8	6.3
Dabbling Ducks / Geese	DDG	7	13.0
Scavengers	SC	5	2.8
Diving Birds	DB	5	0.8
Wading birds	WB	4	2.7
Raptors	R	4	0.1

birds observed over the duration of the survey, the ring-billed gull, fish crow *Corvus ossifragus*, and herring gull *Larus argentatus*, contributed the greatest numbers of individuals of each species to the average for the scavengers. Diving birds, while representing the same number of species observed over the survey, contributed much lesser numbers in terms of the average numbers of birds found in the mudflat area. The belted kingfisher *Ceryle alcyon,* was frequently represented, likely due to one or more individuals whose territorial range included the mudflat study area. Double crested cormorants *Phalacrocorax auritus*, hooded merganser *Lophodytes cucullatus*, and common merganser *Mergus merganser,* all represented divers in similar numbers, although the cormorant was twice as likely to frequent the area as the mergansers which have shorter migration visits to the area. Wading birds representing 4 species contributed greater average numbers of birds than the diving birds. This was mostly due to the prevalence of the great blue heron, which was the most frequently observed bird in the study area and second in importance only to the killdeer, both of which preferentially feed in the intertidal zone.

Four species of raptor were identified in the study area over the survey period. The low numbers of individuals observed was indicative of the feeding group at the top of the food web and their solitary nature. The osprey *Pandion haliaetus*, true to its alternate common name "fish hawk" was infrequently observed in the study area. One instance of a bald eagle *Haliaeetus leucocephalus*, was of note in that it swooped into the mudflat exclosure study area to carry away a catfish that had been recently stranded by the tide in a shallow pool.

3.5.2 Fish

Electrofishing conducted at Kenilworth included 20 surveys in three areas of the marsh, Mass Fill 1 (8 shocking events), Mass Fill 2 (8 shocking events), and Mass Fill 3 (4 shocking events), with an additional 4 bag sein surveys conducted at Mass Fill 3 and 5 shocking events conducted at the Dueling Creek reference marsh (Appendix A, Tables 3.2 to 3.6). A total of 27 species of fish representing 11 families were collected within the 3 Mass Fill areas of Kenilworth and 25 species captured of 11 families at Dueling Creek. Families included: Cyprinidae (carps and minnows); Anguillidae (freshwater eels); Antherinidae (silversides); Fundulidae (killifishes); Clupeidae (herrings); Ictaluridae (bullhead catfishes); Castomomidae (suckers); Percidae (perches); Poeciliidae (livebearers); Moronidae (temperate basses); and Centrarchidae (sunfishes).

3.5.2.1 Mass Fill 1 Fish

Fish captured at the Mass Fill 1 electrofishing site included 22 species in 10 families and 855 individuals (Appendix A, Table 3.2). The site was dominated by gizzard shad *Dorosoma cepedianum* in terms of total numbers caught (247) and relative abundance of the total catch (29%), being captured in 75%, or in 6 of the 8 shocking events (Table 3.3). These large planktivores swim in schools and quickly grow to sizes that make them unlikely prey to other fish. The brown bullhead catfish *Ameiurus nebulosus*, was the next largest contributor species to the survey in total numbers (198) and relative abundance (23%), also caught with a 75% frequency. Brown bullhead catfish, very common to the Anacostia River, are bottom-feeding omnivores that have the unique trait of actually caring for their young.

While captured in fewer numbers and relative abundance, the mummichog *Fundulus heteroclitus*, and banded killifish *Fundulus diaphanus* were caught more frequently (88%) than the gizzard shad or brown bullhead catfish. Ten species contributed greater than 1% of the total catch although the top two species comprised more than 50% of the fish caught with the other 8 each contributing less than 10%. The only piscivore in the top ten for Mass Fill 1 was the white perch *Morone americana*, with a relative abundance of almost 10%, occurring in 75% of the surveys of the site. A single largemouth bass *Micropterus salmoides*, and one striped bass *Morone saxatilis* were the other piscivores identified in the survey.

In terms of relative importance of each species to the site, an importance value (% relative abundance + % frequency / 2) was determined and Table 3.3 ranked them accordingly. Gizzard shad, brown bullhead and mummichog were the top three, with the banded killifish and common carp *Cyprinus carpio*, rounding out the top five. Of note at MF1 was the mosquitofish *Gambusia affinis*, not captured at any of the other sites including the Dueling reference site.

3.5.2.2 Mass Fill 2 Fish

Electrofishing at Mass Fill 2 captured 21 species from 8 families representing 815 individuals (Appendix A, Table 3.3). Similar to that of MF1, the gizzard shad and brown bullhead catfish were the top two species represented in MF2, with the total numbers and relative abundance of brown bullheads (205, 25%) greater than that of the gizzard shad (144, 18%) (Table 3.4). These species, along with the white perch (92, 11%), made up

Table 3.3 Kenilworth Mass Fill 1 marsh fish community from 8 electrofishing surveys; absolute abundance (total # caught); average #/survey; relative abundance (% total #); frequency (% survey sp. appearance); ranked by importance value (relative abundance + frequency / 2).

		Absolute Abundance	Average # / Survey	Relative Abundance	Frequency	Importance Value
Dorosoma cepedianum	Gizzard shad	247	30.9	28.9%	75%	51.9
Ameiurus nebulosus	Brown bullhead	198	24.8	23.2%	75%	49.1
Fundulus heteroclitus	Mummichog killifish	66	8.3	7.7%	88%	47.9
Fundulus diaphanus	Banded killifish	40	5.0	4.7%	88%	46.3
Cyprinus carpio	Common carp	34	4.3	4.0%	88%	46.0
Morone americana	White perch	83	10.4	9.7%	75%	42.4
Hybognathus regius	Eastern silvery minnow	64	8.0	7.5%	75%	41.2
Lepomis gibbosus	Pumpkinseed sunfish	38	4.8	4.4%	75%	39.7
Lepomis gibbosus	Golden shiner	17	2.1	2.0%	50%	26.0
Notropis hudsonius	Spottail shiner	10	1.3	1.2%	50%	25.6
Carassius auratus	Goldfish	8	1.0	0.9%	38%	19.5
Alosa pseudoharengus	Alewife herring	21	2.6	2.5%	36%	19.2
Alosa sapidissima	American shad	5	0.6	0.6%	25%	12.8
Perca flavescens	Yellow perch	5	0.6	0.6%	25%	12.8
Gambusia affinis	Mosquitofish	3	0.4	0.4%	25%	12.7
Notropis procne	Swallowtail shiner	7	0.9	0.8%	13%	6.9
Carpiodes cyprinus	Quillback carpsucker	3	0.4	0.4%	13%	6.7
Menidia beryllina	Atlantic silversides	2	0.3	0.2%	13%	6.6
Alosa aestivalis	Blueback herring	1	0.1	0.1%	13%	6.6
Micropterus salmoides	Largemouth bass	1	0.1	0.1%	13%	6.6
Morone saxatilis	Striped bass	1	0.1	0.1%	13%	6.6
Ameiurus catus	White catfish	1	0.1	0.1%	13%	6.6
	Total	855	107			

more than 50% of the total catch, with 8 species individually comprising less than 1% of the total catch. In terms of frequency of species occurrence, gizzard shad and the pumkinseed sunfish *Lepomis gibbosus*, were caught in 88% of the surveys with brown bullheads and white perch caught in 77% of the surveys. Table 3-4 ranks species of fish for MF2 in order of their importance value, with the top five listed as gizzard shad, brown bullhead, pumpkinseed sunfish, white perch, and mummichog killifish. The piscivores white perch, striped bass and largemouth bass were all represented.

Table 3.4 Kenilworth Mass Fill 2 marsh fish community from 8 electrofishing surveys; absolute abundance (total # caught); average #/survey; relative abundance (% total #); frequency (% survey sp. appearance); ranked by importance value (relative abundance + frequency / 2).

		Absolute Abundance	Average # / Survey	Relative Abundance	Frequency	Importance Value
Dorosoma cepedianum	Gizzard shad	144	18.0	17.7%	88%	52.8
Dorosoma cepedianum	Brown bullhead	205	25.6	25.2%	75%	50.1
Lepomis gibbosus	Pumpkinseed sunfish	57	7.1	7.0%	88%	47.5
Morone americana	White perch	92	11.5	11.3%	75%	43.1
Fundulus heteroclitus	Mummichog killifish	77	9.6	9.4%	63%	36.2
Hybognathus regius	Eastern silvery minnow	66	8.3	8.1%	63%	35.5
Carassius auratus	Goldfish	29	3.6	3.6%	63%	33.3
Notropis hudsonius	Spottail shiner	19	2.4	2.3%	63%	32.7
Cyprinus carpio	Common carp	36	4.5	4.4%	50%	27.2
Alosa pseudoharengus	Alewife herring	12	1.5	1.5%	38%	19.7
Morone saxatilis	Striped bass	6	0.8	0.7%	38%	19.4
Fundulus diaphanus	Banded killifish	10	1.3	1.2%	25%	13.1
Micropterus salmoides	Largemouth bass	5	0.6	0.6%	25%	12.8
Ictalurus punctatus	Channel catfish	2	0.3	0.2%	25%	12.6
Perca flavescens	Yellow perch	2	0.3	0.2%	25%	12.6
Alosa aestivalis	Blueback herring	36	4.5	4.4%	13%	8.7
Notemigonus crysoleucas	Golden shiner	12	1.5	1.5%	13%	7.2
Alosa sapidissima	American shad	2	0.3	0.2%	13%	6.6
Lepomis macrochirus	Bluegill sunfish	1	0.1	0.1%	13%	6.6
Moxostoma macrolepidotum	Shorthead redhorse	1	0.1	0.1%	13%	6.6
Cyprinella spiloptera	Spotfin shiner	1	0.1	0.1%	13%	6.6
	Total	815	102			

3.5.2.3 Mass Fill 3 Fish

This site represents fishes found in the tidal channel adjacent to the mudflat exclosure study area. Electrofishing at Mass Fill 3 captured 19 species from 9 families representing 389 individuals (Appendix A, Table 3.4). Only half the survey events were conducted at this site compared to the MF1 and MF2 sites, as the mudflat system was not considered for study until 1997. The top three species in total numbers and relative abundance, gizzard shad (155, 40%), brown bullhead (91,23%), and pumpkinseed sunfish (66,17%), accounted for 80% of the total fish captured at the site (Table 3.5). These two fish were the only species captured at each of the shocking events with a frequency of 100%. Ranked by importance value, the top five species were gizzard shad, pumpkinseed sunfish, white perch, eastern silvery minnow *Hybognathus regius*, and brown bullhead.

Nine species of fish comprised less than 1% of the total catch. Of the piscivores, the white perch comprised 4% of the total catch while a single striped bass was collected.

Table 3.5 Kenilworth Mass Fill 3 mudflat fish community from 4 electrofishing surveys; absolute abundance (total # caught); average #/survey; relative abundance (% total #); frequency (% survey sp. appearance); ranked by importance value (relative abundance + frequency / 2).

		Absolute Abundance	Average # / Survey	Relative Abundance	Frequency	Importance Value
Dorosoma cepedianum	Gizzard shad	155	38.8	39.8%	100%	69.9
Lepomis gibbosus	Pumpkinseed sunfish	66	16.5	17.0%	100%	58.5
Morone americana	White perch	16	4.0	4.1%	75%	39.6
Hybognathus regius	Eastern silvery minnow	5	1.3	1.3%	75%	38.1
Ameiurus nebulosus	Brown bullhead	91	22.8	23.4%	50%	36.7
Alosa aestivalis	Blueback herring	23	5.8	5.9%	50%	28.0
Notemigonus crysoleucas	Golden shiner	5	1.3	1.3%	50%	25.6
Fundulus heteroclitus	Mummichog Killifish	4	1.0	1.0%	50%	25.5
Cyprinus carpio	Common carp	3	0.8	0.8%	50%	25.4
Lepomis macrochirus	Bluegill sunfish	2	0.5	0.5%	50%	25.3
Carassius auratus	Goldfish	2	0.5	0.5%	50%	25.3
Perca flavescens	Yellow perch	2	0.5	0.5%	50%	25.3
Alosa pseudoharengus	Alewife herring	6	1.5	1.5%	25%	13.3
Menidia beryilina	Atlantic silversides	4	1.0	1.0%	25%	13.0
Alosa sapidissima	American shad	1	0.3	0.3%	25%	12.6
Ictalurus punctatus	Channel catfish	1	0.3	0.3%	25%	12.6
Moxostoma macrolepidotun	Shorthead redhorse	1	0.3	0.3%	25%	12.6
Notropis hudsonius	Spottail shiner	1	0.3	0.3%	25%	12.6
Morone saxatilis	Striped bass	1	0.3	0.3%	25%	12.6
	Total	389	97			

3.5.2.4 Dueling Creek Fish

The Dueling Creek reference marsh electrofishing surveys captured a total of 25 species of fish representing 9 families (1607 individuals) (Appendix A, Table 3.5). The top four species caught in total numbers and relative abundance were blueback herring Alosa aestivalis (451,28%), white perch (308,19%), eastern silvery minnow (250, 16%), and pumpkinseed sunfish (206, 41%), accounted for over 75% of the total catch (Table 3.6). Six species of fish were captured in every survey with a frequency of 100%. These species, in order of their importance, were white perch, eastern silvery minnow, gizzard shad, mummichog killifish, spottail shiner *Notropis hudsonius*, and banded killifish. Thirteen species were found in numbers representing less than 1% of the total catch. A species and family captured at Dueling and not at any of the Kenilworth sites was American eel *Anguilla rostrata*, of which only three individuals were found.

Table 3.6 Dueling Creek marsh fish community from 5 electrofishing surveys; absolute abundance (total # caught); average #/survey; relative abundance (% total #); frequency (% survey sp. appearance); ranked by importance value (relative abundance + frequency / 2).

		Absolute Abundance	Average # / Survey	Relative Abundance	Frequency	Importance Value
Morone americana	White perch	308	61.6	19.2%	100%	59.6
Hybognathus regius	Eastern silvery minnow	250	50	15.6%	100%	57.8
Dorosoma cepedianum	Gizzard shad	125	25	7.8%	100%	53.9
Fundulus heteroclitus	Mummichog killifish	40	8	2.5%	100%	51.2
Notropis hudsonius	Spottail shiner	28	5.6	1.7%	100%	50.9
Fundulus diaphanus	Banded killifish	24	4.8	1.5%	100%	50.7
Lepomis gibbosus	Pumpkinseed sunfish	206	41.2	12.8%	80%	46.4
Alosa aestivalis	Blueback herring	451	90.2	28.1%	60%	44.0
Ameiurus nebulosus	Brown bullhead	41	8.2	2.6%	80%	41.3
Moxostoma erythrurum	Golden redhorse	27	5.4	1.7%	80%	40.8
Perca flavescens	Yellow perch	16	3.2	1.0%	80%	40.5
Micropterus salmoides	Largemouth bass	24	4.8	1.5%	60%	30.7
Notemigonus crysoleucas	Golden shiner	11	2.2	0.7%	60%	30.3
Alosa pseudoharengus	Alewife herring	10	2	0.6%	60%	30.3
Cyprinus carpio	Common carp	6	1.2	0.4%	60%	30.2
Lepomis macrochirus	Bluegill sunfish	5	1	0.3%	60%	30.2
Ictalurus punctatus	Channel catfish	3	0.6	0.2%	60%	30.1
Moxostoma macrolepidotun	Shorthead redhorse	14	2.8	0.9%	40%	20.4
Anguilla rostrata	American eel	3	0.6	0.2%	40%	20.1
Morone saxatilis	Striped bass	3	0.6	0.2%	40%	20.1
Notropis procne	Swallowtail shiner	6	1.2	0.4%	20%	10.2
Alosa sapidissima	American shad	2	0.4	0.1%	20%	10.1
Cyprinella spiloptera	Spotfin shiner	2	0.4	0.1%	20%	10.1
Carassius auratus	Goldfish	1	0.2	0.1%	20%	10.0
Carpiodes cyprinus	Quillback carpsucker	1	0.2	0.1%	20%	10.0
	Total	1607	321			

3.5.2.5 Mass Fill 3 Seine

A minor seining effort was conducted at the Mass Fill 3 mudflat identifying 12 species of fish representing 7 families and 940 individuals (Appendix A, Table 3.6). The dominant species captured was the mummichog killifish with 670 individuals representing 71% of the total catch (Table 3.7). The banded killifish represented the second highest relative abundance of fish in the sein survey with 15% and 143 individuals. The top three fish in importance value were the mummichog. banded killifish, and the brown bullhead catfish. Half of the species of fish were captured less than 1% of the time in the survey. Almost 98% of the fish were captured during one fall survey.

Table 3.7 Kenilworth Mass Fill 3 mudflat fish community from 4 bag sein surveys; absolute abundance (total # caught); average #/survey; relative abundance (% total #); frequency (% survey sp. appearance); ranked by importance value (relative abundance + frequency / 2).

		Absolute Abundance	Average # / Survey	Relative Abundance	Frequency	Importance Value
Fundulus heteroclitus	Mummichog killifish	670	167.5	71.3%	100%	85.6
Fundulus diaphanus	Banded killifish	143	35.75	15.2%	75%	45.1
Ameiurus nebulosus	Brown bullhead	8	2	0.9%	75%	37.9
Lepomis gibbosus	Pumpkinseed sunfish	28	7	3.0%	50%	26.5
Lepomis macrochirus	Bluegill sunfish	14	3.5	1.5%	50%	25.7
Alosa aestivalis	Blueback herring	47	11.75	5.0%	25%	15.0
Notemigonus crysoleucas	Golden shiner	17	4.25	1.8%	25%	13.4
Hybognathus regius	Eastern silvery minnow	4	1	0.4%	25%	12.7
Morone americana	White perch	4	1	0.4%	25%	12.7
Micropterus salmoides	Largemouth bass	2	0.5	0.2%	25%	12.6
Etheostoma olmstedi	Tessellated darter	2	0.5	0.2%	25%	12.6
Cyprinus carpio	Common carp	1	0.25	0.1%	25%	12.6
	Total	940	235			

3.5.3 Fish Survey Site Comparisons

A comparison between each of the sites found that in terms of numbers of species, each of the sites was remarkably similar to each other. A percent similarity matrix relating the numbers of common fish species between each site reflected these commonalities (Table 3.8). Similarity was measured from one site to the other as the number of common species between two sites, divided by the number of total species collected from the first site that is being compared to the other. Sites in the matrix compared to themselves were given a value of 1. The Dueling Creek reference site had 72% of its species in common with the Kenilworth Mass Fill 3 mudflat site. Dueling had 76% and 84% of its species composition in common with the restored marsh Mass Fill 1 and Mass Fill 2 sites respectively. The numbers of common species found at Kenilworth Mass Fill 1 was 73% similar to the mudflat site of Mass Fill 3. Nearly all of the species collected at MF1 (86%) and MF3 (95%) were also represented at the Dueling reference, and 100% of the species captured at MF2 were also caught at Dueling.

Table 3.8 Percent (%) similarity matrix comparing common fish species collected between sites from all years sampling events. Similarities read as far left column % species similarity to next site from left to right.

	Kenilworth Mass Fill 1	Kenilworth Mass Fill 2	Kenilworth Mass Fill 3	Dueling Creek
Kenilworth Mass Fill 1	1	77	73	86
Kenilworth Mass Fill 2	81	1	86	100
Kenilworth Mass Fill 3	84	95	1	95
Dueling Creek	76	84	72	1

Total numbers of fish collected at the restored marsh sites of MF1 and MF2 were 855 and 815 respectively, with each of the two sites shocked 8 times. When total numbers of fish were averaged out for the number of surveys conducted at each site, the MF1 and MF2 sites were expectedly close with 107 and 102 fish caught on average per shocking event respectively. Figure 3.7 combines the Mass Fill 1 and Mass Fill 2 sampling areas and represents the average numbers of each species of fish that were captured in each sampling event for these two areas. Mass Fill 3, shocked on 4 dates, collected 97 fish on average per survey (Table 3.5). Figure 3.8 represents the average

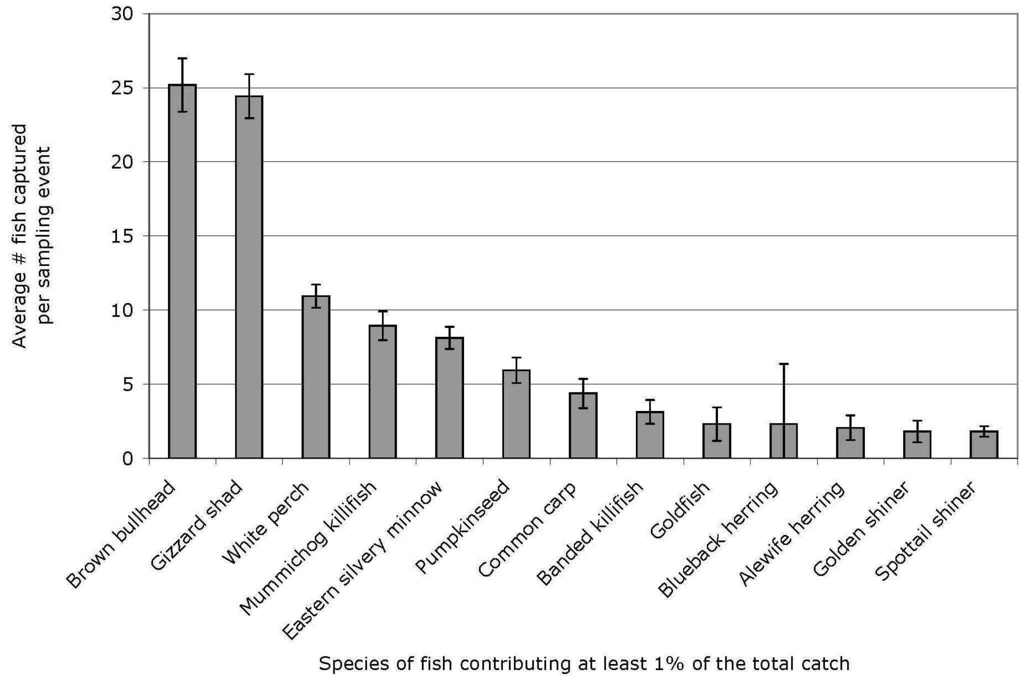

Figure 3.7 Kenilworth MF1 and MF2 combined electrofishing survey results. Fish averages arithmetic means ± SE.

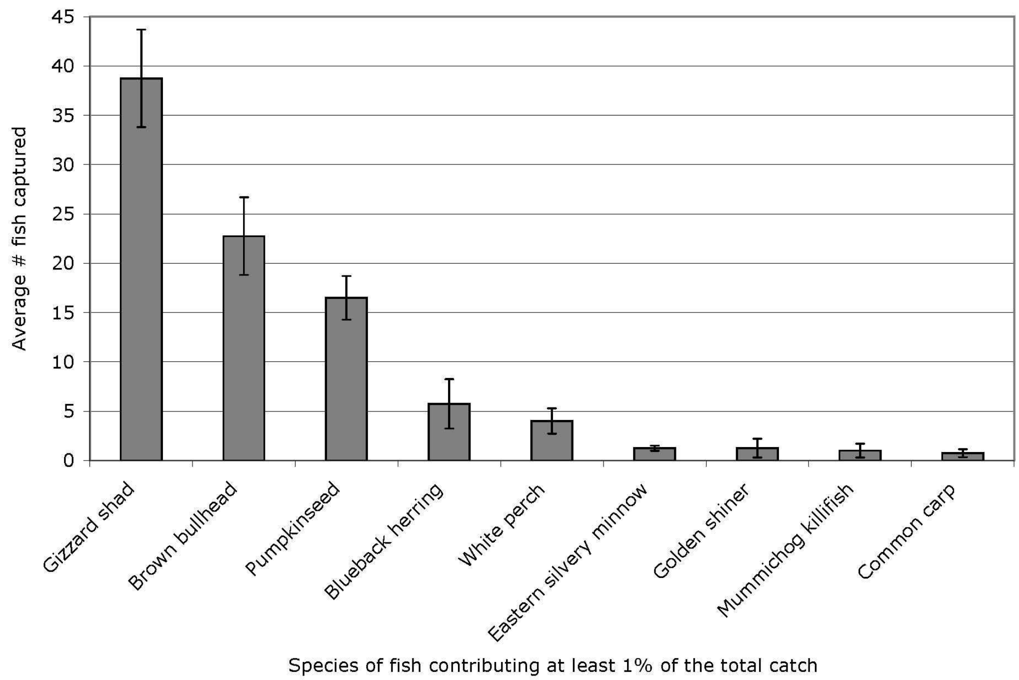

Figure 3.8 Kenilworth MF3 combined electrofishing survey results. Fish averages arithmetic means ± SE.

numbers of fish captured for each species on a given survey date at Mass Fill 3. Dueling Creek, shocked on 5 dates, captured more than three times as many fish on an average survey (321 individuals) than each of the Kenilworth Mass Fill areas (Table 3.6).

Figure 3.9 represents the average numbers of fish captured for each species at Dueling. Each of the sites surveyed had several species of migratory fish, with a least one individual represented from each of the anadromous fish species which included: blueback herring, alewife herring *Alosa pseudoharengus*, American shad *Alosa sapidissima*, and striped bass. Dueling Creek surveys captured the only catadromous species, American eel *Anguilla rostrata*.

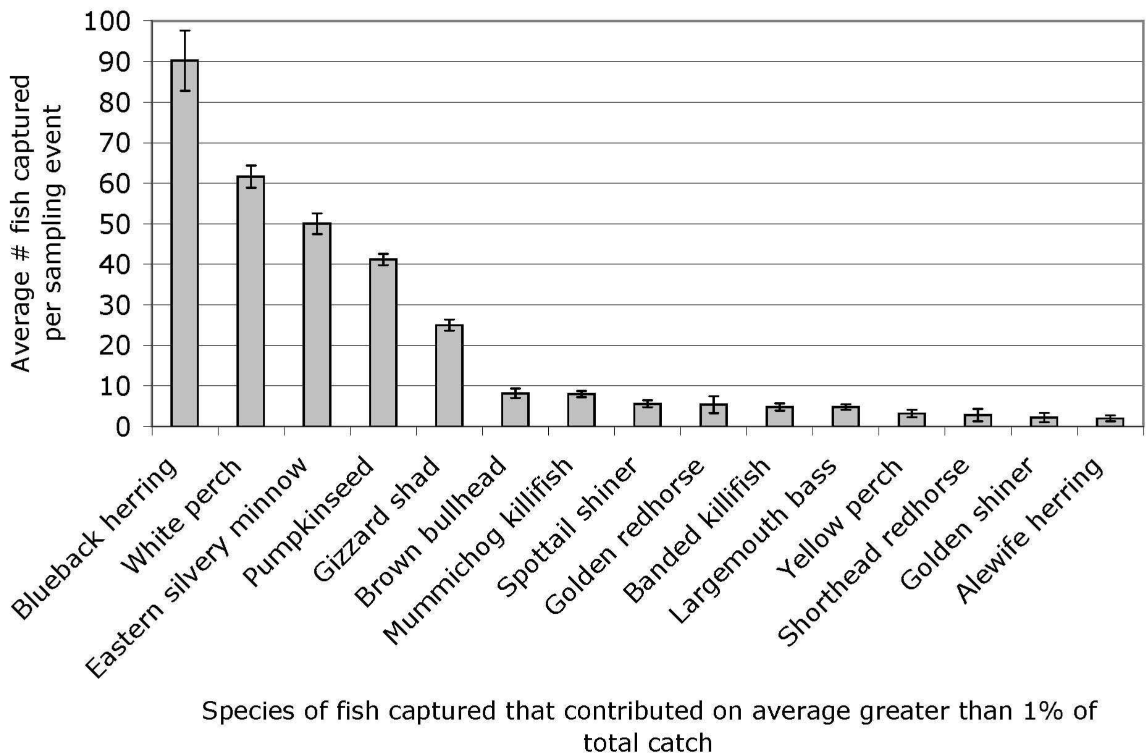

Figure 3.9 Dueling Creek Marsh electrofishing survey results. Fish averages are arithmetic means ± SE.

Comparisons between the species collected from electrofishing and seining surveys of the Mass Fill 3 mudflat revealed that each survey resulted in different total numbers of mummichog killifish captured. Electrofishing collected a total of 4 mummichogs, while seining collected 670 mummichog killifish from the mudflat area with relative abundances of 1% and 71% respectively. The discrepancies in numbers represent a flaw in boat based electrofishing surveys in that they only sample fish that are within their electrical field at high tide. Fish such as *Fundulus* sp. move in schools in shallow water areas with the flooding and ebbing tide to avoid predation so are less likely to be captured by boat, and are more likely to be captured by a seine left in a tidal channel over a tidal cycle.

3.6 <u>Exclosures</u>

3.6.1 1997 Invertebrates

A total of 300 invertebrate sediment core samples were collected in 1997, combined from each of the exclosures treatments in three blocks of treatments. Samples were collected every other month between March and November. Repeated sediment core sampling within the Kenilworth Mass Fill 3 exclosures produced three primary forms of benthic macroinvertebrates. These included the numerically dominant family of aquatic worms, Oligochaeta, the second most numerous mudflat invertebrate from the family of midge fly larvae, Chironomidae, and the non-native bivalve mollusk, Asian clam *Corbicula fluminea* of the family Corbiculidae.

The Chi-Square analysis averaged across the percentages of the three invertebrate types according to exclusion type, had six (6) degrees of freedom and a value of 68 with p <0.01 indicating that there were significant differences in invertebrate group percentages within the each of the exclosure types. Figure 3.10 illustrates the invertebrate group composition within each exclosure type for 1997. Oligochaetes dominated in terms of total numbers of individuals and percentages of the total invertebrate population within each exclosure type (Appendix A, Table 3.7). Across all exclosures, oligochates made up 82% of all invertebrates with 3650 individuals counted, with chironomids totaling 17% with 739 individuals and corbicula comprising 1% with 54 individuals counted of the total numbers of invertebrates collected.

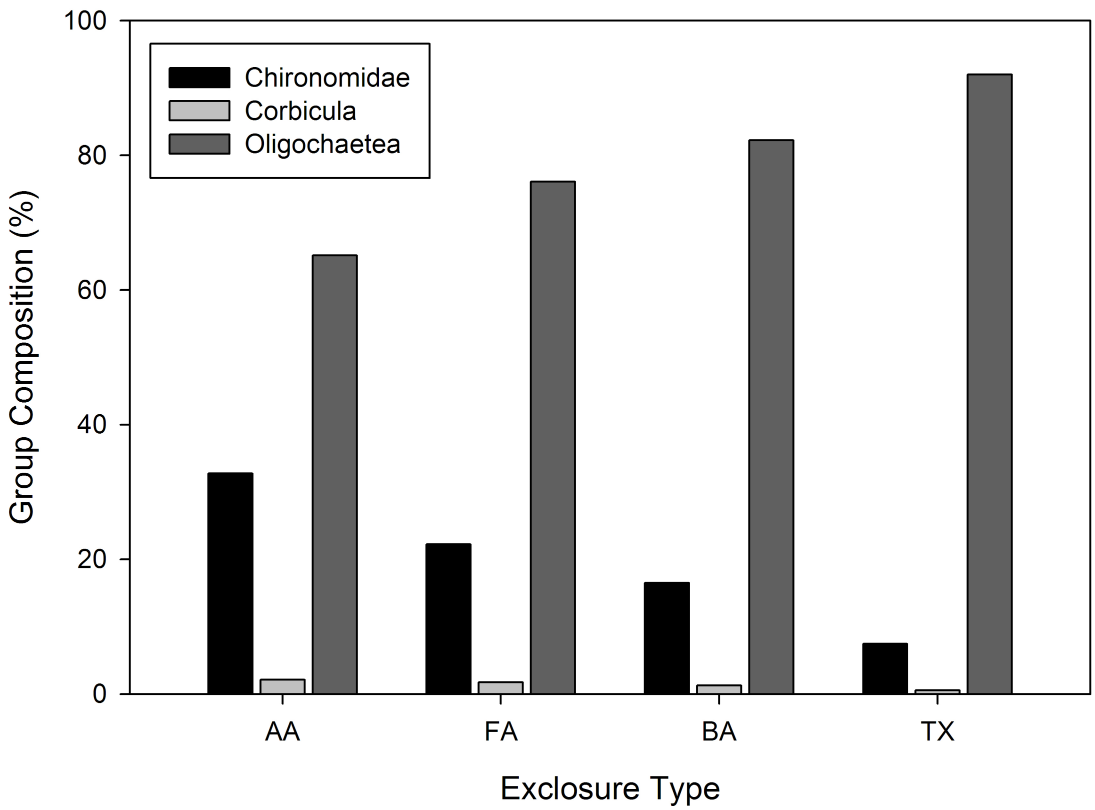

Figure 3.10 1997 Invertebrate group percent composition within each exclosure treatment type. (AA) all accessible control treatment; (FA) fish accessible/ bird exclosure treatment; (BA) bird accessible/ fish exclosure treatment; (TX) total exclosure treatment.

When converted to mean numbers of invertebrates/m^2, analysis of variance for each exclosure type revealed significant differences ($p<0.05$) in the densities of oligochaetes collected from both the total exclosure (TX) and bird accessible/fish exclosure (BA) plots when compared to the control plot, all accessible (AA) exclosures (Figure 3.11). There were also significant differences in oligochaete densities between the total exclosure plots and the fish accessible/bird exclosure plots. Significant differences did not exist for any other exclosure type or invertebrate population in 1997.

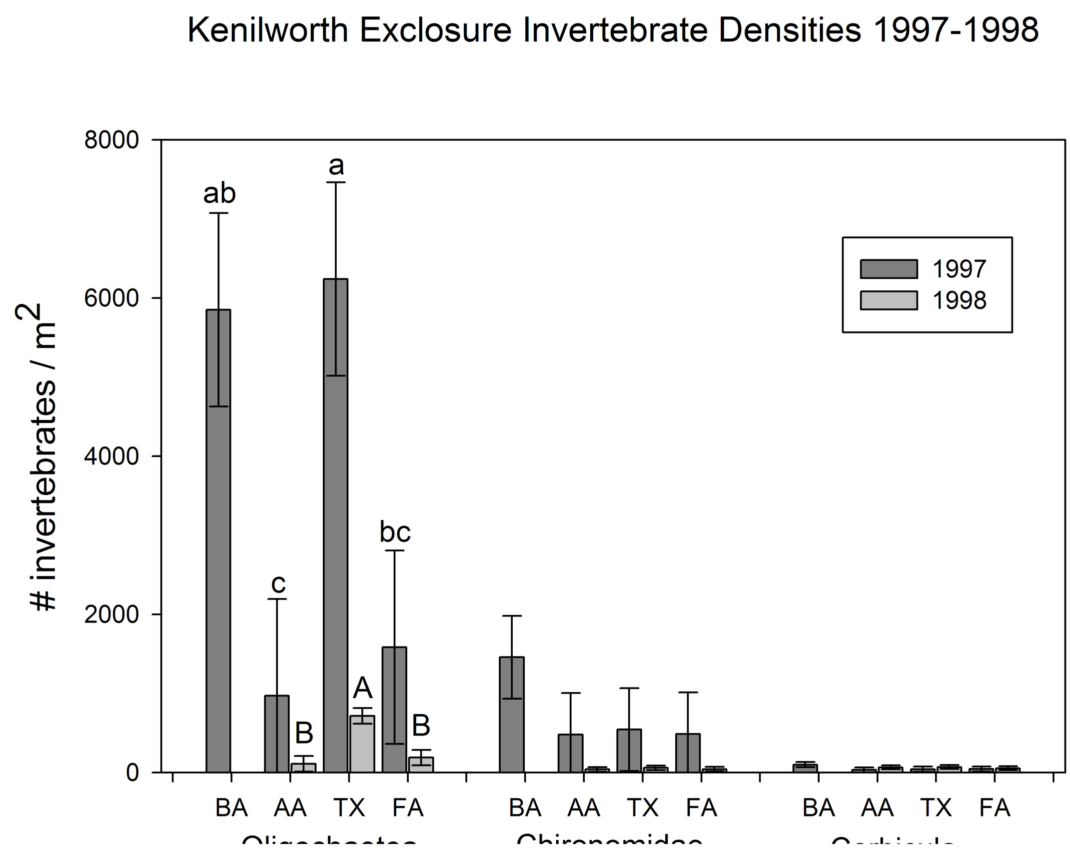

Figure 3.11 Invertebrate densities by year and exclosure type. Densities are Tukey adjusted LS means ± SE. Mean sharing any com on letter are not significantly different ($p < 0.05$). Letter case differentiates years. Means with no letters are also significantly different. (AA) all accessible control treatment; (FA) fish accessible/bird exclosure treatment; (BA) bird accessible/fish exclosure treatment; (TX) total exclosure treatment.

The all accessible (AA) treatment type had lower total numbers of individuals and absolute percentages of oligochates (242 & 7%) than the fish accessible/bird exclusion (FA) (395 & 11%) treatment, with both treatments allowing fish access to the plots. The treatments that prohibited fish access to the plots found higher numbers of individuals and percentages of oligochaetes, with values for bird accessible/fish exclosure (BA) (1458 & 40%) and total exclosure (TX) (1555 & 42%). The all accessible control (AA) treatment had only slightly lower numbers and percentages of chironomid (120 & 16%) and corbicula (8 & 15%) invertebrates within the treatment type than the fish accessible/ bird exclosure (FA) (121 & 16% chironomid; 11 & 20% corbicula), while the bird accessible /fish exclosure (BA) (363 & 49% chironomid; 25 & 46% corbicula) and total exclosure (TX) (135 & 18% chironomid; 10 & 19% corbicula) treatments found higher numbers and percentages of invertebrates.

3.6.2 1998 Invertebrates

The BA, bird accessible/fish exclosure was removed from the study in 1998. It was determined that this treatment effectively functioned as a TX total exclosure, as the only treatment differences were crossed lines over the top of the TX exclosures to prevent birds from landing with them. Because there was no evidence of shorebirds or waterfowl landing within the fencing of the BA treatment from visual observations or the presence or tracks the previous year (an occasional heron was an exception), the exclosure fencing for this treatment was taken down and the plot was no longer sampled. Although this removed 3 replicate exclosure study plots, 8 months of samples were collected monthly between April and November (3 more months than in 1997) so a total of 360 invertebrate sediment cores were collected and analyzed.

The Chi-Square invertebrate analysis for 1998 averaged across the percentages of the three invertebrate types according to exclusion type, had (6,4) degrees of freedom and a value of 84 with $p < 0.01$ that there were again differences in invertebrate percentages within the each of the exclosure types. Figure 3.12 illustrates the percent invertebrate group composition within each exclosure type for 1998. Oligochaetes again dominated in terms of numbers of individuals and percentages of the total invertebrate population within each exclosure type (Appendix A, Table 3.8). Across all exclosures, oligochaetes made up 75% of all invertebrates, with chironomids totaling 11% and corbicula comprising 14% of the total invertebrates collected.

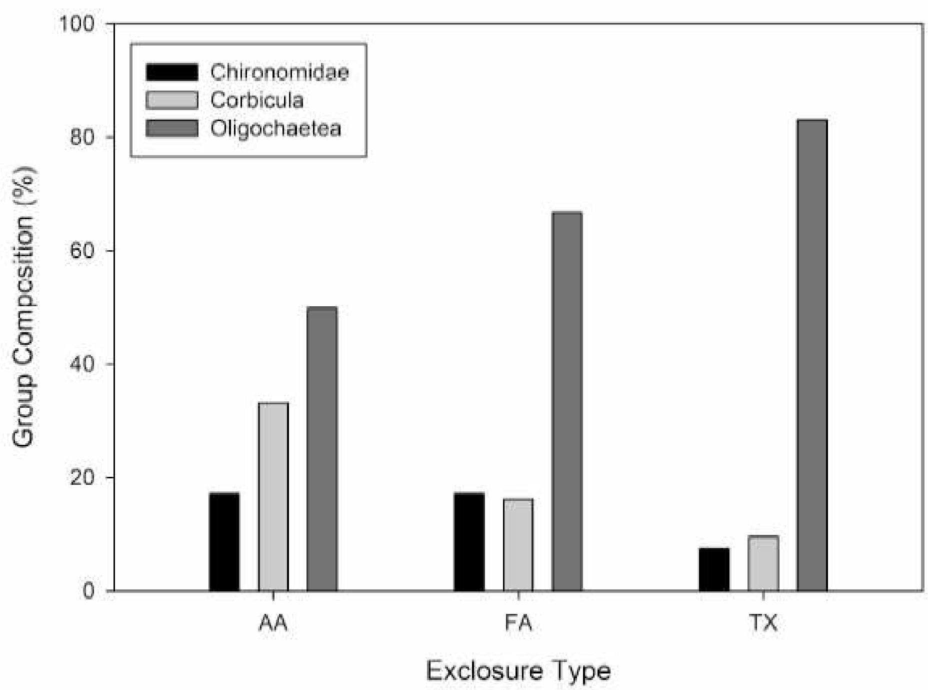

Figure 3.12 Invertebrate group percent composition within each exclosure treatment type. (AA) all accessible control treatment; (FA) fish accessible/bird exclosure treatment; (TX) total exclosure treatment.

When converted to mean numbers of invertebrates/m^2, analysis of variance for each exclosure type revealed significant differences ($p<0.05$) in the densities of oligochaetes collected between the total exclosure plots (TX) and the all accessible control exclosure plots (AA) (Figure 3.11). There were also significant differences in oligochaete densities between the total exclosure plots and the fish accessible/bird exclosure plots. Significant differences did not exist for any other exclosure type or invertebrate population in 1998.

The unfenced control (AA) treatment type had lower numbers and percentages of oligochates (44 & 11%) than the fish accessible (FA) (75 & 18%), and total exclosure (TX) (286 & 71%) treatments respectively. The (AA) control treatment had similar numbers and percentages of chironomid (16 & 28%) and corbicula (26 & 34%) within the treatment type to the fish accessible (FA) (17 & 30% chironomid; 21 & 28% corbicula) treatment type, while the total (TX) exclosure treatments had higher numbers and percentages (24 & 42% chironomid; 28 & 37% corbicula) of those invertebrates.

The trend in invertebrate response to exclosure treatment type for the 1997 sampling year was equivalent to the 1998 sampling year when invertebrates were counted across all months. In terms of total numbers, in1998 there were less invertebrates collected, only 537 individuals of all species, when compared to 1997 counts (4,443 individuals of all species). This represents a reduction of 88% even though three additional months were sampled in 1998.

3.6.3 Algae

The dominant form of algae found on the Kenilworth study mudflat was the filamentous blue-green algae *Oscillatoria* sp. along with numerous diatoms. Between 1997 and 1998, 621 separate algae % coverage measurements were made across blocks and exclosure treatments (Appendix A, Table 3.9). The model analysis found that algae % coverage by exclosure type had an F value of 12.07 with (3, 30) degrees of freedom and a $p < 0.01$. Algae % cover by season had an F value of 81.05 with (3, 30) degrees of freedom and a $p < 0.01$ while exclosure type by season had an F value of 1 with 9 degrees of freedom and a $p = 0.41$. Residuals from the mixed model procedure differences of least squares means between exclosure types were found to be within acceptable ranges, so there was no need to transform the data.

The differences in least squares means between exclosure type and differences across both years were similar within seasons. Tukey adjusted differences between algal percent coverage least square means were found to be highly significant ($p < 0.001$) between the AA control treatments and the TX total exclosure treatments across both years (Figure 3.13). Additionally, there were significant differences ($p < 0.01$) between the AA control treatment and the BA bird accessible/fish exclosure treatment, which was tested in 1997 but not 1998. No significant difference ($p = 0.99$) was found between the BA bird accessible and TX total exclosure types. The AA control and FA fish accessible exclosure types also had no significant differences ($p = 0.39$) between the treatment types across both years.

The FA fish accessible treatment appears to have reacted similarly to the AA control treatment in terms of repressed algal coverage when compared to the TX total exclosure and BA bird accessible treatments, both of which effectively blocked fish and access. The accessibility of fish to the AA control and FA fish accessible exclosures was the main commonality between the two treatments.

Significant differences between the FA fish accessible and TX total exclosure treatments ($p < 0.01$) and the FA fish accessible and BA bird accessible treatments ($p < 0.01$) reflected greater algal percent coverages in the TX total exclosure and BA bird accessible exclosures. (Figure 3.13). As evidenced by the swarms of killifish (*Fundulus* sp.*)* observed to move across the mudflats on the vanguard of flooding tides (Appendix A, Table 3.10), these schools of fish were turning over the top layers of sediment looking for food and in the process most likely limiting the potential of algae to develop the dense algal mats found in the fish excluding treatment types. The fact that there was no significant difference between the AA all accessible and FA fish accessible/bird exclosure treatment types effectively means that a disturbance effect from birds on algae could not be differentiated from that of fish alone.

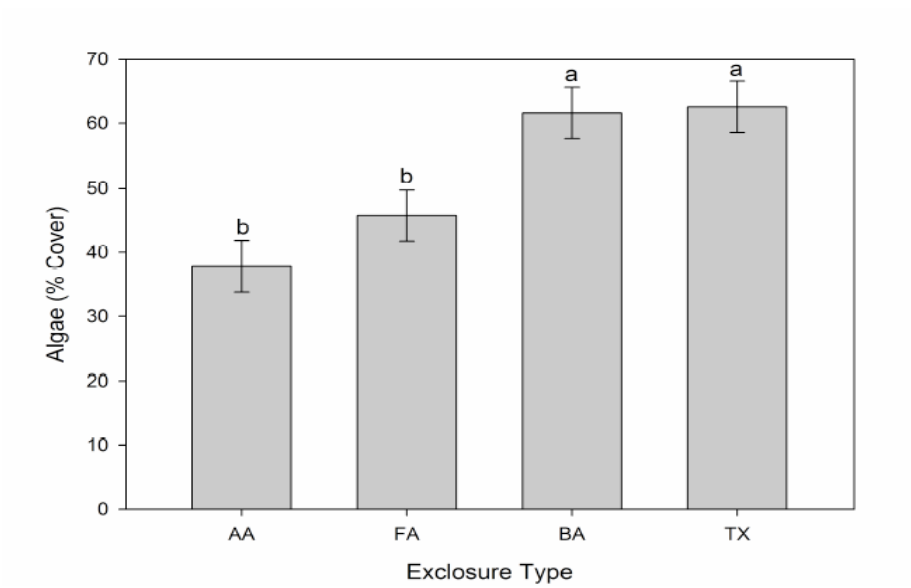

Figure 3.13 1997–1998 combined algae mean percent cover. Means are Tukey adjusted LS means + SE. Means with different letters are significantly different ($p < 0.05$). Means sharing the same letter are not significantly different. (AA) all accessible control treatment; (FA) fish accessible/bird exclosure treatment; (BA) bird accessible/fish exclosure treatment; (TX) total exclosure treatment.

Differences of least squares means found significant effects of season for all treatments between three of four seasons across both years (Figure 3.14). This result suggests the differences in algal percent coverage due to seasonality can be explained by differences in photoperiod and temperature, and the physical effects of each of these on fish feeding and movement habits that would impact algae grazing and disturbance. There was a significant effect of season on algae percent coverage on all treatments: between the Fall and Spring ($p < 0.01$); Fall and Winter ($p < 0.\ 01$); Spring and Summer ($p = 0.02$); Spring and Winter ($p < 0.\ 01$); and Summer and Winter ($p < 0.\ 01$). The two seasons that were not significantly different from each other were with respect to algae coverage on all exclosure treatments were Fall and Summer ($p = 0.33$).

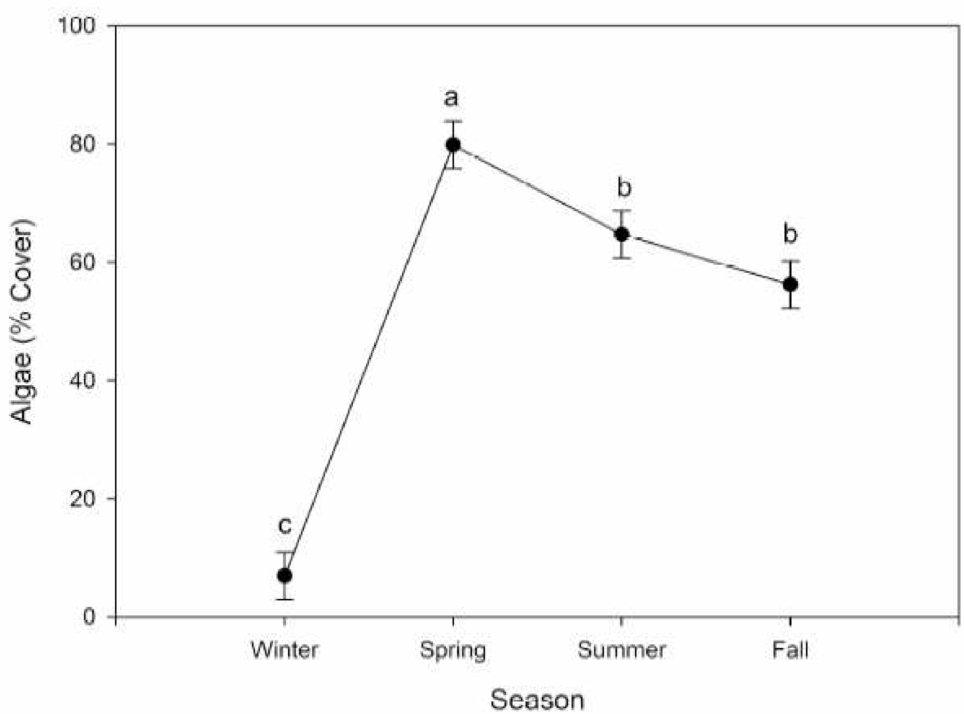

Figure 3.14 Figure 3.12. 1997–1998 combined algae mean cover by season. Cover are Tukey adjusted LS means + SE. Means not sharing common letters are significantly different (p < 0.05). Means sharing common letters are not significantly different.

3.6.4 Emergent Macrophytes

The emergent macrophytes, *Pontederia cordata* and *Polygonum* sp., were observed to volunteer in several of the exclosures beginning in July of 1997 (Figure 3.15). The presence of *Pontederia* or *Polygonum* clonal groups from each exclosure treatment were noted as they developed throughout the growing season (Figure 3.16)(Appendix A, Table 3.11). By August, *Polygonum* was found in each exclosure type with TX total exclosures and BA bird accessible/fish exclosures having greater numbers than the AA all accessible control or the FA fish accessible/bird exclosures (Figure 3.17). By the end of October, no *Polygonum* was found in any of the exclosure treatments. *Pontederia* also volunteered prolifically in both the TX total exclosures and BA bird accessible/fish exclosures throughout each of the growing season observations yet not at all in the any of the AA control exclosures (Figure 3.18). In July there were 17 *Pontederia* volunteers with the same total number found in August. September and October each had 16 and 15 individual plants persisting respectively. Only in July did two *Pontederia* individuals volunteer in one FA fish accessible/bird exclosure but they both disappeared from this exclosure type throughout the rest of the season.

In 1998, intentionally planted *Pontederia* individuals (5 in each exclosure type and block, 45 total) were observed for presence/absence twice within the week after planting and 5 times after that throughout the growing season (Appendix A, Table 3.12). Within the first week after planting on June 3rd, only three of 15 individuals from the AA all accessible control plots remained, and these three were stems only with no leaves. While the control plots retained only 20% of their initial plantings, both the TX total

Figure 3.15 View of 1997 total exclosure (TX) treatment plot with young *Pontederia cordata* clonal volunteers.

Figure 3.16 View of 1997 mid-summer exclosure plot *Pontederia cordata* and *Polygonum sp*. clonal volunteers. The 1m x1m wood frame on the left is the algae cover measuring quadrant.

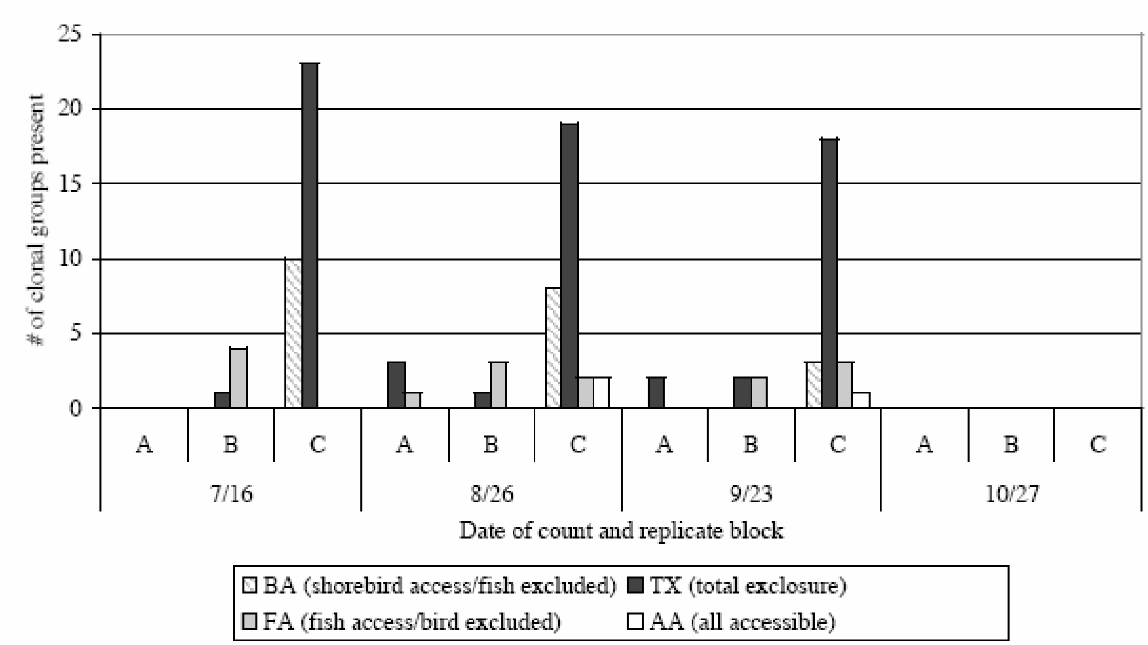

Figure 3.17 1997 Kenilworth Mudflat exclosure *Polygonum sp.* volunteerism grouped by treatment block. A B and C are replicate treatment blocks.

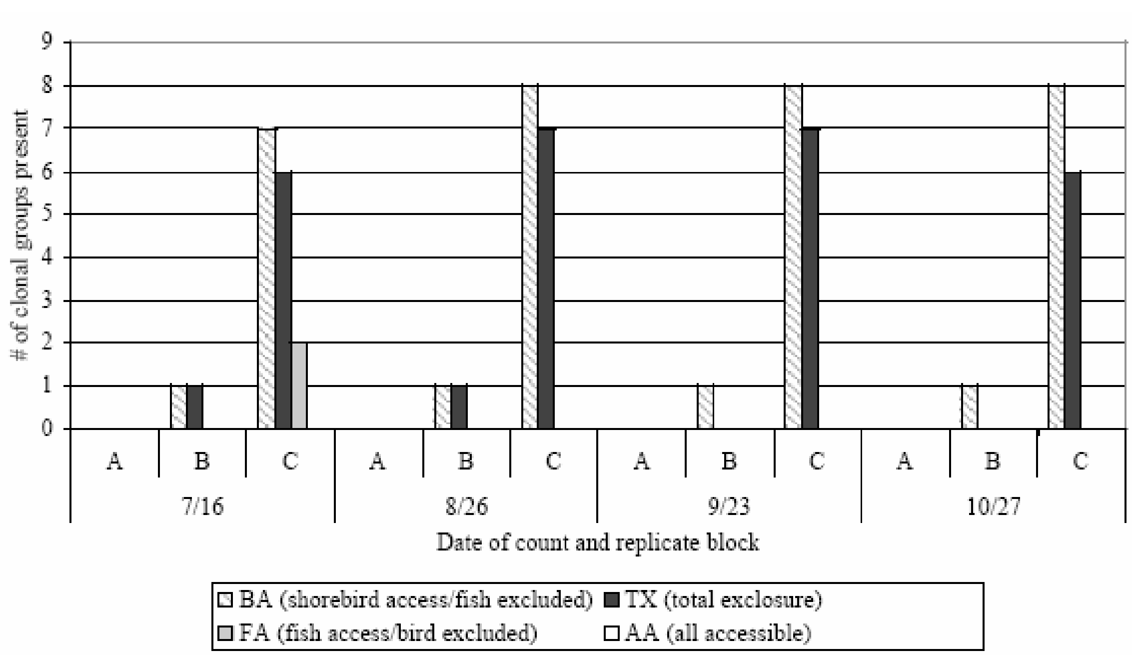

Figure 3.18 1997 Kenilworth mudflat exclosure *Pontederia cordata* volunteerism grouped by treatment block. A B and C are replicate treatment blocks.

exclosure and FA fish accessible exclosures maintained 100% of their plantings throughout the month of June (Figure 3.19). By July, the control treatment plots that provided complete access to fish and birds had 0% *Pontederia* plants remaining, while FA fish accessible/bird excluded plantings dropped to 60% and TX total exclosure treatment plots still retained 100% of their planting survival. At the end of the presence/absence survey the TX total exclosure plots retained 100% of their plantings that had grown well in all plots throughout the growing season while the FA fish accessible/bird exclosure plots retained only 46% of their initial numbers and most were visibly stunted in growth and had noticeable grazer damage to leaves and stems. Canada geese *Branta canadensis* were the likely grazer in the AA control treatment plots, as evidenced by numerous easily identifiable goose tracks in the mud within the plot areas (Appendix A, Table 3.13). For the FA fish accessible treatment plots, geese were definitely excluded but the grazer was not as easily identified. Likely grazers or bioturbators included common carp *Cyprinus carpio*, and/or one or more of several turtle species that inhabit the area and were occasionally found inside of exclosure plots (Appendix A, Table 3.14).

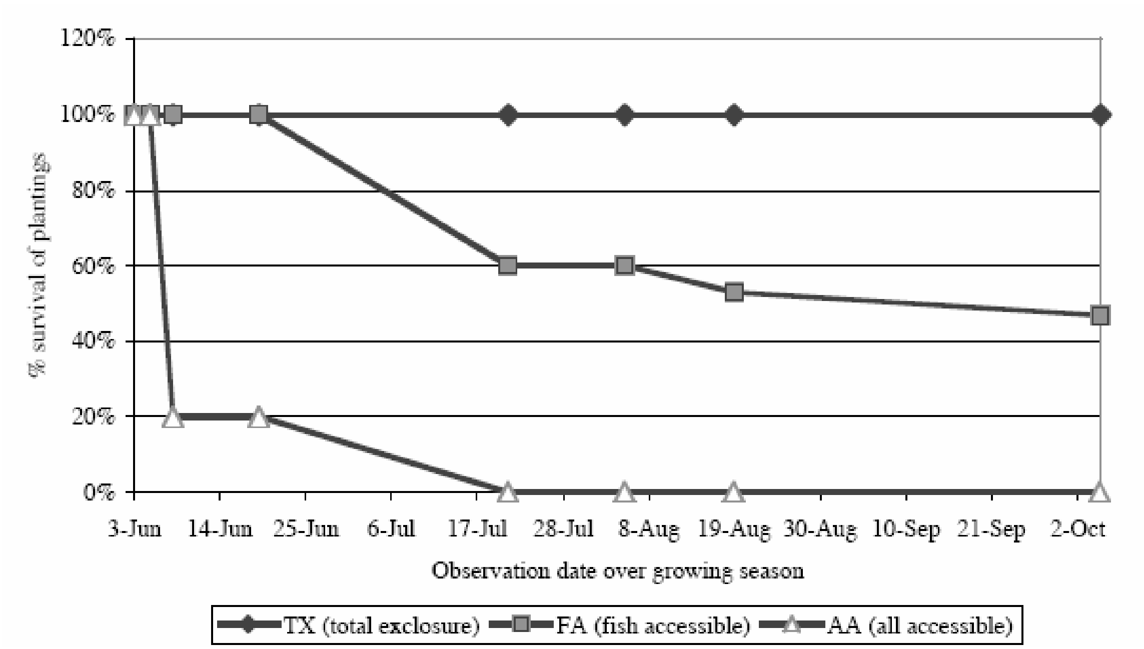

Figure 3.19 1998 Kenilworth mudflat exclosure treatment *Pontederia cordata* experimental planting survivorship.

The mudflat exclosure *Pontederia cordata* biomass data was collected at the end of the growing season in 1998 (Appendix A, Table 3.15). There were inherently obvious significant differences between each of the non-fenced control AA plots that had no plants present and so no biomass, and the TX total exclosure and FA fish accessible/bird exclosure treatment plots which had biomass. There were significant differences identified in dry weight biomass (g/m^2) lease squares means between the AA control plots and the TX total exclosure treatment plots ($p < 0.01$) as well as between the AA control plots and the FA fish accessible/bird exclosure treatment plots ($p < 0.01$) (Figure 3.20). Especially notable is that there was also a significant difference in mean dry weight biomass between the FA fish accessible/bird exclosure treatment plots and the TX total exclosure treatment plots ($p <0.01$). Tukey adjustments made to the data found the same significant differences between the treatments with all adjusted least squared means with p <0.01.

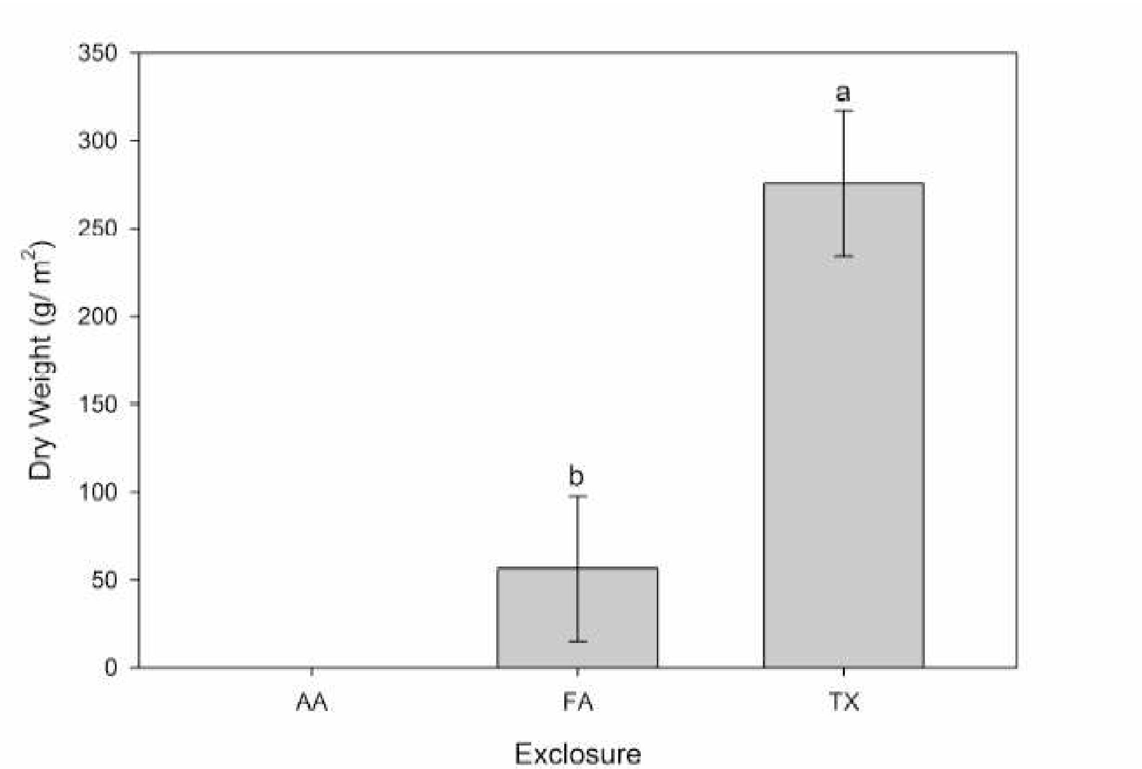

Figure 3.20 1998 Kenilworth mudflat *Pontederia cordata* experimental planting above ground biomasss LS means + SE. Different letters denote significant difference in biomass ($p < 0.0001$). The AA treatment type was significantly different than FA or TX with no variance within the exclosure treatment between the AA treatment blocks.

3.7 Discussion

3.7.1 Bird and Fish Predation on Mudflat Invertebrates

The experimental exclosure research was originally initiated to determine the use and impact of bird and fish predation, grazing or bioturbation on mudflat benthic macroinvertebrate communities and algal coverage (Quammen, 1984; Reise, 1985). Birds in tidal freshwater marshes are known to be significant with respect to species diversity and the number of guilds, in large part due to the variety and complexity of habitat types (literature review by Odum et al., 1984) that always includes a degree of unvegetated intertidal mudflat area. Some migratory shorebird species and many species of waterfowl are attracted to the open spaces of mudflats in which to feed, rest, and avoid predation (Recher, 1966; Quammen, 1984; Riese, 1985; Hayman et al., 1986; Evans 1987; Bull and Farrand, 1994; Perry and Deller, 1996).

According to the Weller's "hemimarsh" concept (1978), an equal mixture of open water and interspersed emergent plant cover in freshwater marshes are most productive for waterfowl use. While this concept was applied to non-tidal marshes, the understanding that a heterogenous mixture of wetland conditions maximizes bird productivity may still be applied in the case of tidal marshes that include mudflats, which attract shorebirds and wading birds as well as waterfowl. Maximizing edge effects as a means of improving wildlife has long been thought to be important in game management (Leopold, 1933). In the case of shorebirds and some waterfowl this must be tempered by the need for the predation protection of wide edge transitions that expansive mudflat systems often afford between open water subtidal and emergent marsh and upland vegetation (Recher, 1966; Hayman et al., 1986). More than protection for some bird species, mudflats provide aquatic invertebrates, algae, fish, mollusks (Quammen, 1984; Riese, 1985), and a variety of plant matter from seeds to tubers to whole plants and detritus that are consumed by a variety of species from multiple trophic levels illustrated in Figure 3.21 (Lodge, 1991).

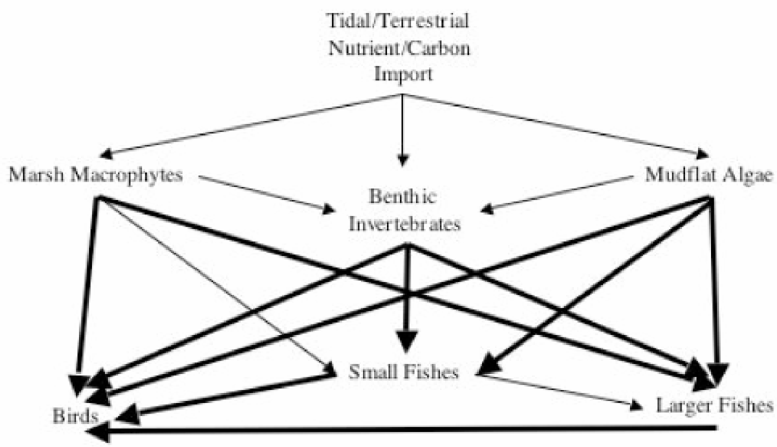

Figure 3.21 Generalized interactions between components of the intertidal mudflat exclosure area at the Kenilworth MF3. Thin layers are likely interactions (sometimes with intermediaries not labeled) that were not directly observed or revealed through the exclosures. Bold lines are interactions that were directly observed on the mudflat or revealed through exclosures.

Excluding birds was found to have significant positive effect on the oligochaete aquatic worm population densities (mean #/m^2) when compared to the control areas (Figure 3.11). The total exclusion effect on these invertebrates was also significantly noticeable with regard to the areas that allowed fish access to the study mudflat but excluded birds. The experiments did not detect a significant difference in oligochaete population densities between the areas that allowed fish and bird access (unfenced control) and those plots that only allowed fish access. This is interesting because it effectively reveals that fish predation is the primary driver of oligochaete population control on the mudflats in this study area, more so than the combined effects of bird and fish predation which was expected to have a greater effect than fish predation alone but did not.

The numerous species of midge larvae, family Chironomidae, are important trophic links in wetlands, consuming algae and detritus and being consumed by other invertebrates, fish (Batzer, 1998) and birds (Batzer et al., 1993). The densities of chironomids collected at the Kenilworth mudflat were not found to be significantly different among the different exclosure plot treatment types (Figure 3.11). Alternatively, as a percentage of invertebrate group composition within each exclosure type, chironomids actually decreased significantly in both years with greater degrees of exclosure (Figures 3.8, 3.10). This is counter to what was originally hypothesized when the study design was created.

There are numerous species in the family Chrionomidae (Pennak, 1978), with many found on the study mudflat of a size and coloration that would seem to make them very noticeable to the keen eyes of shorebirds (Evans, 1987) and some fishes (Batzer, 1998). It was hypothesized that the combination of shorebird and fish exclusion from the mudflat, releasing them from predation pressure, would allow for significant increases of chironomids given their ability to regenerate quickly and in high numbers. This was not the case.

3.7.2 Algae Cover and Invertebrate Densities

There was an expectation that significantly increased algal coverage found in total exclosures over the control plots and fish only accessible plots would stimulate chironomid invertebrate populations with an abundant food source. To the contrary, chironomid group percentages within exclosures (Figures 3.10, 3.12) appeared to be inversely proportional to algae percent cover within the same exclosures (Figure 3.13), With many species of fish and birds known to utilize chironomids as a food source and important trophic link between algae and larger predators (Batzer, 1998), the results of the exclosure experiments appeared confounding.

It is possible that the dense mats of algae that formed in total exclosures did have significant numbers of chironomids. These algal mats were observed to become so dense that they trapped pockets of gas bubbles under them (methane from the sediments or oxygen from the algae), and on subsequent incoming tides the mats would reach a critical density peel up, and float to exclosure edges. It is likely that chironomids went with these mats periodically leaving relatively bare mudflat still inhabited by the sub-surface dwelling oligochaete worms. It is also possible that in contrast to the lighter colored, higher albedo mud and less algae in control plots, the much darker, low albedo and dense blue-green filamentous mats created some kind of physical threshold from heat or oxygen depletion beyond which these species of chironomid could not tolerate. Was this a case of an artificially induced bottom-up control of algae on a specific invertebrate, or an unforeseen result of the lack of a top-down grazer control exposed by the exclosure experiment? (Power, 1990,1992).

The enclosure/exclosure experiments of adult and larval fish conducted by Batzer (1998) found that while fish were consuming chironomids, exclusion of fish actually harmed midge populations rather than benefiting them. Their conclusion was that the fish were also consuming other invertebrates that were predators or competitors of the chironomids which had an indirect positive feedback to the midges greater than the direct effect of fish predation on the midges directly. This emphasizes the usefulness of exclosures in uncovering species interactions, and the difficulty in determining trophic level influences, even in the seemingly simple tidal freshwater mudflat system. The

Kenilworth mudflat interaction between chironomids and mudflat algae should be investigated further, as these findings and those of the above studies contradict the findings of others that reduced predation and increased algal coverage should enhance some invertebrate populations (Campeau et al., 1994; Rader and Richardson, 1994).

3.7.3 Mudflat Invertebrate Population Crash?

Another interesting result of the invertebrate exclosure study was the 89% decrease in total oligochaete numbers and 92% reduction in total chironomid numbers across all treatment plots between 1997 and 1998 yearly total invertebrate counts (Appendix A, Tables 3.7 & 3.8). Severe flooding of the Anacostia River in January-February of 1998 effectively kept the mudflat permanently submerged for several weeks with unusually high water levels for several months (Figure 3.22).

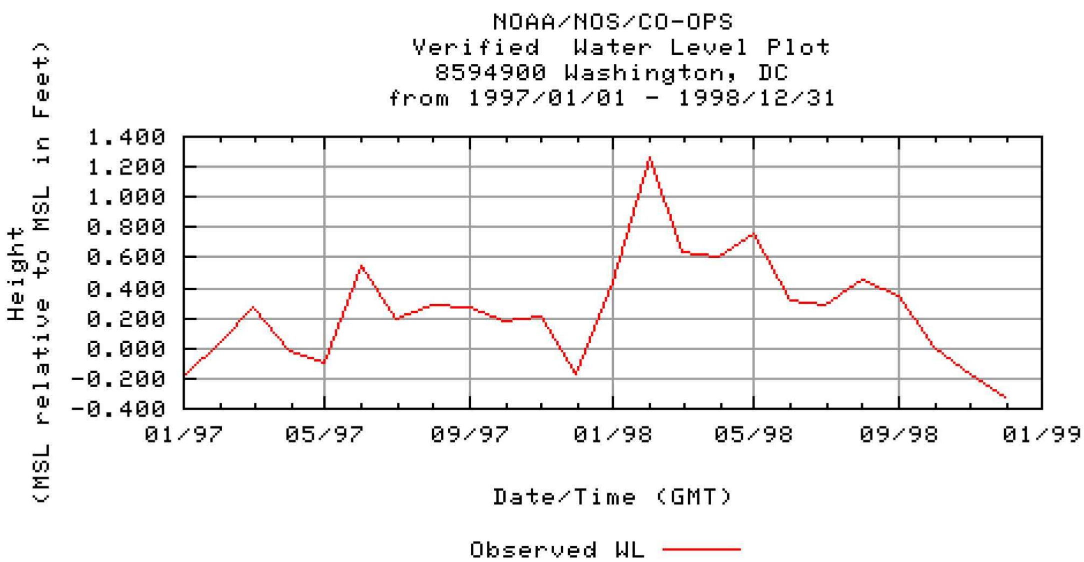

Figure 3.22 Water levels depicting higher levels in 1998 over 1997.

While it is not certain why this would have an effect on the oligochaete and chironomid invertebrate communities, if it did at all, it was the only outstanding event that occurred in 1998 that might explain the drastic reduction in the populations of these two groups. Corbicula was not negatively affected and had a 28% increase in total numbers.

Perhaps the effective temporary conversion of the study mudflat from an intertidal to a subtidal zone allowed greater invertebrate predation by fish, although these invertebrate communities are known for rapid population increases within short time periods and should have recovered to be identified in the monthly sampling throughout the year. Ice shear may have been a factor, or the greater deposition of sediment on the study mudflat from the flooding. It is also possible that the 1998 numbers were the "normal" populations for these two groups and that some effect in 1997 caused greatly increased populations of the two groups to occur. Without longer term invertebrate sampling it is difficult to determine.

3.7.4 Strong Fish Influence Over Invertebrates

Direct observations of feeding and evidence of shorebird and goose tracks within openly accessible control plots revealed that shorebirds and waterfowl were utilizing the areas (Appendix A, Table 3.13). While shorebird predation of invertebrates on mudflats is well documented (Quammen, 1984; Riese, 1985, 2001), the evidence from the treatment exclosures at the Kenilworth study mudflat indicates that fish exert a stronger effect on the oligochaete and chironomid invertebrate populations than shorebirds as invertebrate densities were not significantly different between the control AA and fish accessible FA treatments. If the numbers of these invertebrates were significantly lower in the control treatment than the fish accessible only treatment, assumptions could be made that shorebirds have a strong effect on Kenilworth oligochaete and chironomid invertebrate populations. Although shorebird utilization of the Kenilworth mudflat was documented by regular bird surveys, observations of significant numbers of fish (most notably *Fundulus* sp. swarming the mudflats on the edge of flood tides) are most likely the driving force affecting the oligochaete and chironomid populations at Kenilworth.

Herons were also using the site as successful feeding grounds for fish during tidal exchanges. Predation risk for fish by birds can be great (Power, 1984; Crowder et al., 1997), but intertidal food sources such as abundant oligochaetes and piscivorous fish predator avoidance appear to be an irresistible draw for the *Fundulus* sp. and other small fishes (Rozas and Odum, 1987; McIvor and Odum, 1988; Rozas et al., 1988; Horn et al., 1999).

Tidal freshwater marshes are important spawning, nursery and feeding habitat for numerous resident freshwater and estuarine fishes, as well as anadromous, semi-anadromous and catadromous species of fish (Odum et al., 1984; Rozas and Odum, 1987, Rozas et al.,1988; Mitsch and Gosselink, 2000). Electrofishing of the Kenilworth restored marsh Mass Fill 1 &2 areas, the Kenilworth Mass Fill 3 mudflat area, and the Dueling Creek reference marsh all revealed similarities among them in the shared species of fish collected (Table 3.8). There are, however some differences in average numbers of particular species and total fish collected as well as the relative abundances of specific species of fish (Tables 3.3 to 3.6).

In terms of average numbers of fish collected, electrofishing at the two restored marsh (MF1 & MF2) and one mudflat (MF3) site were dominated by the omnivorous bottom feeding brown bullhead catfish *Ameiurus nebulosus*, and the gizzard shad *Dorosoma cepedianum,* a planktivore (Figures 3.5 to 3.7). Alternatively, the Dueling Creek marsh reference site was dominated by schools of young of the year, migratory blueback herring *Alosa aestivalis*, the semi-migratory piscivore white perch *Morone americana*, and the small prey fish the eastern silvery minnow *Hybognathus regius*. Dueling also supported greater average numbers of the top end tertiary consumer the largemouth bass *Micropterus salmoides* (4.8 fish/survey) when compared to the three other Kenilworth sites combined (0.7 fish/survey) (Tables 3.3 to 3.6). These numbers may suggest that the Dueling reference site reflects the fish composition of what might be expected of a more mature marsh, with a greater balance of species and trophic level interactions. The Kenilworth sites were surveyed for fish when the restored marsh was less than 5 years old. Kenilworth had existed almost completely as an intertidal mudflat prior to restoration. The restored marsh may still be living with the ecological memory (Peterson, 2002) of a mudflat and will take some time for the marsh to develop and the fish community to respond.

Experimental evidence from the Kenilworth fish exclusion treatment plots, when compared to the fish accessible plots, suggests that benthic feeding fish found in electrofishing surveys from the families *Fundulidae, Cyprinidae,* and *Ictaluridae,* were a dominant predation, grazing and disturbance factor on the mudflats with regard to invertebrates and algae.

3.7.5 Algal Grazer/Disturbance Activity

Algal primary production is considered a potentially important energy base for tidal marsh food webs (Odum et al., 1984; Stribling and Cornwell, 1997; Mitsch and Gosselink, 2000; Currin et al., 2003). It is interesting that grazer pressure on primary production at the study mudflat seems to be proportionately related to size, with invertebrates and fish affecting a relatively greater influence on the algae than birds, while some waterfowl, specifically Canada geese *Branta canadansis*, appear to have a much greater influence on emergent macrophyte growth. To a different degree the geese influence algae as more of a disturbance factor from trampling across exposed mudflats and shoveling up mud in search of macrophyte roots, tubers and seeds (Belanger and Bedard, 1994). The initial hypothesis was that there may be an additive effect of bird and fish disturbance and grazing factors affecting algae coverage on the mudflat. Fish grazing and disturbance on algae was expected to be from common carp *Cyprinis carpio*, and brown bullhead catfish *Ameiurus nebulosus*, which both have bottom-feeding behaviors (Rohde et al., 1994). The effect of killifish on algae growth may also be significant, and for those that have observed them closely possibly analogous to a wave of roto-tillers turning over the thin surface layer of the mudflat in their mouths and with their tails on the edge of flooding tides while searching for food.

Although the bird accessible control plots had lower percent cover of algae across both years when compared to fish only accessible treatment plots, the effect was not statistically significant (Figure 3.13). Fish only accessible treatments did have a higher algae percent cover than the control plots but less than the total exclosures, supporting the differential effect of grazing and disturbance by fish and birds. Because the bird accessible/ fish exclosure was not successful in allowing birds into the plots, the reverse effect of fish accessible/bird exclosure could not be tested. What is certain though, is that by excluding the grazing and bioperturbation effects of fish and geese from the algae growing on the study mudflat, the result would be significantly greater algal coverage.

3.7.6 Response of Emergent Macrophytes to Birds and Fish

Bird surveys conducted at the study mudflat were clear in which species were the most dominant in total numbers, and likely to be the most important in their effect on macrophyte emergence and survivorship. The Canada goose *Branta canadensis*, (both resident and migratory) was the most numerous bird observed on and around the mudflat study area at Kenilworth (Table 3.1). Large waterfowl grazers such as these have been known to have a significant impact on emergent macrophyte vegetation when their populations become too much for the natural areas they frequent to sustain (Smith and Odum, 1981; Lodge, 1991; Kotanen and Jefferies, 1997).

The unexpected emergence of volunteer plants within exclosure plots and not within control plots gave impetus to a controlled intentional planting study which yielded results similar to that of the algae. Differences were expected between the non-fenced control treatment plots and the total exclosure treatment plots. Almost immediately all of the intentional plantings in each of the control plots had completely disappeared within 2 weeks of their placement (Figure 3.19). There was some question as to whether the fish accessible/bird exclosure treatment plots would respond similarly to the control treatments, as both were completely open and accessible to carp *Cyprinus carpio*, which were known to be utilizing the area and have been demonstrated to be a disturbance factor (King et al., 1997; Lougheed et al., 1998). The greater numbers of volunteers found within block C over the other two block replicates may be due to slightly higher elevations within the C block or its proximity to the tidal inlet.

Interestingly, the separate and combined effects of fish and birds on algae was also seen with emergent macrophytes. The fact that all planted plugs persisted within the fish accessible/ bird exclosure treatment plots for several weeks suggested that the exclosure type might respond more like the total exclosure plots which also had no loss of plants. While this was initially the case, regular visits to the site noted persistent grazer pressure on the plants within the fish accessible treatments in the form of missing leaves and stalks as well as the complete disappearance of several of the planted plugs within each of the those exclosure plots.

Additionally, there were also notable differences in the growth and vigor of the plants from the total exclosure plots, of which every planted plug survived and grew well without any evidence of grazing. By comparison, the fish accessible/ bird exclosure plants appeared stunted and often had stalks with no leaves from grazing. There were significant differences in the dry weight biomass between the total exclosure and fish only accessible treatment types (Figure 3.20). This could be accounted for by the repeated stress of the grazed plants within the fish only accessible plots undergoing the stress of having to regenerate biomass while the ungrazed plants were free to grow more vigorously without the stress. Basically, if there was no exclosure barrier to geese, then no plants survived at the exclosure mudflat elevations. If fish could access the biogenic mudflat but not geese there was some survivorship and moderate biomass while if there was no access by fish or geese then there was complete survivorship and significantly more biomass then either of the other two treatments that allowed some access by grazers.

3.7.7 River Turtle Influence

While the most likely grazers to be impacting the fish accessible/bird exclosure plots were thought to be carp, turtles such as the painted *Chrysemys picta picta*, red-eared slider *Chrysemys scripta elegans*, and snapping turtle *Chelydra serpintia*, were also found within exclosures and noted around the mudflat study area (Appendix A, Table 3.14). It is believed that they could have also been opportunistically grazing on the young shoots, leaves and regrowth of the planted plugs, contributing to the stress and reduced dry weight biomass of the macrophytes from the fish accessible treatment plots.

Evidence of river turtle use of the mudflats was unexpectedly observed on the study mudflat and within exclosure plots (Appendix A, Tables 3.14 & 3.16). Their effects on the mudflat are not certain, although when occasionally found trapped in an exclosure during spring high tides the disturbance to the biogenic mudflat algae was noticeable as they slid about the exclosure searching for an exit at low tide. Many species of turtles are known to be omnivores, and could be a factor in the grazing or bioturbation caused removal of the experimental plantings in the biogenic mudflat exclosures (Moll and Moll, 2004). There is certainly a need for a greater understanding of the role that turtles have in the Anacostia River, as it may be significant (Iverson, 1982; Congdon and Gibbons, 1986; Moll and Moll, 2004).

3.7.8 Mollusks and Mammals on the Mudflats

Identified use of the study mudflat by mammals, primarily raccoons *Procyon lotor*, was revealed by obvious signs of digging with tracks found around holes in the mud. The Asiatic clam *Corbicula fluminea*, are a likely subject of the search as they were found in numbers within each of the exclosure treatments (Figure 3.11) and empty shells were found scattered around sites where a raccoon had obviously been digging. Empty shells of the freshwater mussel *Anadonta* sp. were also found, although as many of the genus with the common name "floater" suggests, they could have come in on the tide as they were not found in subsurface sediments of the study muflat but were found in tidal flats on other parts of the Anacostia River. The apple or "Asian mystery" snail of the family Vivipridae was also regularly found within or near the study exclosures, and occasionally Planorbid or Physid snails were also identified (Appendix A, Table 3.17). The snails could have also been prey for raccoons as well as some wading birds, fish or carnivorous waterfowl. They were not found in numbers on the study mudflat that would suggest they are a significant factor in algae grazing and they may be suppressed by predation on the exposed flats. The relative lack of snails within exclosures may be a result of their inability to reach the refugia in any numbers without being eaten. Larger snails would also have trouble penetrating the small mesh size.

3.7.9 The Most Interesting Animal

Probably the most interesting animal(s) found on the mudflat study area, and within several of the exclosure plots, were the colonies of the phylum Ectoprocta, the bryzoan *Pectinatella magnifica* (Appendix A, Table 3.18). A freshwater species of the more common marine forms, they are structured and function similarly to corals but are not related. These animals were likely carried in on the tide and settled on the study site adding another interesting, albeit incidental, species to the ecology of the mudflat.

3.8 Conclusions

The Kenilworth Marsh experimental biogenic mudflat exclosure study determined that fish and birds had differing impacts and unforeseen influences on benthic macroinvertebrate densities and algae coverage as well as macrophyte emergence, survivability and biomass. The exclosure experiments followed for two years at Kenilworth were proven to be an important tool in revealing the sometimes complex and unexpected interrelationships of the intertidal mudflat food web. Several basic interactions are now better understood and the case for a greater appreciation of these systems can be made.

The theory of alternate stable states was first considered with the voluntary emergence of plants within the exclosure study plots. The study mudflat, which had existed in an unvegetated state for over 3 years, was released from plant grazing and disturbance pressure by fish, possibly river turtles, and most certainly geese. The 1998 study of intentional plantings of emergent macrophytes revealed a stark and significant contrast between total, partial and non-excluded control treatment plots. What is interesting is that there appears to be a gradient of grazer pressure that would have not been realized without the partial "fish only accessible" exclosure treatment.

The removal of exclosure treatment fencing in 1999 revealed that even a completely vegetated 7m x 7m plot of almost 2m high *Pontederia cordata* (Figure 3.23) could be completely removed by geese within a week. Within two weeks there would be almost no evidence of roots or tubers as the geese would have dug them out, leaving nothing but their numerous tracks in the mud at low tide (Figure 3.24). No regeneration of the plants occurred in the following years after the exclosure fencing was removed.

Figure 3.23 Kenilworth exclosure filled with *Pontederia cordata*. The exclosure to the right is fish accessible.

Figure 3.24 Goose tracks covering the mudflat study area at Kenilworth Mass Fill 3.

This complete change in condition, from biogenic mudflat to emergent marsh and back again to biogenic mudflat, exemplifies several of the tenets of alternate state theory. Alternate state changes are often sudden, obvious and triggered by some external mechanism. In this case the triggers were exclosure fencing, and goose grazer pressure. In a review article 30 years ago, May (1977) stated that he felt without empirical evidence, multiple or alternate species states would remain a theory, and evidence would be largely metaphorical. It is believed that this study of a tidal freshwater biogenic mudflat was able to add empirically to the debate over alternate state theory, and in this case move the theory from the metaphorical to the verifiable.

Chapter 4: Kingman Lake/Marsh Experimental Ecology

4.1 *<u>Introduction</u>*

The area that was known as Kingman Lake once existed as part of the expansive emergent marshes that historically dominated the Anacostia River. Coues and Prentiss (1883) describe the marshes "for three miles above the railroad bridge the channel winds tortuously between extensive marshes composed of wild rice (*Zizania aquatica*)…" which were renowned for seasonal bird hunting (Figure 4.1). The silting in of the river and the threat of malaria from mosquitoes spurred plans to dredge the river marshes to create a "lake" for recreational boating, which was undertaken by the U.S. Army Corps of Engineers (USACE) between the 1920's and late 1940's (Figure 4.2)(USACE, 1913; Syphax and Hammerschlag, 1995). After the dredging of the marshes and straightening of the river was completed, Kingman Lake began filling in with decades of deposited sediment from erosion in the watershed to the river. Intertidal mudflats formed and became the dominant feature of the Kingman area at low tide.

Figure 4.1 Nineteenth-century image of rail hunting on Anacostia River wild rice marshes (Coues and Prentiss, 1883).

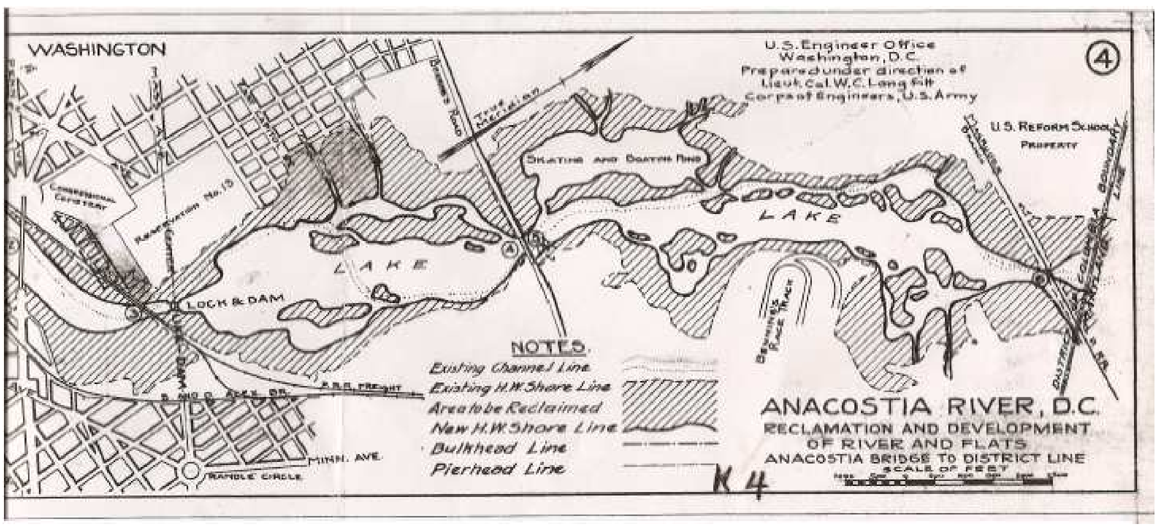

Figure 4.2 U.S. Army Corps of Engineers 1913 map of existing and planned Anacostia River shorelines.

In 2000, intertidal portions of Kingman Lake were reconstructed by the U.S. Army Corps of Engineers to restore the historic emergent marshes. With management oversight by the U.S. National Park Service and the District of Columbia City

Government, Kingman Lake would become Kingman Marsh. Dredged river sediments from the Anacostia River channel were used to increase mudflat surface elevations to levels that would support a restored emergent marsh similar to that of the Kenilworth Marsh restoration effort that was completed in 1993. For Kenilworth Marsh, a range of target elevations above mean sea level was designed for low (1.75'), middle (2.1'), and high (2.5') marsh NGVD '29 (National Geodetic Vertical Datum based on mean tide levels around the year 1929) (Syphax and Hammerschlag, 1995). Learning from the results of the initial Kenilworth Marsh vegetation patterns that revealed a high degree of high marsh volunteer native and invasive species (Guerrero and Hille, 1994), the Kingman Marsh restoration design elevations were planned to be lower (2.0' NGVD '29) to supress the establishment of invasive non-native species such as purple loosestrife (*Lythrum salicaria*) and common reed (*Phragmites australis*), that were found to be a problem at Kenilworth with higher elevations (Hammerschlag et al., 2006). Optimal surface elevations for emergent marsh establishment and macrophyte species diversity and cover was determined to be at 2.1' NGVD '29, which on the Anacostia River is approximately mean high tide (Bowers, 1993; Hammerschlag et al., 2006). Tidal channels or "guts" were cut into the planted restoration areas to allow for river waters to access the restored marsh areas.

Approximately 13 hectares of marsh were restored with 700,000 individual macrophyte plugs installed comprised of 6 native species spaced evenly throughout the area. The restoration areas were defined as Kingman Marsh "Cell" 1 and "Cell" 2, with a majority of the restoration area (11 ha) located in Cell 1 (Figure 4.3). While marsh restoration planting was taking place, resident Canada geese *Branta canadensis maxima*, (non-migratory descendants of captive birds released in the early 20th Century) began grazing newly planted material and triggered adaptive management decisions by managers to erect goose exclusion fencing around the perimeter and within the interior of the marsh restoration areas (Hammerschlag et al., 2001). With goose exclusion fencing in place, by the end of the first growing season in 2000 average emergent marsh plant cover of both restoration Cells was considered successful with nearly100% cover attained (Hammerschlag et al., 2001).

Figure 4.3 Locations of Anacostia River marsh restoration projects with year of completion and Dueling Creek reference area. Kingman Marsh Cell 1 restoration area at the center bottom. Image from USGS Patuxent Wildlife Research Center, 2003.

By September of 2000 the marsh vegetation in Cell 1 was colonized by numerous species that had not been planted, including small numbers of the non-natives *Lythrum salicaria and Phragmites australis. S*pecies planted for the restoration included, *Pontederia cordata*, *Sagittaria latifolia*, *Peltandra virginica, Schoenoplectus tabernaemontani*, *Juncus effusus*, and *Nuphar luteum*. With the removal of goose exclosure fencing in early 2001, percent cover at both restoration areas of Kingman declined 40-60% (Hammerschlag et al., 2002). Subsequent years cover also declined considerably, a result of combined goose grazer pressure and the erosion and settling of the dredged river sediments resulting in lower surface elevations than had been planned (Hammerschlag et al., 2006). It was estimated that roughly 50%, or between 300,000 and 400,000 plants installed for the restoration were grazed upon or pulled out by the geese, preferentially consuming *Sagittaria* and *Pontederia*, although the young shoots of other typically non-palatable species such as *Peltandra* have been known to be eaten (Harris, 2002).

In 2000, as a result of the unexpectedly intense goose herbivory found during the restoration planting, a preliminary plan for the implementation of an experimental goose exclosure study was developed. The study was influenced by the results of the exclosure studies conducted at Kenilworth Marsh that found geese to be the limiting factor in voluntary macrophyte emergence (Chapter 3). The Kingman Marsh exclosures comprised a much larger area of potentially biogenic mudflat, with the focus of the study on the effects of goose grazer pressures suppressing emergent marsh regeneration. The exclosures were sited in an area of Cell 1 that had not been previously planted and remained a mudflat (Figure 4.4).

In early June of 2001, the experimental exclosures were constructed. While the entire experimental exclosure study area (including unfenced control plots) at Kenilworth comprised 588m^2, the Kingman study area covered 2,700m^2 . The exclosures in this area, which existed as an intertidal mudflat with surface elevations ranging from 1.3’ to 2.0’ NGVD ‘29 (USGS Survey, 2004), were maintained for 4 years to follow the emergent macrophyte community that immediately developed under the exclusion of goose grazer pressures.

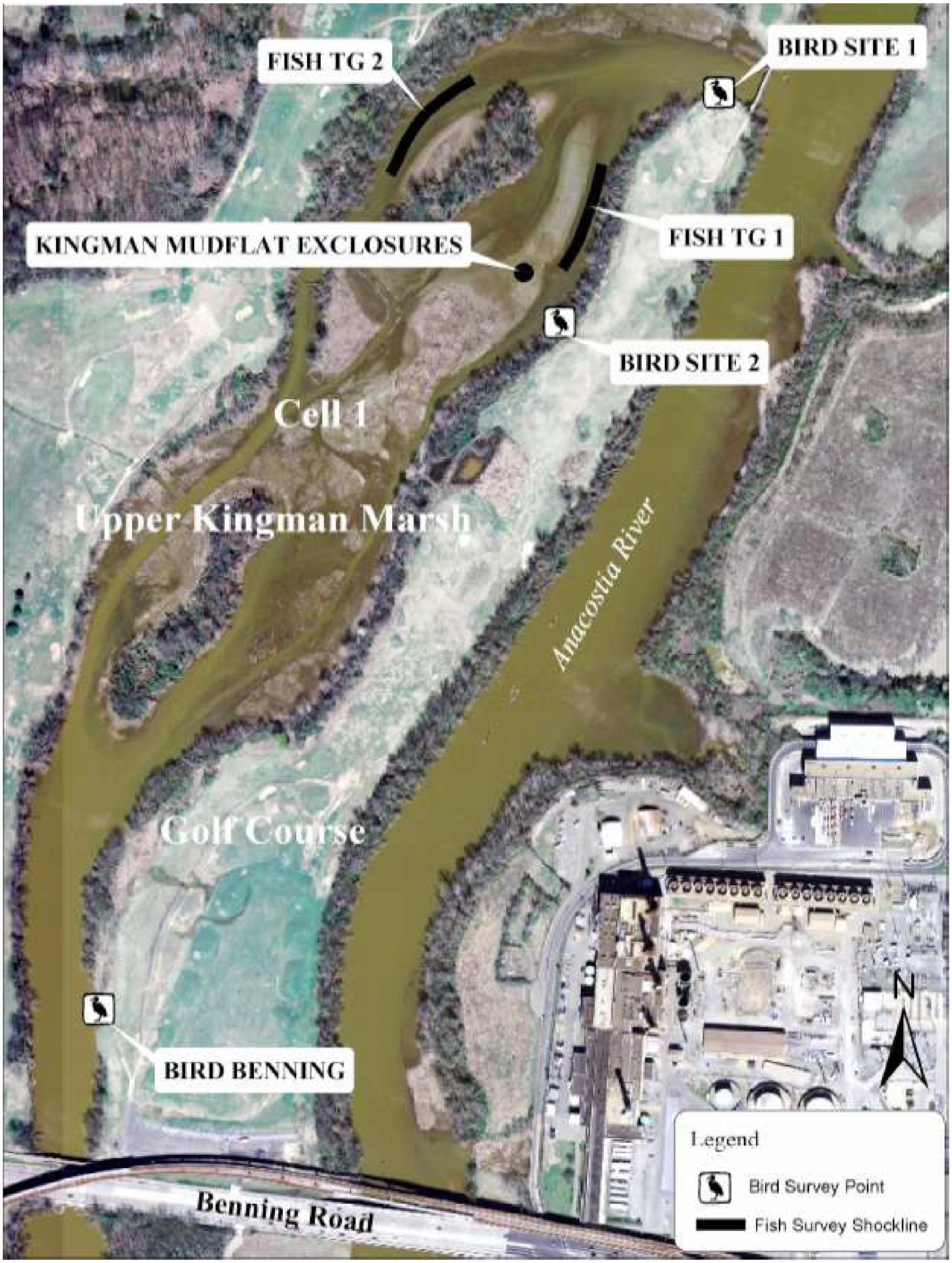

Figure 4.4 Upper Kingman Marsh Cell 1 restoration area with study site locations.

Between in 1997 and 2001 bird surveys were conducted on the mudflats of Kingman Cell 1 as well as the golf course on Kingman Island. These surveys revealed an increasing trend in the numbers of geese that resided in and around Kingman Lake that was a factor in the restoration of Kingman Marsh (Figure 4.5). Fish surveys of the mudflats of Kingman Cell 1 were also conducted beginning in 1996.

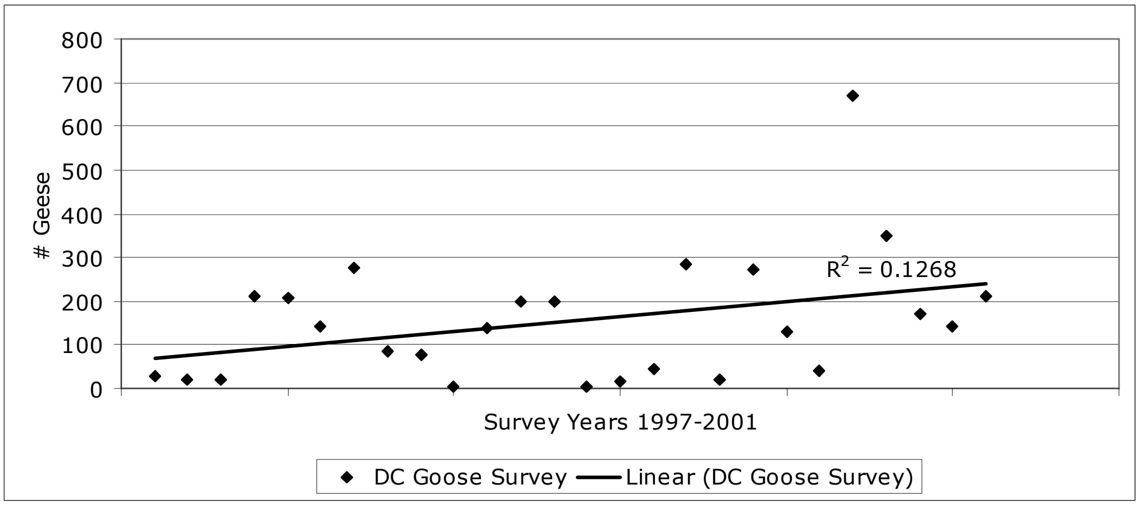

Figure 4.5 Kingman Lake/Marsh Canada goose counts showing increasing numbers found on the mudflats, open water, and golf course around Upper Kingman Cell 1.

The effects of the exclosure fencing in stimulating the mudflats toward the emergence of macrophytes, confirmed the role of herbivore grazing at Kingman Marsh as a strong top down force in controlling macrophyte emergence, survivorship and growth (Power, 1988,1992). Just as the results of the Kenilworth exclosure study inferred, the Kingman exclosures were also expected to support the potential for the low-middle marsh intertidal mudflat areas on the Anacostia River to be models of the rationale behind alternate state theory. As already stated in Chapters 2 and 3, this theory has been forwarded as a way to describe the parallel potential, yet alternate emergence, of different community types within a single environmental condition triggered by some internal or external force. In the case of Anacostia River marsh restoration, the triggers were the Army Corps of Engineers as a marsh attractor and resident geese as a mudflat attractor (Kangas et al., 2004). The alternate state concept, and its application to the results of the Kingman mudflat research, would also apply to future emergent marsh restoration on Anacostia River.

4.2 Study Area Description

The Kingman Marsh (38° 54' 17"N, 76° 57' 42"W) exists as a 45 ha tidal impoundment of which approximately 13 ha of emergent marsh was restored in 2000. It is situated just west of the Anacostia River, separated by Kingman Island and connected tidally by northern and southern inlets (Figure 4.3). Kingman Island is bisected by Benning Road bridge, with the northern half of the island managed as a golf course by the National Park Service and the southern half of the island forested and administered by the District of Columbia City Government. Kingman Marsh is less than 1 km below the Kenilworth Marsh on the river. The site is influenced by a semi-diurnal freshwater tide with an average tidal amplitude of approximately 1.0 m. At low tide, large areas of unvegetated mudflats still exist around and in between the seasonally dense, restored vegetated areas. Soil variables for Kingman surface sediments 48% sand, 33% silt and 19% clay with 6% organic matter and a pH of 7.06 (Neff, 2002). Kingman Marsh north of Benning Road (Kingman Cell 1) consisted of 11 ha of emergent marsh in 2000, and is the location of the work completed for this study (Figure 4-4). The exclosure experiment area was located on unplanted tidal flats approximately 300m southwest of the northern

Kingman inlet and immediately north of the marsh restoration planting area.

4.3 Research Methods and Materials

4.3.1 Birds

Birds were observed at the Kingman mudflats beginning with two surveys at one site in the fall/winter of 1997 and then twice monthly beginning in spring 1998 continuing through January of 2001 (Appendix B, Table 4.1). Observations were initially made in 1997 from one site (Site #1) at the northern edge of Kingman Island (Figure 4.4). In spring of 1998 another site was added (Site #2) from the edge of a wooded area approximately 300m south of Site #1 adjacent to the mudflats. Counts of geese were also made from the golf course on Kingman Island and in the open water area just above Benning Road Bridge. All bird surveys were conducted at low tide, as low tide counts are considered representative of average waterbird usage (Burton et al, 2004). A count of all birds within the field of view of the mudflat study area was conducted over a period of 30 minutes, with each species and their numbers recorded. Only birds with a water connection were identified, with all primarily terrestrial bird species not counted in the survey. After an initial count over 15 minutes, the remainder of the time was spent observing the behaviors of the birds on the mudflat with additional counts made for new birds entering to the site. All counts of large numbers of birds were double-checked during this time period and the lesser of the two numbers used as the official count. Basic abundance, numbers of species, frequency and relative importance of each species found during the observation period were calculated.

4.3.2 Fish

Fish surveys were conducted over two sites (TG1 and TG2) along tidal "gut" (TG) channels within Kingman Lake (Figure 4.4) using a Smith-Root fish electroshocking boat operated by the D.C. Government Fisheries Division. Surveys were conducted on a flooding high to slack tide during each shocking run. Shocking levels were set at 240-500 volts at 3-5 amps, 60 pulses/sec, adjusted for conductivity (D.C. Fisheries standard operating procedures). Approximately 1000 seconds of shocking time was conducted along each electrofishing shock line. Each survey was completed through two, 100m passes over the same area, once in and once out of the survey line. A total of 6 electrofishing surveys were completed (two on each shocking date) covering a spring, summer and fall season in 1996 and 1998 (Appendix B, Table 4.2). All fish collected were kept in live wells on the boat and identified to species, counted, measured for length and released after shocking was completed. Game fish and larger fish species were also weighed to the nearest whole gram.

4.3.3 Exclosures

In early June of 2001, exclosure fencing was installed in an area of Kingman Marsh Cell 1 that had been left unplanted and remained mudflat (Figure 4.4). Two different sized treatments of fenced exclosure plots and unexclosed control plots with three replicates each were constructed. The two different rectangular exclosure sizes (15m x 10m and 15m x 20m) established a total of 6 exclosed and 6 unexclosed plots with a total area of 2,700m^2 (0.27ha), half of which excluded geese (Figure 4.6). Plots were identified by size (10 or 20) and excluded (X) or unexcluded (U), with replicates

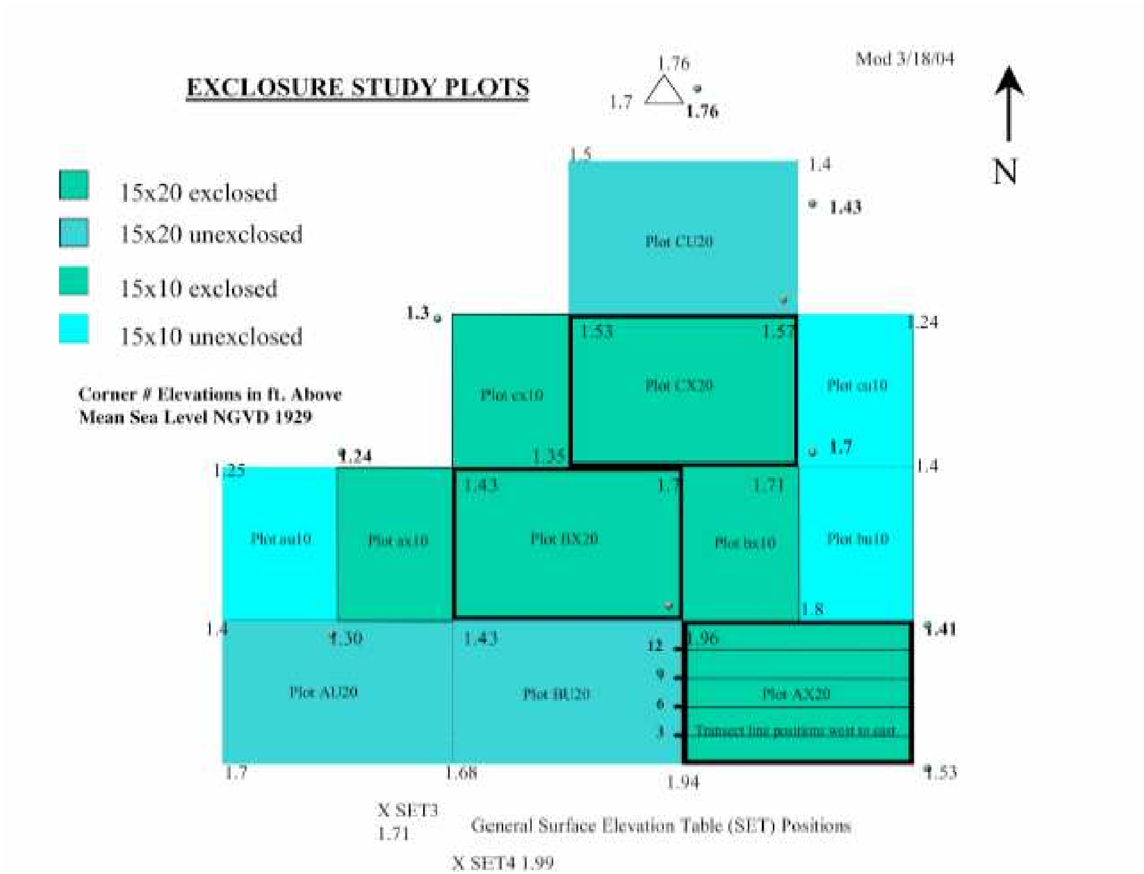

Figure 4.6 Kingman Marsh exclosure study plots with corner surface elevation points.

identified by the letters A, B, or C. The two plot sizes were used for the purpose of determining the effect that exclosure size would have on goose accessibility and the restoration potential of larger sized fenced plots. Vinal coated wire fencing with 3cm diameter mesh and 1.2m in height was utilized as exclosure material and staked with 5cm x 5cm, 2m wood stakes that were left in the marsh from the restoration work. The mudflat surface elevations at the corners of each plot were surveyed by the USGS and tied to NGVD '29 (National Geodetic Vertical Datum based on mean tide levels in the year 1929). Plots were arranged with fenced treatment plots sharing common sides to maximize available exclosure area with available fencing. An attempt was made to stratify the location of the entire block of all plots on the mudflat so as to incorporate the range of visually observable surface elevations while fitting into the available mudflat area. While treatment plots were not random or independent, the primary goal of the exclosure plot design was to test the ability of two sizes of exclosures and unfenced control plots to support macrophyte emergence. Exclosure design was determined through collaboration with staff of the USGS.

4.3.3.1 Emergent Macrophytes

Transects were run from west to east across each exclosure plot from 3, 6, 9, and 12m along each plots 15m side (Figure 4.6) using a 100m tape. Species percent cover between each meter mark, species presence/height at each meter mark and 4 randomly placed quadrats of above ground biomass were collected along each of the four 10m or 20m transects crossing each exclosure plot. The macrophyte data were collected once a year in late August or September for four years (2001-2004). These measurements were not necessary in unexcluded (control) plots as no plants volunteered in any year and they remained 100% biogenic mudflat. Access across each plot was consistently made along the north side of each transect line to reduce trampling effects on plant measurements made on the south side of each transect line (Cahill et al, 2001). Visual estimations of cover for each species present were made between each meter mark to 1m south of the transect, with percentages rounded to the nearest 5.0%. Cover from species with less than this were marked as having 1% increments. The estimation of the percent cover of mud was also determined. The presence of the species found at each meter mark on the transect line and its height above the biogenic mudflat surface was recorded.

For biomass collections, a random numbers table generated four locations along each of the plots 4 transect lines at which a 0.25 m^2 aluminum hoop quadrat was laid on the south side of the tape. All surface vegetation falling within the quadrat was cut at mud level, collected and bagged with a plot and transect location code. This system accumulated a total of $4m^2$ of randomized biomass data for each of the 6 treatment plots sampled. Samples were taken to a lab where each was rinsed of mud and separated into different species within each sample. All samples were initially spread out and air dried in the lab, then paper bagged and oven dried at 80° C for not less than 48 hours, after which they were weighed to the nearest 0.01g and recorded for species and location code.

4.4 Data Analysis Methods

Absolute and relative abundance, average numbers of individuals observed/survey, frequency and importance values of each species recorded during the observation periods were calculated for all bird and fish data.

Arithmetic means of all macrophyte cover data for each species were calculated through the SAS Proc Means procedure plus/minus one standard deviation (SAS version 9.1, 2006). Analysis of variance was not conducted on exclosure macrophytes as there was not enough data from each species to support an ANOVA and the lack of randomization and independence of the plot design violated the assumptions of the ANOVA. The complete lack of any macrophyte cover in the control plots throughout the 4-year study created an interesting situation with the data for which there was no variance, so no ANOVA could be run to compare exclosure treatments to controls. The arithmetic means plus 1 standard deviation were plotted for cover for each species measured in the two exclosure sizes for each year. Cover data was also applied to mudflat surface elevations plus/minus 1 standard deviation. Biomass data was handled similarly to cover data. Arithmetic means were used for each species biomass over the four year period with means produced from Proc Means.

Mudflat surface elevation points taken at the corners of each excluded and unexcluded plot (Figure 4.6) analyzed using the SAS procedure Proc G3D (SAS, 2006). SAS Proc G3D was set to extrapolate the surface area at 1.0 ft. major intervals to match the intervals of the surface elevation survey data to create the three dimensional field topography of the experimental plot area (Figure 4.7). Plane coordinates for X and Y for each transect were created to fit the field as the entire experimental area was essentially set up as a grid. Arithmetic means cover data for transect coordinates were matched within extrapolated surface elevation ranges (1.25', 1.35' NGVD '29, etc.) and plotted.

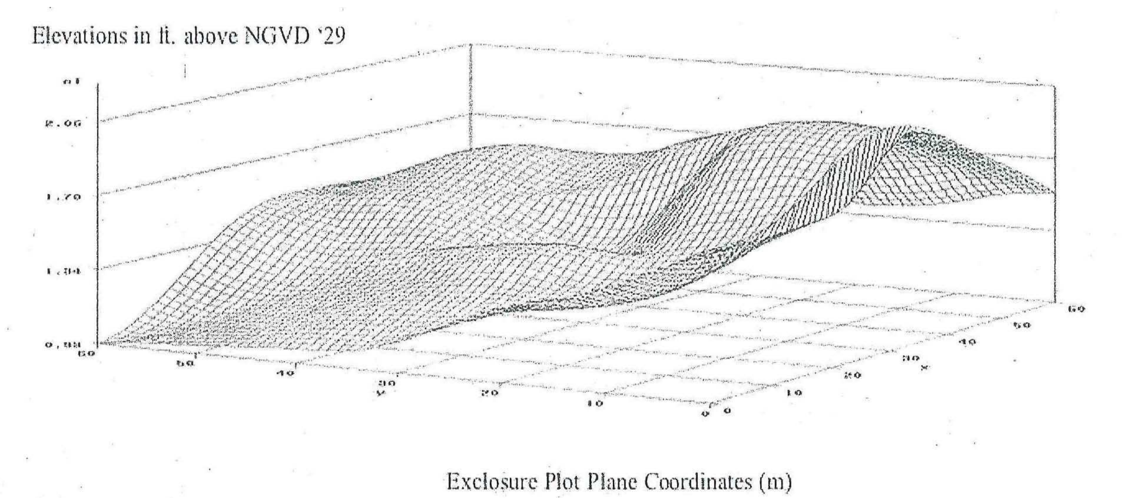

Figure 4.7 Kingman Exclosure plot area exaggerated sediment surface elevations.

Biomass data were analyzed similarly to cover data. Arithmetic means were used for each species biomass over the four year period with means produced from Proc Means. Mean biomass was plotted against elevation between the 1.5-1.7' NGVD '29 low marsh zone to focus on the elevations points where biomass begins to increase.

For the species presence data a general linear mixed model procedure was used (Proc Glimmix), as the data was set up to be binary (1/0, presence/absence) for each species. The Glimmix allows a binary distribution to be modeled, which is not normally distributed as opposed to the assumption of a normal distribution for an ANOVA (SAS, 2006). Species height data was applied to the 3D mudflat surface elevation model and plotted at their location along each transect within each exclosure plot.

4.5 *<u>Results</u>*

4.5.1 Birds

Surveys of birds at Kingman were taken at 103 site visits on 34 dates between 1997 and 2001 (Appendix B, Table 4.1). Over this period of time, a total of 7,247 were counted representing 7 families of birds. Of that number 5,297 were Canada geese *Branta canadensis* (Appendix B, Table 4.2), representing 73% of the total number of birds observed (Table 4.1). Surveys of goose populations in and around the Kingman Marsh over the three years leading up to the restoration found an increasing trend in the population of resident geese (Figure 4.5). The second most abundant species of bird observed was the ring-billed gull *Larus delawarensis*, of which 787 were recorded with a relative abundance of 11%. The killdeer *Charadrius vociferous,* a common inland shorebird followed with 719 individuals recorded comprising 10% of the total number

Table 4.1 Kingman bird surveys 1997-2001 listed in order of importance value (relative abundance + frequency / 2)

23 Species	34 Observation Dates 28 Mudflat Only	Absolute Abundance	Average # / Survey	Relative Abundance	Frequency	Importance Value
Branta canadensis	Canada goose	5297	155.79	73.1%	85%	79.19
Ardea herodias	Great blue heron	120	4.29	1.7%	93%	47.26
Larus delawarensis	Ring billed gull	787	28.11	10.9%	61%	35.79
Charadrius vociferus	Killdeer	719	25.68	9.9%	54%	31.75
Anas platyrhynchos	Mallard	137	4.89	1.9%	39%	20.59
Corvus ossifragus	Fish crow	40	1.43	0.6%	32%	16.35
Casmerodius albus	Great egret	25	0.89	0.3%	25%	12.67
Larus argentatus	Herring gull	16	0.57	0.2%	14%	7.25
Tringa melanoleuca	Greater yellowlegs	28	1.00	0.4%	11%	5.55
Anas acuta	Northern pintail	14	0.50	0.2%	11%	5.45
Calidris pusilla	Semipalmated plover	10	0.36	0.1%	11%	5.43
Haliaeetus leucocephalus	Bald eagle	2	0.07	0.0%	7%	3.59
Gallinago gallinago	Common snipe	2	0.07	0.0%	7%	3.59
Larus philadelphia	Bonaparts gull	30	1.07	0.4%	4%	1.99
Anas crecca	Green-winged teal	6	0.21	0.1%	4%	1.83
Anas rubripes	American black duck	5	0.18	0.1%	4%	1.82
Podiceps grisegena	Red-necked grebe	2	0.07	0.0%	4%	1.80
Tringa solitaria	Solitary sandpiper	2	0.07	0.0%	4%	1.80
Actitus macularia	Spotted sandpiper	1	0.04	0.0%	4%	1.79
Butorides virescens	Green herron	1	0.04	0.0%	4%	1.79
Ceryle alcyon	Belted kingfisher	1	0.04	0.0%	4%	1.79
Pandion haliaetus	Osprey	1	0.04	0.0%	4%	1.79
Tringa flavipes	Lesser yellowlegs	1	0.04	0.0%	4%	1.79
		7247	225.44			

observed. While less numerous, 6 other species of shorebirds were observed on the mudflats. The mallard *Anas platyrhynchos* and great blue heron *Ardea herodias* completed the 5 species of birds that comprised greater than 1% relative abundance.

In terms of frequency of occurance, the great blue heron was most often observed in surveys appearing 93% of the time ahead of geese at 85%, and ring-billed gull and killdeer at 61% and 54% respectively. While the geese were top rated in their importance value at Kingman, the great blue heron was ranked second due in large part to its high frequency of occurance. Other birds of note were the two crow species American and fish crow *Corvus* sp., which were combined due to their difficulty to distinguish at a distance, greater yellowlegs *Tringa melanoleuca,* and two bald eagles *Haliaeetus leucocephalus*.

4.5.2 Fish

Fish collected at Kingman Lake prior to marsh restoration included 16 species of fish representing 7 families and 1012 individuals collected from 6 electrofishing surveys (Appendix B, Table 4.3). The greatest numbers of fish captured were the brown bullhead catfish Ameiurus nebulosus with 414 individuals, followed by pumpkinseed sunfish Lepomis gibbosus, and gizzard shad Dorosoma cepedianum. Brown bullheads had the greatest relative abundance (41%), and along with the spottail shiner Notropis hudsonius were observed at a frequency of 83% (Table 4.2).

Table 4.2 Kingman Lake mudflat fish community from 6 electrofishing surveys; absolute abundance (total # caught); average #/survey; relative abundance (% total #); frequency (% survey sp. appearance); ranked by importance value (relative abundance + frequency / 2).

		Absolute Abundance	Average # /Survey	Relative Abundance	Frequency	Importance Value
Ameiurus nebulosus	Brown bullhead	414	69	40.9%	83.0%	62.0
Lepomis gibbosus	Pumpkinseed sunfish	175	29	17.3%	100%	58.6
Dorosoma cepedianum	Gizzard shad	127	21	12.5%	100%	56.3
Morone americana	White perch	41	7	4.1%	100%	52.0
Notropis hudsonius	Spottail shiner	18	3	1.8%	83%	42.4
Alosa aestivalis	Blueback herring	106	18	10.5%	67%	38.7
Hybognathus regius	Eastern silvery minnow	55	9	5.4%	67%	36.2
Cyprinus carpio	Common carp	33	6	3.3%	67%	35.1
Notemigonus crysoleucas	Golden shiner	7	1	0.7%	67%	33.8
Perca flavescens	Yellow perch	7	1	0.7%	50%	25.3
Lepomis macrochirus	Bluegill sunfish	5	0.8	0.5%	50%	25.2
Alosa pseudoharengus	Alewife herring	17	3	1.7%	33%	17.3
Morone saxatilis	Striped bass	2	0.3	0.2%	33%	16.6
Ictalurus punctatus	Channel catfish	3	0.5	0.3%	17%	8.6
Fundulus diaphanus	Banded killifish	1	0.2	0.1%	17%	8.5
Carassius auratus	Goldfish	1	0.2	0.1%	17%	8.5
	Total	**1012**	**169**			

Pumpkinseed, gizzard shad, and white perch Morone americana, were each collected with 100% frequency. The white perch and striped bass Morone saxatilis were the only piscivorous fish captured making up just over 4% of the total catch. Half of the species of fish collected made up at least 1% of the total catch (Figure 4.8). While the brown bullhead was ranked highest in importance on the Kingman mudflats, the other benthic feeding fishes, common carp Cyprinis carpio and channel catfish Ictalurus punctatus were only ranked 8th and 14th out of 16 species. An average of 169 fish were caught per survey at Kingman with brown bullheads representing an average of 69 captured per survey.

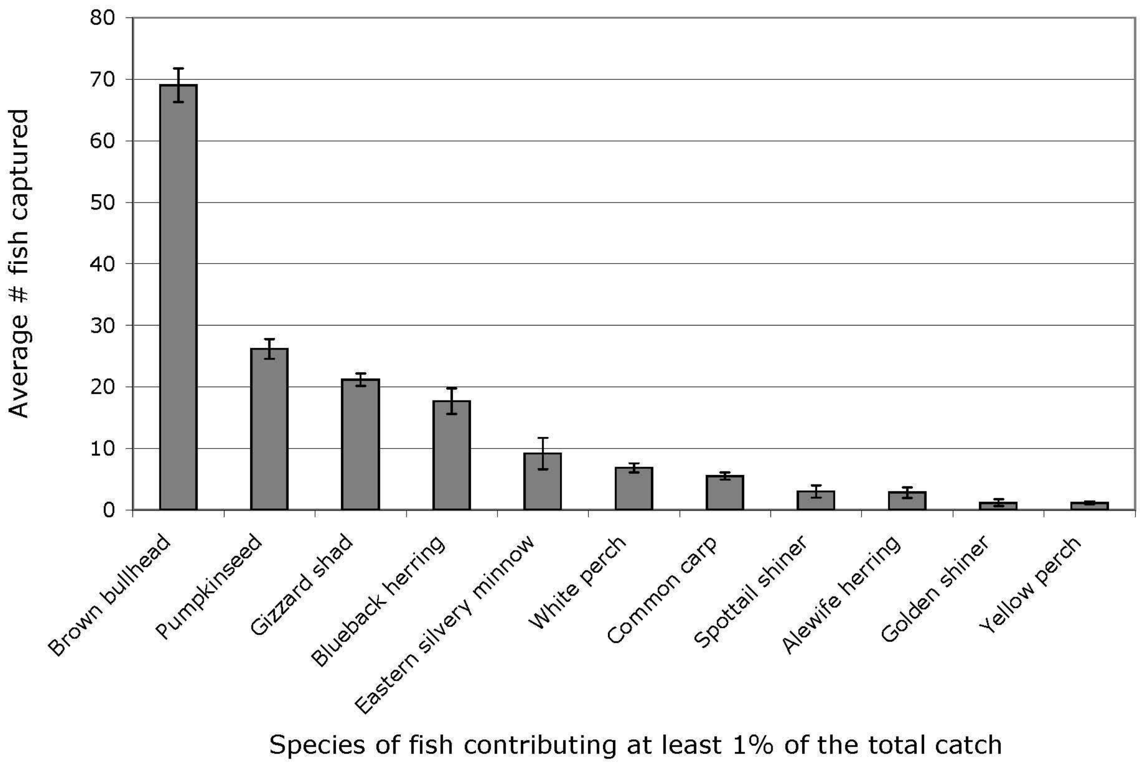

Figure 4.8 Kingman mudflat electrofishing survey results.

4.5.3 Exclosure Macrophytes

4.5.3.1 Cover

After erection of the Kingman mudflat exclosures, the voluntary emergence of multiple species of macrophtes within each of the 6 exclosure plots was contrasted by the complete lack of any plant emergence in each of the 6 control unfenced plots (Figure 4.9). Total vegetative cover data collected in the exclosures from each plot size between 2001-2004 are presented in Figure 4.10 (Appendix B, Tables 4.4 and 4.5). Trends in combined species arithmetic mean cover for both plot sizes, 10x and 20x, mirrored each other across the four years. Mean cover in 2001 began at 20% for the 10x exclosures and 60% cover for the 20x exclosures. Each of these mean covers increased in 2002 with the 10x cover improving to near 40% while the 20x cover had a more modest increase to approximately 65%.

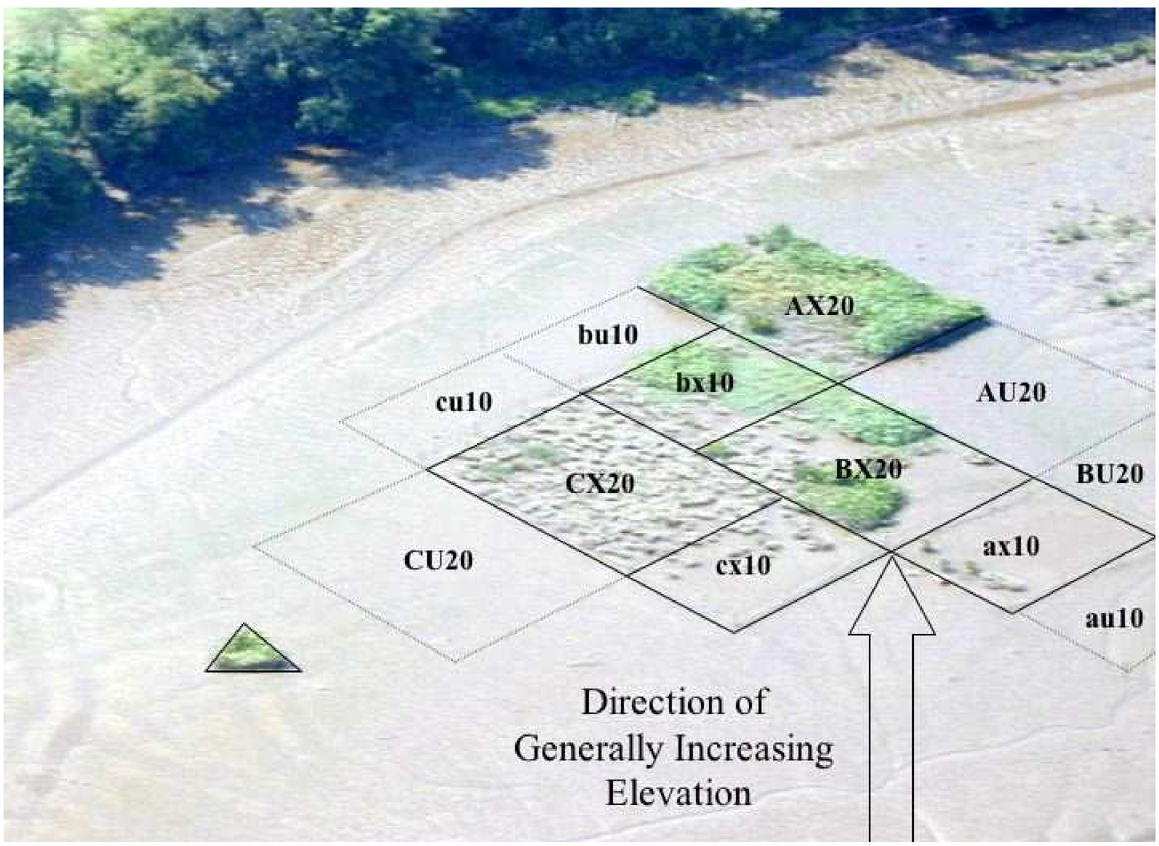

Figure 4.9 Kingman plot exclosures. Direction of generally increasing elevation.

Year 2003 mean cover for both plot sized dropped considerably, and fell again in

2004 with 10x cover at less than 5% with 20x cover decreasing to just over 30%. These consecutive yearly decreases are likely attributable to multiple storm events occurring within 2003, producing flooding that compromised several of the fenced exclosures with large woody debris (logs and trees). When exclosure fences were repaired, tell tale signs of goose access to compromised plots included multiple crater like holes in the mudflats where feeding on the tubers of the previous years perennial plants had been. Once emergence of the plants had occurred, another storm and breech of several plot fence lines in 2003 allowed the resident geese in again, with evidence of the browsing or topping of all the young leaves of plants occurring in several areas. Repeated grazing and lack of growth in several of the plots in 2003 likely inhibited re-emergence in many of the exclosure plots in 2004 and drove down mean cover values.

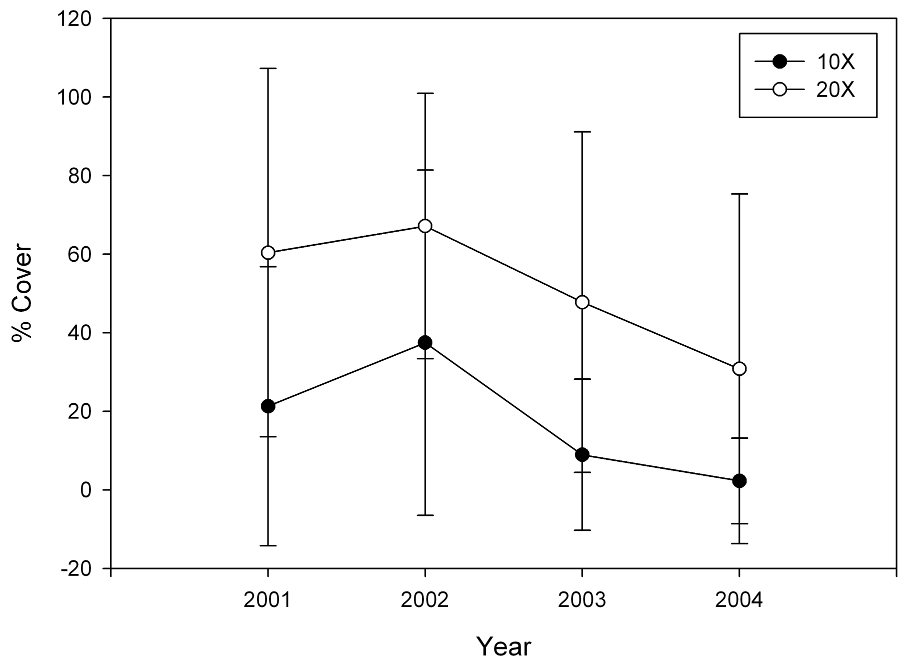

Figure 4.10 Kingman exclosure plot total cover arithmetic means and standard deviations for all species of plants across four years for each exclosure type.

The top five macrophyte species that emerged with greater than 1% cover in both plot sizes were *Sagittaria latifolia, Pontederia cordata, Peltandra virginica, Echinochloa walteri, and Ludwigia palustris.* Other species identified that did not comprise a notable percentage of the macrophyte cover within the exclosures included *Leersia oryzoides, Polygonum* sp., *Bidens* sp., and instances of the native invasive *Typha* sp. and the non-native invasive *Lythrum salicaria.* The last two occurred only at two locations early then disappeared from later years data collection. It is notable that the two invasive species were dominant in areas of higher elevation not far from the study site and yet failed to establish within the exclosure plots.

The two exclosure sizes behaved similarly with regard to species cover changes over the four year study period, although they differed in the mean cover values with the smaller 10x exclosures generally reflecting less cover per species than the 20x exclosure plots (Figures 4.11, 4.12). In 2001, *Pontederia* clearly dominated in cover over all other species in both plot sizes with *Sagittaria* and *Echinochloa* relatively even although less than half the cover of *Pontederia*. In 2002 and 2003, *Sagittaria* mean cover surged in both plot sizes, while *Pontederia* and *Echinochloa* decreased and disappeared from cover transects all together by 2004. The dramatic increase in Sagittaria was mirrored by a decline in *Pontederia* over the same period. While also eventually decreasing in 2004, *Sagittaria* cover dominated all species cover in both plot sizes but for *Peltandra* cover in the 10x plots, which remained somewhat constant across both plot sizes in most years. Of note is the dramatic increase in Ludwigia cover in 2002, becoming the dominant species in the 10x plots and then practically disappearing in 2003 the following year.

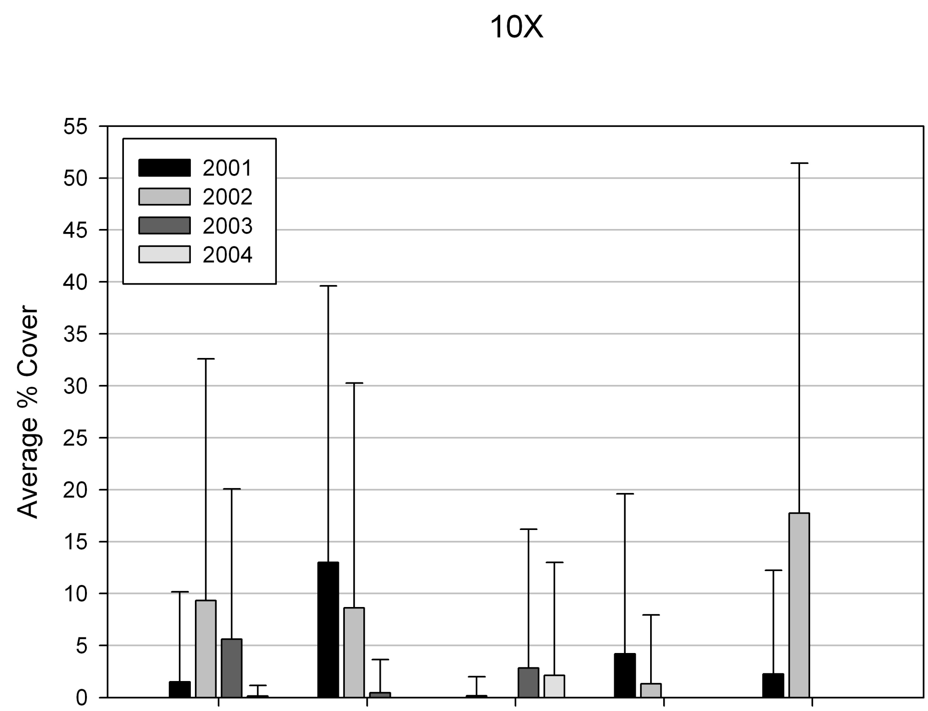

Figure 4.11 Kingman combined 10x exclosure plot arithmetic mean cover by species across years with 1 standard deviation.

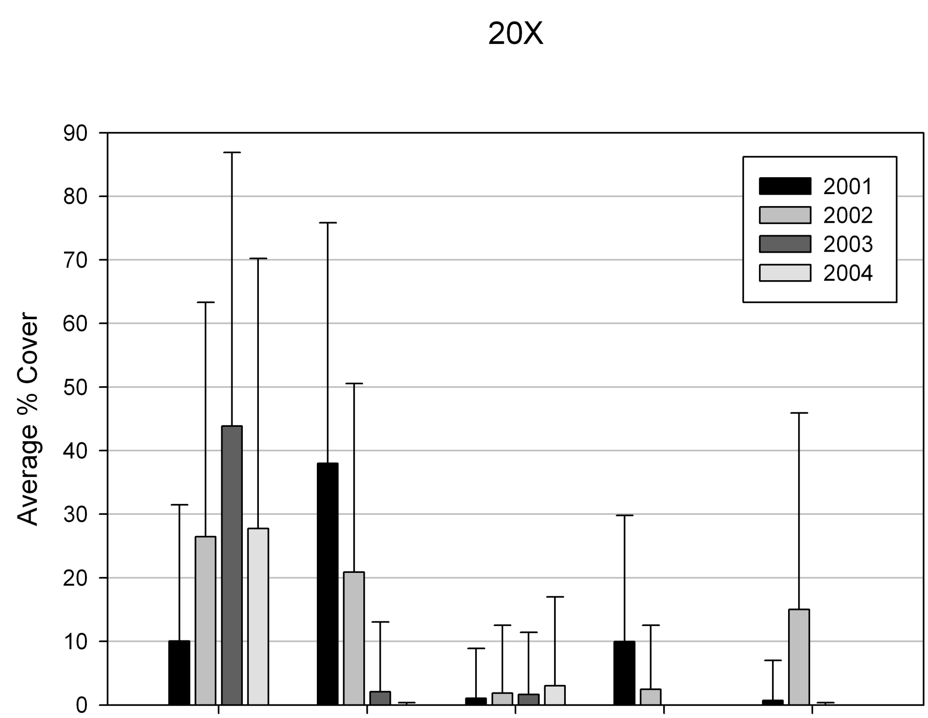

Figure 4.12 Kingman combined 20x exclosure plot arithmetic mean cover by species across years with 1 standard deviation.

When the top 5 species mean cover data for both sized plots were combined and plotted against mudflat surface elevations for each year, cover for each species was translated into the elevation zone where each species was found (Figures 4.13 to 4.16). In 2001 the dominance of *Pontederia* cover over other species was found across all elevations, although mean cover peaked between the 1.5'-1.6' NGVD '29 elevation range (Figure 4.13). *Echinochloa* and *Sagittaria* shared roughly equal cover between 1.5'-1.8' NGVD '29, although above 1.9' NGVD '29 *Sagittaria* had greater cover but much less still than *Pontederia*. By 2002 *Sagittaria* began to increase its cover across several elevations, notably between 1.7'-2.0' NGVD '29. *Ludwigia* also showed gradual increases in cover between 1.4'-2.0' NGVD '29, with peak cover between 1.8'-1.9' NGVD '29. *Pontederia* cover between 1.4'-1.7' NGVD '29 was still greater than other species at these elevations (Figure 4-14). By 2003, *Sagittaria* had moved into cover dominance at elevations from 1.3'-2.0' NGVD '29with other species representing less than 5% mean cover at other elevations and *Echinochloa* disappearing entirely from the cover surveys (Figure 4-15). The trend in *Sagittaria* cover dominance increased with increasing elevation. Between 1.4'-1.7' NGVD '29 mean cover ranged from more than 20% to 30%, while between 1.7'-1.9' NGVD '29 cover increased to between 40% and 50%. At the highest elevation within the exclosure plots, between 1.9'-2.0' NGVD '29, *Sagittaria* mean cover reached its peak at over 80%. In 2004, *Ludwigia* joined *Echinochloa* in loosing cover representation within the exclosure plots, with *Sagittaria* maintaining cover dominance at all elevations and *Peltandra* and *Pontederia* existing at elevations between 1.5'-1.8' NGVD '29 at covers of less than 10% (Figure 4.16).

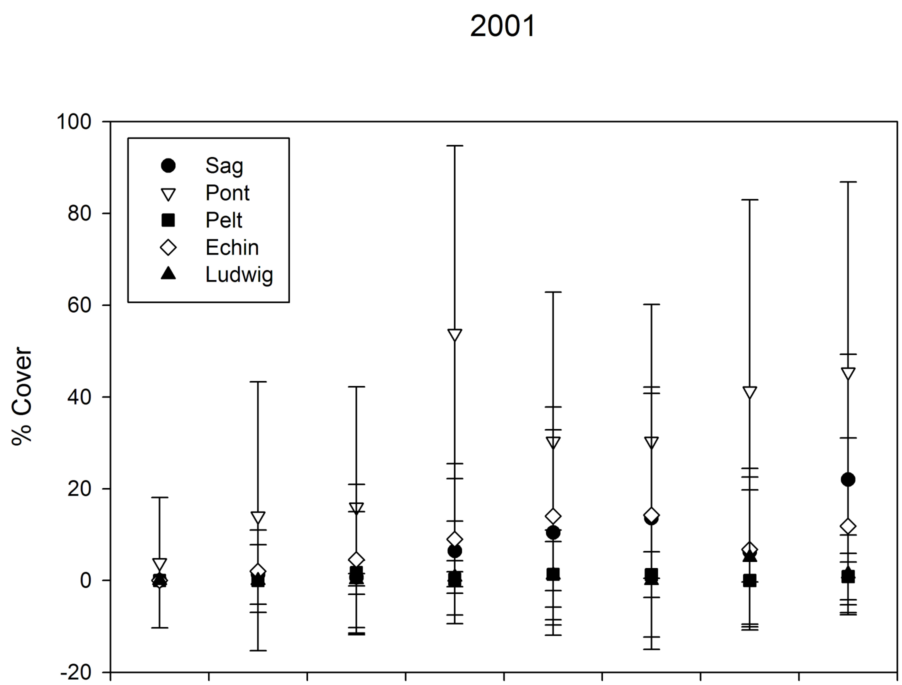

Figure 4.13 2001 combined exclosure plot arithmetic mean cover by species across mudflat surface elevation midpoints with 2 standard deviations. Species are represented unless there was no cover.

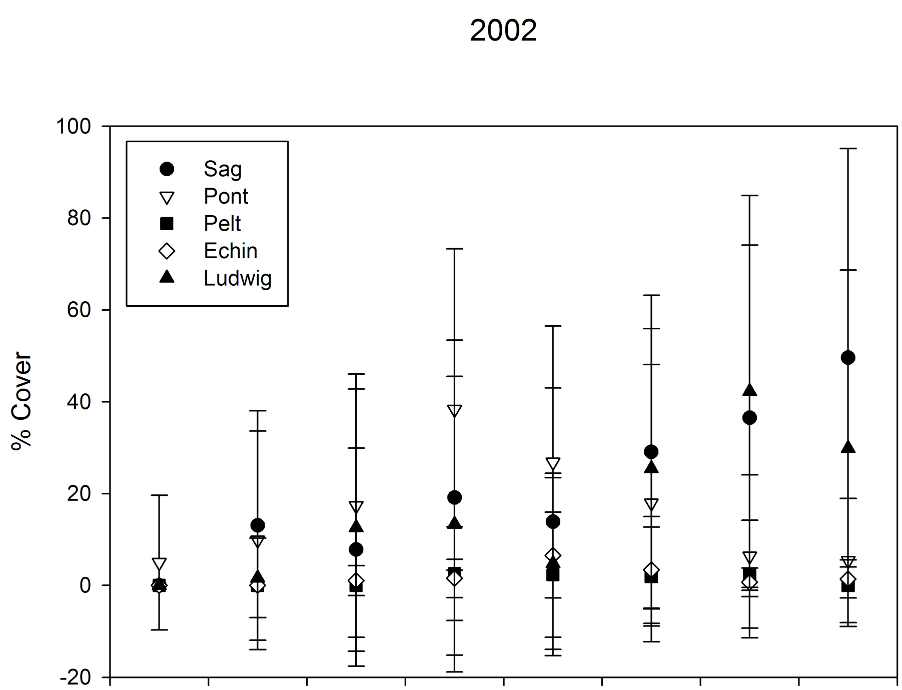

Figure 4.14   2002 combined exclosure plot arithmetic mean cover by species across mudflat surface elevation midpoints with 2 standard deviations. Species are represented unless there was no cover.

2003

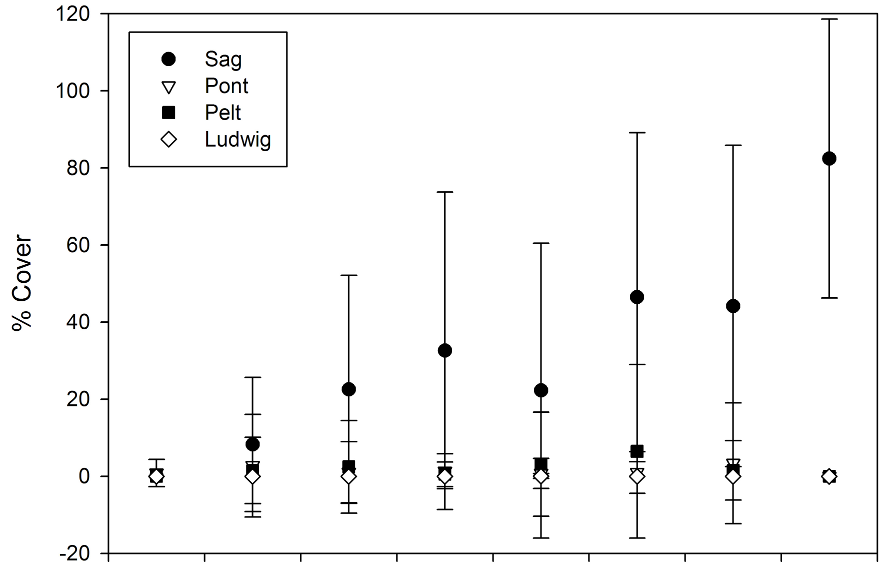

Figure 4.15 2003 combined exclosure plot arithmetic mean cover by species across mudflat surface elevation midpoints with 2 standard deviations. Species are represented unless there was no cover.

2004

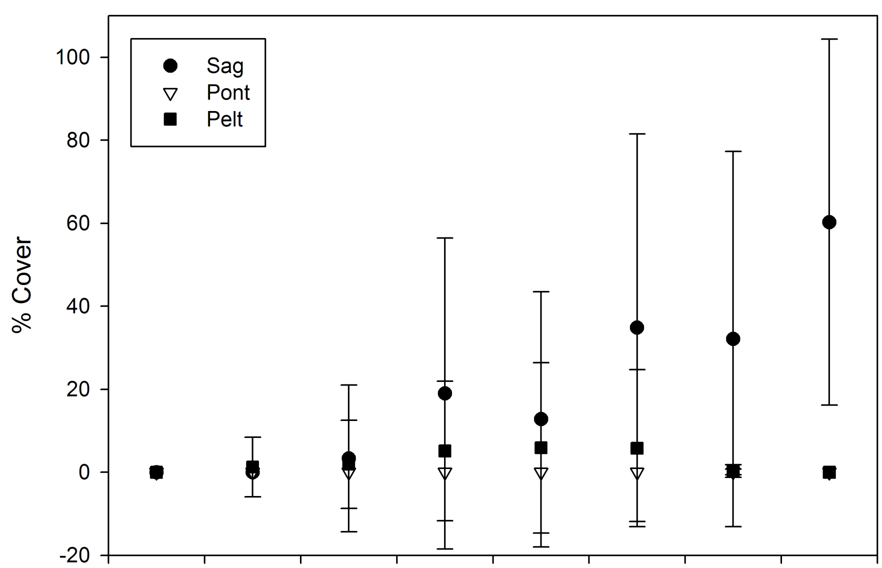

Figure 4.16 2003 combined exclosure plot arithmetic mean cover by species across mudflat surface elevation midpoints with 2 standard deviations. Species are represented unless there was no cover.

4.5.3.2 Biomass

Four randomized quadrats of biomass data from each of the four transect lines crossing each of the 6 exclosure plots were collected once each year between 2001-2004 (Appendix B, Tables 4.6 and 4.7). Biomass data collected in the exclosures exhibited similar trends to those of the macrophyte cover data. *Pontederia* and *Echinochloa* were the largest contributors of mean biomass (g/m^2) in both exclosure sizes in 2001, with *Sagittaria* and *Ludwigia* biomass representing to a lesser degree (Figures 4.17 & 4.18). By the next year, *Sagittaria* biomass began a dramatic increase in the 20x exclosures that would continue for the rest of the study period. In 2002, *Echinochloa* biomass dropped considerably in the 20x exclosures and disappeared altogether in the 10x exclosures. *Peltandra* biomass revealed a sharp increase in the 20x exclosures not seen in the 10x plots. *Ludwigia* surged to become the largest contributor in mean biomass in the 10x plots in 2002, just ahead of *Pontederia* which had increased in the 10x plots but decreased in the 20x plots over the previous year. Like *Echinochloa* in 2001, *Ludwigia* had reached its peak biomass in 2002 and declined considerably the following year, disappearing from random biomass collections completely by 2004. The mean biomass of *Peltandra* increased in 2003 in the 10x study plots to dominate all other species in these exclosures although its numbers in the 20x plots had decreased considerably. By the last survey year in 2004, *Peltandra* and *Sagittaria* were the only two species noted in biomass collections, with *Sagittaria* reaching its highest levels in the 20x exclosure plots and *Peltandra*, while reduced over the previous year still holding a dominant edge over *Sagittaria* in the 10x exclosure plots. Every species represented in the biomass survey

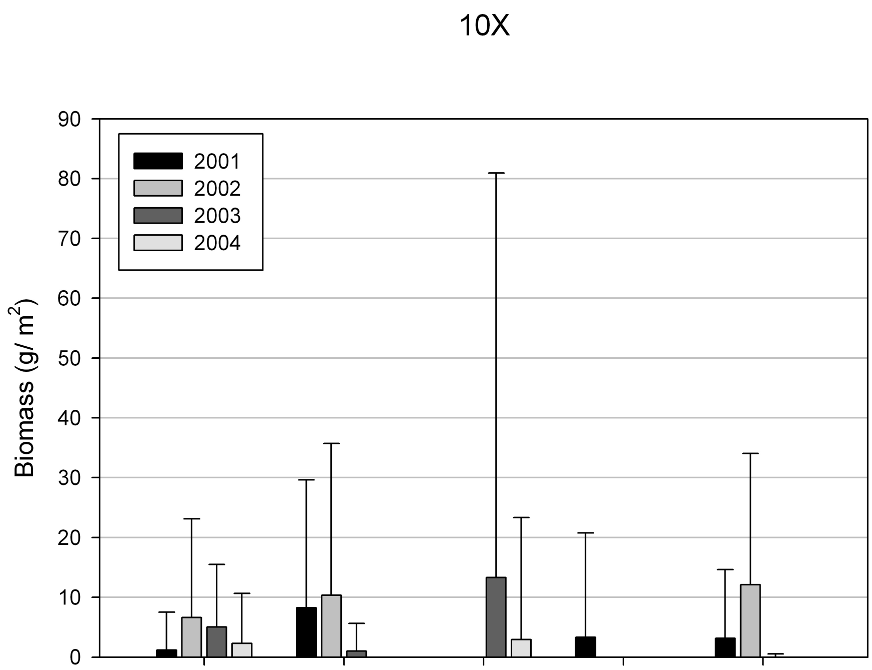

Figure 4.17 Combined 10x exclosure plot biomass by species across years. Data are arithmetic means with 1 standard deviation.

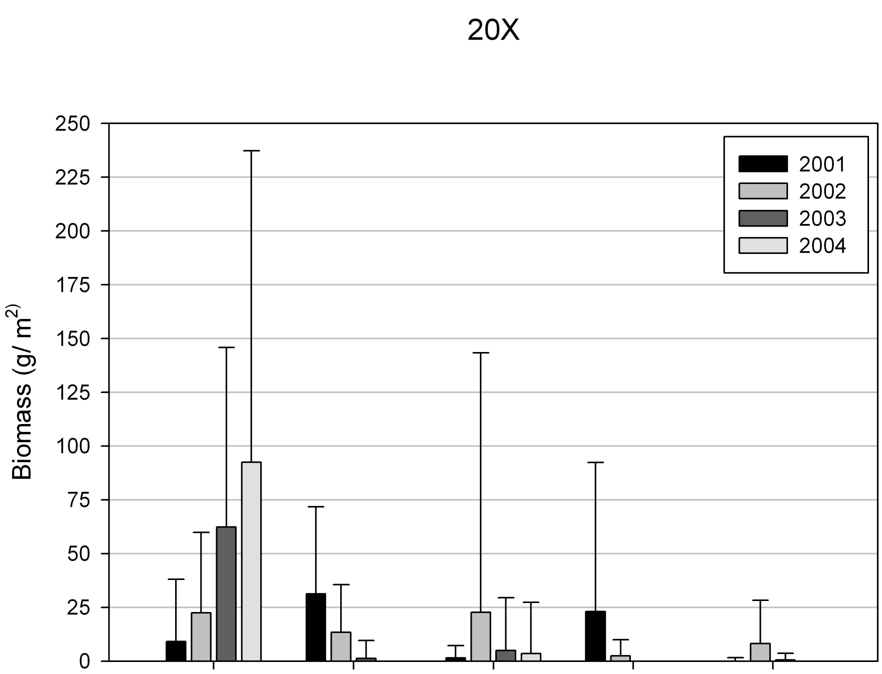

Figure 4.18 Combined 20x exclosure plot biomass by species across years. Data are arithmetic means with 1 standard deviation.

revealed a net decrease in mean biomass by 2004 when compared to the initial year biomass levels, with the exception of *Sagittaria* which reported marked increases in total mean biomass, and *Peltandra* which had higher mean biomass in the intervening years but still ended with greater biomass than when the experiment began (Tables 4.3 and 4.4).

Table 4.3 20X exclosure plot mean biomass 2001-20004

Species	2001 g/m^2	2002 g/m^2	2003 g/m^2	2004 g/m^2	01' – 04' Change
Sagittaira latifolia	36.29	84.71	248.94	369.63	Increase
Pontederia cordata	132.2	53.2	4.82	0.0	Decrease
Ludwigia sp.	0.32	45.67	1.83	0.0	Decrease
Peltandra virginica	5.81	90.82	19.54	13.79	Increase
Echinachloa sp.	220.83	9.59	0.0	0.0	Decrease

Table 4.4 10X exclosure plot mean biomass 2001-20004

Species	2001 g/m^2	2002 g/m^2	2003 g/m^2	2004 g/m^2	01' – 04' Change
Sagittaira latifolia	4.65	26.45	20.08	9.16	Increase
Pontederia cordata	32.98	41.27	2.37	0.0	Decrease
Ludwigia sp.	12.62	48.4	0.26	0.0	Decrease
Peltandra virginica	0.0	0.0	53.22	11.78	Increase
Echinachloa sp.	13.36	0.0	0.0	0.0	Decrease
Polyganum sp.	0.89	1.32	0.0	0.0	Decrease

Inherently obvious differences in biomass between excluded and control plots occurred, with no biomass present within unexcluded plots throughout the four years.

When biomass from all species were combined, mean biomass from each plot size was adjusted to extrapolated mudflat surface elevations and plotted. For the surface elevation gradient within exclosure plots between 1.55’ and 1.70’ NGVD ’29 low marsh elevations, a gradually increasing trend in biomass with increasing elevation could be detected from 2001 to 2002 in the 10x exclosures (Figure 4.19). In 2003, beginning with reduced mean biomass for the 10x exclosure plots, the previous years increasing trend reversed itself with gradually decreasing biomass as elevation increased. By 2004 the mean biomass in the 10x exclosures had declined further with the biomass across elevation trend line evening out. The 20x exclosure plot biomass over elevation revealed some interesting results (Figure 4.20). The 2001 mean biomass increased gradually and steadily across the low elevations as they had in the 10x plots. In 2002 and 2003 the effect of elevation on biomass was sharper and more pronounced, beginning with less biomass at the lower elevations in each year and rising to greater biomass each successive year approaching the 1.7’ NGVD ’29 elevation mark. There is an apparent break point between the 1.63’-1.65’ NGVD ’29 elevations where biomass is noted to reverse its trend of less biomass over successive years to an increase in biomass over previous years. The 2004 mean biomass data also revealed a break at 1.60’ NGVD ’29, where small increases in elevation resulted in more rapid increases in biomass when compared to 2001.

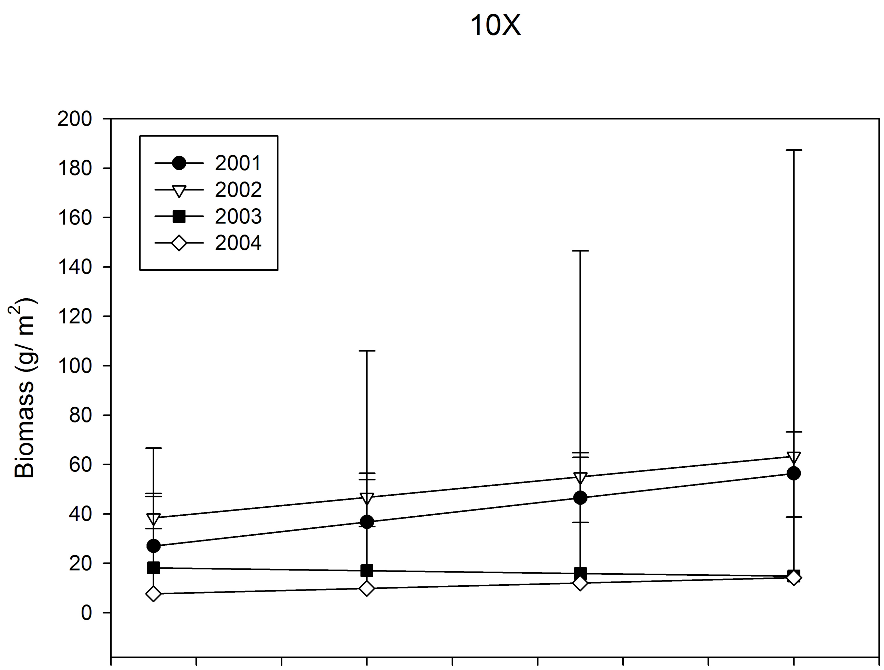

Figure 4.19 Combined 10x exclosure plot biomass for all species by year over elevation. Year lines are biomass continuum values of predicted LS means + SE from analysis of covariance. Points along the lines are biomass values from predicted means within the low to middle marsh zone represented by the data.

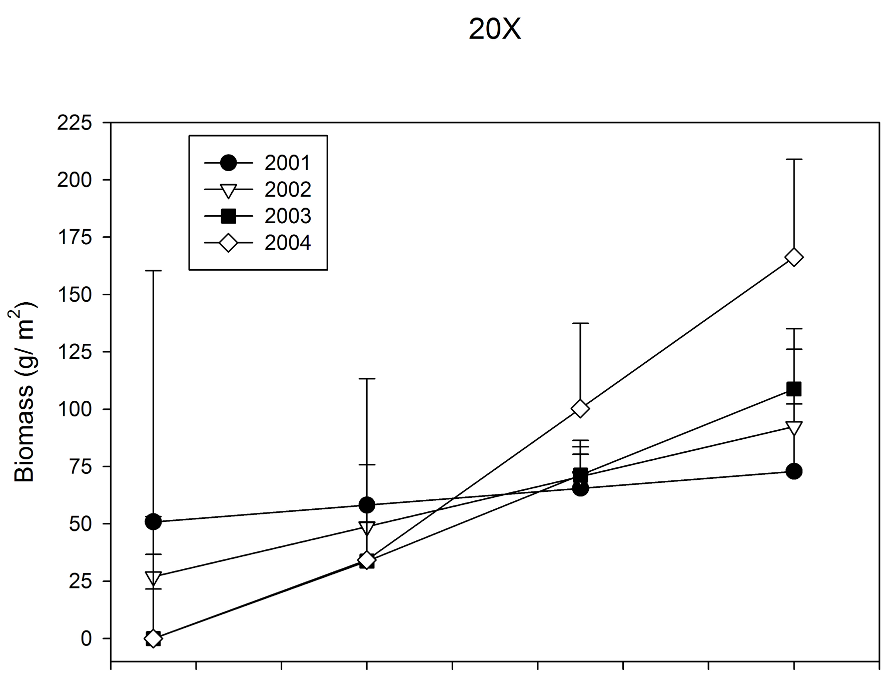

Figure 4.20 Combined 10x exclosure plot biomass for all species by year over elevation. Year lines are biomass continuum values of predicted LS means + SE from analysis of covariance. Points along the lines are biomass values from predicted means within the low to middle marsh zone represented by the data.

4.6 Presence / Height

Species presence and height data were collected at each meter mark along 12-ten meter and 12-twenty meter exclosure transects each year of the four year study period (Appendix B, Tables 4.8 and 4.9). The differences in exclosure size was not determined to have a significant effect on species presence between years (p>0.8). Some differences were found in terms of the total number of species found along these transects over the four year study period when compared to those species intentionally planted by the restoration effort in Cell 1 areas outside of the exclosure study area (Table 4.5).

Table 4.5 Planted Species at Kingman Marsh Restoration compared to those found in exclosure area transects.

Y= Present N= Absent T= Trace #'s (< 1%)	2000 Species Planted in Marsh	2001 Species Found in Exclosures	2002 Species Found in Exclosures	2003 Species Found in Exclosures	2004 Species Found in Exclosures
Sagittaria latifolia	Y	Y	Y	Y	Y
Pontederia cordata	Y	Y	Y	Y	Y-T
Peltandra virginica	Y	Y	Y	Y	Y
Juncus effusus	Y	N	N	N	N
Schoenoplectus tabernaemontani	Y	N	N	N	N
Schoenoplectus pungens	N	N	N	N	N
Nuphar luteum	Y	N	N	N	N
Echinochloa walteri	N	Y	Y	N	N
Ludwigia palustris	N	Y-T	Y	Y-T	N
Typha latifolia	N	N	Y-T	Y-T	Y-T
Lythrum salicaria	N	Y-T	Y-T	Y-T	N
Leersia oryzoides	N	N	Y-T	N	N
Bidens sp.	N	Y-T	Y-T	N	N
Polygonum punctatum	N	Y-T	Y-T	N	N
Patomogeton sp.	N	Y-T	N	N	N
Species Totals	6	9	10	6	4
Total Species > 1%	6	4	5	3	2

A total of nine species were found along transect lines in 2001 and 10 species in 2002 although only four and five species respectively contributed numbers greater than 1% of all those species observed. In 2003, total numbers of species found along transect lines decreased to six with only *Sagittaria latifolia, Pontederia cordata and Peltandra virginica* contributing to notable presence within the exclosures. The final sampling year (2004) saw the total species presence reported in transect data decline to 4 with only 2 species, *Sagittaria* and *Peltandra* contributing greater than 1% of the total plot occurrances.

The location and height of the species identified along each of the exclosure plot transects were plotted over a SAS generated mudflat surface topography to give a graphical representation of the location and height of each species found within each of the 6 exclosures (Figures 4.21 to 4.24). The 4 year progression of the species presence and height relative to each plot and its position on the mudflat surface elevation gradient gives a more realistic visual interpretation of the changes in species composition, position relative to elevation, density and height than can be inferred through two dimensional figures and data tables. Figure 4.21 reveals that in 2001, the dominance of *Pontederia* was evident throughout the exclosure plots with height related to the differences in mudflat surface elevation. In 2002, the increased presence of *Sagittaria* can be seen in the higher elevations, with *Pontederia* consolidation in lower plot elevations and a resulting noticeable decrease in species height (Figure 4.22). *Ludwigia* also becomes pervasive throughout the exclosures in 2002 and contributes to a noticeable increase in the density and diversity of species in the lower/middle elevations.

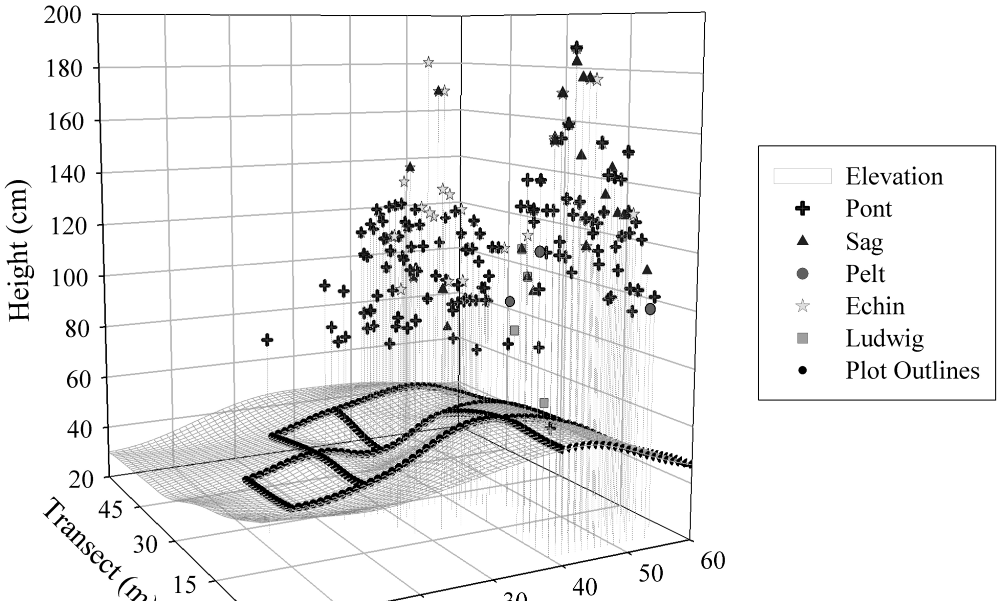

Figure 4.21 2001 species presence along exclosure plot transect lines and each species height in relation to the exaggerated surface elevation of the plots.

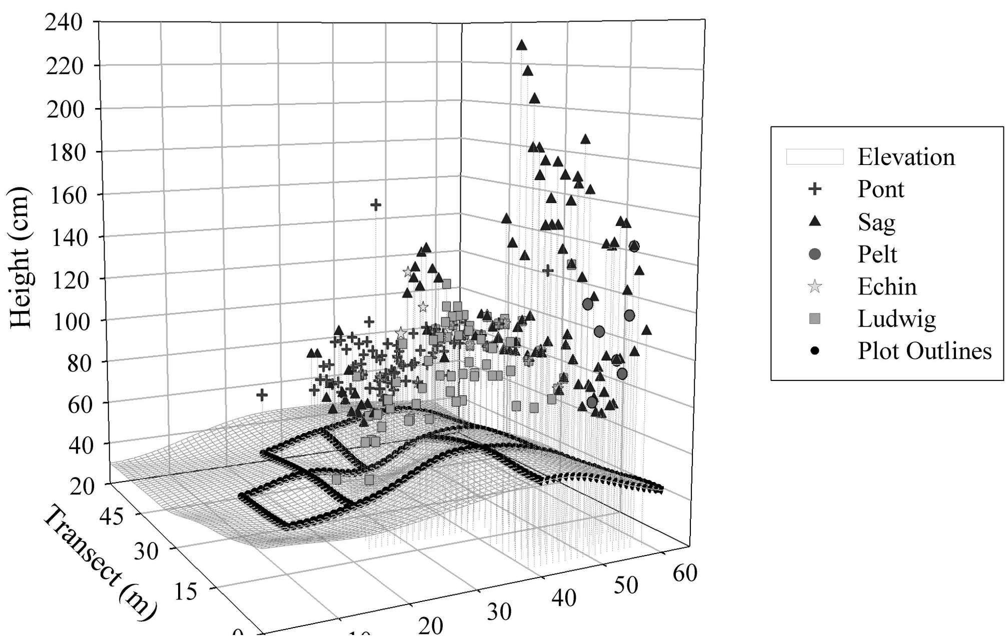

Figure 4.22 2002 species presence along exclosure plot transect lines and each species height in relation to the exaggerated surface elevation of the plots.

The 2003 survey revealed a noticeable thinning of the density of individual plants as well as a marked decrease in the numbers of species represented throughout the plots with the effective disappearance of *Ludwigia* and *Echinochloa* (Figure 4.23). The spread of *Sagittaria* becomes obvious while *Peltandra* and *Pontederia* presence also becomes clear. By 2004, the dominance of Sagittaria in the higher plot elevations is contrasted by the sparse presence of *Peltandra* throughout the lower plot elevations (Figure 4.24). Overall plant heights remain high with virtually no lower level "understory" found. This is effectively the result of the growth and maturation of *Sagittaria* as the dominant perennial within the exclosure plot that occupied the highest elevations. The growth in height and spread of wide, shade inducing leaves left little else that could compete, although *Peltandra* is still a presence in this area. Figures 4.21 to 4.24 effectively represent the emergence and self-organization of the macrophyte community within the exclosure study area throughout the 4 year study period.

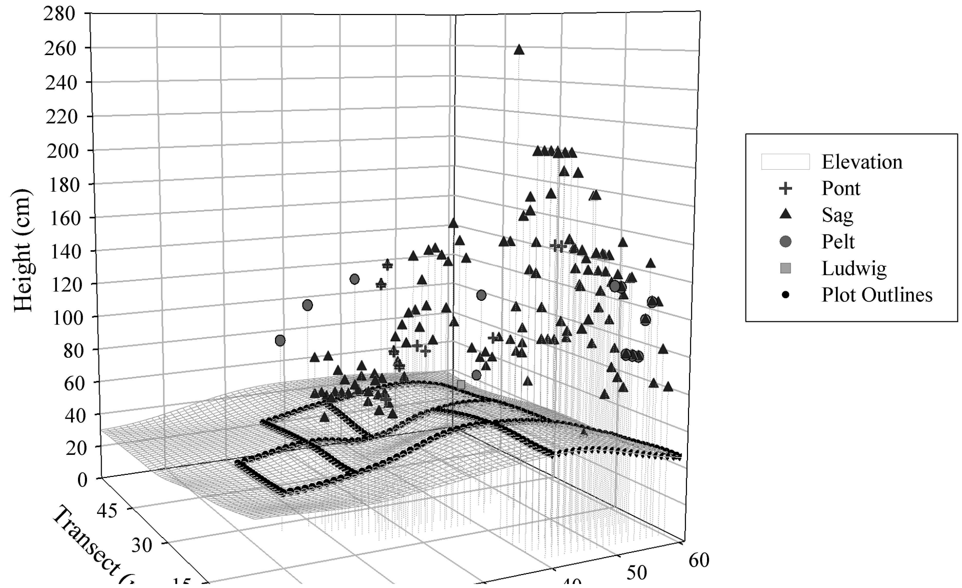

Figure 4.23 2003 species presence along exclosure plot transect lines and each species height in relation to the exaggerated surface elevation of the plots.

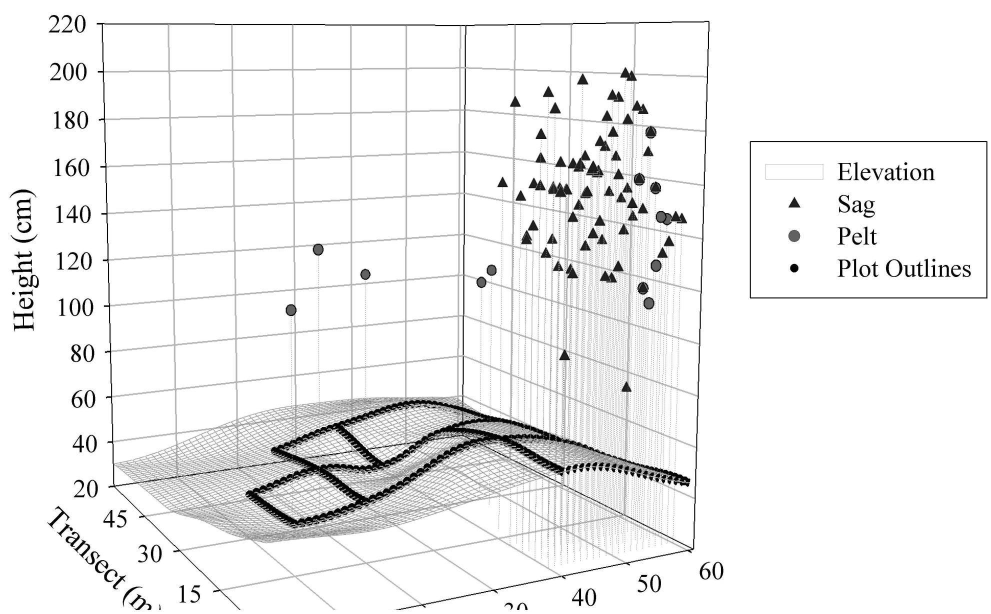

Figure 4.24 2004 species presence along exclosure plot transect lines and each species height in relation to the exaggerated surface elevation of the plots.

4.7 Discussion

The Kingman Marsh exclosure plots revealed the potential for the low-middle marsh elevation (1.5-2.0 ft. NGVD '29) biogenic mudflats to support a dense and relatively diverse native emergent plant community with the exclusion of resident goose grazer pressures (Figure 4.25). It is the geese that appear to be the dominant force controlling native plant vegetation dynamics at these elevations absent exclosures. At lower sediment surface elevations (< 1.5' NGVD '29) a relative lack of volunteer plants within exclosures is likely due to the stress of increased flooding depth and duration over the physical mudflats that effectively suppresses emergent vegetation. As mudflat surface elevation increased across each exclosure, the potential for macrophytes to be present and have greater cover, biomass and height increased.

Figure 4.25 View in 2002 southeast across Kingman exclosure plots in the direction of generally increasing elevation. Cover, density and diversity is apparent, with native species. Vegetation on the far right in the distance past the exclosures is a dense stand of non-native *Lythrum salicaria*.

The complete lack of vegetation presence in unfenced control plots (Figure 4.26) at any elevation supports the assertion that two alternate states, one biogenic mudflat and one emergent marsh, can exist in the same space and time within certain elevation zones on Anacostia River.

Figure 4.26 View northeast across the unvegetated mudflat of an unfenced control plot. Fence lines of exclosure plots marked a stark contrast between areas that were, or were not accessible to goose herbivory.

Herbivory of macrophytes in freshwater wetlands has been well documented (literature review by Lodge, 1991), with the effects of goose herbivory on wetlands in general also a well studied area (Smith and Odum, 1981; Cargill and Jefferies, 1984; Bazely and Jeffries, 1986; Giroux and Bedard, 1987; Kerbes et al., 1990; Hik et al., 1992; Belanger and Bedard, 1994; Beaulieu et al., 1996). Most of these goose herbivory studies focused on migratory stopover or breeding grounds, with some of the research finding that the migratory goose populations had no effect on plant production (Beaulieu et al., 1996) or even a positive synergistic effect (Cargill and Jefferies, 1984; Bazely and

Jeffries, 1986). While migratory waterfowl are only in an area a portion of the year, resident waterfowl such as Canada geese and mallards are present year round and may be expected to impact a site to a greater degree (Haramis and Kearns, 2007).

The effects of resident Canada geese on wetlands have become especially apparent in Maryland in the last several decades, but were not a concern in the District of Columbia until 2000 (Harris, 2002). During the Kingman Marsh restoration, the strong effects of goose grazing became evident from the beginning of the marsh planting when exclosure fencing was installed to prevent rapid losses of planted material by the geese. It was thought that a successful growing season with goose exclusion would establish a marsh that would be resistant to goose herbivory in the following years by nature of the ability of the marsh to "outgrow" goose grazer pressure. This had been the case with the Kenilworth Marsh restoration. In retrospect, the increasing numbers of geese present year round on the adjacent golf course, mudflats and open water areas of Kingman (Figure 4.5) made restoration without exclosure fencing not an option if certain species of desireable marsh plants (i.e. *Sagittaria latifolia* and *Pontederia cordata*) were to exist.

The context of landscape position (and surrounding land use) is considered to be an important element influencing ecosystem development (review by Farina, 2006). The behavioral ecology of animals includes decision making for movement, habitat selection, and feeding that is integral to the landscape (MacArthur and Pianka, 1966; Gagliardo et al., 2001). This is especially true for resident Canada geese (Harris, 2002). At Kingman Lake, landscape context was not taken into consideration with regard to its influence on the resident goose population prior to restoration activities, as it was not seen as a significant problem at Kenilworth Marsh. Although it is clear that in some landscape contexts animals can wield considerable control over their environment (Butler, 1995), achieving proper surface elevations was understood to be the primary driving force behind marsh restoration outcomes in terms of cover and species distribution, as was determined by the relative success at Kenilworth Marsh.

Unlike Kenilworth Marsh, the Kingman Marsh restoration areas were bordered by a golf course (Cell 1) and mowed lawn (Cell 2), with numerous access points for geese to enter the marsh area. Expanses of open water also allowed for easy flight approaches and additional access to the restored marsh. Kenilworth Marsh did have an expansive recreational lawn area nearby, although this area was buffered by wider unbroken wooded areas unlikely to be used by the geese for access. The only large open water suitable for goose approach in Kenilworth Marsh was that which surrounded the Mass Fill 3 sites and as recounted in Chapter 3, this area was heavily grazed by geese after restoration planting, reverting the site back to a mudflat state.

The presence of overwhelming goose herbivory effectively made the case for two alternate marsh states at Kingman, one dominated by low-middle marsh elevation mudflats with some high marsh invasives plant species not palatable to geese, and one without goose herbivory protected by exclosure fencing. The experimental exclosures were constructed to determine if the low to middle marsh mudflat surface elevations (1.5’-2.0’ NGVD ’29) would support the type of emergent marsh planned for in the Kingman restoration without the pressure of goose herbivory.

Of the six species that were initially planted for the Kingman Marsh restoration in 2000, three of these species, *Sagittaria latifolia, Pontederia cordata and Peltandra virginica,* voluntarily emerged in each of the 6 experimental exclosures in 2001.

Combined plot species cover along transects against mudflat surface elevation reveal that *Pontederia* can emerge and cover at elevations as low as 1.3’ NGVD '29 and begin to increase in cover above 1.5’ NGVD '29 (Figure 4.13).

Garbish and Coleman (1978) found that *Pontederia* seed germination at all elevations in their tidal fresh vegetation experiment was poor, while transplanted nursery stock seedlings survival was satisfactory at all elevations. However they cautioned that their experimental area was also exposed to a large fetch, which subjected the study plots to consistent wind/wave energy and debris scour/accumulation that may have negatively influenced seed germination. The results of tidal freshwater marsh vegetation emergence from the seed bank in the Anacosia restoration areas (Baldwin and DeRico, 1999) and with field experiments in other tidal freshwater systems (Baldwin et al., 2001 had more positive results, although study plots were not subjected to the energies as Garbish and Coleman.

The differences in exclosure size was not determined to be significant in plant species presence or biomass between years, although the prevalence of 2 of the 3 the smaller exclosures on the northern side of the study area with exposure to greater fetch made them more likely to be breeched by storm driven floating logs and trees. The loss of exclosure protection, even temporarily, was an opportunity for goose access and herbivory that some of the plot areas with lower elevations could not recover from in subsequent years. The interactive effects of herbivory and elevation are seen as important controlling factors in the Kingman Marsh restoration effort (Baldwin and Pendleton, 2003; Hammerschlag et al., 2006).

The species cover dominance of *Pontederia* in 2001 across all exclosure elevations continued in 2002, although only up to the edge of the low marsh elevation of 1.7’ NGVD ’29 where *Sagittaria* cover began to increase over *Pontederia* at higher elevations approaching 2.0’ NGVD '29 (Figure 4.14) which appears to be the classic result of competitive exclusion (Grime, 1973; Cronk and Fennessy, 2001). Significantly, the 6 control plots revealed that without the human intervention of fenced exclosures, no vegetation would voluntarily develop at any low-middle marsh elevations.

While mudflat surface elevation did have an observed if not significant influence on species presence, cover, and biomass of emergent volunteers within the exclosures, the complete lack of vegetation in control plots throughout the 4 year study (Table 4.6) highlighted the influence of goose herbivory as the inherently significant overriding factor in determining plant presence within the range of elevations found in the unexcluded plot study areas. This was further supported by the fence failure of several of the exclosure plots in 2003 following successive storm and flood events. While the exclosure fencing was repaired within weeks, the presence of a developing emergent macrophyte community prior to the storm events within those plots was severely impacted in the intervening period of fence failure. Direct evidence of goose grazing was observed in the form leaf browse, tracks and characteristic crater like “grub-outs” in the mud where the foraging for below ground roots and tubers occurred. This sub-surface grazing effectively reduces or eliminates any chance of vegetation regeneration (Belanger and Bedard, 1994). Even with fencing re-erected and maintained, the 3 exclosure plots affected reported reduced cover and biomass for 2003, which continued into 2004 resulting in almost no cover or biomass in most of those exclosure plot areas. The exclosure that was located at the higher elevations kept near complete cover throughout the study, although it was also the only one to not have a fence failure. Of the plots that did have fence failures, the lower elevation exclosures had a difficult time revegetating after an eat-out while those plots at higher elevations were more likely to be recolonized.

Table 4.6 Comparison of Kingman mudflat exclosure plant community attributes over four survey years. Averages are arithmetic means combining both plot sizes across all elevations.

	Kingman Exclosures 2001	Kingman Exclosures 2002	Kingman Exclosures 2003	Kingman Exclosure 2004	Kingman Un-excluded (control) '01-'04
Total Average Biomass g/m^2	460.0	401.4	425.4	404.4	0.0
% Cover All Sp. All Plots Average	41.0	52.5	49.4	33.9	0.0
# of Species Total All Plots	9	10	6	4	0

The effects of different disturbance regimes (Odum et al., 1979) particularly on wetlands have been increasingly well studied (review by McKee and Baldwin, 1999), with the interactive effects of multiple disturbance agents and stresses on wetland vegetation of particular interest to the Kingman exclosure study (Belanger and Bedard, 1994; Brewer et al., 1997; Gough and Grace, 1998; Rachich and Reader, 1999; Baldwin and Pendleton, 2003, Bertness et al., 2004). Several studies of tidal freshwater wetlands have found a negative effect of lower sediment surface elevation (and subsequent increased depth and duration of tidewater inundation) on wetland plant seedling emergence, survival and growth (Baldwin et al., 2001; Peterson and Baldwin, 2004). Studies of the interactive effects of herbivory and disturbance with sediment surface elevation have also found that these interactions can potentially have an additive negative effect on growth and species composition (Brewer et al., 1997; Baldwin and Pendleton, 2003). Interestingly, several studies actually found positive synergistic effects between plant herbivory and the promotion of alternative species interactions (Noy-Meir, 1975; Belanger and Bedard, 1994; Gough and Grace, 1998; Rachich and Reader, 1999) although the added effect of elevation was not considered.

The Kingman restoration target elevation of 2.0' NGVD '29 was in the middle marsh zone, which was expected to keep invasive macrophytes from colonizing at their preferred higher elevations (Hammerschlag et al., 2006). Higher than designed for post construction sediment surface elevations in some areas allowed for the establishment of the invasive macrophytes *Lythrum salicaria, Phragmites australis* and *Typha sp.* Known competitors, these species, particularly *Lythrum*, appear to have established at the higher elevation areas of Kingman Marsh to the exclusion of many native planted species. It is possible that these invasive species might have dominated regardless of goose grazing, although the goose herbivory of native planted species created gaps for competitively dominant species that were much wider than they would have been without the grazing effect (Gough and Grace, 1998; Rachich and Reader, 1999; Cronk and Fennessy, 2001). It is notable that the invasive species *Lythrum* was dominant in areas of higher elevation not far from the study site and yet while present in trace numbers, failed to spread within the exclosure plots even at the highest elevations approaching 2.0' NGVD '29. This "elevational resistance" to undesirable plant invaders was part of the design intent of the Kingman marsh restoration (Hammerschlag et al., 2006), which was revealed to be a successful design strategy as long as target elevations are met as evidenced by the experimental exclosure plot species composition and coverage.

It is believed that goose herbivory acting as the primary control factor, combined with the secondary physical stress of lower substrate elevations, accounts for the persistence of the mudflat as a dominant feature of the low to middle marsh (1.5-2.0 ft NGVD '29) intertidal areas of Kingman Marsh. Bertness and associates (2004) estimate that it takes one adult goose just one hour to remove all above and below ground salt marsh vegetation across one square meter leaving bare mudflat. With the goose counts of this study (Appendix B, Table 4.1) and National Park Service estimates of between 500 and 2000 geese possible in the Kingman area (Harris, 2002), the potential and realized effect they have on marsh restoration is obvious. The capability of the resident geese to significantly transform their environment to such a degree qualifies them as ecosystem engineers (Jones et al., 1994) able to confound the best efforts of the Army Corps of Engineers.

Once marsh vegetation is removed, the additional combined stress of lower mudflat surface elevation becomes too much for the marsh system to rebound from in the short term (Baldwin and Pendleton, 2003; Peterson and Baldwin, 2004) even with an available seed bank source (Baldwin and DeRico, 1999). Because of this, the lack of the marsh state resiliency at the low-middle marsh elevations allows the switch to the alternate biogenic mudflat state, becoming more resilient. Under the continued pressure of strong resident goose herbivory, the biogenic mudflat state will remain the dominant condition in this zone of elevation without intervention to reduce the goose population (Harris, 2002). Attempts to artificially switch the biogenic mudflat into the emergent marsh state again with fenced exclosures is understood to be a temporary solution.

The concept of ecological memory may be strong with the biogenic mudflat state (McKee and Baldwin, 1999; Peterson, 2002), as mudflats had persisted in the landscape of the Anacostia River for almost half a century as the dominant feature (Syphax and Hammerschlag, 1995) and potentially for more than a century in association with emergent marshes given the river's long depositional history (Coues and Prentiss, 1883). The strong mudflat memory reinforces itself with time and tends to inhibit an ecological response to change unless the change is rapid and intense (Peterson, 2002). Pethick (1996) has determined that mudflats may persist for centuries without some extraordinary change in condition. The restoration work of the Army Corps of Engineers would be considered such a change, and in effect the trigger to switch the mudflat state over to the emergent marsh alternate state. This trigger was effective at Kenilworth Marsh and was assumed that it could work again at Kingman Lake were it not for the unanticipated confounding influence of the resident geese.

Further efforts at the large scale conversion of mudflats to emergent marsh have taken place along the Anacostia River fringe opposite Kingman Island (Figure 4.3)(Hammerschlag et al., 2006). This emergent marsh, constructed in 2003 in a similar manner to Kenilworth and Kingman Marshes, has been artificially kept in the vegetated marsh state with a complex matrix of perimeter and interior exclosure fencing as well as aerial exclusion lines crossing the tops of the exclosures to keep birds from entering. It is anticipated that the goose exclusion will remain throughout the Fringe Marsh until a plan for managing the geese can be developed. As of this writing, a goose management plan is still in development.

4.8 <u>Conclusion</u>

With any large-scale restoration project, uncertainty and natural variation from intended goals can be expected (Zedler, 2001, Mitsch and Jorgensen, 2004; Baldwin, 2004). The dramatic loss of 40-60% of the total restored marsh cover from the Kingman Marsh restoration in 2001 was unexpected and primarily from resident goose herbivory (Hammerschlag et al., 2006) despite relatively less goose grazer impacts at Kenilworth Marsh. Some would argue that resident geese (or any non-native species) are not natural and are not a proper part of the Anacostia River system (Kangas, 2004a, 2004b; Kangas et al., 2004). While efforts to cull their numbers in rural and even some urban areas have proven successful, the decision to reduce their numbers in the District of Columbia will be an interesting case in political ecology, the result of which is not yet known but has the potential to be controversial (Peterson, 2000; Harris, 2002). In a quote highlighted in Kangas' comprehensive book on ecological engineering (2004a), Marston Bates (1961) has this to say about exotic species:

"The animals and plants that have been accidentally or purposefully introduced into various parts of the world in the past offer many opportunities for study that have hardly been utilized. They can, in a way, be considered as gigantic, though unplanned, experiments in ecology, geography, and evolution, and surely we can learn much from them."

Ecologically engineered systems are attempts to design and direct the natural energies of ecosystem processes to serve some societal purpose that also benefits the natural world in some way (Odum, 1989; Kangas, 2004a; Mitsch and Jorgensen, 1989, 2004). Understanding and accepting the ability of ecosystems to organize themselves is essential to ecological engineering and wetland restoration ecology (Mitsch and Wilson, 1996; Odum, 1989; Mitsch, 2000). While adaptive management decisions are important in directing the restoration of complex systems like tidal marshes toward a desired outcome, the recognition that unexpected forces may dramatically alter restoration goals beyond human management fixes may need to be accepted (Mitsch and Jorgensen, 2004). Restoration projects are excellent opportunities to learn from successes and failures and every effort should be made to apply the knowledge gained in future restoration work in order to advance the field of ecological engineering and restoration ecology.

The Army Corps of Engineers has made efforts to learn and adapt from its restoration efforts, as the funding for vegetation, sediment elevation, seed bank studies and several other research efforts attest (Hammerschlag et al., 2006). The problem with some of its failures in the restoration planning and decision making process may be more of a result of restoration ecologists and designers not asking the right questions, posing hypotheses and sufficiently testing them (Kangas, 2004a, 2004b). Taking the time and investing comparatively modest sums of money in smaller trial and error research efforts with a view of the next restoration project from a whole systems perspective would probably prove more cost effective in the long run. Instead it appears that the important yet distracting budget cycles and implementation schedules of large restoration efforts tend to overshadow and in many ways preclude the “go slow and learn” approach. Regardless, large scale and expensive restoration efforts that do not result in desired outcomes are still important opportunities for lines of research that can advance the field of ecological engineering and the help to improve the discipline of restoration ecology.

Chapter 5: Emergy Analysis of Kingman Fisheries Production

5.1 Introduction

The discipline of ecological engineering has evolved greatly since the coining of the term in the early 1960's by pioneering ecologist Howard T. Odum (Odum, 1962; Odum et al., 1963; Kangas, 2004a; Mitch and Jorgensen, 1989, 2004). One of the primary goals of ecological engineering, ecosystem restoration, has even developed to the point of becoming an important tool of the U.S. Army Corps of Engineers.

The use of dredge material for the restoration of emergent marsh habitat (U.S. Army Engineer Waterways Experiment Station, 1978, Priest et al., 1996, Streever, 2000; Yozzo et al., 2001) has become the primary ecologically engineered method of wetland re-establishment on Anacostia River in Washington, D.C (USACE, 1993). The most suitable sites for this type of restoration approach are shallow water areas and intertidal mudflats, which are too low in sediment elevation to support emergent marsh vegetation (Syphax and Hammerschlag, 1995).

As recounted in Chapter 4, the Kingman Lake tidal area was historically dominated by intertidal mudflats at low tide following its creation by dredging in the mid 20th Century. This condition made it attractive for a Kenilworth Marsh type beneficial use of dredge material restoration effort (1993) reported in Chapter 3, and became the model for the Kingman restoration. Onsite marsh restoration activities began on Kingman Lake in early 2000 by the U.S. Army Corps of Engineers. Dredging, filling, grading, marsh planting and fencing was completed in 2000, transforming the Kingman area from its status as a tidal "lake" to that of Kingman Marsh.

Tidal marshes have often been regarded as valuable for their potential to increase sediment trapping, organic matter and nutrient cycling, fisheries/wildlife production and habitat as well as flood control and intrinsic human aesthetic value (Greeson et al., 1979; Odum et al., 1984; Keddy, 2000, Mitsch and Gosselink, 2000, Zedler, 2001; Batzer et al., 2006). These functions and values are often and correctly forwarded as the rationale for the restoration of wetland systems.

One important function of tidal marshes that is often cited is their importance as productive nursery and feeding areas for migratory and resident fishes (Van Engel and Joseph, 1968; E.P. Odum, 1971; W.E. Odum et al., 1984; Mitsch and Gosselink, 2000). E.P. Odum, in describing salt marshes, compared them to "primary production pumps" feeding coastal waters in what he referred to as outwelling (E.P. Odum, 1980, 2000). The flow of energy from salt marshes to adjacent waters was affirmed by Childers et al. (2000), emphasizing the association of the marshes "outwelling" with nearby tidal creeks and the inner estuary. Studies have related commercial fishery catch with the area of intertidal vegetation (Turner, 1977) and marsh edge length (Teal and Howes, 2000). While the outwelling hypothesis has been characterized in terms of salt marshes and estuaries, the same relationship can be made with tidal freshwater marshes which are known to export considerable percentages of their above ground macrophyte biomass (Odum and Heywood, 1978; Odum et al., 1984; Mitsch and Gosselink, 2000). The energy subsidy of the regular tidal pulse to and from intertidal marshes maximizes the efficiency of the system in transforming and exporting energy flows to adjacent waters (Odum, Odum and Odum, 1995). A major pathway for the transfer of energy from lower to higher trophic levels in wetlands is made through fish (Van Engel and Joseph, 1968; Smith et al., 2000) which are then as a "fishery" the link to the human social and economic system (Bahr et al., 1982; Martin, 2002).

The transfer, or export, of restored Kingman Marsh energies through the fishery is examined through the use of emergy analysis. The comparison of production exports with the resulting changes in energy signatures from an existing, pre-restored condition to a restored condition for natural systems are rarely undertaken (H.T. Odum, 1983, 1996; W.E. Odum et al., 1984; Martin, 2002; Kangas et al., 2004). The structure and function of a pre-existing or restored system is influenced by the sum of the natural and human energies that contribute to it (Nixon, 1988). While economic analyses recognize monetary values, they typically do not incorporate or greatly underestimate the value of natural environmental inputs and exports due to the lack of a direct monetary valuation for natural services (Odum, 2001). An environmental accounting methodology that evaluates the total natural and human economic energy flows of a system on a common energy basis is termed an emergy evaluation or emergy analysis, with emergy the measure of natural or human work previously required to support an environmental system, product or service (Odum, 1996; Martin, 2002).

The value of large scale environmental restoration projects to the human economy and society, such as improved fisheries production, as well as to the natural systems they are constructed in, (increased primary production) is worth a detailed systems level investigation to advance the understanding of some of the results of restoration (Odum, 1984, 1996; Martin, 2002; Kangas, 2004a; Kangas et al., 2004; Mitsch and Jorgensen, 2004). The work of Martin (2002) and his emergy analysis of U.S. Army Corps of

Engineers river diversions intended to restore the tidal marshes of the Mississippi River delta is utilized as an appropriate template for an emergy analysis of the Kingman Marsh primary production and secondary fishery production under pre-restoration mudflat conditions, early restored marsh conditions and a mature marsh condition scenario. Using data specific to Kingman, the Anacostia River, the region, and several referenced assumptions, the emergy evaluation seeks to determine if the new marsh restoration would improve the exports of primary production and sport fisheries over the existing mudflat condition.

Cairns (1988) described restoration ecology as "full or partial placement of structural or functional characteristics that have been extinguished or diminished and the substitution of alternative qualities or characteristics than the ones originally present with the proviso that they have more social, economic, or ecological value than existed in the disturbed or displaced state." If some form of Cairns definition is to be accepted, then an accounting and comparison of the energy flows of the alternate states of pre-restoration mudflat and restored marsh is warranted to determine the relative contributions of each. To understand ecosystems and effectively restore aspects of them, the rates of energy circulation within a system as well as the rates of flows of energy and matter into and out of the system must be understood (Odum, H.T., 1971). The usefulness of the emergy analysis is found in objectively quantifying the total amounts of energy from the environment and the economy that are used. Comparing the restored marsh primary and fisheries production to the production of the mudflat alternate state can be useful when observed through an emergy analysis. In other words, in terms of primary production and fisheries export, is a restored marsh at Kingman more productive than the mudflats that they replaced? The following emergy analysis is intended to attempt to answer these questions.

5.2 Operational Definitions

5.2.1 Defining Emergy

An expression of energy that accounts for all of the available energy flows of one type of energy that are used directly or indirectly in creating a resource or service is known as emergy, short for energy memory (Odum, 1996). Emergy analysis is a method by which all of the energy inputs to and exports from the natural and human constructed systems may be valued and accounted for in a common non-monetary way with the energy base of solar energy (Odum, 1996). Solar emergy, termed the solar emjoule (sej) is the equivalent solar energy required to produce a natural or human product or service. Solar emergy is calculated by multiplying units of energy in Joules (the international standard of energy measure) by emergy per energy ratios called transformities (Odum, 1988, 1996).

5.2.2 Defining Transformity

These ratios, called transformities, are obtained by dividing the total emergy that was used in a process by the energy yielded by the process (Odum, 1988, 1996). The transformity ratios effectively convert different energy types such as fuel, to the common unit of emergy the solar emjoule. Transformity ratios have been calculated and placed in tables for numerous natural and human products and services and are central to quantifying the common emergy values needed when performing emergy analyses

(Odum, 1996). Several ratios used for calculation are emergy per mass and emergy per dollar ratios, also termed emdollars.

5.2.3 Defining Emdollars

The emdollar (em$) ratio is important in converting emergy flow to a common monetary amount, which is useful when translating natural products or services, which are not often given an economic value, to that which can be related to the human economy (Odum, 1996; 2001). The emdollar is defined as the total amount of money flow generated by a given amount of emergy input (Odum, H.T., 1996; 2000, 2001; Martin 2002). Emdollars allow the direct comparison and calculation of non-monetary emergy found in environmental inputs, services and functions to that of standard economic equivalents in dollars (Odum, 1996; 2001; Martin, 2002). Emdollars are obtained by dividing the emergy flows by the emergy/money ratio (which is determined as the total emergy of a region divided by the gross economic product of that region in a given year) (Odum 1996, Odum et. al. 2000, 2001; Martin, 2002). In this way the value of natural resources and services to the human economy can be equated so that an analysis can inform management decisions concerning the optimum use of human resources.

5.2.4 Kingman Mudflats and Marsh, Primary and Fisheries Production Emergy Analysis

An emergy analysis of the production exports that result from the marsh restoration of the Kingman area of Anacostia River (profiled in Chapter 4) is detailed for the purposes of determining the net value and benefits of this type of restoration to the primary and fisheries production. The natural environmental contributions to an existing or newly restored system are often characterized individually, but rarely aggregated and quantified in a manner which is directly comparable. Determining the net benefit of environmental restoration in terms of emergy is seen as a way to guide management policy and efficiently utilize money for environmental projects (Odum, 1996, 2001; Kangas et al., 2004). The results of the emergy analysis will help inform future restoration projects of this type. The analysis conducted here is patterned on the work conducted by Martin (2002).

Information collected relating to the Kingman area pre-restoration (intertidal mudflat/open water) and post-restoration (emergent marsh, mudflat/open water) physical and biological conditions are compiled and detailed. Fishery production exports for the restored marsh condition and mature marsh condition are based upon fishery data collected within the newly restored Kenilworth Marsh and Dueling Creek mature marsh systems detailed in Chapter 3. A determination of the natural and human emergy inputs required for the Kingman Marsh restoration project and its emergy exports are first diagrammed and then listed and calculated. As a final analysis, economic (emdollar) equivalents are developed to compare the environmental economic services of primary and fisheries production supplied by the pre-existing Kingman condition dominated by intertidal mudflats vs. that of the restored Kingman emergent tidal marsh as it existed the year it was completed in 2000 and with a mature marsh projection 50 years into the future.

It is fundamental to emergy analysis to assume that the contribution of a resource or service is proportional to the amount of energy required to create the resource or service (Brown and Herendeen, 1996). The emergy analysis of the total economic and natural emergy (person hours, fuel, information, solar insolation, tides, biomass production, sediment processes, etc.) required to build and maintain the restored Kingman marsh are calculated and displayed in a table. The transformation of these different energy types into the common unit of emergy, the solar emjoule (sej), provides a platform for a clear analysis of the relative benefits of the Kingman marsh restoration over mudflats, with the expectation that over time the primary and fisheries production provided by the marsh restoration will be improved (Odum, 1996).

5.2.4.1 Methods

5.2.5 Energy Systems Diagram and Analysis Table

First an energy systems diagram for the mudflat/open water and newly restored emergent marsh conditions at Kingman is developed to help conceptually organize the relationships between the system components and their energy flow pathways (Figure 5.1). The diagram represents the structure and functions of the system in order to help identify the inputs and particular outflows that are to be evaluated (Odum, 1996; Odum and Odum, 2000, Odum et.al., 2000; Martin, 2002). The important system components that contribute to the Kingman boundary area include the sun, rain, tides, river components, wind and the resources imported to restore emergent marsh. While many of the values are based on referenced data particular to the area and the region, assumptions are made that they apply particularly to the Kingman study site and several assumptions are made that are applied from the literature. The primary productivity of mudflats, open

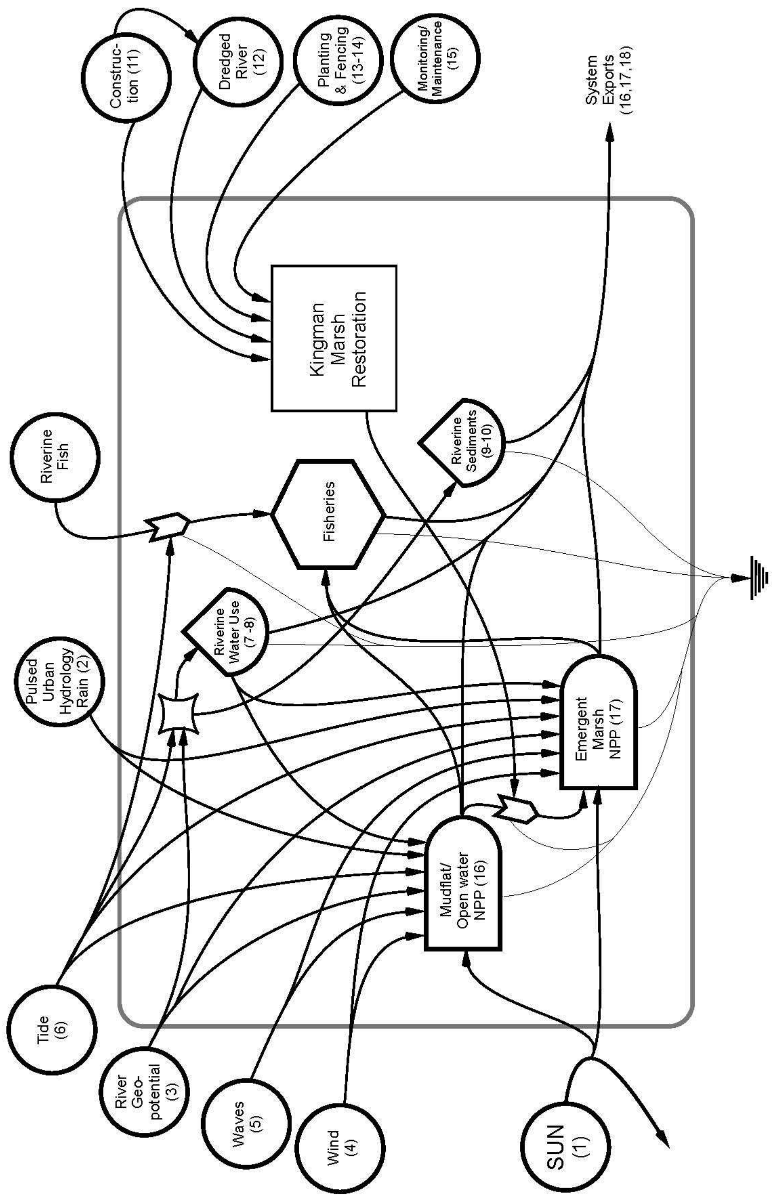

Figure 5.1 Kingman Marsh restoration energy circuit diagram detailing renewable energy flows, inputs from the economy for restoration, and system exports from the mudflat/open water and emergent marsh systems.

water and emergent marsh are calculated from literature values and applied in proportion to their assumed area coverage in the pre and post restoration conditions. Secondary production in the form of the contribution of the sport fishery utilization of the two conditions are also calculated from actual fishery data collected earlier (Chapters 3 and 4) and applied to this study.

An emergy analysis table (Table 5.1) is then constructed directly from the systems diagram and values of the annual amounts of import or export of each energy flow are quantified in raw units (joules, grams, dollars) using inflows and outflows crossing the system boundary as row headings (Odum, 1996; Odum and Odum 2000; Odum et.al. 2000; Martin 2002). Transformities reported by Odum (1996) and other cited literature sources are applied to convert the flows of different raw unit energies to emergy of the same type in solar emjoules (sej) for comparison and analysis (Odum, 1996; Odum and Odum, 2000; Odum et.al., 2000; Martin 2002). The calculations of each of these raw unit flows of energy that contribute directly to the emergy analysis Table 5.1 are detailed in the footnotes to the table in Appendix C, Table 5.1.

Table 5.1 Kingman Marsh emergy analysis table

Note	Item	Raw units Without Marsh (mudflat)	Raw units With Marsh (restored)	Transformity (sej/unit)	Kingman Solar Emergy Without Marsh (Mudflat) E13 sej	Kingman Solar Emergy With Marsh estored year 1) E13 sej	Kingman Solar Emergy With Marsh (Years 1-50) E13 sej	Kingman Solar Emergy Without Marsh (Years 1-50) E13 sej
	Renewable Resources							
1	Sunlight	1.29E+16 J	1.29E+16 J	1.00E+00 sej/J	1293.57	1293.57	64678.52	64678.52
2	Rain-chemical potential energy	7.34E+12 J	7.34E+12 J	1.82E+04 sej/J	13364.41	13364.41	668220.53	668220.53
3	River geopotential	1.96E+13 J	1.96E+13 J	3.83E+04 sej/J	75003.17	75003.17	3750158.65	3750158.65
4	Wind-kinetic	1.66E+12 J	1.66E+12 J	1.50E+03 sej/J	249.68	249.68	12484.07	12484.07
5	Waves	5.46E+06 J	3.87E+06 J	3.06E+04 sej/J	0.02	0.01	0.59	0.84
6	Tide	4.65E+10 J	3.30E+11 J	1.68E+04 sej/J	78.13	553.58	27679.06	3906.60
7	Riverine water used - mudflat / open water	1.91E+12 J	1.35E+12 J	4.11E+04 sej/J	7841.90	5556.15	277807.36	392095.20
8	Riverine water used - marsh		1.28E+12 J	4.11E+04 sej/J	0.00	5278.88	263944.20	0.00
9	Riverine sediments captured	4.04E+08 g	3.75E+08 g	8.51E+08 sej/g	34348.50	31921.37	1596068.49	1717424.77
10	Riverine sediments stored	3.37E+08 g	3.08E+08 g	8.51E+08 sej/g	28658.61	26231.48	1311574.16	1432930.44
	Total renewable resources (rows 8,9,11,12,13,14)				96287.64	99756.21	4987810.39	4814381.82
	Imports							
11	Construction		$76,601.91 $	1.00E+12 sej/$	0.00	7660.19	383009.55	0.00
12	Dredged river sediments		4.27E+09 g	8.51E+08 sej/g	0.00	362846.78	18142338.78	0.00
13	Plantings		$16,750.00 $	1.00E+12 sej/$	0.00	1675.00	83750.00	0.00
14	Fencing		$7,804.09 $	1.00E+12 sej/$	0.00	780.41	39020.45	0.00
15	Monitoring and maintenance		$13,146.74 $	1.00E+12 sej/$	0.00	1314.67	65733.70	0.00
	Total imports				0.00	374277.05	18713852.48	0.00
	Exports							
16	Net primary production- mudflat/open water	1.33E+12 J	7.20E+11 J	4.70E+03 sej/J	625.59	338.44	16922.03	31279.72
17	Net primary production-marsh		3.58E+12 J	6.96E+03 sej/J	0.00	2488.99	124449.44	0.00
18	Fisheries (with catfish)	5.72E+10 J	1.73E+10 J	3.07E+06 sej/J	17565.74	5317.78		878286.90
	(without catfish)	5.93E+09 J	4.35E+09 J	3.07E+06 sej/J	1821.63	1334.01		91081.60
	(mature marsh with catfish)		1.89E+10 J	3.07E+06 sej/J			290558.99	
	(mature marsh without catfish)		1.21E+10 J	3.07E+06 sej/J			186396.33	
	Total exports (with catfish)	1.39E+12 J	4.31E+12 J		18191.33	8145.21		909566.61
	(without catfish)	1.34E+12 J	4.30E+12 J		2447.23	4161.44		122361.32
	(mature marsh with catfish)		4.32E+12 J				431930.46	
	(mature marsh without catfish)		4.31E+12 J				327767.80	
	Kingman Area Specifications							
	Kingman Watershed Area	148.6 ha		1.49E+06 m^2				
	Total Kingman Tidal Area	44.6 ha		4.46E+05 m^2				
	Marsh (2000)	13 ha		1.30E+05 m^2				
	Mudflat at low tide	15.8 ha		1.58E+05 m^2				
	Open water at low tide	15.8 ha		1.58E+05 m^2				
	Tidal amplitude = 3ft (0.91m)	0.91 m						
	Low tide volume = 5,662,000ft^3 (160,331m	160331 m^3						
	High tide volume = 7,623,000ft^3 (215,860m	215860 m^3						

Footnotes to Emergy Analysis Table 5.1 in Appendix C

5.2.6 Renewable Resources

Because the sun, wind and rain are all supported by and interdependent on the same initial solar energies, their values are not cumulatively added to the total value of renewable resources. To avoid double counting the contributions of these inputs, the largest input is selected as the surrogate for the sum of the inputs (Odum, 1996; Martin, 2002). For the Kingman boundary area, this would be the chemical potential emergy of the rain. The river geopotential emergy was determined by multiplying the percentage of flow of Anacostia River water into the Kingman area by the transformity calculated for geopotential specific to the Anacostia River (Table 5.2).

River sediment flow was determined as the annual total suspended solids (TSS) flow into Kingman as a percentage of that from the Anacostia River minus sediment reduced due to subsidence in the Kingman study area. Sediment was multiplied by the emergy per mass for mineral sediment from Table 5.2 as assumed by Martin (2002). Geologic uplift was considered negligible for the Kingman area and was left out of the calculations while river geopotential was added to the sum of the total renewable resources.

Table 5.2 Emergy per mass of river geopotential and river sediments

		Annual Flow	Transformity	Annual solar emjoules
1	Rainfall	4.56E+14 g	8.99E+04 sej/g	4.10E+19 sej
2	Total annual solar emjoules			4.10E+19 sej
3	Annual flow sediments from Anacostia to Kingman	4.82E+10 g		
4	Anacostia River sediment		8.51E+08 sej/g	
5	River potential energy	1.07E+15 J		
6	River geopotential		3.83E+04 sej/J	

1 Annual rainfall= annual ht. rain (1.0 m/yr) * density water (1.00E+6g/m^3) * Anacostia basin area (4.56E+08 m^2), Emergy per mass from Martin (2002) from Romitelli (1997)
2 Total from row 1
3 Warner (1997)
4 Row 2 divided by row 3
5 Annual river flow (1.2E+8 m3/yr) * density water (1.0E+6g/m^3) * gravity (9.81m/s^2) * average river elevation relative to mean sea level (0.91m)
6 Row 2 divided by row 5

5.2.7 Inputs to the Kingman Marsh Restoration

The energy inputs to the marsh restoration in the form of dollars and volume of dredged river sediment were broken into several groups as detailed by the U.S. Army Corps of Engineers (Appendix C, Table 5.2)(personal communication, 2004). Construction management and design, physical construction, dredged river sediment, marsh plantings, goose exclosure fencing, and monitoring and maintenance costs were all added to a total imported emergy for the Kingman Marsh restoration work. The emergy to dollar ratio calculated for the year of the restoration in 2000 (1.0×10^{12} sej/$) was used as a conservative estimate to convert dollar values to solar emjoules (Odum, 2001). It is calculated as the annual U.S. inflow of emergy divided by the U.S. Gross National Product (Odum, 1996).

5.2.8 Exports from the Kingman System

There are several components of production in tidal freshwater systems that are exported to different degrees. The concept of resource export, or outwelling, from tidal marshes and shallow water zones in estuaries discussed earlier has been articulated since the 1960's (E.P Odum, 1971, 1980, 2000). This is considered to be true of the Kingman Marsh system which is predominantly intertidal, with most water leaving the system to move further down the Anacostia River on an ebbing tide. The model created for this emergy analysis attempts to account for the primary and fishery production exports from the Kingman system with a similar methodology and accounting to that of Martin (2002). While Odum et al., (1984) reported that energy flow in tidal freshwater marshes was largely speculative, a rough energy flow description identified three primary sources of energy to support the marsh food webs: emergent macrophytes, terrestrial organic material and phytoplankton, with benthic microflora also considered of possible importance. The primary production group contributions estimated in this analysis for export from Kingman under pre and post-marsh restoration conditions included: open water phytoplankton (Footnote 5.1), mudflat algae (Footnote 5.2), and emergent marsh (Footnote 5.3) primary production. These are considered to be the largest contributors to export from the marsh (Odum et al., 1984) and are unique features of estuaries in having three distinct classes of primary producers (Odum, 1980).

Fish and bird groups are also represented. Although both fish and bird data were collected at Kingman, only the fish data was utilized for the emergy analysis as a primary exporter of energy from the system (Footnote 5.4). This fits with the accepted paradigm of the marsh as a nursery for fisheries (Boesch and Turner, 1984; Deegan, 1993; Houde and Rutherford, 1993; Mitch and Gosselink, 2000). The role of the higher level fish consumers in the emergy analysis is to represent the ultimate extraction and export of the saprotrophs, primary and secondary consumers that are converting flows of energy from terrestrial carbon and the detrital pool, which are important components of the system (Odum, E.P, 1971, 1980; Odum et al., 1984; Mitch and Gosselink, 2000).

Approximately 100% turnover of aboveground macrophyte primary production on an annual basis is possible for many tidal freshwater marshes, with almost all above ground plant matter from several dominant species of middle and lower marsh zones completely decomposing and leaving bare mud within months after senescence (Odum and Heywood, 1978; Odum et al., 1984). Phytoplankton in Kingman also have 100% export potential on an annual basis with the outflow of almost all open water on an ebb tide as well as higher trophic level consumption and export. Algae biomass transition through higher trophic levels is also assumed a large proportion of export. The observed tendency of mudflat algae to form algal mats that detach and float away once reaching a critical density is assumed to increase export combined with trophic transfers at Kingman to 100% (personal observation).

Emergent marsh macrophyte biomass export was set at 80% to account for several factors, including: incomplete decomposition of some species; trapping of plant material in marsh sediments; and the inclusion of belowground root biomass in the production calculations which generally does not leave the system, although a case could be made for some export through waterfowl that dig up marsh plant tubers (Odum and Heywood, 1978; Whigham et al., 1978). Exports of energy flow through fish populations are also assumed to be 100% on an annual basis.

5.2.9 Kingman Marsh Area

Marsh areas for Kingman were assumed to be that of the initial year of restoration in 2000 at 13 ha (Hammerschlag et al., 2001) which was the full extent of marsh restoration without the impacts of latter years herbivory. Under typical marsh development trajectories with ample sediment supplies it might be assumed that the emergent marshes would expand their coverage over time or at least retain their current coverage in the immediate timeframe (Stevenson et al., 1988). This was found to not be the case, due to extreme goose herbivory as discussed in Chapter 4. For this reason, the same area coverage for emergent marsh and fishery useable open water area at high tide was assumed for Kingman Marsh (year 2000) when fishery production numbers for the Kenilworth restored marsh and Dueling mature marsh hypothetical scenarios were applied. The same marsh area coverage was assumed over the 50 year time frame with the Dueling Creek fishery numbers applied to this hypothetical future of Kingman Marsh as a mature marsh fishery similar to that of Dueling. Fishery useable open water area is defined for this analysis as all areas not occupied by emergent marsh at high tide or 31.2 ha. This is considered because the species comprising the sport fishery do not typically penetrate the marsh itself, but utilize the adjacent open water areas at high and low tide to hunt for prey fish that are utilizing the marsh for food and refugia (Rozas and Odum, 1987).

5.2.10 Emergy Indicies Calculation

Emergy indices are calculated from the fisheries export values found in the emergy analysis table and are used to draw inferences from the emergy analyses. The emergy indicies used are as follows with their basic terms represented in Figure 5-2.

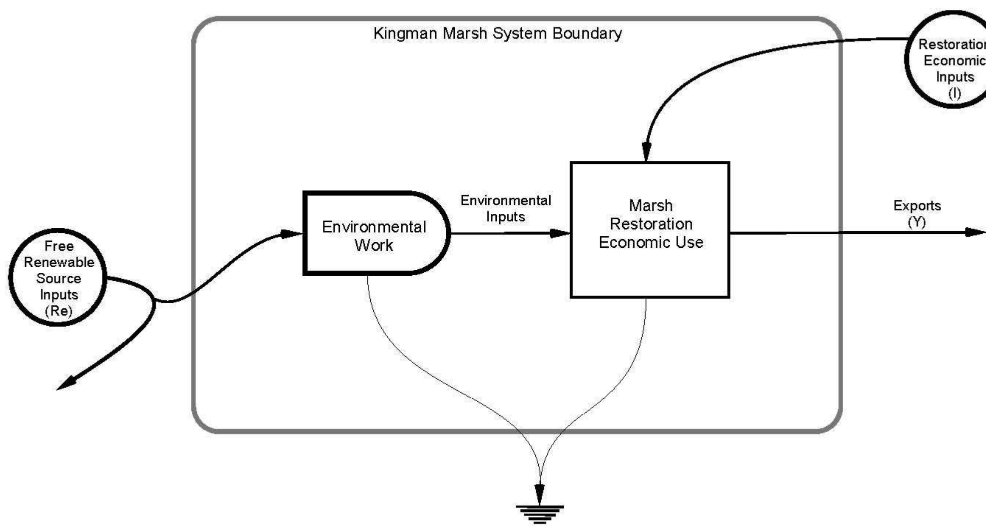

Figure 5.2 Simplified energy circuit diagram illustrating the basic flow of energies used to calculate the emergy indices.

5.3 <u>Fisheries Emergy Yield Ratio</u>

An interpretation of fisheries benefit, this ratio is the emergy of the fisheries production export, or yield from the system (Y) divided by the emergy of the renewable resources (Re) plus the primary production that supports the fishery (P). This ratio (Y/(Re+P)) indicates which system state (intertidal mudflat or emergent marsh) and condition (unchanged, newly restored or mature marsh) is more productive from a fisheries perspective. The process with a greater value produces more fisheries to the system with larger values representing larger contributions.

5.4 Results

5.4.1 Emergy Analysis Table

5.4.1.1 Renewable Resources

Total emergy from marsh restoration in year one (2000) estimated from renewable resources increased by 3.47×10^{16} sej over estimated mudflat renewable resources due to the Kingman Marsh restoration (Table 5.1). Fifty year total increases in emergy flow due to the marsh restoration was calculated at 1.73×10^{18} sej over the purely mudflat state during that time period. As stated in the methods, a fifty-year time horizon for Kingman was chosen as a comparison to the marsh development point that the Dueling Creek mature marsh reference condition had attained. The total emergy values did not include those that would be considered "double counting" as described earlier in the methods section. River input contributions, including riverine water used by the restored marsh and to a lesser extent tidal energy absorbed by the marsh, were determined as the difference between the restored marsh and pre-existing mudflat conditions. Annual river geopotential (Table 5.1, row 3) and the annual chemical potential energy of the rain (Table 5.1, row 2), acting on both state conditions equally, were the largest emergy contributors to the system with annual sediments captured and stored (Table 5.1, rows 9-10) and annual river water used (Table 5.1, rows 7-8) following with their contributions.

The differential between water emergy used followed the differences between the open water available under the marsh and mudflat conditions, with the restored marsh condition reflecting an annual increase of 2.99×10^{16} sej in the year one 2000 analysis (Table 5.1, rows 7-8). Both conditions received the same sediment subsidy from the tidal Anacostia River. From the three surface elevation table (SET) readings recorded nearest to the study period of the emergy analysis, it appeared that the lower elevation mudflat SET station (1.7' NGVD '29) showed a greater average net gain of sediment while the higher elevation marsh SET station (2.4' NGVD '29) had a more modest average net gain (Hammerschlag, personal communication). While three readings are difficult to judge a long-term trend by, the emergy analysis for the restoration year of 2000 were assumed to be indicative of that year.

Even as a rough approximations, it seems inconsistent with tidal wetland function conventional wisdom that a vegetated marsh would capture and store less sediment than an unvegetated mudflat or subtidal area (Stevenson et al., 1988), although both these systems are known for their potential to have seasonal and yearly changes in sedimentation due to localized conditions (Serodes and Troude, 1984).

Net emergy for sediments captured and stored under the pre-restoration, mudflat condition reflected a modest annual increase of 3.88×10^{15} sej over the restored marsh condition (Table 1, rows 9-10). The lack of difference in sediments captured vs. sediments stored within each condition was a result of the relatively insignificant effect of geologic subsidence assumed for the area for one year (Kearney and Stevenson, 1991), when compared to the potential volume of sediments captured in the system under both conditions. The sediments captured and stored values turned out to not be important in the analysis, however, and to avoid double counting of emergy flows only the largest of the riverine sediment inputs (river geopotential) was used leaving sediment captured and sediment stored out of the total renewable resource calculation.

Tide was the next largest emergy contributor of renewable resources, with the marsh area assumed to absorb and more efficiently utilize a greater amount of tidal energy (5.53×10^{15} sej annually) due to the increased roughness of the marsh surface over that of the open water / mudflat condition (7.8×10^{14} sej) (Table 5.1, row 6). The daily pulses of this renewable energy source, in following nature's pulsing paradigm (W.E., E.P. and H.T. Odum, 1995), subsidizes both the mudflat/open water and the emergent marsh states, although the marsh is assumed to maximally utilize and convert more of these energies into production than the mudflat state. Wind was assumed to have the same relative effect on both conditions (2.49×10^{15} sej annually) while wave contributions in the largely sheltered tidal embayment were comparatively insignificant, although also differed due to the relative areas of open water under both conditions (Table 5.1, rows 4-5).

5.4.1.2 Inputs and Exports

Emergy imported from the economy in 2000 for the restoration of Kingman was calculated to be 3.74×10^{18} sej. This included year one of the 50 year amortized dollar emergy amount from over \$5.7 million in direct economic investment as well as the emergy of the imported dredged sediments for year 2000 (Table 5.1, rows 11-15). When expressed in emdollars (em\$) by dividing the solar emjoules by the emergy to dollar ratio for year 2000 (1.00×10^{12} sej/\$), this was calculated to be 3.74×10^{6} em\$ amortized over 50 years. No investment from the economy was being directly expended on Kingman to keep it in the mudflat condition, as it was supporting itself entirely with natural energies, this state was assumed to have zero direct monetary imports from the economy.

5.4.2 Renewable Energies and Production Exports

5.4.2.1 Primary Production

By investing money in marsh restoration, the Kingman system was able to capture more renewable energies, and resulted in annual exports of primary production emergy increasing from 6.26×10^{15} sej under the pre-restoration mudflat condition, to 2.83×10^{16} sej with a restored marsh, an annual net increase of 2.20×10^{16} sej in primary productivity due to the restoration (Table 5.1, rows 16-17). Over the 50-year time scale, this accounted for a net increase of 1.1×10^{18} sej in exported primary production from marsh restoration over the pre-existing mudflat state.

Under the pre-restoration mudflat state, primary productivity accounted for just over 3% of total annual emergy exports, with the remainder owing to the large contribution of the fisheries. Under the restored marsh state, primary production increased to over 35% of the total emergy exported from the system annually. Renewable resource emergy increased modestly under the restored system state, as much of the natural energy contributions to Kingman from the environment were applied almost equally under both state conditions.

5.4.3 Fisheries Production and Export

Primary production from phytoplankton, mudflat algae, and emergent macrophytes were not the only exports accounted for in the emergy analysis. The considerable effort to account for fisheries production under the pre-restoration mudflat condition in Kingman to compare to a restored marsh and a mature marsh condition revealed some interesting and unexpected results (Chapters 3 & 4). Under pre-restoration mudflat conditions that had existed for decades in Kingman Lake, the total annual sport fishery emergy production (with catfish, 1.76×10^{17} sej) was greater than three times that of the restored marsh scenario (5.32×10^{16} sej) (Table 5.1, row 18). The greater emergy from fisheries production that was supported by the mudflat state over restored marsh (1.23×10^{17} sej) was 75% attributable to the biomass of bullhead catfishes coming from the mudflat state (1.59×10^{17} sej).

To take this a step further, the fishery production estimates for the mature Dueling Creek marsh system were applied to the Kingman Marsh. This was done with the assumption that given enough time (several decades or more) the Kingman Marsh fishery might develop in much the same way as Dueling Marsh to reflect somewhat less catfish and a more diverse species composition that included top level piscivores. When these calculations were completed, the result was only slightly better, with the mudflat condition still producing an emergy surplus of 1.18×10^{17} sej over the mature marsh hypothetical scenario (Table 5.4).

The total emergy exports from the two alternate Kingman systems, including primary production and fisheries (with catfish), found the pre-restoration mudflat state to be exporting 1.82×10^{17} sej, with the restored Kingman Marsh state only exporting 8.15×10^{16} sej, a net positive export from the mudflat state of 1.00×10^{17} sej. The District of Columbia fishery is estimated to be a $1.35 million annual contributor to the local economy (Appendix C, Table 5.7). This value is also thought to be an underestimate considering the basis of the economic numbers were from shoreline angler surveys that did not include boat based fishers, or the highly economically intensive bass boat fishing public (Cummins and Rockland, 1987; Byers, 2005).

5.4.4 Catfish and Emergy

The inclusion of bullhead catfish is the "normal" state of the fishery, with the emergy analysis reflecting more emergy exported for the pre-restoration condition, which was greatly influenced by the biomass of catfish caught in the mudflat state as compared to the restored marsh. This is interesting, in that previous emergy analyses that included local fisheries estimates and economic data revealed a direct connection between wetland area and fishery production (Bahr et al., 1982; Martin, 2002). Of course these analyses were conducted on the highly productive and economically important Louisiana coastal fishery, and a direct comparison of results from these studies is not intended.

The family of bullhead catfish (Ictaluridae) are considered to be commercially important, and for the individual angler, an important gamefish (Rohde et al., 1994). While there is no commercial fishing allowed in District waters for any species, individual anglers are generally free to fish. Catfish are bottom dwelling omnivorous fish and they come into close contact with riverine sediments. In the Anacostia River, bottom sediments in several locations were found to be contaminated to different degrees by location by PCBs, PAHs, chlordane, DDTs, and several heavy metals (Velinsky et al., 1997). Due to this acknowledged contamination and the findings of elevated levels of many of these contaminants in catfish tissue (Velinsky and Cummins, 1996), the D.C. Department of Health, Environmental Health Administration imposed a public health advisory on their consumption in the city that has been in effect for over a decade (Byers, 2005). Potomac River commercial and hook and line catfish harvests for Maryland and Virginia were almost 200,000 lbs in 2000, yet dropped to over 1,500 lbs in 2004 and 550 lbs in 2005 (Potomac River Fisheries Commission statistics, 2007 personal communication). This is likely due to the extension of a fishery advisory for catfish to these downriver portions of the Potomac by their resource management agencies.

A shoreline angler fishery survey conducted in 2004 by the Government of the District of Columbia, Department of Health, Environmental Health Administration, Fisheries and Wildlife Management Division, found that of the anglers surveyed, about 19% had caught catfish and that the fish species (family) favored by the anglers was 48% catfish (Byers, 2005). The same survey estimated the annual angler catch of all gamefish (Footnote 5.4, Table 1) in the District to be approximately 909kg, of which about 400kg (44%) were estimated to be catfish (Appendix C, Table 5.7).

The catfish public health advisory and its ban on consumption effectively removes catfish from the list of important gamefish in the District, just as it has for the Potomac River fishery which essentially saw the complete removal of catfish from commercial and hook and line harvests in just a few short years despite the fact that some numbers are still reported. For these reasons, and to determination of what kind of economically important “fishery” a restored Kingman Marsh would have, assumptions about the fishery production from Kingman also created scenarios that excluded catfish from the emergy calculations (Tables 5.1, 5.4, Appendix C, Tables 5.3 to 5.5). This was done much as the 19 other species of fish that were captured during the electrofishing surveys (Appendix A, Table 3.5, Appendix B, Table 4.3) were left out of the emergy analysis in order to evaluate the effect that the marsh restoration had on the “fishery” as opposed to the fishes as a whole, which was the intention of the analysis.

5.4.5 No Catfish Emergy Scenarios

The same emergy evaluations for fishery production that were calculated from the full suite of gamefish species typical for freshwater systems (Footnote 5.4, Table 1) were recalculated without the bullhead catfishes. Once this was done, the estimated annual fishery production of dry weight fish biomass for Kingman Lake mudflats prior to restoration declined from 3.0×10^6 g to 3.12×10^5 g, a difference of 2.67×10^6 g (Table 5.4). The restored Kingman Marsh fishery scenario also declined without the catfish biomass, from 9.17×10^5 g to 2.13×10^5 g, a difference of 7.04×10^5 g. This still left the restored marsh condition with less annual biomass production than the pre-restoration mudflat state, in large part due to larger mudflat biomass values for yellow perch, pumpkinseed and bluegill sunfish and values for white perch that were more than half that of the restored marsh condition (Appendix C, Table 5.4).

When translated into emergy values, the pre-restoration mudflat state for annual fishery emergy production transformed to 1.82×10^{16} sej (Table 5.1, row 18). Restored marsh fishery emergy production totaled 1.33×10^{16} sej, a decrease in emergy from the mudflat condition of 4.9×10^{15} sej, making the marsh restoration a net loss in terms of sport fishery emergy production even without catfish contributions. Mature marsh emergy from fisheries without catfish came to 3.73×10^{16} sej. This represented the first fishery scenario in which the marsh emergy came out ahead of the mudflat emergy, revealing the value of a mature marsh to fisheries that may only come with development over time.

5.4.6 Total Annual Emergy Exported (Without Catfish)

The total annual emergy exports from the two alternate Kingman systems, including primary production and fisheries without catfish, found the pre-restoration mudflat state to be exporting 2.45 x 10^{16} sej, with the restored Kingman Marsh state exporting 4.16 x 10^{16} sej, a positive export from the restored marsh state of 1.71 x 10^{16} sej, or 1.7 times that of the mudflat state (Table 5.1, row 18). The same was true of the mature marsh fishery scenario with 3.28 x 10^{18} sej in total emergy exported over 50 years, an increase of 1.41 x 10^{18} sej, or 2.7 times that of the 50 year old mudflat state. Conversely, if catfish were left in the equation, the mudflat state would have had 4.78 x 10^{18} sej, or 2.1 times that of the mature marsh. This scenario, without catfish, revealed that a simple adjustment in species biomass allocation to fall in line with social management objectives can have much different emergy outcomes that are not immediately evident from total biomass or even energy conversions to joules.

The annual total energy in joules from the combined primary production and fisheries exported from the restored and mature marsh scenarios (with or without catfish) were greater than that of the mudflat state, although once the joule energy was transformed by their respective emergy to joule ratios, only the marsh conditions without catfish came out ahead in emergy over the mudflats. This attests to the power and value of having a common unit basis in solar energy, and transformities that adjust the relative quality, or true value of the energy. This methodology is intended to be used in developing and analyzing differing types of data in a comparative way to be able to make more informed management decisions. The system that exports the greatest amount of emergy to the public economy is usually considered to be the socially more beneficial, and it would seem that without catfish being considered a part of the sport fishery in the District of Columbia, a newly restored and mature marsh system improves the human economy with respect to the fisheries.

5.4.7 Emergy Indices

Emergy indices (Table 5.3) are developed from calculations applied to the data from the emergy analysis (Table 5.1) to help quantify the production export contributions of the mudflat and emergent marsh systems to the Anacostia River ecosystem. Additionally, when alternately compared natural systems provide an economic service to the local economy, as with a sport fishery, the system that exports the greatest amount of fishery emergy to the public economy is considered to be the best system for the economy in providing certain services (fisheries) to society (Brown and McClanahan, 1996; Martin, 2002).

Table 5.3 Emergy indices for Kingman fisheries

Note	Description	Calculation	Units	Kingman Without Marsh (Mudflats)	Kingman With New Marsh (Restored)	Kingman With Mature Marsh (Restored) (Years 1-50)	Kingman Without Marsh (Mudflats) (Years 1-50)
1	Renewable Emergy Flow	Re	E+13 sej	96288	99756	4987810	4814382
2	Total System Export	Y					
	(system with catfish)		E+13 sej	18191	8145	431930	909567
	(system without catfish)		E+13 sej	2447	4161	327768	122361
3	Primary Production	P	E+13 sej	626	2827	141372	31280
4	Fisheries Emergy Yield Ratio	Y/(Re+P)					
	(system with catfish)		sej/sej	0.19	0.08	0.08	0.19
	(system without catfish)		sej/sej	0.03	0.04	0.06	0.03
5	Fisheries Emergy						
	(system with catfish)		E+13 sej	17566	5318	290559	878287
	(system without catfish)		E+13 sej	1822	1334	186396	91082
6	Fisheries Emdollar Value						
	(system with catfish)		em$	175,660	53,180	2,905,590	8,782,870
	(system without catfish)		em$	18,220	13,340	1,863,960	910,820

Notes on values taken from Table 5.1

1 Renewable emergy flow: Rain + River geopotential + Waves + Tide + Riverine water used-mudflat + Riverine water used-marsh
2 Exports (yield) from Kingman: NPP mudflat and open water + NPP marsh + Fisheries scenarios with and without catfish
3 Primary Production: NPP mudflat and open water + NPP marsh
4 Fisheries Emergy Yield Ratio: Total exports under each scenario divided by renewable resources plus primary production
5 Fisheries Emergy: Values for each scenario taken from Table 5.1
6 Fisheries Emdollar Value: Fisheries emergy divided by emergy to dollar ratio for US for year 2000 (1.0E+12 sej/$)(Odum,2001)

5.4.7.1 Fisheries Emergy Yield Ratio

An interpretation of net fisheries benefit, this ratio is the emergy of the fisheries production export, or yield from the system (Y) divided by the emergy of the renewable resources (Re) plus the primary production (P) that ultimately supports the fisheries. This ratio (Y/(Re+P)) indicates which system state (intertidal mudflat or emergent marsh) and condition (unchanged mudflat, newly restored or mature marsh) is more productive from a fisheries perspective. The process with a greater ratio produces more fisheries to the system with larger values representing larger contributions. Fisheries production emergy yield for the mudflat, restored marsh and 50 year mudflat and mature marsh are calculated in Table 5.3. Under the one year mudflat state the fisheries production ratio with catfish calculated to 0.19, more than twice that of the restored marsh state of 0.08. If catfish were taken out of the fisheries equation, the mudflat state produced the lesser value of 0.03 while the restored marsh state fishery production ratio value was greater at 0.04. When the 50 year time frame is applied the index calculation reveals that under the fishery scenario that includes catfish the mudflat state is again more productive (0.19) than the mature marsh (0.08) while removing the catfish from the fishery reverses the result with the mature marsh producing a fishery index value of 0.06, twice that of the mudflat state.

5.5 *Discussion*

The emergy analysis from Martin (2002), on which much of the Kingman analysis is patterned, created a year 1 and 50 year time horizon for the analysis based on the life expectancy of the river diversions that were constructed to supply sediment to build and expand Louisiana coastal marshes. Reasonable assumptions were made about marsh accretion rates as a result of the diversions, and the emergy and emdollar return on investment was significant given the time allowance and the economic importance of expanded wetland coverage to the lucrative coastal fishery as well as providing for greater flow of renewable energies (Bahr et al., 1982; Martin, 2002). With the Kingman Marsh, the unexpected effects of goose herbivory and surface elevation reduction on the marsh restoration significantly decreased the area and extent of emergent marsh coverage from its original planted cover in year 2000 of 100% to only 25% coverage four years later (Hammerschlag et al., 2006). For these reasons, an estimated expansion of marsh area from its existing cover in year 2000 was not considered and for the hypothetical 50 year time horizon the year 2000 coverage was kept.

Large amounts of low transformity, renewable river inputs and primary productivity support higher quality emergy products such as fish. The investment in restoration of coastal tidal marshes can in some ways be compared to agricultural systems where imported energies are used to support and capture the natural energies that yield a valuable economic export. The capture of sun, rain and wind by agriculture systems still requires substantial imported energy from the human economy, which results in a lower renewable emergy captured. Unlike agriculture, the investment in marsh restoration is usually a single up front cost that sets the stage for natural processes to take over and sustain the system supporting processes and production (as with fisheries) to enhance the ecological and human economy.

As stated earlier, the D.C. urban recreational fishery was estimated at $1.35 million annually. With the significant dependence of many species of migratory and resident gamefish on wetland energy transformation and flow, improving the state of coastal wetlands is usually seen as a very positive action providing benefits to local and regional economies (Bahr et al., 1982; Odum et al., 1984; Houde and Rutherford, 1993; Mitsch and Gosselink, 2000; Martin, 2002).

The conversion of fisheries emergy to an emdollar (em$) equivalent allows the marsh fisheries production export to be related to the economy. This is done by dividing the fisheries emergy flow by the emergy to dollar ratio for the year of the investment, which in 2000 was 1.0×10^{12} sej/$ (H.T. Odum, 2001). Interestingly, the mudflat condition produced a higher fishery emergy and emdollar value than the restored marsh condition at Kingman, unless catfish were removed from the calculation under the 50 year projection (Table 5.3).

Marsh systems also benefit societies in ways that often transcend easily accounted for economic benefits. These benefits, such as aesthetic enjoyment and recreational use, potential educational opportunities for schools and the general public, scientific studies related to restored systems, nutrient transformation, sediment trapping, flood attenuation and wildlife habitat, are all amplified when marsh restoration occurs in close proximity to human development, such as in urban areas like the District of Columbia. These benefits, as well as creating a diversity of habitat types and species found in the Anacostia system, are important factors to consider when valuing restoration activities.

5.6 Conclusion

Through the application of emergy analysis and environmental accounting methodologies, emergy calculations can illustrate the potential of investment in ecologically engineered natural systems to harness natural renewable "free" energies for the benefit of society and the environment (Odum ,1996; Martin, 2002; Kangas, 2004a; Mitsch and Jorgensen, 2004). With emergy analysis, the value of marsh restoration to the natural and human economy can be better understood in general and insights drawn with the Kingman Marsh restoration in particular.

5.6.1 Fisheries use of Tidal Freshwater Mudflats

Kingman's longtime status as a shallow water tidal impoundment, dominated by mudflats at low tide, was considered to be of limited habitat value (Syphax and Hammerschlag, 1995). There has been significant research on and recognition of the habitat value of intertidal mudflats in marine and some estuarine systems (Peterson, 1981; Quammen, 1984; Zedler, 2001), especially in other countries such as Germany and Japan (Riese, 1985, 2001; Hosokawa, 1997; Imamura, 2000). The benthic invertebrate / fish / bird interactions are especially notable.

The importance and ecological role of tidal freshwater marshes have been studied as mentioned earlier, although their associated intertidal mudflats have not been widely investigated (Serodes and Troude, 1984). The initial focus of the fishery survey of Kingman was to characterize the fish utilization of the expansive mudflat areas in the total absence of any emergent marsh vegetation. A similar survey was also ongoing in the restored Kenilworth emergent marshes and mudflat areas as well as a nearby mature tidal marsh at Dueling Creek, with the goal of making generalized comparisons of the fish populations from each of these nearby systems in different stages of development.

The fisheries analysis provided for an interesting dilemma in that the pre-restoration mudflat state produced greater annual gamefish biomass and emergy (with catfish) than either the restored or mature marsh states when these conditions were applied to the Kingman restored marsh scenario. This result was due entirely to the massive contributions of bullhead catfish biomass that were surveyed by electrofishing boat from the Kingman mudflats in the years prior to the marsh restoration. While the restored marsh of Kenilworth and the mature marsh of Dueling Creek both supported catfish as well, their fish communities were somewhat more balanced in terms of species, numbers and biomass. These marsh sites also had numbers of higher trophic level piscivores in largemouth bass while Kingman had none. Because catfish are typically included as a part of any sportfishery, initial emergy calculations naturally included them. A rationale was created for the removal of catfish from each fishery emergy evaluation scenario to see what effect their removal would have on the emergy analysis in terms of fishery production export and total production export. For strictly fishery production export, only the mature marsh scenario without catfish produced more fish emergy, while under total exports including primary production the restored marsh and mature marsh (again without catfish) produced a greater total emergy export scenario.

These created scenarios, and their emergy analysis, reveal how significant an impact that the mudflat condition has on the energy flow of the system when compared to the marsh system. Removing the bullhead catfish from the "fishery" might seem arbitrary and not a true representation of the natural state of the fishery. This has been done for other species of fish for health reasons as in the District ban on carp and eel consumption, and stock recovery as was done with striped bass. A fishery is really an arbitrary human creation dictated by the norms of the society that utilize it. In many cultures carp are a significant aspect of a fishery, as are eels and numerous other species that some cultures don't even consider attempting to catch much less eat. Catfish have been and will probably continue to be a significant aspect of the D.C. fishery despite a health advisory, with 65% of anglers surveyed reporting that they eat the fish they catch and of those 48% responding that the fish they prefer to catch and eat is catfish, despite the fact that 75% of anglers acknowledge that they are aware of the public health advisory on the fish (Byers, 2005).

When comparing the fisheries of the two system states of Kingman (intertidal mudflat and emergent marsh), from the human fisheries oriented perspective the one considered the most beneficial is that which exports the most fishery emergy to the public economy and natural systems (Brown and McClanahan, 1996; Martin, 2002). With this in mind, the mudflat state is the greater of the two given the local anglers desire to keep catching catfish.

5.6.2 Emergy and Alternate State Theory Informing Restoration

The application of the emergy analysis method of environmental accounting to the comparison of mudflats and emergent marshes helps to build a logical framework from which alternate state theory may be better understood in relation to the Anacostia River's natural history and present change. As ecological processes are thought to be shaped by a system's history (Peterson, 2002; Price and Morin, 2004) an assessment and valuation of the mudflat characteristics that defined the Anacostia for almost 60 years should be considered invaluable in understanding and refining marsh restoration strategies. The mudflats that evolved over the last half of the 20th century essentially created a system model that had adapted to its present state. Dominated by mudflat algae and plankton as the primary production drivers, catfish thrived on the smooth mud plains that supported benthic aquatic worms, aquatic insect larvae, mollusks and the smaller forage fish that eat them. Migratory shorebirds also benefited from the mudflat condition. There is existing value in mudflats, which are valued differently in different societies such as Germany and Japan, and even in regions within the same society (Reise, 1985, Hosokawa, 1997; Imamura, 2000)

The forcing functions involved in a change to an alternate state are often sudden, powerful and difficult to reverse (Knowlton, 1992; Peterson, 2002). An analysis of the human (Army Corps of Engineers construction) and natural (goose herbivory) switching functions between the marsh and biogenic mudflat alternate states described in Chapters 3 & 4 revealed linkages and disconnects to outcomes that were not immediately obvious to planners prior to the completion of restoration activities at Kingman Marsh. While the evidence of goose herbivory at Kenilworth Mass Fill 3 was noticed by resorationists, it was a small area and the emergence of a marsh in a majority of the other sites at Kenilworth was seen as a success. Nature does give us clues, whether we decide to follow them is up to us.

Because the restoration and management of ecosystems involves an inherent degree of uncertainty (Zedler, 2001), especially in systems that have alternate state potentials (Peterson et al., 2003), the value of an emergy analysis and its potential to inform the decision making process and shape environmental policy could save managers and society a considerable amount of time and expense (Odum, 1996; Martin, 2002). Fisheries improvement was never a primary goal of the restoration, as it was a driver of the emergy analysis completed here. Nutrient uptake, sediment trapping, marsh bird habitat, public education, research and aesthetics, as well as a desire to reclaim a piece of marshland that was an important part of the Anacostia River were some of the additional goals of the restoration.

The nature of political ecology (Peterson, 2000) and the ecological mores of our society were the driving forces behind the restoration of Kingman Lake to Kingman Marsh. The US Army Corps of Engineers had dredged away almost all of the Anacostia River's expansive marshes over the first half of the 20^{th} century. The restoration of these marshes is generally seen as a positive endeavor, tidal marshes are now valued in most of U.S. society. The value of tidal flats to other societies, such as Japan, reveals how different cultures can look at ecosystems differently, and subject their societal mores upon them. And so it becomes a social value judgment in the end as to what perceived benefits are desired through the restoration of any natural system, and emergy analysis can attempt to address and inform these judgements.

As resource managers commit to becoming increasingly involved in the often costly restoration of ecosystems, there is the potential for societies and their economies to expect that these expenditures be utilized in more efficient ways under the likely scenario of shrinking future regional and world economies (Odum and Odum, 2000). It will also become significantly more important to have information which will help to make informed decisions about the direction that restoration will take, as with fisheries used in this analysis, that may be expected with large capital expenditures (Odum, 1996, Peterson, 2000; Martin, 2002, Kangas et al. 2004).

In the case of the Kingman Marsh restoration, the fishery emergy yields under the mudflat state and that of the restored marsh state were entirely dependent upon the inclusion or exclusion of catfish from the analysis. Only once catfish were removed from the evaluation under the future mature marsh scenario was the fisheries yield from a restored marsh greater than that of the pre-existing mudflat condition. Mudflats are understood to be ecologically valuable in other societies, their value to the Anacostia River and the local economy was poorly understood until the completion of the fishery emergy analysis comparing them to restored and mature emergent marshes. The complete services that the Anacostia River tidal freshwater marshes provide are still poorly understood, and should be investigated further in future work. The restoration of ecosystems is still an evolving discipline, and with emergy analysis informing environmental decision making projects that are in early planning stages may be balanced against natural existing conditions to potentially provide improved restoration outcomes depending upon the restoration goals.

FOOTNOTES

Footnote 5-1. Phytoplankton

Phytoplankton primary productivity in tidal freshwater marshes is considered to be largely unknown although critical to any energy flow analysis (Odum et al., 1984; Mitsch and Gosselink, 2000). Primary production in the form of phytoplankton in Kingman may be considered to be a function of the percentage of time that the waters of the Anacostia River are within the Kingman area that is subtidal. Under both pre and post restoration scenerios this is considered to be the same, as the only areas that were “filled” with dredged river sediments were not subtidal, but were those that included intertidal mudflats which were exposed at low tide. The annual phytoplankton production for Kingman was extrapolated from Maryland Department of Natural Resources data for the tidal freshwater Potomac River (DNR, 2007). While the Maryland data was a measure of the rate of annual phytoplankton production (315.7 g $C/m^2/yr$), it was also a measure for the entire water column of the mainstem Potomac River, often upwards of 30 ft. in depth in this area. Although under high turbidity the euphotic zone is limited to the upper 1 to 2.5 m with highest photosynthetic rates in the upper 0.5 m of the water column, tides and winds do mix the water column and lower rates of productivity extend to some greater depths (Ragotzkie, 1959).

To account for the reported production rate of the whole Potomac water column, the rate was divided by a factor of five to adjust the rate to the depth of the Kingman subtidal areas, which at high tide are on average approximately 6 ft (personal depth observations). The estimated value used for this analysis (63.1 g $C/m^2/yr$), when compared to reported values for southeastern estuaries and coastal waters (67-375 g C /m^2/yr) are on the low end with even the higher values considered conservative (Pomeroy and Wiegert, 1981). Additionally, the value that is used for Kingman which is applied only to the subtidal area, was divided in half to account for the turnover of half the tidal prism in the marsh each day. Annually, 100% of the phytoplankton is assumed to be exported from Kingman.

Footnote 5-2. Mudflat Algae

Primary production values for Kingman included estimates for mudflat algae. Algae on mudflats and in emergent marshes make important contributions to numerous trophic levels and taxa, including nematodes, chironomids, gastropods and numerous fish (Reise, 1985; Campeau et al., 1994). Investigations into intertidal epibenthic algae productivity have been primarily found in saltmarsh systems (Gallagher and Daiber, 1974; Van Raalte et al., 1976a; Pomeroy and Wiegert, 1981). Some measurements of algal productivity within the emergent saltmarsh plant community were found to be as high as 30% of net annual production (Gallagher and Daiber, 1974). A study of algae specifically separating out a bare intertidal creekbank from measurements made within *Spartina alterniflora* and *S. patens* at high and low tide found the bare creekbank surface algae production to be 12-19 times more productive respectively when exposed than that of algae measurements made within the *Spartina* (Whitney and Darley, unpubl. data, from Pomeroy and Wiegert, 1981). An annual estimate of net productivity of approximately 190 g C/m^2 of mudflat algae was determined from the above study with more than 75% of the production occurring during ebb tide.

Algal production in tidal freshwater wetlands has been asserted to be less than one percent of net annual production (Whigham and Simpson, 1975; Whigham and Simpson, 1976), far less than the 30% reported by Gallagher and Daiber for saltmarsh algae (1974). This is not incongruous considering that the much taller and broader leaves of tidal freshwater macrophytes provide for considerable shading during the growing season (Mitch and Gosselink, 2000) than that of the short and slender *Spartina sp*. While shading would account for reduced algae growth within stands of freshwater marsh vegetation as compared to that of saltmarshes, the lack of research into tidal freshwater mudflat algae production reasonably allows for the assumption that algal productivity there may be roughly equivalent to that of saltmarsh exposed creekbanks.

Observational evidence of dense algal mats forming on Kenilworth mudflat exclosures (detailed in Chapter 3) supports the assumption that algae production on Anacostia tidal flats can be a significant contributor to overall net primary productivity. This is especially important considering that the turnover rate of algae is much faster than that of emergent macrophytes (Mitsch and Gosselink, 2000) and is also growing year round. An assumption that 100% of algae NPP is exported from the Kingman system is made for the emergy analysis.

Footnote 5-3. Emergent Macrophytes

Typically the largest component of primary production in the tidal freshwater marsh comes from the emergent marsh plants (Whigham et al., 1978; Odum et al., 1984; Mitsch and Gosselink, 2000). Estimates of annual marsh plant net primary production that are obtained by a single, aboveground harvest method are not considered accurate, as they do not include data on belowground biomass, growing season mortality of whole plants and plant parts, herbivore consumption, or the production of species that may dominate before or after the single harvest (Whigham et al., 1978).

The value used as the best estimate surrogate for the Kingman emergent marsh annual NPP (2,346.5 g/m^2) was obtained from an estimate that included multiple harvests throughout the growing season of 14 species of annuals and perennials, as well as estimations of leaf mortality and belowground production (Whigham et al., 1978). While this estimate is more complete than the many estimates of single harvest aboveground annual NPP often quoted in the literature for tidal freshwater wetlands (Whigham et al., 1978; Simpson et al., 1983; Odum et al., 1984; Mitsch and Gosselink, 2000), it is still considered an underestimate as it did not include belowground production for all species sampled or account for herbivory (Whigham et al., 1978).

As stated earlier, annual marsh NPP export was set at 80% to account for reductions in total production export from incomplete decomposition, some trapping of plant material in marsh sediments and the inclusion of belowground root biomass in the calculations which is not exported (Odum and Heywood, 1978; Whigham et al., 1978).

Footnote 5-4. Fisheries

Tidal freshwater marshes are important spawning, nursery and feeding habitat for numerous resident freshwater, estuarine, anadromous, semi-anadromous and catadromous species of fish (Odum et al., 1984; Rozas and Odum, 1987; Mitsch and Gosselink, 2000), with estuarine and coastal marshes in general considered critical to the support of fishery stocks (Boesch and Turner, 1984; Deegan, 1993; Houde and Rutherford, 1993; Mitsch and Gosselink, 2000; Martin, 2002). Improvement of the fishery is often an argument for the restoration of emergent marsh habitat (Able et al., 2000, Mitsch and Gosselink, 2000; Zedler, 2001). The emergy analysis conducted by Martin (2002) relied on a linear relationship between primary production and fisheries yield developed by Nixon (1988) and supported with commercial fishery / energy information from Bahr et al. (1982). For the Kingman emergy analysis, site specific fisheries data was collected from Kingman itself, from the adjacent restored Kenilworth Marsh (1993), as well as from Dueling Creek marsh, a nearby reference system that has been unaltered for over 50 years. The methodology and complete fisheries dataset, collected over multiple years and seasons, is reported in Chapters 3 and 4.

For the purposes of this analysis, the fishery data used for Kingman included only those species considered to be a part of the D.C. urban fishery as sport / game fish (Byers, 2005) (Footnote 5.4, Table 1). This followed the methods of Bahr et al. (1982) and Martin (2002), as well as representing the potential of Kingman to support the top trophic energy levels that could be available to the D.C. fishery.

Footnote 5.4, Species of fish used in the Kingman emergy analysis

Family / Latin	Family / Common Name
Ictaluridae	Bullhead catfishes
Ameiurus nebulosus	Brown bullhead
Ameiurus catus	White catfish
Ictalurus punctatus	Channel catfish
Percidae	Perches
Perca flavescens	Yellow perch
Moronidae	Temperate basses
Morone americana	White perch
Morone saxatilis	Striped bass
Centrarchidae	Sunfishes
Lepomis gibbosus	Pumpkinseed
Micropterus salmoides	Largemouth bass
Lepomis macrochirus	Bluegill

As detailed in the fish survey methodology of Chapter 3, approximately the same level of electrofishing effort was expended at each site and the surveys covered approximately the same total area. The only differences were if the shocking occurred over mudflats with no emergent marsh vegetation, or in flooded tidal “gut” channels surrounded by emergent marsh vegetation. Kingman was only sampled in the pre-restoration, or mudflat condition, while Kenilworth had two marsh survey locations and one mudflat location, and Dueling had one marsh survey location representing a mature marsh. The Kenilworth marsh fish survey data was used as a surrogate for the Kingman restored marsh condition and the Dueling fish survey data was used as a hypothetical, future Kingman mature marsh condition.

To determine the total annual production of fish biomass from each system for the emergy analysis, several calculations were made from the fish survey data. First, the total numbers of each fish species captured from each survey area were aggregated by each location and each system (mudflat or marsh), then divided by the number of surveys conducted at each ecotype to obtain an average fish abundance for each species at every site (Appendix C, Tables 5.3-5.5). Because each site was sampled at least once and often more than once in each of the Spring, Summer and Fall seasons, the fish survey numbers were assumed to be indicative of annual average species abundance and composition.

The average numbers of individuals of each fish species caught at each survey site were multiplied by an average individual fish wet weight as determined from the actual fish survey values (Chapters 3 & 4) or as found in the literature (Appendix C, Table 5.6) to get an average wet weight biomass for each species of fish for each location. An interesting aspect of the fish data was realized when this was done. It became apparent that the Kingman and Kenilworth mudflat survey areas were heavily dominated by catfish biomass and absent of the top piscivore the largemouth bass. At the same time, both the Kenilworth and Dueling emergent marsh sites had largemouth bass and greater biomass of white perch while the Dueling site had also greater average fish weights of yellow perch, striped bass and pumpkinseed sunfish. The difference in species composition was likely due to feeding strategies, with catfish being tactile omnivorous bottom feeders comfortable with the mudflat environment and piscivores such as the largemouth bass more visual and comfortable in areas with some shade and structure where they can hide and wait for prey to swim by (Rohde et al., 1994). Because of the potential impact that the different species composition and abundances was expected to have on total fish productivity for the mudflat vs. restored marsh vs. mature marsh evaluation scenarios being developed for the emergy analysis, it was decided to create two sportfish biomass production scenarios, one with catfish and one without.

The average wet weights of sportfish species were segregated out from the other species caught and tabulated under each sampling location/system type and a separate table created for the no catfish scenario (Tables 5.4). These values were then divided by the total area sampled, which was standardized across all sites (approximately 500 m^2) to give the average biomass (g/m^2) collected for each species at each sampling location.

Annual fish production was determined by multiplying the average biomass for each species by a production to biomass (P/B) ratio. Production is generally defined as the total net generation of new fish tissue over a period of time by a species-population, usually reported in $g/m^2/yr$ (Chapman, 1978). Because only a few reasonable estimates of production for some freshwater species have been made, and P/B ratios developed for them to aid in research on fish populations, an average of P/B ratios was taken for the various species where reported values were given (Chapman, 1978; Wetzel, 1983), and that average ratio (1.5) applied to each of the gamefish species to obtain annual fish production numbers for the emergy analysis.

Production was then converted to an energy value per unit area. This was calculated by first converting fish wet weight to dry weight with the assumption that dry weight is approximately 20% of wet weight (Waters, 1977). The production of fish dry weight biomass ($g/m^2/yr$) for the exact area sampled was totaled across all species under the catfish/no catfish scenarios and then multiplied by an estimation of the total area (m^2) that could support the upper level consumer fishery at each location to give an estimated total gram dry weight production for each site. These values were then converted to energy equivalents. The approximate dry weight of 1g of fish is assumed to have the caloric equivalent of 4.5 Kcal (Bahr et al., 1982).

Table 5.4 Summary calculations of secondary production for middle and upper level fish consumers

With Catfish	A Fishery useable estimated area (m^2)	B* Production rate of mid & upper level consumers g dry wt/m^2/yr	C:(AxB) Total area annual production g dry wt/yr	D **Caloric coefficient Kcal/g	E:(BxD) Unit area annual energy production Kcal/m^2	F:(CxD) Total area annual energy production Kcal	G Conversion to Joules J/Kcal	H:(FxG) Total area annual energy J	I ***Emergy transformity sej/J	J:(HxI) Total area annual fish emergy sej
Marsh										
Kenilworth MF1 & MF2	9900	2.9	2.88E+04	4.5	13.10	1.30E+05	4186	5.43E+08	3.07E+06	1.67E+15
Dueling	1000	3.2	3.18E+03	4.5	14.31	1.43E+04	4186	5.99E+07	3.07E+06	1.84E+14
Mudflat										
Kenilworth MF3	19481	2.5	4.89E+04	4.5	11.30	2.20E+05	4186	9.21E+08	3.07E+06	2.83E+15
Kingman without marsh	445000	6.8	3.00E+06	4.5	30.38	1.35E+07	4186	5.66E+10	3.07E+06	1.74E+17
Hypothetical marsh										
Kingman w/Ken marsh	315000	2.9	9.17E+05	4.5	13.10	4.12E+06	4186	1.73E+10	3.07E+06	5.30E+16
Kingman w/Duel marsh	315000	3.2	1.00E+06	4.5	14.31	4.51E+06	4186	1.89E+10	3.07E+06	5.79E+16
Without Catfish										
Marsh										
Kenilworth MF1 & MF2	9900	0.73	7.27E+03	4.5	3.30	3.27E+04	4186	1.37E+08	3.07E+06	4.20E+14
Dueling	1000	2.04	2.04E+03	4.5	9.18	9.18E+03	4186	3.84E+07	3.07E+06	1.18E+14
Mudflat										
Kenilworth MF3	19481	0.41	8.05E+03	4.5	1.86	3.62E+04	4186	1.52E+08	3.07E+06	4.65E+14
Kingman without marsh	445000	0.70	3.12E+05	4.5	3.15	1.40E+06	4186	5.87E+09	3.07E+06	1.80E+16
Hypothetical marsh										
Kingman w/Ken marsh	315000	0.73	2.31E+05	4.5	3.30	1.04E+06	4186	4.36E+09	3.07E+06	1.34E+16
Kingman w/Duel marsh	315000	2.04	6.43E+05	4.5	9.18	2.89E+06	4186	1.21E+10	3.07E+06	3.72E+16

* From Appendix C, Table 5-3. with catfish and Appendix Table 5.4 without catfish
** Coloric coefficient 4.5 Kcal per g dry wt (Bahr et al., 1982)
*** Solar emjoule (sej) transformity of fish biomass calculated as an average of transformities from the number of mid and upper level consumer species (Bahr et al., 1982)

Multiplying the values gave an energy equivalent production in Kcal/m^2/yr.

Transformities for fish energy conversions were calculated from Bahr et al., (1982). As stated earlier, transformites are obtained by dividing the total emergy that was used in a process by the energy yielded by the process (Odum, 1996). The energy flux rates from Bahr et al. detailed solar inputs and outflows through the Louisiana coastal ecosystem and are used as best approximations for this analysis. Solar inputs (1.0 J solar energy = 1.0 solar emjoule) to wetland producers (369 x 10^{12} Kcal/yr) and solar inputs to phytoplankton and benthic algae (134 x 10^{12} Kcal/yr) gave a total of 503 x 10^{12} Kcal/yr. This value was divided by the outflows of energy from middle consumers (0.38 x 10^{12} Kcal/yr) and upper consumers (0.29 x 10^{12} Kcal/yr) and converted to Joules to give transformities of 3.02 x 10^6 sej/J for middle consumers and 3.48 x 10^6 sej/J for upper consumers.

These transformities were applied to each of the gamefish species to give an annual emergy estimate for the fish found in each area, with separate tables created for gamefish communities with catfish and without catfish (Table 5.4; Appendix C, Tables 5.3-5.4). All gamefish were considered to be middle level consumers due to their reported feeding habits (Rohde et al., 1994), except for the largemouth bass, which was considered an upper level consumer. The striped bass would have been given upper level consumer status but for the fact that the majority of these fish captured in the surveys were juveniles so they were considered middle level consumers.

In aggregating the individual species production rates for each area, a new table was formed (Table 5.3), which broke down each sampling location and again created different scenarios for catfish. Again, these production numbers were applied to the total amount of fishery useable area for each location. As reported in Chapter 4, electrofishing surveys were not conducted in Kingman after marsh restoration was completed. To determine what the Kingman Marsh fishery production would be under the restored marsh scenario, the Kenilworth Marsh mass fill areas (MF1 & MF2) fish abundances were aggregated and averaged from data reported in Chapter 3 to use as a hypothetical surrogate for Kingman Marsh post-restoration. These values were entered into Table 5.3. Additionally, the Dueling Creek Marsh fishery production values were also used as a hypothetical surrogate for Kingman Marsh fishery production after many decades of marsh maturation and development. An average fishery transformity (3.07×10^6 sej/J) was used incorporating the middle and upper level fish consumer transformities and applied to the energy values calculated for each location and hypothetical scenario (Table 5.3) and applied to the general fishery in the analysis Table 5.1.

Chapter 6: Conclusion

6.1 Alternate Ecosystem State Changes on Anacostia River

The Anacostia River has a long history of human involvement which has many times significantly altered the structure of the system at general and discrete points in time (Figure 6.1). Impacts such as erosion and sedimentation from colonial tobacco farming are believed to be indirectly responsible for the expansion and maintenance of renowned 19th Century wild rice *(Zizania aquatica*) marshes. Subsequent dredging and filling of these marshes from the 1920's-1940's by the Army Corps of Engineers essentially switched the tidal river system from a shallow emergent marsh dominated state to a short lived deeper water state lacking emergent marshes.

The high sediment loads associated with post WWII development in the watershed switched the system, including Kenilworth and Kingman which had been dredged of its marshes, to one dominated by intertidal mudflats. Mudflats are known to potentially maintain themselves for several hundred years and more if not forced into another state by a significant disturbance (Pethick, 1996), and for 50 -60 years the Anacostia River had large expanses of intertidal mudflats. The implementation of the Kenilworth Marsh (1993) Kingman Marsh (2000) and River Fringe (2003) restoration plans developed in the early '90's by the Army Corps of Engineers (USACE, 1992) was an effort to effectively switch almost 40 ha of mudflat back to emergent marsh again.

These defining events in the Anacostia's natural history may be interpreted as massive disturbance pulses that have been the triggers for significant alternative state

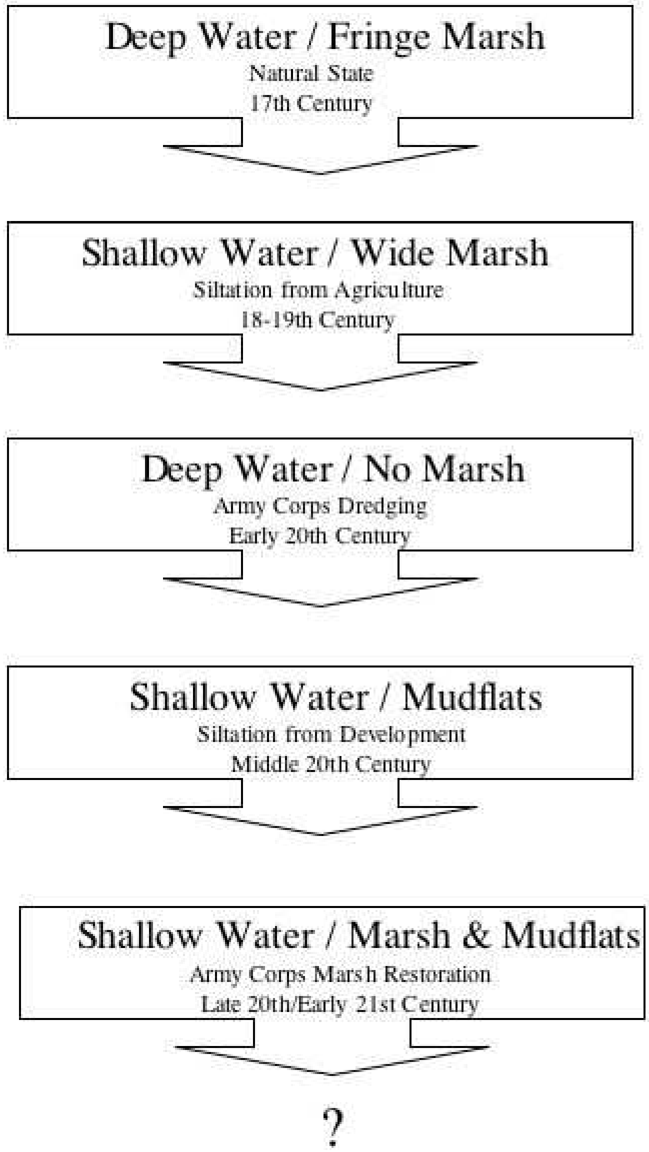

Figure 6.1 Human involvement in Anacostia River system state changes over 400 years.

changes (May 1977; Odum, 1995; Knowlton, 1992; Rietkerk and van de Koppel, 1997). In essence, the Army Corps of Engineers dredging project has been the catalyst for changes to two alternate states within the last 60 years, marsh to mudflat and mudflat to marsh. While these were human induced impacts and effectively caused multiple state changes to occur within the Anacostia River, the unplanned response of the system to these disturbances is of equal if not greater interest. In Zedler's book on restoring tidal wetlands (2001), she notes that “the effects of unplanned disturbances on natural or restored ecosystems offer an opportunity to learn a great deal about restoration site management and the resiliency or frailty of restored marshes”.

Learning from unplanned or planned disturbances of wetland restoration sites can prompt lines of questioning and hypothesis testing that will invariably further the field of ecological engineering and restoration ecology (Zedler, 2001, Kangas et al., 2003; Mitsch and Jorgensen, 2004). To this end field experimentation is essential. As the only manipulative research experiment employed to monitor and measure the direct effects of the goose herbivory impacts to the Kingman Marsh restoration, these exclosure studies represent an important contribution to the understanding of wetland restoration ecology.

Figure 6.2 is an elegant model of the interactive effects that sediment surface elevation and grazing pressure have on wetland vegetation communities from the subtidal through the intertidal to the terrestrial zones of a hypothetical marsh system on Anacostia River. As detailed in the exclosure study of Kingman Marsh mudflats in Chapter 4, resident goose grazing pressure was determined to be the dominant force controlling the presence of emergent marsh vegetation within the low to middle marsh sediment surface elevation gradient. It was also recognized that in the absence of grazing pressure through

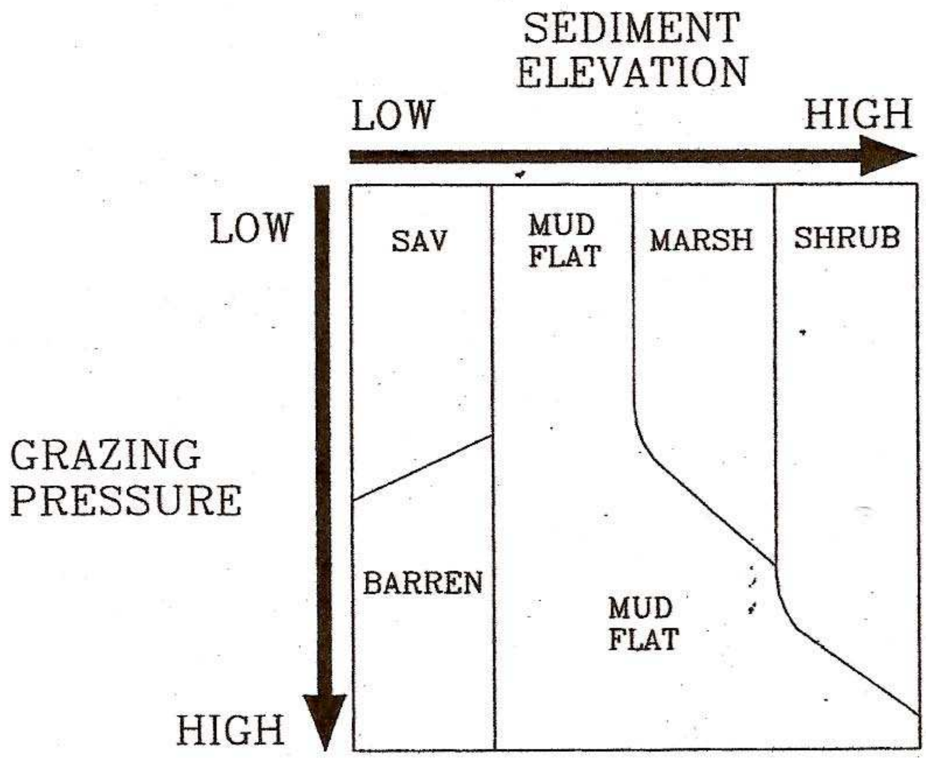

Figure 6.2 Representation of the dual influences of grazing pressure and sediment surface elevation in determining the potential extent of mudflats (Kangas et al., 2004).

the use of exclosures, emergent vegetation would develop within this middle level elevation gradient into an emergent marsh condition. This is represented by the marsh quarter of the elevation axis in Figure 6.2, which extends to some hypothetical break point halfway between the low and high grazer pressure axis after which grazing pressure becomes so high that the mudflat state will eventually take over from its alternate marsh state.

The results of the Kingman Marsh exclosure study also revealed the strong effect of elevation on the emergent plant community below a break point on the elevation gradient. This is represented as the upper quarter of Figure 6.2 labeled mudflat. Even with little or no grazer pressure, the physical effects of elevation influencing depth and duration of tidal inundation prevents most species of emergent plants from establishing themselves. Areas between tidal mean low water and the lower end of the low marsh elevation gradient may be expected to exist as physical mudflat at low tide. These physical mudflats are typically associated with tidal marshes to some extent due to physical stresses and do not have the potential to switch to an alternate marsh state easily. It is these areas that the Army Corps of Engineers believed they were targeting for their restoration work. The fact that the intertidal mudflats of the Anacostia River supported no emergent marsh vegetation was thought to be purely elevation influenced and that by filling and grading the mudflats to increase the sediment elevations, restoration plantings and volunteer vegetation would re-establish a marsh system.

The Kenilworth and Kingman exclosure studies revealed that some of these mudflats that were thought to be too low in elevation to support emergent marshes were actually biogenic, influenced by herbivory and bioturbation as well as elevation. It is possible that many of the original Anacostia River mudflats within the low to middle marsh elevation gradient could have supported some depth tolerant species of emergent marsh vegetation without the Army Corps of Engineers dredging and filling operations. The lack of voluntary emergence of species such as *Pontederia cordata, Sagittaria latifolia* and *Zizania aquatica* on the original mudflats may have been hindered by several factors. While much of the original mudflat area may have existed at elevations below which even depth tolerant species could survive, in other areas it is likely that the combined interactive effects of lower elevation stresses and predation or disturbance by birds and fish could have suppressed germination and reduced the stock of viable seeds (Baldwin and Pendleton, 2003). Herbivory of those seedlings that did emerge would be likely on open mudflats as they would be obvious targets even under low levels of grazing pressure.

The planning for the Kingman Marsh restoration in 2000 relied solely on the elevation model of plant zonation that was used for the 1993 Kenilworth project, and had not factored into their designs the influence of grazing pressure on marsh vegetation establishment. The unexpected effect of voluntary emergent plant growth in Kenilworth mudflat exclosures in 1997 revealed that goose herbivory was strongly influencing plant emergence and growth on a small mudflat study area. In 1998 an experimental study of this effect in the same exclosures verified the top-down control of emergent vegetation in large part through goose herbivory. Because this effect was only seen in a small area of Kenilworth with a majority of the restoration plantings not impacted, the grazer influence was not expected to be an issue with the Kingman restoration work.

In hindsight, a careful consideration of the different landscape contexts that Kenilworth and Kingman represented and their effects on influencing herbivory would have been useful. The fact that the majority of the Kingman Marsh restoration area was surrounded by a golf course with a known resident goose population was an incredible oversight in restoration planning. The surveys of birds at Kingman between 1997 and 2001 revealed an increasing trend in the numbers of resident geese using the mudflats, open water and golf course areas.

The Kingman and Kenilworth Marsh exclosures revealed that in the absence or exclusion of goose grazer pressure a relatively diverse and vigorous vegetative community can develop on the biogenic mudflats. A recognition that predetermined marsh restoration goals may not be naturally attainable in the presence of these grazer pressures must be realized. The complete lack of any vegetative growth in the non-excluded plots speaks volumes of the ability of large grazers to foil the goals of expensive marsh restoration projects if their effects are not taken into account. The understanding that the Anacostia River system has alternate system states in biogenic mudflats and emergent marshes and that both are of value may move the restoration debate away from a rigid imposition of wetland design, toward an understanding that unintended change in restoration may be useful in understanding and creating new ecosystems.

Intertidal habitats are widely understood to be of great importance to migrating shorebirds and waterfowl (Recher, 1966; Quammen, 1984; Lane and Jensen, 1999; Burton et al., 2004). The dramatic decline of these habitat types over the last century has coincided with the increase in development and filling of shoreline areas and the hardening of the land/water interface to prevent erosion (Perry and Deller, 1996). While wetlands and other shallow water habitats have been lost at increasing rates, the emergence of the intertidal mudflat in low energy urban/urbanizing coastal areas may have provided a "new" acceptable alternative for some species of birds. These altered mudflat habitats have the potential to provide for alternative feeding and resting areas for migratory shorebirds as well as waterfowl (Lane and Jensen, 1999). A recognition of the value of these habitat types as an integral system component with emergent marshes is essential to an understanding of the new ecological dynamic on Anacostia River.

Appendices

Appendix A – Kenilworth Marsh Ecological Data Tables

Appendix A, Table 3.1. Kenilworth MF3 bird survey (inside mudflat zone and immediately outside mudflat exclosure area)

		1/6/97		2/28/97	3/6/97		3/17/97	
		In	Out	In	In	Out	In	Out
Anatidae	**Waterfowl**							
Branta canadensis	Canada goose		6	3	2	3		4
Anas platyrhynchos	Mallard							
Anas rubripes	Black duck							
Bucephala albeola	Bufflehead							
Aix sponsa	Wood duck							
Anas acuta	Pintail							
Aythya americana	Redhead							
Lophodytes cucullatus	Hooded merganser							
Mergus merganser	Common merganser		1					
Scolopacidae	**Shorebirds**							
Charadrius vociferus	Killdeer				2			3
Actitus macularia	Spotted sandpiper							
Tringa solitaria	Solitary sandpiper							
Calidris pusilla	Semipalmated plover							
Calidris alba	Sanderling							
Gallinago gallinago	Common snipe							
Tringa melanoleuca	Greater yellowlegs	7						
Tringa flavipes	Lesser yellowlegs							
Ardeidae	**Wading birds**							
Ardea herodias	Great blue heron							
Butorides virescens	Green heron							
Casmerodius albus	Great egret							
Egretta thula	Snowy egret							
Alcedinidae	**Kingfishers**							
Ceryle alcyon	Belted kingfisher		1			1		
Phalacrocoracidae	**Cormorants**							
Phalacrocorax auritus	Double crested cormorant							
Laridae	**Gulls and Terns**							
Larus argentatus	Herring gull							
Larus delawarensis	Ring billed gull					3		
Larus philadelphia	Bonaparts gull							
Larus marinus	Greater black backed gull							
Sterna hirundo	Common tern							
Accipitridae	**Raptors**							
Buteo jamaicensis	Red-tailed hawk							
Buteo lineatus	Red-shouldered hawk							
Haliaeetus leucocephalus	Bald eagle							
Pandion haliaetus	Osprey							
Corvidae	**Crows**							
Corvus ossifragus	Crow sp.			1				

Kenilworth MF3 bird survey

	3/21/97		3/22/97		4/3/97		4/4/97		4/6/97	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose		2		3	2	4			3	2
Mallard						2		2		
Black duck										
Bufflehead										
Wood duck										
Pintail										
Redhead										
Hooded merganser										
Common merganser										
Shorebirds										
Killdeer		3	2	3	1		1	2		2
Spotted sandpiper										
Solitary sandpiper										
Semipalmated plover										
Sanderling										
Common snipe										
Greater yellowlegs										
Lesser yellowlegs										
Wading birds										
Great blue heron						1		4		3
Green heron										
Great egret										
Snowy egret										
Kingfishers										
Belted kingfisher								1		1
Cormorants										
Double crested cormorant										
Gulls and Terns										
Herring gull	1									
Ring billed gull	1									
Bonaparts gull										
Greater black backed gull										
Common tern										
Raptors										
Red-tailed hawk										
Red-shouldered hawk										
Bald eagle	1									
Osprey										
Crows										
Crow sp.				2		1				

Kenilworth MF3 bird survey

	4/16/97		4/20/97		5/14/97		5/19/97		5/20/97	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose		12		4		4		6	6	15
Mallard										
Black duck										
Bufflehead										
Wood duck										
Pintail										
Redhead										
Hooded merganser										
Common merganser										
Shorebirds										
Killdeer		2			2		7		4	
Spotted sandpiper										
Solitary sandpiper										
Semipalmated plover										
Sanderling									1	
Common snipe										
Greater yellowlegs										
Lesser yellowlegs										
Wading birds										
Great blue heron		5		3		2		2		2
Green heron										
Great egret										
Snowy egret				1						
Kingfishers										
Belted kingfisher										
Cormorants										
Double crested cormorant				2						
Gulls and Terns										
Herring gull										
Ring billed gull		1					1			
Bonaparts gull										
Greater black backed gull										
Common tern										
Raptors										
Red-tailed hawk						1				
Red-shouldered hawk										
Bald eagle										
Osprey										
Crows										
Crow sp.		1								

Kenilworth MF3 bird survey

	6/16/97		6/17/97		6/25/97		6/27/97		7/16/97	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose										
Mallard										
Black duck										
Bufflehead										
Wood duck										
Pintail										
Redhead										
Hooded merganser										
Common merganser										
Shorebirds										
Killdeer	6		5		6		4		6	
Spotted sandpiper										
Solitary sandpiper										
Semipalmated plover										
Sanderling										
Common snipe										
Greater yellowlegs										
Lesser yellowlegs										
Wading birds										
Great blue heron		4		2				2		3
Green heron										1
Great egret				1						1
Snowy egret										
Kingfishers										
Belted kingfisher		1								1
Cormorants										
Double crested cormorant				1						
Gulls and Terns										
Herring gull										
Ring billed gull										
Bonaparts gull										
Greater black backed gull										
Common tern										
Raptors										
Red-tailed hawk				1						
Red-shouldered hawk										
Bald eagle										
Osprey					1	1				
Crows										
Crow sp.										2

Kenilworth MF3 bird survey

	7/17/97		7/28/97		8/26/97		8/27/97		8/29/97	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose				1						
Mallard				4					1	
Black duck										
Bufflehead										
Wood duck										
Pintail										
Redhead										
Hooded merganser										
Common merganser										
Shorebirds										
Killdeer	4		14		9		3	1	5	
Spotted sandpiper										
Solitary sandpiper										
Semipalmated plover										
Sanderling										
Common snipe										
Greater yellowlegs			1			3		2	1	3
Lesser yellowlegs										
Wading birds										
Great blue heron		6		4	1	3		3		3
Green heron			1							3
Great egret	1	6		10		13		11	2	
Snowy egret								2		
Kingfishers										
Belted kingfisher		1								
Cormorants										
Double crested cormorant				2						1
Gulls and Terns										
Herring gull										
Ring billed gull								1		1
Bonaparts gull										
Greater black backed gull										
Common tern										
Raptors										
Red-tailed hawk										
Red-shouldered hawk										
Bald eagle										
Osprey										
Crows										
Crow sp.										

Kenilworth MF3 bird survey

	9/16/97		9/23/97		9/24/97		10/14/97		10/27/97	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose		8				28				12
Mallard						6				
Black duck										
Bufflehead										
Wood duck										
Pintail										
Redhead										
Hooded merganser										
Common merganser										
Shorebirds										
Killdeer	10		7				2		7	
Spotted sandpiper										
Solitary sandpiper										
Semipalmated plover										
Sanderling										
Common snipe										
Greater yellowlegs			2	3				3	3	
Lesser yellowlegs										
Wading birds										
Great blue heron		3		3		3		3		2
Green heron										
Great egret	2	5		2		3		1		1
Snowy egret										
Kingfishers										
Belted kingfisher										1
Cormorants										
Double crested cormorant								2		3
Gulls and Terns										
Herring gull						2			3	7
Ring billed gull		2	1				1	24		
Bonaparts gull										
Greater black backed gull										
Common tern										
Raptors										
Red-tailed hawk						1				
Red-shouldered hawk										
Bald eagle		1								
Osprey										
Crows										
Crow sp.								1		

Kenilworth MF3 bird survey

	10/29/97		11/20/97		11/24/97		11/26/97		12/23/97	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose										15
Mallard				30						2
Black duck				3						
Bufflehead										
Wood duck										
Pintail			4							
Redhead										
Hooded merganser			2			3				
Common merganser										
Shorebirds										
Killdeer			33					16		
Spotted sandpiper										
Solitary sandpiper										
Semipalmated plover										
Sanderling										
Common snipe										
Greater yellowlegs										
Lesser yellowlegs										
Wading birds										
Great blue heron		3				1		2		1
Green heron										
Great egret										
Snowy egret										
Kingfishers										
Belted kingfisher					1					1
Cormorants										
Double crested cormorant										
Gulls and Terns										
Herring gull		4						9		
Ring billed gull		6								3
Bonaparts gull										
Greater black backed gull										
Common tern										
Raptors										
Red-tailed hawk										
Red-shouldered hawk										
Bald eagle										
Osprey										
Crows										
Crow sp.								4	2	

Kenilworth MF3 bird survey

	12/24/97		12/29/97		1/22/98		1/27/98		2/10/98	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose							12	100		12
Mallard						12		16		
Black duck										
Bufflehead						14				
Wood duck										
Pintail										
Redhead										
Hooded merganser										
Common merganser										
Shorebirds										
Killdeer				4						
Spotted sandpiper										
Solitary sandpiper										
Semipalmated plover										
Sanderling										
Common snipe										
Greater yellowlegs										
Lesser yellowlegs										
Wading birds										
Great blue heron				1			1			
Green heron										
Great egret										
Snowy egret										
Kingfishers										
Belted kingfisher						1		1		
Cormorants										
Double crested cormorant										
Gulls and Terns										
Herring gull										
Ring billed gull		4		5		18		6		2
Bonaparts gull										
Greater black backed gull		1								
Common tern										
Raptors										
Red-tailed hawk										
Red-shouldered hawk										
Bald eagle										
Osprey										
Crows										
Crow sp.						6				

Kenilworth MF3 bird survey

	2/25/98		4/21/98		4/22/98		4/23/98		4/24/98	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose		2		8		18		18	2	32
Mallard										
Black duck		2								
Bufflehead										
Wood duck										
Pintail										
Redhead										
Hooded merganser										
Common merganser										
Shorebirds										
Killdeer									2	
Spotted sandpiper							2			
Solitary sandpiper										
Semipalmated plover										
Sanderling										
Common snipe										
Greater yellowlegs				1						2
Lesser yellowlegs										
Wading birds										
Great blue heron				2		4		1		4
Green heron										
Great egret				2					1	
Snowy egret										
Kingfishers										
Belted kingfisher		1								
Cormorants										
Double crested cormorant										
Gulls and Terns										
Herring gull										
Ring billed gull		3								10
Bonaparts gull										
Greater black backed gull										
Common tern										
Raptors										
Red-tailed hawk										
Red-shouldered hawk										
Bald eagle						1				
Osprey						1				
Crows										
Crow sp.				3		6		4		3

Kenilworth MF3 bird survey

	5/7/98		5/8/98		6/3/98		6/5/98		6/8/98	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose			2	29	2					10
Mallard										
Black duck										
Bufflehead										
Wood duck										
Pintail										
Redhead										
Hooded merganser										
Common merganser										
Shorebirds										
Killdeer	3						2		3	
Spotted sandpiper			2							
Solitary sandpiper										
Semipalmated plover										
Sanderling										
Common snipe										
Greater yellowlegs										
Lesser yellowlegs										
Wading birds										
Great blue heron		4	1			1		1		
Green heron										
Great egret										
Snowy egret										
Kingfishers										
Belted kingfisher										
Cormorants										
Double crested cormorant		1								
Gulls and Terns										
Herring gull										
Ring billed gull										
Bonaparts gull										
Greater black backed gull										
Common tern										
Raptors										
Red-tailed hawk										
Red-shouldered hawk										
Bald eagle										
Osprey						2		1		
Crows										
Crow sp.										

Kenilworth MF3 bird survey

	6/19/98		6/22/98		7/9/98		7/21/98		7/22/98	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose										
Mallard		1		4				3		3
Black duck										
Bufflehead										
Wood duck										
Pintail										
Redhead										
Hooded merganser										
Common merganser										
Shorebirds										
Killdeer	6		3		6		10	4	6	
Spotted sandpiper							1			
Solitary sandpiper										
Semipalmated plover										
Sanderling										
Common snipe										
Greater yellowlegs								4		2
Lesser yellowlegs										
Wading birds										
Great blue heron		1				3		1		
Green heron				1						
Great egret						1				
Snowy egret										
Kingfishers										
Belted kingfisher		1								
Cormorants										
Double crested cormorant										
Gulls and Terns										
Herring gull										
Ring billed gull										
Bonaparts gull										
Greater black backed gull										
Common tern										
Raptors										
Red-tailed hawk										
Red-shouldered hawk										
Bald eagle										
Osprey										
Crows										
Crow sp.								1		

Kenilworth MF3 bird survey

	7/31/98		8/5/98		8/19/98		8/20/98		8/26/98	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose										
Mallard										
Black duck		4				5		1		
Bufflehead										
Wood duck										
Pintail										
Redhead										
Hooded merganser										
Common merganser										
Shorebirds										
Killdeer	12		9		13		10	1	10	
Spotted sandpiper										
Solitary sandpiper										
Semipalmated plover					3					
Sanderling										
Common snipe										
Greater yellowlegs	3		1	2		3		1	1	
Lesser yellowlegs	1									
Wading birds										
Great blue heron		1		2		3		1		1
Green heron										
Great egret										
Snowy egret										
Kingfishers										
Belted kingfisher	1							1		
Cormorants										
Double crested cormorant		1								
Gulls and Terns										
Herring gull										
Ring billed gull				5		4				
Bonaparts gull										
Greater black backed gull										
Common tern						2				
Raptors										
Red-tailed hawk										
Red-shouldered hawk										
Bald eagle										
Osprey										
Crows										
Crow sp.						1			1	

Kenilworth MF3 bird survey

	9/1/98		9/18/98		9/28/98		10/1/98		10/5/98	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose										
Mallard			25			5	6			5
Black duck										
Bufflehead										
Wood duck										4
Pintail										
Redhead										
Hooded merganser										
Common merganser										
Shorebirds										
Killdeer	9		10		14		10	4	42	
Spotted sandpiper			2							
Solitary sandpiper							2		2	1
Semipalmated plover									1	
Sanderling									1	
Common snipe										
Greater yellowlegs				2	3	1		2		1
Lesser yellowlegs										
Wading birds										
Great blue heron		1		2		1		1		2
Green heron										
Great egret		4		4		1				2
Snowy egret										
Kingfishers										
Belted kingfisher						1				
Cormorants										
Double crested cormorant								2		
Gulls and Terns										
Herring gull										
Ring billed gull		2		4		4				7
Bonaparts gull									2	
Greater black backed gull										
Common tern			1							
Raptors										
Red-tailed hawk										
Red-shouldered hawk										
Bald eagle										
Osprey										
Crows										
Crow sp.				4				1		

Kenilworth MF3 bird survey

	10/6/98		10/20/98		10/28/98		10/29/98		11/18/98	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose		47								
Mallard						33		3		
Black duck										
Bufflehead										
Wood duck						2		2		
Pintail										
Redhead										
Hooded merganser										
Common merganser										
Shorebirds										
Killdeer			3		10	10	3	1		
Spotted sandpiper										
Solitary sandpiper										
Semipalmated plover										
Sanderling										
Common snipe										
Greater yellowlegs				2				2		
Lesser yellowlegs										
Wading birds										
Great blue heron		1		1		1		1		
Green heron										
Great egret		3								
Snowy egret										
Kingfishers										
Belted kingfisher		1						2		
Cormorants										
Double crested cormorant										
Gulls and Terns										
Herring gull								1		
Ring billed gull				10		3		8		12
Bonaparts gull										
Greater black backed gull										
Common tern										
Raptors										
Red-tailed hawk										
Red-shouldered hawk										
Bald eagle										
Osprey										
Crows										
Crow sp.								1		

Kenilworth MF3 bird survey

	11/19/98		11/30/98		12/16/98		12/29/98		12/30/98	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose				60						
Mallard				11		23		31		35
Black duck										
Bufflehead				6						
Wood duck										
Pintail										
Redhead										
Hooded merganser										
Common merganser										
Shorebirds										
Killdeer								7	14	11
Spotted sandpiper										
Solitary sandpiper										
Semipalmated plover										
Sanderling										
Common snipe								1		
Greater yellowlegs										
Lesser yellowlegs										
Wading birds										
Great blue heron				2		2		1		1
Green heron										
Great egret										
Snowy egret										
Kingfishers										
Belted kingfisher				1		1		1		1
Cormorants										
Double crested cormorant										
Gulls and Terns										
Herring gull										
Ring billed gull		4		9						
Bonaparts gull										
Greater black backed gull										
Common tern										
Raptors										
Red-tailed hawk										
Red-shouldered hawk										
Bald eagle										
Osprey										
Crows										
Crow sp.				5						

Kenilworth MF3 bird survey

	1/26/99		1/27/99		1/29/99		2/12/99		2/26/99	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose		2		138				6		2
Mallard		28		22		14		6		15
Black duck										
Bufflehead										
Wood duck										
Pintail						14				22
Redhead										
Hooded merganser	4					4				
Common merganser	4			4						
Shorebirds										
Killdeer									5	
Spotted sandpiper										
Solitary sandpiper										
Semipalmated plover										
Sanderling										
Common snipe										
Greater yellowlegs										
Lesser yellowlegs										
Wading birds										
Great blue heron		1				1				
Green heron										
Great egret										
Snowy egret										
Kingfishers										
Belted kingfisher		1								
Cormorants										
Double crested cormorant										
Gulls and Terns										
Herring gull		1								
Ring billed gull		7		7		2				
Bonaparts gull										
Greater black backed gull										
Common tern										
Raptors										
Red-tailed hawk										
Red-shouldered hawk	1									
Bald eagle										
Osprey										
Crows										
Crow sp.						4				

Kenilworth MF3 bird survey

	2/27/99		3/15/99		3/29/99		3/30/99		5/26/99	
	In	Out	In	Out	In	Out	In	Out	In	Out
Waterfowl										
Canada goose	2	10						7		
Mallard		4		2						
Black duck										
Bufflehead										
Wood duck										
Pintail		2		14						
Redhead								7		
Hooded merganser										
Common merganser				2						
Shorebirds										
Killdeer	6		4						1	
Spotted sandpiper										
Solitary sandpiper										
Semipalmated plover										
Sanderling										
Common snipe										
Greater yellowlegs	1							1		
Lesser yellowlegs										
Wading birds										
Great blue heron		2		1		2		1		2
Green heron										
Great egret										
Snowy egret										
Kingfishers										
Belted kingfisher				1						
Cormorants										
Double crested cormorant										
Gulls and Terns										
Herring gull										
Ring billed gull		14						1		
Bonaparts gull		7								
Greater black backed gull										
Common tern										
Raptors										
Red-tailed hawk										
Red-shouldered hawk										
Bald eagle										
Osprey										
Crows										
Crow sp.					1		1			

Kenilworth MF3 bird survey

	6/25/99		7/6/99		8/20/99		
	In	Out	In	Out	In	Out	Total #
Waterfowl							
Canada goose							666
Mallard							354
Black duck							15
Bufflehead							20
Wood duck				1			9
Pintail							56
Redhead							7
Hooded merganser							13
Common merganser							11
Shorebirds							
Killdeer	2		10		5	3	460
Spotted sandpiper							7
Solitary sandpiper							5
Semipalmated plover							4
Sanderling							2
Common snipe							1
Greater yellowlegs				1			64
Lesser yellowlegs							1
Wading birds							
Great blue heron		3	1	4		3	145
Green heron				1			7
Great egret							77
Snowy egret							3
Kingfishers							
Belted kingfisher			1			1	28
Cormorants							
Double crested cormorant							15
Gulls and Terns							
Herring gull							28
Ring billed gull						8	204
Bonaparts gull						1	10
Greater black backed gull							1
Common tern							3
Raptors							
Red-tailed hawk							3
Red-shouldered hawk							1
Bald eagle							3
Osprey							6
Crows							
Crow sp.	1					4	61

Appendix A. Table 3.2. Kenilworth Mass Fill 1 Electrofishing Surveys

		Jul-93	Aug-93	Sep-94	May-96	Aug-96	Apr-97	Jul-97	Oct-97	Total	Average #/Survey
Cyprinidae	**Carps and Minnows**										
Cyprinus carpio	Common carp		3	2	19	1	1	6	2	34	4.3
Carassius auratus	Goldfish			1	6				1	8	1.0
Hybognathus regius	Eastern silvery minnow		12	5	1	7		12	27	64	8.0
Notemigonus crysoleucas	Golden shiner		2	3		6		6		17	2.1
Notropis hudsonius	Spottail shiner			3	1			1	5	10	1.3
Cyprinella spiloptera	Spotfin shiner										0.0
Notropis procne	Swallowtail shiner		7							7	0.9
Anguillidae	**Freshwater eels**										0.0
Anguilla rostrata	American eel										0.0
Antherinidae	**Silversides**										0.0
Menidia beryilina	Atlantic silversides		2							2	0.3
Fundulidae	**Killifishes**										0.0
Fundulus diaphanus	Banded killifish	20	5	4	1	7		2	1	40	5.0
Fundulus heteroclitus	Mummichog killifish	16	16	13	1	7		9	4	66	8.3
Clupeidae	**Herrings**										0.0
Dorosoma cepedianum	Gizzard shad		22	23	9		13	76	104	247	30.9
Alosa aestivalis	Blueback herring			1						1	0.1
Alosa pseudoharengus	Alewife herring	8	12	1						21	2.6
Alosa sapidissima	American shad	1	4							5	0.6
Ictaluridae	**Bullhead catfishes**										0.0
Ameiurus nebulosus	Brown bullhead	18	10	13	7	49		101		198	24.8
Ameiurus catus	White catfish				1					1	0.1
Ictalurus punctatus	Channel catfish										0.0
Castomomidae	**Suckers**										0.0
Carpiodes cyprinus	Quillback carpsucker			3						3	0.4
Moxostoma erythrurum	Golden redhorse										0.0
Moxostoma macrolepidotum	Shorthead redhorse										0.0
Percidae	**Perches**										0.0
Perca flavescens	Yellow perch					4		1		5	0.6
Poeciliidae	**Livebearers**										0.0
Gambusia affinis	Mosquitofish	2		1						3	0.4
Moronidae	**Temperate basses**										0.0
Morone americana	White perch	15	38	16	4			9	1	83	10.4
Morone saxatilis	Striped bass	1								1	0.1
Centrarchidae	**Sunfishes**										0.0
Lepomis gibbosus	Pumpkinseed	2	19	10	3	1		3		38	4.8
Micropterus salmoides	Largemouth bass							1		1	0.1
Lepomis macrochirus	Bluegill										0.0
	Total # Fish	83	152	99	53	82	14	227	145	855	106.9
# Fish Anadromous/Semianadromous/Catadromous		25	76	41	13	4	5	86	105	355	44
	Total # Species	9	13	15	11	8	2	12	8	22	10
# Sp. Anadromous/Semianadromous/Catadromous		4	4	4	2	1	1	3	2	7	3

Appendix A. Table 3.3. Kenilworth Mass Fill 2 Electrofishing Surveys

		Jul-93	Aug-93	Sep-94	May-96	Aug-96	Apr-97	Jul-97	Oct-97	Totals	Average #/Survey
Cyprinidae	**Carps and Minnows**										
Cyprinus carpio	Common carp	2	5		26			3		36	4.5
Carassius auratus	Goldfish	2	1		21		2	3		29	3.6
Hybognathus regius	Eastern silvery minnow		2	18		24		8	14	66	8.3
Notemigonus crysoleucas	Golden shiner			12						12	1.5
Notropis hudsonius	Spottail shiner		1	3		4		5	6	19	2.4
Cyprinella spiloptera	Spotfin shiner				1					1	0.1
Notropis procne	Swallowtail shiner										0.0
Anguillidae	**Freshwater eels**										0.0
Anguilla rostrata	American eel										0.0
Antherinidae	**Silversides**										0.0
Menidia beryilina	Atlantic silversides										0.0
Fundulidae	**Killifishes**										0.0
Fundulus diaphanus	Banded killifish	4	1	5						10	1.3
Fundulus heteroclitus	Mummichog killifish	6	3	39		28		1		77	9.6
Clupeidae	**Herrings**										0.0
Dorosoma cepedianum	Gizzard shad		41	31	11	1	7	22	31	144	18.0
Alosa aestivalis	Blueback herring			36						36	4.5
Alosa pseudoharengus	Alewife herring	2	9					1		12	1.5
Alosa sapidissima	American shad	2								2	0.3
Ictaluridae	**Bullhead catfishes**										0.0
Ameiurus nebulosus	Brown bullhead	19	26	37	5	8		110		205	25.6
Ameiurus catus	White catfish										0.0
Ictalurus punctatus	Channel catfish		1				1			2	0.3
Castomomidae	**Suckers**										0.0
Carpiodes cyprinus	Quillback carpsucker										0.0
Moxostoma erythrurum	Golden redhorse										0.0
Moxostoma macrolepidotum	Shorthead redhorse				1					1	0.1
Percidae	**Perches**										0.0
Perca flavescens	Yellow perch				1			1		2	0.3
Poeciliidae	**Livebearers**										0.0
Gambusia affinis	Mosquitofish										0.0
Moronidae	**Temperate basses**										0.0
Morone americana	White perch	9	21	17	4	16		25		92	11.5
Morone saxatilis	Striped bass			1	1			4		6	0.8
Centrarchidae	**Sunfishes**										0.0
Lepomis gibbosus	Pumpkinseed	3	1	12	5	29		4	3	57	7.1
Micropterus salmoides	Largemouth bass			4		1				5	0.6
Lepomis macrochirus	Bluegill	1								1	0.1
Total # Fish		50	112	215	76	111	10	187	54	815	101.9
# Fish Anadromous/Semianadromous/Catadromous		13	71	68	17	17	7	53	31	277	35.0
Total # Species		10	12	12	10	8	3	12	4	21	9
# Sp. Anadromous/Semianadromous/Catadromous		3	3	4	4	2	1	5	1	7	3

Appendix A. Table 3.4. Kenilworth Mudflat Mass Fill 3 Electrofishing Surveys

		Apr-97 MF3	Jul-97 MF3	Oct-97 MF3	Jul-98 MF3	Totals	Average #/Survey
Cyprinidae	**Carps and Minnows**						
Cyprinus carpio	Common carp		2	1		3	0.8
Carassius auratus	Goldfish		1	1		2	0.5
Hybognathus regius	Eastern silvery minnow		2	2	1	5	1.3
Notemigonus crysoleucas	Golden shiner		4		1	5	1.3
Notropis hudsonius	Spottail shiner			1		1	0.3
Cyprinella spiloptera	Spotfin shiner						0.0
Notropis procne	Swallowtail shiner						0.0
Anguillidae	**Freshwater eels**						
Anguilla rostrata	American eel						0.0
Antherinidae	**Silversides**						
Menidia beryilina	Atlantic silversides			4		4	1.0
Fundulidae	**Killifishes**						
Fundulus diaphanus	Banded killifish						0.0
Fundulus heteroclitus	Mummichog killifish			3	1	4	1.0
Clupeidae	**Herrings**						
Dorosoma cepedianum	Gizzard shad	5	131	14	5	155	38.8
Alosa aestivalis	Blueback herring			3	20	23	5.8
Alosa pseudoharengus	Alewife herring				6	6	1.5
Alosa sapidissima	American shad				1	1	0.3
Ictaluridae	**Bullhead catfishes**						
Ameiurus nebulosus	Brown bullhead		19		72	91	22.8
Ameiurus catus	White catfish						0.0
Ictalurus punctatus	Channel catfish		1			1	0.3
Castomomidae	**Suckers**						
Carpiodes cyprinus	Quillback carpsucker						0.0
Moxostoma erythrurum	Golden redhorse						0.0
Moxostoma macrolepidotum	Shorthead redhorse				1	1	0.3
Percidae	**Perches**						
Perca flavescens	Yellow perch			1	1	2	0.5
Poeciliidae	**Livebearers**						
Gambusia affinis	Mosquitofish						0.0
Moronidae	**Temperate basses**						
Morone americana	White perch		4	1	11	16	4.0
Morone saxatilis	Striped bass				1	1	0.3
Centrarchidae	**Sunfishes**						
Lepomis gibbosus	Pumpkinseed	3	23	1	39	66	16.5
Micropterus salmoides	Largemouth bass						0.0
Lepomis macrochirus	Bluegill		1		1	2	0.5
Total # Fish		8	188	32	161	389	97.3
# Fish Anadromous/Semianadromous/Catadromous		1	135	19	45	204	50.0
Total # Species		2	10	11	14	19	9.0
# Sp. Anadromous/Semianadromous/Catadromous		1	2	4	7	7	4.0

Appendix A. Table 3.5. Dueling Creek Fish Electroshocking Survey Data

		Aug-93	Sep-94	Aug-96	Oct-97	Jul-98	Totals	Average #/Survey
Cyprinidae	**Carps and Minnows**							
Cyprinus carpio	Common carp		3	2		1	6	1.2
Carassius auratus	Goldfish		1				1	0.2
Hybognathus regius	Eastern silvery minnow	7	102	83	21	37	250	50
Notemigonus crysoleucas	Golden shiner		8	1		2	11	2.2
Notropis hudsonius	Spottail shiner	7	13	2	2	4	28	5.6
Cyprinella spiloptera	Spotfin shiner	2					2	0.4
Notropis procne	Swallowtail shiner	6					6	1.2
Anguillidae	**Freshwater eels**							
Anguilla rostrata	American eel	1				2	3	0.6
Antherinidae	**Silversides**							
Menidia beryilina	Atlantic silversides							
Fundulidae	**Killifishes**							
Fundulus diaphanus	Banded killifish	4	12	5	2	1	24	4.8
Fundulus heteroclitus	Mummichog killifish	11	13	10	4	2	40	8
Clupeidae	**Herrings**							
Dorosoma cepedianum	Gizzard shad	37	42	12	27	7	125	25
Alosa aestivalis	Blueback herring		97	328		26	451	90.2
Alosa pseudoharengus	Alewife herring	2		6		2	10	2
Alosa sapidissima	American shad	2					2	0.4
Ictaluridae	**Bullhead catfishes**							
Ameiurus nebulosus	Brown bullhead	5	5	10		21	41	8.2
Ameiurus catus	White catfish							
Ictalurus punctatus	Channel catfish	1		1	1		3	0.6
Castomomidae	**Suckers**							
Carpiodes cyprinus	Quillback carpsucker					1	1	0.2
Moxostoma erythrurum	Golden redhorse	1	2		1	23	27	5.4
Moxostoma macrolepidotum	Shorthead redhorse			3		11	14	2.8
Percidae	**Perches**							
Perca flavescens	Yellow perch	1		2	4	9	16	3.2
Poeciliidae	**Livebearers**							
Gambusia affinis	Mosquitofish							
Moronidae	**Temperate basses**							
Morone americana	White perch	110	112	43	1	42	308	61.6
Morone saxatilis	Striped bass	2				1	3	0.6
Centrarchidae	**Sunfishes**							
Lepomis gibbosus	Pumpkinseed	21	61	59		65	206	41.2
Micropterus salmoides	Largemouth bass		12	6		6	24	4.8
Lepomis macrochirus	Bluegill	1	3	1			5	1
Total # Fish		221	486	574	63	263	1607	321.4
# Fish Anadromous/Semianadromous/Catadromous		154	251	391	32	87	918	183
Total # Species		18	15	17	9	19	25	16
# Sp. Anadromous/Semianadromous/Catadromous		7	3	5	3	7	8	5

Appendix A. Table 3.6. Kenilworth Mudflat MF3 Fish Bag Seine Surveys

		7-Jan-97	9-Jan-97	28-Feb-97	Oct-98	Total	Average #/ Survey
Cyprinidae	**Carps and Minnows**						
Cyprinus carpio	Common carp	1				1	0.25
Carassius auratus	Goldfish						0
Hybognathus regius	Eastern silvery minnow	4				4	1
Notemigonus crysoleucas	Golden shiner				17	17	4.25
Notropis hudsonius	Spottail shiner						0
Cyprinella spiloptera	Spotfin shiner						0
Notropis procne	Swallowtail shiner						0
Anguillidae	**Freshwater eels**						0
Anguilla rostrata	American eel						0
Antherinidae	**Silversides**						0
Menidia beryilina	Atlantic silversides						0
Fundulidae	**Killifishes**						0
Fundulus diaphanus	Banded killifish		1	6	137	144	36
Fundulus heteroclitus	Mummichog killifish	1		2	667	670	167.5
Clupeidae	**Herrings**						0
Dorosoma cepedianum	Gizzard shad						0
Alosa aestivalis	Blueback herring				47	47	11.75
Alosa pseudoharengus	Alewife herring						0
Alosa sapidissima	American shad						0
Ictaluridae	**Bullhead catfishes**						0
Ameiurus nebulosus	Brown bullhead		4	1	3	8	2
Ameiurus catus	White catfish						0
Ictalurus punctatus	Channel catfish						0
Castomomidae	**Suckers**						0
Carpiodes cyprinus	Quillback carpsucker						0
Moxostoma erythrurum	Golden redhorse						0
Moxostoma macrolepidotum	Shorthead redhorse						0
Percidae	**Perches**						0
Etheostoma olmstedi	Tessellated darter				2	2	0.5
Perca flavescens	Yellow perch						0
Poeciliidae	**Livebearers**						0
Gambusia affinis	Mosquitofish						0
Moronidae	**Temperate basses**						0
Morone americana	White perch						0
Morone saxatilis	Striped bass				4	4	1
Centrarchidae	**Sunfishes**						0
Lepomis gibbosus	Pumpkinseed		1		27	28	7
Micropterus salmoides	Largemouth bass				2	2	0.5
Lepomis macrochirus	Bluegill		1		13	14	3.5
Total # Fish		6	7	9	919	941	235.25
# Fish Anadromous/Semianadromous/Catadromous		0	0	0	51	51	13
Total # Species		3	4	3	10	12	5
# Sp. Anadromous/Semianadromous/Catadromous		0	0	0	2	2	1

Appendix A, Table 3.7. 1997 Kenilworth MF3 mudflat exclosure total numbers of invertebrates from 5 cores by treatment and block for each month sampled

	Oligochaetes				Chironomids				Corbicula			
	A	B	C	Total	A	B	C	Total	A	B	C	Total
BA (Bird Access/Fish Excluded)												
March	34	40	60	134.0	7	2	2	11.0	0	0	0	0
May	51	95	17	163.0	0	0	0	0.0	3	0	0	3
July	298	324	221	843.0	84	18	3	105.0	1	2	0	3
Sept	32	67	37	136.0	9	5	0	14.0	3	10	0	13
Nov	50	16	116	182.0	199	30	4	233.0	5	0	1	6
AA (All Accessible)												
March	55	25	30	110.0	6	0	2	8.0	1	0	0	1
May	12	4	9	25.0	0	0	0	0.0	2	0	0	2
July	26	29	16	71.0	28	15	3	46.0	1	1	1	3
Sept	2	0	1	3.0	4	2	2	8.0	0	1	0	1
Nov	18	3	12	33.0	15	16	27	58.0	0	1	0	1
TX (Total Exclosure)												
March	61	46	27	134.0	3	7	7	17.0	1	0	0	1.0
May	26	43	8	77.0	0	2	0	2.0	1	0	0	1.0
July	360	288	326	974.0	7	17	2	26.0	2	1	0	3.0
Sept	78	66	25	169.0	6	3	0	9.0	2	2	0	4.0
Nov	121	27	53	201.0	52	27	2	81.0	0	1	0	1.0
FA (Fish Accessible/ Bird Exclosure)												
March	39	24	76	139.0	4	0	2	6.0	0	0	0	0.0
May	13	24	9	46.0	1	1	0	2.0	1	0	0	1.0
July	46	39	37	122.0	11	23	1	35.0	1	1	0	2.0
Sept	19	3	5	27.0	6	3	0	9.0	4	0	0	4.0
Nov	32	14	15	61.0	42	17	10	69.0	4	0	0	4.0
			Total	3650.0				739.0				54.0

Appendix A, Table 3.8. 1998 Kenilworth MF3 mudflat exclosure total numbers of invertebrates from 5 cores by treatment and block for each month sampled

	Oligochaetes				Chironomids				Corbicula			
	A	B	C	Total	A	B	C	Total	A	B	C	Total
AA (All Accessible)												
April	0	1	0	1.0	0	0	0	0	1	0	0	1.0
May	0	2	5	7.0	0	0	0	0	1	2	2	5.0
June	0	2	0	2.0	0	0	0	0	1	1	0	2.0
July	3	2	3	8.0	0	0	0	0	2	0	2	4.0
August	2	8	2	12.0	0	0	0	0	4	1	0	5.0
Sept	0	1	4	5.0	0	1	0	1.0	0	1	1	2.0
October	1	0	1	2.0	0	0	5	5.0	1	3	1	5.0
Nov	2	1	4	7.0	2	3	5	10.0	2	0	0	2.0
TX (Total Exclosure)												
April	12	4	1	17.0	0	1	0	1.0	2	2	0	4.0
May	15	13	43	71.0	0	0	0	0	2	2	1	5.0
June	4	1	12	17.0	0	0	0	0	3	2	0	5.0
July	4	6	8	18.0	0	0	0	0	3	1	0	4.0
August	26	47	10	83.0	0	0	0	0	4	1	0	5.0
Sept	1	3	8	12.0	0	0	0	0	0	0	1	1.0
October	0	13	12	25.0	0	0	0	0	0	0	0	0.0
Nov	0	9	34	43.0	8	15	0	23.0	2	1	1	4.0
FA (Fish Accessible/ Bird Exclosure)												
April	0	3	0	3.0	0	0	0	0	3	1	0	4.0
May	8	6	7	21.0	0	0	3	3	1	1	1	3.0
June	0	3	0	3.0	0	0	0	0	1	0	1	2.0
July	0	0	0	0.0	0	0	0	0	0	1	0	1.0
August	20	3	5	28.0	1	0	1	2.0	6	0	0	6.0
Sept	3	5	2	10.0	0	0	0	0	1	1	0	2.0
October	1	0	1	2.0	0	0	0	0	2	0	0	2.0
Nov	4	4	0	8.0	5	5	2	12	0	1	0	1.0
			Total	405.0				57				75.0

Appendix A. Table 3.9. Kenilworth Marsh Algae Data 1997-1998

Date	Excl Type	Repetition	% Cover
Apr-97	BA	A-1	79
Apr-97	BA	B-1	76
Apr-97	BA	C-1	61
Apr-97	TX	A-3	68
Apr-97	TX	B-4	88
Apr-97	TX	C-2	69
Apr-97	FA	A-4	72
Apr-97	FA	B-3	87
Apr-97	FA	C-3	89
Apr-97	AA	A-2	51
Apr-97	AA	B-2	90
Apr-97	AA	C-4	77
May-97	BA	A-1	98
May-97	BA	B-1	99
May-97	BA	C-1	100
May-97	TX	A-3	94
May-97	TX	B-4	100
May-97	TX	C-2	100
May-97	FA	A-4	65
May-97	FA	B-3	77
May-97	FA	C-3	63
May-97	AA	A-2	67
May-97	AA	B-2	86
May-97	AA	C-4	73
Jun-97	BA	A-1	55
Jun-97	BA	B-1	75
Jun-97	BA	C-1	49
Jun-97	TX	A-3	65
Jun-97	TX	B-4	88
Jun-97	TX	C-2	96
Jun-97	FA	A-4	49
Jun-97	FA	B-3	38
Jun-97	FA	C-3	44
Jun-97	AA	A-2	48
Jun-97	AA	B-2	48
Jun-97	AA	C-4	96

Date	Excl Type	Repetition	% Cover
Jul-97	BA	A-1	100
Jul-97	BA	B-1	100
Jul-97	BA	C-1	100
Jul-97	TX	A-3	22
Jul-97	TX	B-4	74
Jul-97	TX	C-2	100
Jul-97	FA	A-4	19
Jul-97	FA	B-3	17
Jul-97	FA	C-3	13
Jul-97	AA	A-2	19
Jul-97	AA	B-2	23
Jul-97	AA	C-4	11
Aug-97	BA	A-1	63
Aug-97	BA	B-1	93
Aug-97	BA	C-1	100
Aug-97	TX	A-3	67
Aug-97	TX	B-4	88
Aug-97	TX	C-2	100
Aug-97	FA	A-4	68
Aug-97	FA	B-3	79
Aug-97	FA	C-3	100
Aug-97	AA	A-2	59
Aug-97	AA	B-2	84
Aug-97	AA	C-4	28
Sep-97	BA	A-1	84
Sep-97	BA	B-1	95
Sep-97	BA	C-1	100
Sep-97	TX	A-3	83
Sep-97	TX	B-4	91
Sep-97	TX	C-2	100
Sep-97	FA	A-4	86
Sep-97	FA	B-3	70
Sep-97	FA	C-3	36
Sep-97	AA	A-2	68
Sep-97	AA	B-2	70
Sep-97	AA	C-4	3

Appendix A. Table 3.9. Kenilworth Marsh Algae Data Cont.

Date	Excl Type	Repetition	% Cover
Oct-97	BA	A-1	100
Oct-97	BA	B-1	97
Oct-97	BA	C-1	100
Oct-97	TX	A-3	100
Oct-97	TX	B-4	100
Oct-97	TX	C-2	97
Oct-97	FA	A-4	93
Oct-97	FA	B-3	77
Oct-97	FA	C-3	48
Oct-97	AA	A-2	80
Oct-97	AA	B-2	81
Oct-97	AA	C-4	14
Nov-97	BA	A-1	0
Nov-97	BA	B-1	0
Nov-97	BA	C-1	1
Nov-97	TX	A-3	0
Nov-97	TX	B-4	0
Nov-97	TX	C-2	5
Nov-97	FA	A-4	0
Nov-97	FA	B-3	0
Nov-97	FA	C-3	0
Nov-97	AA	A-2	0
Nov-97	AA	B-2	0
Nov-97	AA	C-4	0
Dec-97	BA	A-1	0
Dec-97	BA	B-1	0
Dec-97	BA	C-1	43
Dec-97	TX	A-3	0
Dec-97	TX	B-4	0
Dec-97	TX	C-2	33
Dec-97	FA	A-4	0
Dec-97	FA	B-3	0
Dec-97	FA	C-3	0
Dec-97	AA	A-2	0
Dec-97	AA	B-2	0
Dec-97	AA	C-4	0

Date	Excl Type	Repetition	% Cover
Jan-98	BA	A-1	0
Jan-98	BA	B-1	5
Jan-98	BA	C-1	88
Jan-98	TX	A-3	0
Jan-98	TX	B-4	0
Jan-98	TX	C-2	56
Jan-98	FA	A-4	0
Jan-98	FA	B-3	0
Jan-98	FA	C-3	9
Jan-98	AA	A-2	0
Jan-98	AA	B-2	0
Jan-98	AA	C-4	0
Feb-98	BA	A-1	0
Feb-98	BA	B-1	0
Feb-98	BA	C-1	0
Feb-98	TX	A-3	0
Feb-98	TX	B-4	0
Feb-98	TX	C-2	0
Feb-98	FA	A-4	0
Feb-98	FA	B-3	0
Feb-98	FA	C-3	0
Feb-98	AA	A-2	0
Feb-98	AA	B-2	0
Feb-98	AA	C-4	0
Apr-98	TX	A-3	96
Apr-98	TX	B-4	93
Apr-98	TX	C-2	89
Apr-98	FA	A-4	92
Apr-98	FA	B-3	90
Apr-98	FA	C-3	94
Apr-98	AA	A-2	92
Apr-98	AA	B-2	88
Apr-98	AA	C-4	73
May-98	TX	A-3	62
May-98	TX	B-4	65
May-98	TX	C-2	98

Appendix A. Table 3.9. Kenilworth Marsh Algae Data Cont.

Date	Excl Type	Repetition	% Cover
May-98	FA	A-4	44
May-98	FA	B-3	74
May-98	FA	C-3	74
May-98	AA	A-2	20
May-98	AA	B-2	79
May-98	AA	C-4	68
Jun-98	TX	A-3	95
Jun-98	TX	B-4	95
Jun-98	TX	C-2	88
Jun-98	FA	A-4	56
Jun-98	FA	B-3	71
Jun-98	FA	C-3	77
Jun-98	AA	A-2	27
Jun-98	AA	B-2	65
Jun-98	AA	C-4	58
Jul-98	TX	A-3	0
Jul-98	TX	B-4	51
Jul-98	TX	C-2	67
Jul-98	FA	A-4	0
Jul-98	FA	B-3	44
Jul-98	FA	C-3	44
Jul-98	AA	A-2	0
Jul-98	AA	B-2	49
Jul-98	AA	C-4	37
Aug-98	TX	A-3	92
Aug-98	TX	B-4	90
Aug-98	TX	C-2	99
Aug-98	FA	A-4	92
Aug-98	FA	B-3	84
Aug-98	FA	C-3	70
Aug-98	AA	A-2	28
Aug-98	AA	B-2	79
Aug-98	AA	C-4	87
Sep-98	TX	A-3	95
Sep-98	TX	B-4	89
Sep-98	TX	C-2	100

Date	Excl Type	Repetition	% Cover
Sep-98	FA	A-4	84
Sep-98	FA	B-3	90
Sep-98	FA	C-3	71
Sep-98	AA	A-2	65
Sep-98	AA	B-2	31
Sep-98	AA	C-4	75
Oct-98	TX	A-3	81
Oct-98	TX	B-4	84
Oct-98	TX	C-2	100
Oct-98	FA	A-4	72
Oct-98	FA	B-3	47
Oct-98	FA	C-3	0
Oct-98	AA	A-2	28
Oct-98	AA	B-2	28
Oct-98	AA	C-4	0
Nov-98	TX	A-3	76
Nov-98	TX	B-4	80
Nov-98	TX	C-2	100
Nov-98	FA	A-4	79
Nov-98	FA	B-3	80
Nov-98	FA	C-3	0
Nov-98	AA	A-2	13
Nov-98	AA	B-2	23
Nov-98	AA	C-4	0
Dec-98	TX	A-3	0
Dec-98	TX	B-4	30
Dec-98	TX	C-2	23
Dec-98	FA	A-4	0
Dec-98	FA	B-3	0
Dec-98	FA	C-3	0
Dec-98	AA	A-2	0
Dec-98	AA	B-2	0
Dec-98	AA	C-4	0

Appendix A. Table 3.10. Fish Found Stranded on Kenilworth Mudflat Study Area

5/14/97	pumpkinseed in A-3
5/19/97	2 pumpkinseed in A-3
6/16/97	killifish swarms in A-4,B-3,C-3
6/25/97	killifish swarms all over flat receeding tide
6/27/97	57 killifish trapped in A-1 in from fence break
8/16/97	1 killifish dead in B1
6/3/98	several killifish in B4,C2
6/8/98	16 mummichog trapped in C2

Appendix A, Table3.11. 1997 Kenilworth volunteer plant (presence) observations in mudflat exclosure treatment cells
(Exclosures Constructed March 22, 1997)

	Pontederia cordata			*Polygonum sp.*	
	A	B	C	A	B
BA (Bird Access/Fish Excluded)					
7/16/97		1	7		
8/26/97		1	8		
9/23/97		1	8		
10/27/97		1	8		
AA (All Accessible)					
7/16/97					
8/26/97					
9/23/97					
10/27/97					
TX (Total Exclosure)					
7/16/97		1	6		1
8/26/97		1	7	3	1
9/23/97			7	2	2
10/27/97			6		
FA (Fish Accessible/ Bird Exclosure)					
7/16/97			2		4
8/26/97				1	3
9/23/97					2
10/27/97					

Appendix A. Table 3.12. 1998 Kenilworth Experimental Plants in Mudflat Exclosure Cells
(5 Pickerelweed plugs planted in each cell on 1m centers on June 3)
# of Pontederia Plugs Surviving

		Block		
		A	B	C
AA (All Accessible)				
	6/3/98	5	5	5
	5-Jun	5	5	0
	8-Jun	0	3*	0
	19-Jun	0	3*	0
	21-Jul	0	0	0
	5-Aug	0	0	0
	19-Aug	0	0	0
	5-Oct	0	0	0
TX (Total Exclosure)				
	6/3/98	5	5	5
	5-Jun	5	5	5
	8-Jun	5	5	5
	19-Jun	5	5	5
	21-Jul	5	5	5
	5-Aug	5	5	5
	19-Aug	5	5	5
	5-Oct	5	5	5
FA (Fish Accessible/ Bird Exclosure)				
	6/3/98	5	5	5
	5-Jun	5	5	5
	8-Jun	5	5	5
	19-Jun	5	5	5
	21-Jul	3	2*	4
	5-Aug	3	2*	4
	19-Aug	4	1*	4
	5-Oct	3	0	4

*Stems only no leaves

Appendix A. Table 3.13. Bird Tracks Found in Kenilworth Mudflat Exclosure Study Area

5/14/97	herron tracks in B-1, B-2
	many goose tracks in B-2
6/16/97	goose tracks all over flat
6/27/97	herron tracks in A-2,B-2, near A-1,C-1,C-2,C-3,C-4
7/16/97	shorebird tracks in C-4
7/17/97	herron tracks in B2,C1,C2,C4
7/28/97	shorebird tracks in A2,B2, B3
8/29/97	greater yellowlegs picking open corbicula shell
9/16/97	herron and shorebird tracks in B2
9/23/97	numerous shorebird tracks in A2
	numerous GBH tracks in B2
	6 "dug out" goose holes in A4
10/27/97	numerous goose tracks and droppings all over flats
	multiple dugout holes in A2 (15-30cm diameter)
10/29/97	numerous goose and shorebird tracks in A2,B2,C4 and over flat
11/26/97	shorebird tracks in A2,B2
12/29/97	goose tracks all over flat especially in B2
1/27/98	many goose and shorebird tracks on flat, some new digging
	shorebird tracks in A2,B2
4/24/98	goose tracks in B2
6/5/98	shorebird tracks in B2,C4
	herron tracks in C2
6/8/98	heavy shorebird tracks in B2 and on flat
	heavy goose tracks in C1
6/22/98	shorebird tracks in B1,B2
7/21/98	shorebird tracks in B2,C4
8/19/98	shorebird tracks in B2
9/18/98	beginning of "dug out" shovel craters
9/28/98	heavy shorebird and goose tracks on flat
11/30/98	heavy shorebird and goose tracks on flat
12/30/98	heavy shorebird tracks in B2
2/26/98	heavy shorebird tracks in A2,A4,B2 and on flat
	some goose tracks 2 dugouts in B2, and on flat
2/27/98	goose tracks in A4
3/15/98	shorebird tracks in A1
3/30/98	heavy goose tracks in B2,C1, 3 dugouts at root base in C2

Appendix A. Table 3.14. Reptiles and Tracks Found on Kenilworth Mudflat Study Area

4/6/97	Red Eared Slider Inside Exclosure-C1
5/20/97	60 cm RE Slider just outside C-1
	45 cm Painted turtle inside B-4
6/17/97	60 cm Snapping turtle in A-1
	25 cm Painted in A-1
	Turtle tracks in A-1,A-2,A-3
6/25/97	3 Painted, one in A-3
6/27/97	15 cm Painted in A-1
	tracks in B-2
7/28/97	turtle tracks in A1
12/29/97	turtle tracks in A2
6/3/98	20cm painted in A3
	turtle tracks in A2
6/22/98	turtle tracks in C2
8/19/98	14cm painted in B2

Appendix A. Table 3.15. Kenilworth experimental *Pontederia cordata* planting biomass

	Total g dry weight of each plant			Area (m squared) occupied by each plant		
	A	B	C	A	B	C
AA (All Accessible)						
Plant #						
#1	0	0	0	0	0	0
#2	0	0	0	0	0	0
#3	0	0	0	0	0	0
#4	0	0	0	0	0	0
#5	0	0	0	0	0	0
TX (Total Exclosure)						
Plant #						
#1	822.6	1261.7	462.3	2.01	2.84	1.77
#2	874.2	217.7	100.9	3.3	1.19	1.33
#3	690.1	431.9	257	3.4	1.86	1.84
#4	1397.7	758.7	146.2	2.84	1.74	1.13
#5	803.5	669.9	90.5	2.11	1.72	0.95
	4588.1	3339.9	1056.9	13.66	9.35	7.02
FA (Fish Accessible/ Bird Exclosure)						
Plant #						
#1	182.1	0	0	0.92	0	0
#2	0	0	19.5	0	0	0.32
#3	0	0	91.2	0	0	1.02
#4	239.2	0	299.2	1.5	0	2.22
#5	239.4	0	3.3	1.33	0	0.15
	660.7	0	413.2	**3.75**	0	3.71

Appendix A. Table 3.16. Mammal Tracks Found on Kenilworth Mudflat Study Area

9/23/97	raccoon tracks outside of C4
10/29/97	raccoon tracks in and around A2,B2,B3,C3,C4 signs of digging for clams?
11/16/97	raccoon tracks on Florida mudflats found
11/26/97	raccoon and dog tracks in B2
12/29/97	raccoon tracks in C2, dog tracks on flat
1/27/98	raccoon tracks and digging in C2
	unknown large (20cm) 4 finger "hand" prints in mud on flat
8/19/98	raccoon tracks and digging in C4
10/5/98	raccoon tracks on flat
	beaver sighted in water just outside flat
11/30/98	raccoon tracks on flat
12/30/98	raccoon tracks in C3
3/30/98	dog tracks in and around B2

Appendix A. Table 3.17. Snails found on Kenilworth Mudflat Study Area

6/27/97	3 Vivipridae "Apple Snails" in B-4
9/16/97	1 Vivipridae each in B2,C4
4/24/98	1 Vivipridae each in A4,B3
5/8/98	1 Vivipridae found on flat
6/3/98	1 Vivipridae each in B2,C1
6/19/98	1 Vivipridae and one physid found in A3
9/28/98	1 Vivipridae found on flat near A4
6/25/98	1 Vivipridae found in A4

Appendix A. Table 3.18. Bryzoans Found on Kenilworth Mudflat Study Area
Likely to be *Pectinatella magnifica*

9/16/97	1 each found in A2,A4,B2 with 3 more on mudflats adjacent
9/23/97	35cm found in A4
	20cm found in B3
10/27/97	one found in B3
7/21/98	35cm found outside of C2
8/19/98	12cm found in C3
9/1/98	42cm found on flat
9/28/98	25cm found in B3

Appendix B – Kingman Lake Ecological Data Tables

Kingman Bird Counts

		6/8/98			6/22/98		7/23/98		
		Site#1	Site#2	GC	Site#1	Site#2	Site#1	Site#2	GC
Branta canadensis	Canada goose		6	200					144
Charadrius vociferus	Killdeer	20	8		8	5	68	12	
Actitus macularia	Spotted sandpiper								
Tringa solitaria	Solitary sandpiper								
Calidris pusilla	Semipalmated plover								
Gallinago gallinago	Common snipe								
Tringa melanoleuca	Greater yellowlegs								
Tringa flavipes	Lesser yellowlegs								
Ardea herodias	Great blue heron	5			5	1	6	2	
Butorides virescens	Green herron								
Casmerodius albus	Great egret					1		1	
Anas platyrhynchos	Mallard	7	10		2	10			
Anas rubripes	American black duck							5	
Anas acuta	Northern pintail								
Anas crecca	Green-winged teal								
Podiceps grisegena	Red-necked grebe								
Ceryle alcyon	Belted kingfisher								
Larus argentatus	Herring gull	2							
Larus delawarensis	Ring billed gull				1		1	1	
Larus philadelphia	Bonaparts gull								
Haliaeetus leucocephalus	Bald eagle								
Pandion haliaetus	Osprey		1						
Corvus ossifragus	Fish crow		1				1		

Kingman Bird Counts		8/20/98			9/18/98			10/20/98		
		Site#1	Site#2	GC	Site#1	Site#2	GC	Site#1	Site#2	GC
Branta canadensis	Canada goose			275		7	78			77
Charadrius vociferus	Killdeer	89	20		42	15		85	1	
Actitus macularia	Spotted sandpiper							1		
Tringa solitaria	Solitary sandpiper									
Calidris pusilla	Semipalmated plover	5								
Gallinago gallinago	Common snipe							1		
Tringa melanoleuca	Greater yellowlegs									
Tringa flavipes	Lesser yellowlegs								1	
Ardea herodias	Great blue heron	5			2			3		
Butorides virescens	Green herron									
Casmerodius albus	Great egret		2					2		
Anas platyrhynchos	Mallard									
Anas rubripes	American black duck									
Anas acuta	Northern pintail									
Anas crecca	Green-winged teal									
Podiceps grisegena	Red-necked grebe									
Ceryle alcyon	Belted kingfisher									
Larus argentatus	Herring gull							1		
Larus delawarensis	Ring billed gull									
Larus philadelphia	Bonaparts gull									
Haliaeetus leucocephalus	Bald eagle									
Pandion haliaetus	Osprey									
Corvus ossifragus	Fish crow		1							

Kingman Bird Counts		11/19/98			12/2/98			12/30/98		
		Site#1	Site#2	GC	Site#1	Site#2	GC	Site#1	Site#2	GC
Branta canadensis	Canada goose	4			140					200
Charadrius vociferus	Killdeer	23								
Actitus macularia	Spotted sandpiper									
Tringa solitaria	Solitary sandpiper									
Calidris pusilla	Semipalmated plover									
Gallinago gallinago	Common snipe									
Tringa melanoleuca	Greater yellowlegs									
Tringa flavipes	Lesser yellowlegs									
Ardea herodias	Great blue heron	1	3		2	6		1	2	
Butorides virescens	Green herron									
Casmerodius albus	Great egret									
Anas platyrhynchos	Mallard							2		
Anas rubripes	American black duck									
Anas acuta	Northern pintail									
Anas crecca	Green-winged teal									
Podiceps grisegena	Red-necked grebe									
Ceryle alcyon	Belted kingfisher									
Larus argentatus	Herring gull									
Larus delawarensis	Ring billed gull	8			109			65	1	
Larus philadelphia	Bonaparts gull							30		
Haliaeetus leucocephalus	Bald eagle									
Pandion haliaetus	Osprey									
Corvus ossifragus	Fish crow				6			4	4	

Kingman Bird Counts		1/29/99			2/27/99			3/30/99		
		Site#1	Site#2	GC	Site#1	Site#2	GC	Site#1	Site#2	GC
Branta canadensis	Canada goose			200	5			17		
Charadrius vociferus	Killdeer	29			24			24	6	
Actitus macularia	Spotted sandpiper									
Tringa solitaria	Solitary sandpiper									
Calidris pusilla	Semipalmated plover									
Gallinago gallinago	Common snipe							1		
Tringa melanoleuca	Greater yellowlegs									
Tringa flavipes	Lesser yellowlegs									
Ardea herodias	Great blue heron	2	5		1				1	
Butorides virescens	Green herron									
Casmerodius albus	Great egret									
Anas platyrhynchos	Mallard							5	2	
Anas rubripes	American black duck									
Anas acuta	Northern pintail					2				
Anas crecca	Green-winged teal							6		
Podiceps grisegena	Red-necked grebe									
Ceryle alcyon	Belted kingfisher								1	
Larus argentatus	Herring gull									
Larus delawarensis	Ring billed gull	159			72	97		31	2	
Larus philadelphia	Bonaparts gull									
Haliaeetus leucocephalus	Bald eagle									
Pandion haliaetus	Osprey									
Corvus ossifragus	Fish crow							1	1	

Kingman Bird Counts

		1/29/99			2/27/99			3/30/99		
		Site#1	Site#2	GC	Site#1	Site#2	GC	Site#1	Site#2	GC
Branta canadensis	Canada goose			200	5			17		
Charadrius vociferus	Killdeer	29			24			24	6	
Actitus macularia	Spotted sandpiper									
Tringa solitaria	Solitary sandpiper									
Calidris pusilla	Semipalmated plover									
Gallinago gallinago	Common snipe							1		
Tringa melanoleuca	Greater yellowlegs									
Tringa flavipes	Lesser yellowlegs									
Ardea herodias	Great blue heron	2	5		1				1	
Butorides virescens	Green herron									
Casmerodius albus	Great egret									
Anas platyrhynchos	Mallard							5	2	
Anas rubripes	American black duck									
Anas acuta	Northern pintail					2				
Anas crecca	Green-winged teal							6		
Podiceps grisegena	Red-necked grebe									
Ceryle alcyon	Belted kingfisher								1	
Larus argentatus	Herring gull									
Larus delawarensis	Ring billed gull	159			72	97		31	2	
Larus philadelphia	Bonaparts gull									
Haliaeetus leucocephalus	Bald eagle									
Pandion haliaetus	Osprey									
Corvus ossifragus	Fish crow							1	1	

Kingman Bird Counts

		5/26/99			6/23/99			7/30/99		
		Site#1	Site#2	GC	Site#1	Site#2	GC	Site#1	Site#2	GC
Branta canadensis	Canada goose		43		296	53				
Charadrius vociferus	Killdeer	12	6		13			6	56	
Actitus macularia	Spotted sandpiper									
Tringa solitaria	Solitary sandpiper		2							
Calidris pusilla	Semipalmated plover				1				4	
Gallinago gallinago	Common snipe									
Tringa melanoleuca	Greater yellowlegs									
Tringa flavipes	Lesser yellowlegs									
Ardea herodias	Great blue heron	9	1		12	1			5	
Butorides virescens	Green herron									
Casmerodius albus	Great egret							2		
Anas platyrhynchos	Mallard		2		14	5				
Anas rubripes	American black duck									
Anas acuta	Northern pintail									
Anas crecca	Green-winged teal									
Podiceps grisegena	Red-necked grebe	2								
Ceryle alcyon	Belted kingfisher									
Larus argentatus	Herring gull									
Larus delawarensis	Ring billed gull									
Larus philadelphia	Bonaparts gull									
Haliaeetus leucocephalus	Bald eagle	1						1		
Pandion haliaetus	Osprey									
Corvus ossifragus	Fish crow							1	1	

Kingman Bird Counts

		8/20/99			6/9/00	7/26/00	Aug-00	9/7/00
		Site#1	Site#2	GC	All Kng Goos	All Kng Goos	All Kng Goos	All Kng Goos
Branta canadensis	Canada goose				285	22	273	130
Charadrius vociferus	Killdeer	38	8					
Actitus macularia	Spotted sandpiper							
Tringa solitaria	Solitary sandpiper							
Calidris pusilla	Semipalmated plover							
Gallinago gallinago	Common snipe							
Tringa melanoleuca	Greater yellowlegs							
Tringa flavipes	Lesser yellowlegs							
Ardea herodias	Great blue heron	4	2					
Butorides virescens	Green herron							
Casmerodius albus	Great egret							
Anas platyrhynchos	Mallard							
Anas rubripes	American black duck							
Anas acuta	Northern pintail							
Anas crecca	Green-winged teal							
Podiceps grisegena	Red-necked grebe							
Ceryle alcyon	Belted kingfisher							
Larus argentatus	Herring gull							
Larus delawarensis	Ring billed gull	47						
Larus philadelphia	Bonaparts gull							
Haliaeetus leucocephalus	Bald eagle							
Pandion haliaetus	Osprey							
Corvus ossifragus	Fish crow							

Kingman Bird Counts

		10/19/00			10/20/00		
		Site#1	Site#2	GC	Site#1	Site#2	GC
Branta canadensis	Canada goose						42
Charadrius vociferus	Killdeer						
Actitus macularia	Spotted sandpiper						
Tringa solitaria	Solitary sandpiper						
Calidris pusilla	Semipalmated plover						
Gallinago gallinago	Common snipe						
Tringa melanoleuca	Greater yellowlegs						
Tringa flavipes	Lesser yellowlegs						
Ardea herodias	Great blue heron	2	2		1		
Butorides virescens	Green herron						
Casmerodius albus	Great egret	1					
Anas platyrhynchos	Mallard						
Anas rubripes	American black duck						
Anas acuta	Northern pintail						
Anas crecca	Green-winged teal						
Podiceps grisegena	Red-necked grebe						
Ceryle alcyon	Belted kingfisher						
Larus argentatus	Herring gull						
Larus delawarensis	Ring billed gull						
Larus philadelphia	Bonaparts gull						
Haliaeetus leucocephalus	Bald eagle						
Pandion haliaetus	Osprey						
Corvus ossifragus	Fish crow						

Kingman Bird Counts

		11/18/00				12/18/00			
		Site#1	Site#2	GC	Lower K	Site#1	Site#2	GC	Benning Rd
Branta canadensis	Canada goose	13		204	467	394	9	45	168
Charadrius vociferus	Killdeer								
Actitus macularia	Spotted sandpiper								
Tringa solitaria	Solitary sandpiper								
Calidris pusilla	Semipalmated plover								
Gallinago gallinago	Common snipe								
Tringa melanoleuca	Greater yellowlegs								
Tringa flavipes	Lesser yellowlegs								
Ardea herodias	Great blue heron	1	1						1
Butorides virescens	Green herron				1				
Casmerodius albus	Great egret								
Anas platyrhynchos	Mallard				2				27
Anas rubripes	American black duck								
Anas acuta	Northern pintail								6
Anas crecca	Green-winged teal								
Podiceps grisegena	Red-necked grebe								
Ceryle alcyon	Belted kingfisher								
Larus argentatus	Herring gull								
Larus delawarensis	Ring billed gull				2				72
Larus philadelphia	Bonaparts gull								
Haliaeetus leucocephalus	Bald eagle								
Pandion haliaetus	Osprey								
Corvus ossifragus	Fish crow								

Kingman Bird Counts

		12/19/00				1/16/01			
		Site#1	Site#2	GC	Benning Rd	Site#1	Site#2	GC	Benning Rd
Branta canadensis	Canada goose	152	14		157				142
Charadrius vociferus	Killdeer								
Actitus macularia	Spotted sandpiper								
Tringa solitaria	Solitary sandpiper								
Calidris pusilla	Semipalmated plover								
Gallinago gallinago	Common snipe								
Tringa melanoleuca	Greater yellowlegs								
Tringa flavipes	Lesser yellowlegs								
Ardea herodias	Great blue heron	1	1		1				
Butorides virescens	Green herron								
Casmerodius albus	Great egret								
Anas platyrhynchos	Mallard				23				12
Anas rubripes	American black duck								
Anas acuta	Northern pintail	4			2				
Anas crecca	Green-winged teal								
Podiceps grisegena	Red-necked grebe								
Ceryle alcyon	Belted kingfisher								
Larus argentatus	Herring gull				1				
Larus delawarensis	Ring billed gull				32				32
Larus philadelphia	Bonaparts gull								
Haliaeetus leucocephalus	Bald eagle								
Pandion haliaetus	Osprey								
Corvus ossifragus	Fish crow								18

Kingman Bird Counts

		1/17/01 Site#1	Site#2	Benning Rd	3/7/01 All Kng Goos	9/19/01 All Kng Goos	Totals
Branta canadensis	Canada goose	64		147	526	15	5297
Charadrius vociferus	Killdeer						719
Actitus macularia	Spotted sandpiper						1
Tringa solitaria	Solitary sandpiper						2
Calidris pusilla	Semipalmated plover						10
Gallinago gallinago	Common snipe						2
Tringa melanoleuca	Greater yellowlegs						28
Tringa flavipes	Lesser yellowlegs						1
Ardea herodias	Great blue heron	1	1				120
Butorides virescens	Green herron						1
Casmerodius albus	Great egret						25
Anas platyrhynchos	Mallard			14			137
Anas rubripes	American black duck						5
Anas acuta	Northern pintail						14
Anas crecca	Green-winged teal						6
Podiceps grisegena	Red-necked grebe						2
Ceryle alcyon	Belted kingfisher						1
Larus argentatus	Herring gull						16
Larus delawarensis	Ring billed gull			3			787
Larus philadelphia	Bonaparts gull						30
Haliaeetus leucocephalus	Bald eagle						2
Pandion haliaetus	Osprey						1
Corvus ossifragus	Fish crow						40
							7247

Table 4.2. Kingman Canada Goose Counts

		9/26 1997	9/27 1997	9/28 1998	9/29 1998	9/30 1998	10/1 1998	10/2 1998	10/3 1998	10/4 1998	10/5 1998	10/6 1998	10/7 1998	10/8 1998	10/9 1998	10/10 1999
DC Survey	Site#1	30			21	5							4	140		
	Site#2					7	6				7					
	On Turf @ Driving Range			20		200	200		144	155	78	55			200	200
	On Water @ Driving Range									120		22				
	Upper KI															
Total		30	0	20	21	275	206	0	144	275	85	77	4	140	200	200

		10/11 1999	10/12 1999	10/13 1999	10/14 1999	10/15 1999	10/16 1999	10/17 1999	10/27 2000	10/30 2000	11/1 2000	11/2 2000	11/3 2000	11/4 2000	11/5 2000	11/6 2000	11/7 2001	11/8 2001
DC Survey	Site#1	5	17			296									9			
	Site#2				43	53									137	14		64
	On Turf @ Driving Range													204	45			
	On Water @ Driving Range												42	467	168	157	142	147
	Upper KI								285	22	273	130						
Total		5	17	0	43	249	0	0	285	22	273	130	42	671	350	171	142	211

Appendix B, Table 4.3. Kingman Lake Electrofishing Survey Data

		Sep-96		Apr-98		Jul-98			Averag
		KNG01	KNG02	KNGTG1	KNGTG2	KNGTG1	KNGTG2	Total	#/
Cyprinidae	**Carps and Minnows**								
Cyprinus carpio	Common carp	8		9	4	12		33	
Carassius auratus	Goldfish			1				1	
Hybognathus regius	Eastern silvery minnow	42	5	2	6			55	
Notemigonus crysoleucas	Golden shiner		1		4	1	1	7	
Notropis hudsonius	Spottail shiner	3	11	1	1	2		18	
Cyprinella spiloptera	Spotfin shiner								
Notropis procne	Swallowtail shiner								
Anguillidae	**Freshwater eels**								
Anguilla rostrata	American eel								
Antherinidae	**Silversides**								
Menidia beryilina	Atlantic silversides								
Fundulidae	**Killifishes**								
Fundulus diaphanus	Banded killifish	1						1	
Fundulus heteroclitus	Mummichog killifish								
Clupeidae	**Herrings**								
Dorosoma cepedianum	Gizzard shad	19	6	31	37	23	11	127	
Alosa aestivalis	Blueback herring	34	53			6	13	106	
Alosa pseudoharengus	Alewife herring					6	11	17	
Alosa sapidissima	American shad								
Ictaluridae	**Bullhead catfishes**								
Ameiurus nebulosus	Brown bullhead	3		77	111	69	154	414	
Ameiurus catus	White catfish								
Ictalurus punctatus	Channel catfish			3				3	
Castomomidae	**Suckers**								
Carpiodes cyprinus	Quillback carpsucker								
Moxostoma erythrurum	Golden redhorse								
Moxostoma macrolepidotum	Shorthead redhorse								
Percidae	**Perches**								
Perca flavescens	Yellow perch	2	3	2				7	
Poeciliidae	**Livebearers**								
Gambusia affinis	Mosquitofish								
Moronidae	**Temperate basses**								
Morone americana	White perch	4	1	12	11	3	10	41	
Morone saxatilis	Striped bass					1	1	2	
Centrarchidae	**Sunfishes**								
Lepomis gibbosus	Pumpkinseed	38	30	15	67	13	12	175	
Micropterus salmoides	Largemouth bass								
Lepomis macrochirus	Bluegill	3			1		1	5	
Total # Fish		157	110	153	242	136	214	1012	
# Fish Anadromous/Semianadromous/Catadromous		59	63	45	48	38	46	299	
Total # Species		11	8	10	8	10	9	16	
# Sp. Anadromous/Semianadromous/Catadromous		4	4	3	2	5	5	23	

Appendix B, Table 4.4. Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2001	0	A	10	3	100	0	0	0	0	0	0	0
2001	0	B	10	3	60	40	0	0	0	0	0	0
2001	0	C	10	3	100	0	0	0	0	0	0	0
2001	1	A	10	3	100	0	0	0	0	0	0	0
2001	1	B	10	3	100	0	0	0	0	0	0	0
2001	1	C	10	3	100	0	0	0	0	0	0	0
2001	2	A	10	3	100	0	0	0	0	0	0	0
2001	2	B	10	3	99	0	0	0	1	0	0	0
2001	2	C	10	3	50	50	0	0	0	0	0	0
2001	3	A	10	3	100	0	0	0	0	0	0	0
2001	3	B	10	3	99	0	0	0	1	0	0	0
2001	3	C	10	3	100	0	0	0	0	0	0	0
2001	4	A	10	3	100	0	0	0	0	0	0	0
2001	4	B	10	3	100	0	0	0	0	0	0	0
2001	4	C	10	3	40	60	0	0	0	0	0	0
2001	5	A	10	3	100	0	0	0	0	0	0	0
2001	5	B	10	3	100	0	0	0	0	0	0	0
2001	5	C	10	3	90	10	0	0	0	0	0	0
2001	6	A	10	3	100	0	0	0	0	0	0	0
2001	6	B	10	3	40	0	50	0	10	0	0	0
2001	6	C	10	3	100	0	0	0	0	0	0	0
2001	7	A	10	3	100	0	0	0	0	0	0	0
2001	7	B	10	3	30	30	10	0	0	20	10	0
2001	7	C	10	3	100	0	0	0	0	0	0	0
2001	8	A	10	3	100	0	0	0	0	0	0	0
2001	8	B	10	3	30	30	0	0	0	40	0	0
2001	8	C	10	3	20	80	0	0	0	0	0	0
2001	9	A	10	3	100	0	0	0	0	0	0	0
2001	9	B	10	3	20	0	0	0	0	80	0	0
2001	9	C	10	3	0	100	0	0	0	0	0	0
2001	0	A	10	6	100	0	0	0	0	0	0	0
2001	0	B	10	6	90	0	0	0	0	0	10	0
2001	0	C	10	6	100	0	0	0	0	0	0	0
2001	1	A	10	6	100	0	0	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2001	1	B	10	6	100	0	0	0	0	0	0	0
2001	1	C	10	6	100	0	0	0	0	0	0	0
2001	2	A	10	6	100	0	0	0	0	0	0	0
2001	2	B	10	6	100	0	0	0	0	0	0	0
2001	2	C	10	6	100	0	0	0	0	0	0	0
2001	3	A	10	6	100	0	0	0	0	0	0	0
2001	3	B	10	6	20	80	0	0	0	0	0	0
2001	3	C	10	6	100	0	0	0	0	0	0	0
2001	4	A	10	6	100	0	0	0	0	0	0	0
2001	4	B	10	6	20	80	0	0	0	0	0	0
2001	4	C	10	6	100	0	0	0	0	0	0	0
2001	5	A	10	6	100	0	0	0	0	0	0	0
2001	5	B	10	6	50	30	0	0	0	20	0	0
2001	5	C	10	6	100	0	0	0	0	0	0	0
2001	6	A	10	6	100	0	0	0	0	0	0	0
2001	6	B	10	6	10	0	40	0	0	50	0	0
2001	6	C	10	6	100	0	0	0	0	0	0	0
2001	7	A	10	6	100	0	0	0	0	0	0	0
2001	7	B	10	6	10	0	70	0	0	20	0	0
2001	7	C	10	6	100	0	0	0	0	0	0	0
2001	8	A	10	6	100	0	0	0	0	0	0	0
2001	8	B	10	6	10	60	10	0	0	20	0	0
2001	8	C	10	6	70	30	0	0	0	0	0	0
2001	9	A	10	6	100	0	0	0	0	0	0	0
2001	9	B	10	6	80	0	0	0	0	20	0	0
2001	9	C	10	6	100	0	0	0	0	0	0	0
2001	0	A	10	9	100	0	0	0	0	0	0	0
2001	0	B	10	9	0	100	0	0	0	0	0	0
2001	0	C	10	9	100	0	0	0	0	0	0	0
2001	1	A	10	9	100	0	0	0	0	0	0	0
2001	1	B	10	9	0	100	0	0	0	0	0	0
2001	1	C	10	9	100	0	0	0	0	0	0	0
2001	2	A	10	9	100	0	0	0	0	0	0	0
2001	2	B	10	9	0	100	0	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2001	2	C	10	9	100	0	0	0	0	0	0	0
2001	3	A	10	9	100	0	0	0	0	0	0	0
2001	3	B	10	9	70	30	0	0	0	0	0	0
2001	3	C	10	9	100	0	0	0	0	0	0	0
2001	4	A	10	9	100	0	0	0	0	0	0	0
2001	4	B	10	9	100	0	0	0	0	0	0	0
2001	4	C	10	9	100	0	0	0	0	0	0	0
2001	5	A	10	9	100	0	0	0	0	0	0	0
2001	5	B	10	9	50	0	0	0	50	0	0	0
2001	5	C	10	9	100	0	0	0	0	0	0	0
2001	6	A	10	9	100	0	0	0	0	0	0	0
2001	6	B	10	9	100	0	0	0	0	0	0	0
2001	6	C	10	9	100	0	0	0	0	0	0	0
2001	7	A	10	9	100	0	0	0	0	0	0	0
2001	7	B	10	9	100	0	0	0	0	0	0	0
2001	7	C	10	9	100	0	0	0	0	0	0	0
2001	8	A	10	9	100	0	0	0	0	0	0	0
2001	8	B	10	9	100	0	0	0	0	0	0	0
2001	8	C	10	9	70	30	0	0	0	0	0	0
2001	9	A	10	9	100	0	0	0	0	0	0	0
2001	9	B	10	9	100	0	0	0	0	0	0	0
2001	9	C	10	9	40	60	0	0	0	0	0	0
2001	0	A	10	12	100	0	0	0	0	0	0	0
2001	0	B	10	12	0	50	0	0	50	0	0	0
2001	0	C	10	12	100	0	0	0	0	0	0	0
2001	1	A	10	12	40	60	0	0	0	0	0	0
2001	1	B	10	12	0	10	0	0	90	0	0	0
2001	1	C	10	12	100	0	0	0	0	0	0	0
2001	2	A	10	12	90	10	0	0	0	0	0	0
2001	2	B	10	12	30	60	0	0	10	0	0	0
2001	2	C	10	12	100	0	0	0	0	0	0	0
2001	3	A	10	12	100	0	0	0	0	0	0	0
2001	3	B	10	12	0	20	0	0	80	0	0	0
2001	3	C	10	12	100	0	0	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2001	4	A	10	12	100	0	0	0	0	0	0	0
2001	4	B	10	12	10	10	0	0	80	0	0	0
2001	4	C	10	12	100	0	0	0	0	0	0	0
2001	5	A	10	12	100	0	0	0	0	0	0	0
2001	5	B	10	12	20	50	0	0	30	0	0	0
2001	5	C	10	12	100	0	0	0	0	0	0	0
2001	6	A	10	12	100	0	0	0	0	0	0	0
2001	6	B	10	12	10	60	0	0	30	0	0	0
2001	6	C	10	12	100	0	0	0	0	0	0	0
2001	7	A	10	12	100	0	0	0	0	0	0	0
2001	7	B	10	12	0	60	0	0	40	0	0	0
2001	7	C	10	12	100	0	0	0	0	0	0	0
2001	8	A	10	12	100	0	0	0	0	0	0	0
2001	8	B	10	12	0	70	0	0	30	0	0	0
2001	8	C	10	12	100	0	0	0	0	0	0	0
2001	9	A	10	12	100	0	0	0	0	0	0	0
2001	9	B	10	12	80	0	0	20	0	0	0	0
2001	9	C	10	12	100	0	0	0	0	0	0	0
2002	0	A	10	3	100	0	0	0	0	0	0	0
2002	0	B	10	3	10	0	0	0	0	90	0	0
2002	0	C	10	3	100	0	0	0	0	0	0	0
2002	1	A	10	3	100	0	0	0	0	0	0	0
2002	1	B	10	3	100	0	0	0	0	0	0	0
2002	1	C	10	3	100	0	0	0	0	0	0	0
2002	2	A	10	3	100	0	0	0	0	0	0	0
2002	2	B	10	3	0	0	0	0	0	90	0	10
2002	2	C	10	3	60	40	0	0	0	0	0	0
2002	3	A	10	3	100	0	0	0	0	0	0	0
2002	3	B	10	3	0	0	0	0	20	80	0	0
2002	3	C	10	3	15	85	0	0	0	0	0	0
2002	4	A	10	3	100	0	0	0	0	0	0	0
2002	4	B	10	3	40	0	0	0	0	60	0	0
2002	4	C	10	3	20	80	0	0	0	0	0	0
2002	5	A	10	3	100	0	0	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2002	5	B	10	3	5	0	0	0	0	95	0	0
2002	5	C	10	3	65	30	5	0	0	0	0	0
2002	6	A	10	3	100	0	0	0	0	0	0	0
2002	6	B	10	3	0	0	0	0	0	100	0	0
2002	6	C	10	3	95	0	5	0	0	0	0	0
2002	7	A	10	3	100	0	0	0	0	0	0	0
2002	7	B	10	3	0	0	20	0	0	80	0	0
2002	7	C	10	3	100	0	0	0	0	0	0	0
2002	8	A	10	3	100	0	0	0	0	0	0	0
2002	8	B	10	3	0	0	50	0	0	50	0	0
2002	8	C	10	3	95	5	0	0	0	0	0	0
2002	9	A	10	3	100	0	0	0	0	0	0	0
2002	9	B	10	3	0	0	40	0	0	60	0	0
2002	9	C	10	3	5	70	0	0	0	10	15	0
2002	0	A	10	6	100	0	0	0	0	0	0	0
2002	0	B	10	6	0	0	0	0	0	100	0	0
2002	0	C	10	6	100	0	0	0	0	0	0	0
2002	1	A	10	6	100	0	0	0	0	0	0	0
2002	1	B	10	6	5	0	0	0	0	95	0	0
2002	1	C	10	6	100	0	0	0	0	0	0	0
2002	2	A	10	6	100	0	0	0	0	0	0	0
2002	2	B	10	6	5	0	0	0	0	95	0	0
2002	2	C	10	6	100	0	0	0	0	0	0	0
2002	3	A	10	6	100	0	0	0	0	0	0	0
2002	3	B	10	6	0	0	15	0	0	85	0	0
2002	3	C	10	6	95	0	5	0	0	0	0	0
2002	4	A	10	6	100	0	0	0	0	0	0	0
2002	4	B	10	6	0	0	30	0	0	70	0	0
2002	4	C	10	6	30	0	70	0	0	0	0	0
2002	5	A	10	6	100	0	0	0	0	0	0	0
2002	5	B	10	6	5	0	90	0	0	5	0	0
2002	5	C	10	6	70	0	30	0	0	0	0	0
2002	6	A	10	6	100	0	0	0	0	0	0	0
2002	6	B	10	6	10	0	90	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2002	6	C	10	6	80	0	20	0	0	0	0	0
2002	7	A	10	6	100	0	0	0	0	0	0	0
2002	7	B	10	6	20	0	80	0	0	0	0	0
2002	7	C	10	6	90	0	10	0	0	0	0	0
2002	8	A	10	6	100	0	0	0	0	0	0	0
2002	8	B	10	6	30	0	70	0	0	0	0	0
2002	8	C	10	6	80	20	0	0	0	0	0	0
2002	9	A	10	6	100	0	0	0	0	0	0	0
2002	9	B	10	6	10	0	90	0	0	0	0	0
2002	9	C	10	6	75	20	0	0	0	0	5	0
2002	0	A	10	9	100	0	0	0	0	0	0	0
2002	0	B	10	9	0	10	0	0	0	90	0	0
2002	0	C	10	9	100	0	0	0	0	0	0	0
2002	1	A	10	9	100	0	0	0	0	0	0	0
2002	1	B	10	9	0	0	0	0	0	100	0	0
2002	1	C	10	9	100	0	0	0	0	0	0	0
2002	2	A	10	9	100	0	0	0	0	0	0	0
2002	2	B	10	9	0	0	0	0	0	100	0	0
2002	2	C	10	9	100	0	0	0	0	0	0	0
2002	3	A	10	9	100	0	0	0	0	0	0	0
2002	3	B	10	9	0	15	10	0	0	75	0	0
2002	3	C	10	9	100	0	0	0	0	0	0	0
2002	4	A	10	9	100	0	0	0	0	0	0	0
2002	4	B	10	9	0	0	30	0	0	70	0	0
2002	4	C	10	9	90	10	0	0	0	0	0	0
2002	5	A	10	9	100	0	0	0	0	0	0	0
2002	5	B	10	9	30	0	70	0	0	0	0	0
2002	5	C	10	9	100	0	0	0	0	0	0	0
2002	6	A	10	9	100	0	0	0	0	0	0	0
2002	6	B	10	9	40	0	60	0	0	0	0	0
2002	6	C	10	9	100	0	0	0	0	0	0	0
2002	7	A	10	9	100	0	0	0	0	0	0	0
2002	7	B	10	9	20	0	80	0	0	0	0	0
2002	7	C	10	9	100	0	0	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2002	8	A	10	9	100	0	0	0	0	0	0	0
2002	8	B	10	9	20	0	80	0	0	0	0	0
2002	8	C	10	9	80	20	0	0	0	0	0	0
2002	9	A	10	9	100	0	0	0	0	0	0	0
2002	9	B	10	9	30	0	70	0	0	0	0	0
2002	9	C	10	9	0	90	0	0	10	0	0	0
2002	0	A	10	12	100	0	0	0	0	0	0	0
2002	0	B	10	12	0	20	0	0	20	55	5	0
2002	0	C	10	12	100	0	0	0	0	0	0	0
2002	1	A	10	12	45	50	0	0	0	0	5	0
2002	1	B	10	12	0	0	0	0	60	40	0	0
2002	1	C	10	12	100	0	0	0	0	0	0	0
2002	2	A	10	12	55	40	0	0	0	0	5	0
2002	2	B	10	12	0	12	0	0	0	85	0	0
2002	2	C	10	12	100	0	0	0	0	0	0	0
2002	3	A	10	12	100	0	0	0	0	0	0	0
2002	3	B	10	12	0	40	0	0	0	60	0	0
2002	3	C	10	12	100	0	0	0	0	0	0	0
2002	4	A	10	12	100	0	0	0	0	0	0	0
2002	4	B	10	12	0	5	0	0	0	95	0	0
2002	4	C	10	12	90	10	0	0	0	0	0	0
2002	5	A	10	12	100	0	0	0	0	0	0	0
2002	5	B	10	12	0	10	0	0	20	70	0	0
2002	5	C	10	12	100	0	0	0	0	0	0	0
2002	6	A	10	12	100	0	0	0	0	0	0	0
2002	6	B	10	12	0	15	0	0	20	65	0	0
2002	6	C	10	12	100	0	0	0	0	0	0	0
2002	7	A	10	12	100	0	0	0	0	0	0	0
2002	7	B	10	12	0	50	0	0	0	50	0	0
2002	7	C	10	12	100	0	0	0	0	0	0	0
2002	8	A	10	12	100	0	0	0	0	0	0	0
2002	8	B	10	12	0	90	0	0	0	10	0	0
2002	8	C	10	12	80	20	0	0	0	0	0	0
2002	9	A	10	12	100	0	0	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2002	9	B	10	12	10	90	0	0	0	0	0	0
2002	9	C	10	12	0	90	0	0	10	0	0	0
2003	0	A	10	3	100	0	0	0	0	0	0	0
2003	0	B	10	3	100	0	0	0	0	0	0	0
2003	0	C	10	3	100	0	0	0	0	0	0	0
2003	1	A	10	3	100	0	0	0	0	0	0	0
2003	1	B	10	3	100	0	0	0	0	0	0	0
2003	1	C	10	3	100	0	0	0	0	0	0	0
2003	2	A	10	3	100	0	0	0	0	0	0	0
2003	2	B	10	3	100	0	0	0	0	0	0	0
2003	2	C	10	3	100	0	0	0	0	0	0	0
2003	3	A	10	3	100	0	0	0	0	0	0	0
2003	3	B	10	3	100	0	0	0	0	0	0	0
2003	3	C	10	3	100	0	0	0	0	0	0	0
2003	4	A	10	3	100	0	0	0	0	0	0	0
2003	4	B	10	3	100	0	0	0	0	0	0	0
2003	4	C	10	3	100	0	0	0	0	0	0	0
2003	5	A	10	3	100	0	0	0	0	0	0	0
2003	5	B	10	3	100	0	0	0	0	0	0	0
2003	5	C	10	3	100	0	0	0	0	0	0	0
2003	6	A	10	3	100	0	0	0	0	0	0	0
2003	6	B	10	3	90	0	10	0	0	0	0	0
2003	6	C	10	3	100	0	0	0	0	0	0	0
2003	7	A	10	3	100	0	0	0	0	0	0	0
2003	7	B	10	3	80	0	20	0	0	0	0	0
2003	7	C	10	3	100	0	0	0	0	0	0	0
2003	8	A	10	3	100	0	0	0	0	0	0	0
2003	8	B	10	3	50	0	50	0	0	0	0	0
2003	8	C	10	3	100	0	0	0	0	0	0	0
2003	9	A	10	3	100	0	0	0	0	0	0	0
2003	9	B	10	3	90	0	10	0	0	0	0	0
2003	9	C	10	3	100	0	0	0	0	0	0	0
2003	0	A	10	6	100	0	0	0	0	0	0	0
2003	0	B	10	6	100	0	0	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2003	0	C	10	6	100	0	0	0	0	0	0	0
2003	1	A	10	6	100	0	0	0	0	0	0	0
2003	1	B	10	6	100	0	0	0	0	0	0	0
2003	1	C	10	6	100	0	0	0	0	0	0	0
2003	2	A	10	6	100	0	0	0	0	0	0	0
2003	2	B	10	6	60	0	40	0	0	0	0	0
2003	2	C	10	6	100	0	0	0	0	0	0	0
2003	3	A	10	6	100	0	0	0	0	0	0	0
2003	3	B	10	6	80	0	20	0	0	0	0	0
2003	3	C	10	6	95	0	5	0	0	0	0	0
2003	4	A	10	6	100	0	0	0	0	0	0	0
2003	4	B	10	6	95	0	5	0	0	0	0	0
2003	4	C	10	6	95	0	5	0	0	0	0	0
2003	5	A	10	6	100	0	0	0	0	0	0	0
2003	5	B	10	6	100	0	0	0	0	0	0	0
2003	5	C	10	6	80	10	10	0	0	0	0	0
2003	6	A	10	6	100	0	0	0	0	0	0	0
2003	6	B	10	6	85	0	15	0	0	0	0	0
2003	6	C	10	6	80	0	20	0	0	0	0	0
2003	7	A	10	6	100	0	0	0	0	0	0	0
2003	7	B	10	6	75	0	25	0	0	0	0	0
2003	7	C	10	6	100	0	0	0	0	0	0	0
2003	8	A	10	6	100	0	0	0	0	0	0	0
2003	8	B	10	6	90	0	10	0	0	0	0	0
2003	8	C	10	6	100	0	0	0	0	0	0	0
2003	9	A	10	6	100	0	0	0	0	0	0	0
2003	9	B	10	6	80	0	20	0	0	0	0	0
2003	9	C	10	6	100	0	0	0	0	0	0	0
2003	0	A	10	9	100	0	0	0	0	0	0	0
2003	0	B	10	9	100	0	0	0	0	0	0	0
2003	0	C	10	9	100	0	0	0	0	0	0	0
2003	1	A	10	9	100	0	0	0	0	0	0	0
2003	1	B	10	9	100	0	0	0	0	0	0	0
2003	1	C	10	9	100	0	0	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2003	2	A	10	9	100	0	0	0	0	0	0	0
2003	2	B	10	9	85	0	15	0	0	0	0	0
2003	2	C	10	9	100	0	0	0	0	0	0	0
2003	3	A	10	9	100	0	0	0	0	0	0	0
2003	3	B	10	9	50	0	50	0	0	0	0	0
2003	3	C	10	9	100	0	0	0	0	0	0	0
2003	4	A	10	9	100	0	0	0	0	0	0	0
2003	4	B	10	9	30	0	70	0	0	0	0	0
2003	4	C	10	9	100	0	0	0	0	0	0	0
2003	5	A	10	9	100	0	0	0	0	0	0	0
2003	5	B	10	9	30	0	70	0	0	0	0	0
2003	5	C	10	9	100	0	0	0	0	0	0	0
2003	6	A	10	9	100	0	0	0	0	0	0	0
2003	6	B	10	9	50	0	50	0	0	0	0	0
2003	6	C	10	9	100	0	0	0	0	0	0	0
2003	7	A	10	9	100	0	0	0	0	0	0	0
2003	7	B	10	9	100	0	0	0	0	0	0	0
2003	7	C	10	9	100	0	0	0	0	0	0	0
2003	8	A	10	9	100	0	0	0	0	0	0	0
2003	8	B	10	9	50	0	50	0	0	0	0	0
2003	8	C	10	9	100	0	0	0	0	0	0	0
2003	9	A	10	9	100	0	0	0	0	0	0	0
2003	9	B	10	9	40	0	60	0	0	0	0	0
2003	9	C	10	9	100	0	0	0	0	0	0	0
2003	0	A	10	12	100	0	0	0	0	0	0	0
2003	0	B	10	12	100	0	0	0	0	0	0	0
2003	0	C	10	12	100	0	0	0	0	0	0	0
2003	1	A	10	12	85	15	0	0	0	0	0	0
2003	1	B	10	12	100	0	0	0	0	0	0	0
2003	1	C	10	12	100	0	0	0	0	0	0	0
2003	2	A	10	12	100	0	0	0	0	0	0	0
2003	2	B	10	12	100	0	0	0	0	0	0	0
2003	2	C	10	12	100	0	0	0	0	0	0	0
2003	3	A	10	12	100	0	0	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2003	3	B	10	12	100	0	0	0	0	0	0	0
2003	3	C	10	12	100	0	0	0	0	0	0	0
2003	4	A	10	12	40	0	0	60	0	0	0	0
2003	4	B	10	12	95	0	5	0	0	0	0	0
2003	4	C	10	12	100	0	0	0	0	0	0	0
2003	5	A	10	12	70	0	0	30	0	0	0	0
2003	5	B	10	12	60	0	0	40	0	0	0	0
2003	5	C	10	12	100	0	0	0	0	0	0	0
2003	6	A	10	12	100	0	0	0	0	0	0	0
2003	6	B	10	12	10	0	0	90	0	0	0	0
2003	6	C	10	12	100	0	0	0	0	0	0	0
2003	7	A	10	12	100	0	0	0	0	0	0	0
2003	7	B	10	12	90	0	10	0	0	0	0	0
2003	7	C	10	12	100	0	0	0	0	0	0	0
2003	8	A	10	12	20	0	0	80	0	0	0	0
2003	8	B	10	12	60	30	10	0	0	0	0	0
2003	8	C	10	12	100	0	0	0	0	0	0	0
2003	9	A	10	12	50	0	10	40	0	0	0	0
2003	9	B	10	12	90	0	10	0	0	0	0	0
2003	9	C	10	12	100	0	0	0	0	0	0	0
2004	0	A	10	3	100	0	0	0	0	0	0	0
2004	0	B	10	3	100	0	0	0	0	0	0	0
2004	0	C	10	3	100	0	0	0	0	0	0	0
2004	1	A	10	3	100	0	0	0	0	0	0	0
2004	1	B	10	3	100	0	0	0	0	0	0	0
2004	1	C	10	3	100	0	0	0	0	0	0	0
2004	2	A	10	3	100	0	0	0	0	0	0	0
2004	2	B	10	3	90	0	10	0	0	0	0	0
2004	2	C	10	3	100	0	0	0	0	0	0	0
2004	3	A	10	3	100	0	0	0	0	0	0	0
2004	3	B	10	3	100	0	0	0	0	0	0	0
2004	3	C	10	3	100	0	0	0	0	0	0	0
2004	4	A	10	3	100	0	0	0	0	0	0	0
2004	4	B	10	3	100	0	0	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2004	4	C	10	3	100	0	0	0	0	0	0	0
2004	5	A	10	3	100	0	0	0	0	0	0	0
2004	5	B	10	3	100	0	0	0	0	0	0	0
2004	5	C	10	3	100	0	0	0	0	0	0	0
2004	6	A	10	3	100	0	0	0	0	0	0	0
2004	6	B	10	3	100	0	0	0	0	0	0	0
2004	6	C	10	3	100	0	0	0	0	0	0	0
2004	7	A	10	3	100	0	0	0	0	0	0	0
2004	7	B	10	3	100	0	0	0	0	0	0	0
2004	7	C	10	3	100	0	0	0	0	0	0	0
2004	8	A	10	3	100	0	0	0	0	0	0	0
2004	8	B	10	3	100	0	0	0	0	0	0	0
2004	8	C	10	3	100	0	0	0	0	0	0	0
2004	9	A	10	3	100	0	0	0	0	0	0	0
2004	9	B	10	3	100	0	0	0	0	0	0	0
2004	9	C	10	3	100	0	0	0	0	0	0	0
2004	0	A	10	6	100	0	0	0	0	0	0	0
2004	0	B	10	6	100	0	0	0	0	0	0	0
2004	0	C	10	6	100	0	0	0	0	0	0	0
2004	1	A	10	6	100	0	0	0	0	0	0	0
2004	1	B	10	6	100	0	0	0	0	0	0	0
2004	1	C	10	6	100	0	0	0	0	0	0	0
2004	2	A	10	6	100	0	0	0	0	0	0	0
2004	2	B	10	6	100	0	0	0	0	0	0	0
2004	2	C	10	6	100	0	0	0	0	0	0	0
2004	3	A	10	6	100	0	0	0	0	0	0	0
2004	3	B	10	6	100	0	0	0	0	0	0	0
2004	3	C	10	6	100	0	0	0	0	0	0	0
2004	4	A	10	6	100	0	0	0	0	0	0	0
2004	4	B	10	6	100	0	0	0	0	0	0	0
2004	4	C	10	6	100	0	0	0	0	0	0	0
2004	5	A	10	6	100	0	0	0	0	0	0	0
2004	5	B	10	6	100	0	0	0	0	0	0	0
2004	5	C	10	6	100	0	0	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2004	6	A	10	6	100	0	0	0	0	0	0	0
2004	6	B	10	6	99	0	1	0	0	0	0	0
2004	6	C	10	6	100	0	0	0	0	0	0	0
2004	7	A	10	6	100	0	0	0	0	0	0	0
2004	7	B	10	6	100	0	0	0	0	0	0	0
2004	7	C	10	6	100	0	0	0	0	0	0	0
2004	8	A	10	6	100	0	0	0	0	0	0	0
2004	8	B	10	6	95	0	5	0	0	0	0	0
2004	8	C	10	6	100	0	0	0	0	0	0	0
2004	9	A	10	6	100	0	0	0	0	0	0	0
2004	9	B	10	6	100	0	0	0	0	0	0	0
2004	9	C	10	6	100	0	0	0	0	0	0	0
2004	0	A	10	9	100	0	0	0	0	0	0	0
2004	0	B	10	9	100	0	0	0	0	0	0	0
2004	0	C	10	9	100	0	0	0	0	0	0	0
2004	1	A	10	9	100	0	0	0	0	0	0	0
2004	1	B	10	9	100	0	0	0	0	0	0	0
2004	1	C	10	9	100	0	0	0	0	0	0	0
2004	2	A	10	9	100	0	0	0	0	0	0	0
2004	2	B	10	9	100	0	0	0	0	0	0	0
2004	2	C	10	9	100	0	0	0	0	0	0	0
2004	3	A	10	9	100	0	0	0	0	0	0	0
2004	3	B	10	9	100	0	0	0	0	0	0	0
2004	3	C	10	9	100	0	0	0	0	0	0	0
2004	4	A	10	9	100	0	0	0	0	0	0	0
2004	4	B	10	9	100	0	0	0	0	0	0	0
2004	4	C	10	9	100	0	0	0	0	0	0	0
2004	5	A	10	9	100	0	0	0	0	0	0	0
2004	5	B	10	9	100	0	0	0	0	0	0	0
2004	5	C	10	9	100	0	0	0	0	0	0	0
2004	6	A	10	9	100	0	0	0	0	0	0	0
2004	6	B	10	9	100	0	0	0	0	0	0	0
2004	6	C	10	9	100	0	0	0	0	0	0	0
2004	7	A	10	9	100	0	0	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2004	7	B	10	9	100	0	0	0	0	0	0	0
2004	7	C	10	9	100	0	0	0	0	0	0	0
2004	8	A	10	9	100	0	0	0	0	0	0	0
2004	8	B	10	9	100	0	0	0	0	0	0	0
2004	8	C	10	9	100	0	0	0	0	0	0	0
2004	9	A	10	9	100	0	0	0	0	0	0	0
2004	9	B	10	9	100	0	0	0	0	0	0	0
2004	9	C	10	9	100	0	0	0	0	0	0	0
2004	0	A	10	12	100	0	0	0	0	0	0	0
2004	0	B	10	12	100	0	0	0	0	0	0	0
2004	0	C	10	12	100	0	0	0	0	0	0	0
2004	1	A	10	12	100	0	0	0	0	0	0	0
2004	1	B	10	12	100	0	0	0	0	0	0	0
2004	1	C	10	12	100	0	0	0	0	0	0	0
2004	2	A	10	12	100	0	0	0	0	0	0	0
2004	2	B	10	12	100	0	0	0	0	0	0	0
2004	2	C	10	12	100	0	0	0	0	0	0	0
2004	3	A	10	12	100	0	0	0	0	0	0	0
2004	3	B	10	12	100	0	0	0	0	0	0	0
2004	3	C	10	12	100	0	0	0	0	0	0	0
2004	4	A	10	12	50	0	0	50	0	0	0	0
2004	4	B	10	12	100	0	0	0	0	0	0	0
2004	4	C	10	12	100	0	0	0	0	0	0	0
2004	5	A	10	12	75	0	0	25	0	0	0	0
2004	5	B	10	12	95	0	0	5	0	0	0	0
2004	5	C	10	12	100	0	0	0	0	0	0	0
2004	6	A	10	12	100	0	0	0	0	0	0	0
2004	6	B	10	12	30	0	0	70	0	0	0	0
2004	6	C	10	12	100	0	0	0	0	0	0	0
2004	7	A	10	12	100	0	0	0	0	0	0	0
2004	7	B	10	12	100	0	0	0	0	0	0	0
2004	7	C	10	12	100	0	0	0	0	0	0	0
2004	8	A	10	12	25	0	0	75	0	0	0	0
2004	8	B	10	12	100	0	0	0	0	0	0	0

Appendix B, Table 4.4. (cont.) Kingman X10 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	LudwigP	PolygP	Bidens
2004	8	C	10	12	100	0	0	0	0	0	0	0
2004	9	A	10	12	70	0	0	30	0	0	0	0
2004	9	B	10	12	100	0	0	0	0	0	0	0
2004	9	C	10	12	100	0	0	0	0	0	0	0

Appendix B, Table 4.5. Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2001	0	A	20	3	0	0	90	0	10	0	0	0	0	0	0	0
2001	0	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	0	C	20	3	50	20	0	0	30	0	0	0	0	0	0	0
2001	1	A	20	3	0	0	70	0	30	0	0	0	0	0	0	0
2001	1	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	1	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	2	A	20	3	0	10	20	0	70	0	0	0	0	0	0	0
2001	2	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	2	C	20	3	60	0	0	0	40	0	0	0	0	0	0	0
2001	3	A	20	3	0	20	40	0	40	0	0	0	0	0	0	0
2001	3	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	3	C	20	3	30	70	0	0	0	0	0	0	0	0	0	0
2001	4	A	20	3	0	30	50	0	20	0	0	0	0	0	0	0
2001	4	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	4	C	20	3	20	80	0	0	0	0	0	0	0	0	0	0
2001	5	A	20	3	0	10	40	0	50	0	0	0	0	0	0	0
2001	5	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	5	C	20	3	20	80	0	0	0	0	0	0	0	0	0	0
2001	6	A	20	3	0	70	10	0	70	0	0	0	0	0	0	0
2001	6	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	6	C	20	3	0	100	0	0	20	0	0	0	0	0	0	0
2001	7	A	20	3	0	90	20	0	20	0	0	0	0	0	0	0
2001	7	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	7	C	20	3	0	60	0	0	70	0	0	0	0	0	0	0
2001	8	A	20	3	89	10	1	0	0	0	0	0	0	0	0	0
2001	8	B	20	3	30	70	0	0	0	0	0	0	0	0	0	0
2001	8	C	20	3	0	40	20	0	50	0	0	0	0	0	0	0
2001	9	A	20	3	0	10	20	0	1	0	0	1	0	0	0	0
2001	9	B	20	3	70	30	0	0	1	0	0	0	0	0	0	0
2001	9	C	20	3	50	20	20	0	10	0	0	0	0	0	0	0
2001	10	A	20	3	0	30	70	0	20	0	0	0	0	0	0	0
2001	10	B	20	3	50	50	0	0	0	0	0	0	0	0	0	0
2001	10	C	20	3	60	40	0	0	0	0	0	0	0	0	0	0
2001	11	A	20	3	0	10	40	0	60	0	0	0	0	0	0	0
2001	11	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	11	C	20	3	10	90	0	0	0	0	0	0	0	0	0	0
2001	12	A	20	3	30	40	10	0	10	0	0	0	0	0	0	0
2001	12	B	20	3	70	0	30	0	0	0	0	0	0	0	0	0
2001	12	C	20	3	10	90	0	0	0	0	10	0	0	0	0	0
2001	13	A	20	3	40	40	0	20	0	0	0	0	0	0	0	0
2001	13	B	20	3	90	0	10	0	0	0	0	0	0	0	0	0
2001	13	C	20	3	10	90	0	0	0	0	0	0	0	0	0	0
2001	14	A	20	3	50	0	0	50	0	0	0	0	0	0	0	0
2001	14	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	14	C	20	3	0	100	0	0	0	0	0	0	0	0	0	0
2001	15	A	20	3	70	0	0	30	0	0	0	0	0	0	0	0
2001	15	B	20	3	70	0	0	0	30	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2001	15	C	20	3	20	80	0	0	0	0	0	0	0	0	0	0
2001	16	A	20	3	90	0	0	10	0	0	0	0	0	0	0	0
2001	16	B	20	3	70	0	0	0	30	0	0	0	0	0	0	0
2001	16	C	20	3	80	20	0	0	0	0	0	0	0	0	0	0
2001	17	A	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	17	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	17	C	20	3	70	20	0	0	10	0	0	0	0	0	0	0
2001	18	A	20	3	100	0	0	1	0	0	0	0	0	0	0	0
2001	18	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2001	18	C	20	3	20	80	0	0	10	0	0	0	0	0	0	0
2001	19	A	20	3	90	0	0	10	0	0	0	0	0	0	0	0
2001	19	B	20	3	40	60	0	0	0	0	0	0	0	0	0	0
2001	19	C	20	3	60	40	0	0	0	0	0	0	0	0	0	0
2001	0	A	20	6	0	70	20	0	0	1	0	0	10	0	0	0
2001	0	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	0	C	20	6	80	20	0	0	0	0	0	0	0	0	0	0
2001	1	A	20	6	0	10	30	0	0	50	0	0	20	0	0	0
2001	1	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	1	C	20	6	80	20	0	0	0	0	0	0	0	0	0	0
2001	2	A	20	6	0	60	40	0	1	0	0	0	0	0	0	0
2001	2	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	2	C	20	6	60	40	0	0	0	0	0	0	0	0	0	0
2001	3	A	20	6	0	60	40	0	0	0	0	0	0	0	0	0
2001	3	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	3	C	20	6	0	90	0	0	10	0	0	0	0	0	0	0
2001	4	A	20	6	0	20	70	0	10	0	0	0	0	0	0	0
2001	4	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	4	C	20	6	0	90	0	0	10	0	0	0	0	0	0	0
2001	5	A	20	6	0	40	90	0	10	0	0	0	0	20	0	0
2001	5	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	5	C	20	6	70	20	0	0	10	0	0	0	0	0	0	0
2001	6	A	20	6	0	20	60	0	10	0	0	0	0	10	0	0
2001	6	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	6	C	20	6	0	80	0	0	30	0	0	0	0	0	0	0
2001	7	A	20	6	0	70	30	0	20	0	0	0	0	0	0	0
2001	7	B	20	6	90	10	0	0	0	0	0	0	0	0	0	0
2001	7	C	20	6	0	100	0	0	10	0	0	0	0	0	0	0
2001	8	A	20	6	0	100	0	0	0	0	0	0	0	0	0	0
2001	8	B	20	6	60	40	0	0	0	0	0	0	0	0	0	0
2001	8	C	20	6	0	90	0	0	20	0	0	0	0	0	0	0
2001	9	A	20	6	70	30	0	0	0	0	0	0	0	0	0	0
2001	9	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	9	C	20	6	10	90	0	0	0	0	0	0	0	0	0	0
2001	10	A	20	6	20	80	0	0	0	0	0	0	0	0	0	0
2001	10	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	10	C	20	6	50	0	0	0	40	0	0	0	0	20	0	0
2001	11	A	20	6	90	10	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2001	11	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	11	C	20	6	80	20	0	0	0	0	0	0	0	0	0	0
2001	12	A	20	6	60	40	0	0	0	0	0	0	0	0	0	0
2001	12	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	12	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	13	A	20	6	70	30	1	0	0	0	0	0	0	0	0	0
2001	13	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	13	C	20	6	50	20	40	0	0	0	0	0	0	0	0	0
2001	14	A	20	6	30	70	0	0	0	0	0	0	0	0	0	0
2001	14	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	14	C	20	6	70	20	10	0	0	0	0	0	0	0	0	0
2001	15	A	20	6	100	0	1	0	0	0	0	0	0	0	1	0
2001	15	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	15	C	20	6	90	10	0	0	0	0	0	0	0	0	0	0
2001	16	A	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	16	B	20	6	90	10	0	0	0	0	0	0	0	0	0	0
2001	16	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	17	A	20	6	30	70	0	0	0	0	0	0	0	0	0	0
2001	17	B	20	6	30	70	0	0	0	0	0	0	0	0	0	0
2001	17	C	20	6	50	50	0	0	10	0	0	0	0	0	0	0
2001	18	A	20	6	70	30	0	0	0	0	0	0	0	0	0	0
2001	18	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	18	C	20	6	30	60	0	0	10	0	0	0	0	0	0	0
2001	19	A	20	6	10	80	0	0	10	0	0	0	0	0	0	0
2001	19	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2001	19	C	20	6	90	10	0	0	0	0	0	0	0	0	0	0
2001	0	A	20	9	0	100	30	0	20	0	0	0	0	0	0	0
2001	0	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	0	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	1	A	20	9	0	90	10	0	10	0	0	0	0	0	0	0
2001	1	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	1	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	2	A	20	9	0	100	20	0	20	0	0	0	0	0	0	0
2001	2	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	2	C	20	9	80	20	0	0	0	0	0	0	0	0	0	0
2001	3	A	20	9	0	100	10	0	10	0	0	0	0	0	0	0
2001	3	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	3	C	20	9	0	100	0	0	20	0	0	0	0	0	0	0
2001	4	A	20	9	0	100	10	0	0	0	0	0	0	0	0	0
2001	4	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	4	C	20	9	0	100	0	0	0	0	0	0	0	0	0	0
2001	5	A	20	9	0	100	20	0	0	0	0	0	0	0	0	0
2001	5	B	20	9	40	60	0	0	0	0	0	0	0	0	0	0
2001	5	C	20	9	0	100	0	0	0	0	0	0	0	0	0	0
2001	6	A	20	9	0	90	0	0	10	0	0	0	0	0	0	0
2001	6	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	6	C	20	9	20	50	30	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2001	7	A	20	9	0	100	0	0	0	0	0	0	0	0	0	0
2001	7	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	7	C	20	9	0	30	20	0	50	0	0	0	0	0	0	0
2001	8	A	20	9	0	100	0	0	0	0	0	0	0	0	0	0
2001	8	B	20	9	100	1	0	0	1	0	0	0	0	0	0	0
2001	8	C	20	9	0	10	70	0	30	0	0	0	0	0	0	0
2001	9	A	20	9	0	100	0	0	0	0	0	0	0	0	0	0
2001	9	B	20	9	0	0	0	0	100	0	0	0	0	0	0	0
2001	9	C	20	9	0	10	70	0	30	0	0	0	0	0	0	0
2001	10	A	20	9	0	100	0	0	0	0	0	0	0	0	0	0
2001	10	B	20	9	30	20	0	0	40	0	10	0	0	0	0	0
2001	10	C	20	9	0	70	10	0	20	0	0	0	0	0	0	0
2001	11	A	20	9	20	10	70	0	0	0	0	0	0	0	0	0
2001	11	B	20	9	50	50	0	0	0	0	0	0	0	0	0	0
2001	11	C	20	9	40	30	10	0	30	0	0	0	0	0	0	0
2001	12	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2001	12	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	12	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	13	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2001	13	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	13	C	20	9	20	0	10	0	10	0	0	0	0	0	0	0
2001	14	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2001	14	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	14	C	20	9	0	10	10	0	90	0	0	0	0	0	0	0
2001	15	A	20	9	0	50	50	0	0	0	0	0	0	0	0	0
2001	15	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	15	C	20	9	30	0	0	0	70	0	0	0	0	0	0	0
2001	16	A	20	9	0	100	0	0	0	0	0	0	0	0	0	0
2001	16	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	16	C	20	9	80	0	0	0	20	0	0	0	0	0	0	0
2001	17	A	20	9	0	100	0	0	0	0	0	0	0	0	0	0
2001	17	B	20	9	60	40	0	0	0	0	0	0	0	0	0	0
2001	17	C	20	9	20	60	0	0	20	0	0	0	0	0	0	0
2001	18	A	20	9	0	80	50	0	0	0	0	0	0	0	0	0
2001	18	B	20	9	90	10	0	0	0	0	0	0	0	0	0	0
2001	18	C	20	9	50	50	0	0	10	0	0	0	0	0	0	0
2001	19	A	20	9	0	80	20	100	0	0	0	0	0	0	0	0
2001	19	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	19	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2001	0	A	20	12	10	90	0	0	0	0	0	0	0	0	0	0
2001	0	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2001	0	C	20	12	30	70	0	0	0	0	0	0	0	0	0	0
2001	1	A	20	12	10	90	0	0	0	0	0	0	0	0	0	0
2001	1	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2001	1	C	20	12	90	10	0	0	0	0	0	0	0	0	0	0
2001	2	A	20	12	0	100	0	0	0	0	0	0	0	0	0	0
2001	2	B	20	12	10	60	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2001	2	C	20	12	70	20	0	0	10	0	0	0	0	0	0	0
2001	3	A	20	12	0	100	0	0	1	0	0	0	0	0	0	0
2001	3	B	20	12	70	30	0	0	0	0	0	0	0	0	0	0
2001	3	C	20	12	0	100	0	0	10	0	0	0	0	0	0	0
2001	4	A	20	12	70	0	0	30	0	0	0	0	0	0	0	0
2001	4	B	20	12	90	10	0	0	0	0	0	0	0	0	0	0
2001	4	C	20	12	0	100	0	0	0	0	0	0	0	0	0	0
2001	5	A	20	12	0	100	0	0	0	0	0	0	0	0	0	0
2001	5	B	20	12	60	40	10	0	0	0	0	0	0	0	0	0
2001	5	C	20	12	10	50	40	0	0	0	10	0	0	0	0	0
2001	6	A	20	12	0	100	0	0	0	0	0	0	0	0	0	0
2001	6	B	20	12	0	100	30	0	0	0	0	0	0	0	0	0
2001	6	C	20	12	0	80	0	0	20	0	0	0	0	0	0	0
2001	7	A	20	12	0	100	0	0	0	0	0	0	0	0	0	0
2001	7	B	20	12	50	20	40	0	0	0	1	0	0	0	0	0
2001	7	C	20	12	0	20	70	0	30	0	0	0	0	0	0	0
2001	8	A	20	12	10	90	0	0	0	0	0	0	0	0	0	0
2001	8	B	20	12	0	100	0	0	0	0	0	0	0	0	0	0
2001	8	C	20	12	20	30	20	0	30	0	0	0	0	0	0	0
2001	9	A	20	12	60	40	0	0	0	0	0	0	0	0	0	0
2001	9	B	20	12	0	50	0	0	50	0	0	0	0	0	0	0
2001	9	C	20	12	40	20	0	0	40	0	0	0	0	0	0	0
2001	10	A	20	12	0	100	0	0	0	0	0	0	0	0	0	0
2001	10	B	20	12	20	80	0	0	40	0	0	0	0	0	0	0
2001	10	C	20	12	0	20	70	0	30	0	0	0	0	0	0	0
2001	11	A	20	12	20	30	50	0	1	0	0	0	0	0	0	0
2001	11	B	20	12	20	80	0	0	0	0	0	0	0	0	0	0
2001	11	C	20	12	0	20	70	0	30	0	0	0	0	0	0	0
2001	12	A	20	12	0	100	10	0	0	0	0	0	0	0	0	0
2001	12	B	20	12	0	80	0	0	20	0	0	0	0	0	0	0
2001	12	C	20	12	40	30	30	0	0	0	0	0	0	0	0	0
2001	13	A	20	12	0	100	10	0	0	0	0	0	0	0	0	0
2001	13	B	20	12	0	40	0	0	50	0	10	0	0	0	0	0
2001	13	C	20	12	20	0	60	0	30	0	0	0	0	0	0	0
2001	14	A	20	12	0	100	20	0	0	0	0	0	0	0	0	0
2001	14	B	20	12	70	20	0	0	0	0	10	0	0	0	0	0
2001	14	C	20	12	0	0	10	0	100	0	0	0	0	0	0	0
2001	15	A	20	12	0	20	0	0	0	80	0	0	0	0	0	0
2001	15	B	20	12	0	60	0	0	50	0	10	0	0	0	0	0
2001	15	C	20	12	0	50	0	0	50	0	0	0	0	0	0	0
2001	16	A	20	12	0	80	0	0	0	20	0	0	0	0	0	0
2001	16	B	20	12	0	20	0	0	90	0	0	0	0	0	0	0
2001	16	C	20	12	10	90	0	0	0	0	0	0	0	0	0	0
2001	17	A	20	12	0	100	20	0	0	10	10	0	0	0	0	0
2001	17	B	20	12	0	50	0	0	50	0	0	0	0	0	0	0
2001	17	C	20	12	40	60	0	0	0	0	0	0	0	0	0	0
2001	18	A	20	12	0	100	20	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2001	18	B	20	12	0	30	0	0	90	0	0	0	0	0	0	0
2001	18	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2001	19	A	20	12	50	20	20	0	0	10	0	0	0	0	0	0
2001	19	B	20	12	20	40	0	0	40	0	0	0	0	0	0	0
2001	19	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2002	0	A	20	3	10	0	70	0	10	0	0	0	10	0	0	0
2002	0	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2002	0	C	20	3	0	70	0	0	0	30	0	0	0	0	0	0
2002	1	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2002	1	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2002	1	C	20	3	10	30	0	0	0	60	0	0	0	0	0	0
2002	2	A	20	3	70	0	30	0	0	0	0	0	0	0	0	0
2002	2	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2002	2	C	20	3	5	0	0	0	0	95	0	0	0	0	0	0
2002	3	A	20	3	40	0	60	0	0	0	0	0	0	0	0	0
2002	3	B	20	3	70	0	0	0	0	30	0	0	0	0	0	0
2002	3	C	20	3	0	50	0	0	0	50	0	0	0	0	0	0
2002	4	A	20	3	10	0	90	0	0	0	0	0	0	0	0	0
2002	4	B	20	3	0	0	0	0	0	100	0	0	0	0	0	0
2002	4	C	20	3	10	70	0	0	15	5	0	0	0	0	0	0
2002	5	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2002	5	B	20	3	0	0	0	0	0	100	0	0	0	0	0	0
2002	5	C	20	3	50	50	0	0	0	0	0	0	0	0	0	0
2002	6	A	20	3	0	0	95	0	5	0	0	0	0	0	0	0
2002	6	B	20	3	0	0	0	0	0	100	0	0	0	0	0	0
2002	6	C	20	3	30	70	0	0	0	0	0	0	0	0	0	0
2002	7	A	20	3	35	5	60	0	0	0	0	0	0	0	0	0
2002	7	B	20	3	0	30	75	0	0	0	0	0	0	0	0	0
2002	7	C	20	3	40	50	0	0	10	0	0	0	0	0	0	0
2002	8	A	20	3	20	0	30	50	0	0	0	0	0	0	0	0
2002	8	B	20	3	0	20	30	0	0	60	0	0	0	0	0	0
2002	8	C	20	3	60	40	0	0	0	0	0	0	0	0	0	0
2002	9	A	20	3	25	0	5	70	0	0	0	0	0	0	0	0
2002	9	B	20	3	0	0	95	0	5	10	0	0	0	0	0	0
2002	9	C	20	3	80	20	0	0	0	0	0	0	0	0	0	0
2002	10	A	20	3	70	0	20	10	0	0	0	0	0	0	0	0
2002	10	B	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2002	10	C	20	3	20	80	0	0	0	0	0	0	0	0	0	0
2002	11	A	20	3	30	0	10	60	0	0	0	0	0	0	0	0
2002	11	B	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2002	11	C	20	3	20	80	0	0	0	0	0	0	0	0	0	0
2002	12	A	20	3	80	0	20	0	0	0	0	0	0	0	0	0
2002	12	B	20	3	10	0	90	0	0	0	0	0	0	0	0	0
2002	12	C	20	3	50	50	0	0	0	0	0	0	0	0	0	0
2002	13	A	20	3	50	0	50	0	0	0	0	0	0	0	0	0
2002	13	B	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2002	13	C	20	3	40	60	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2002	14	A	20	3	30	0	10	60	0	0	0	0	0	0	0	0
2002	14	B	20	3	10	0	90	0	0	0	0	0	0	0	0	0
2002	14	C	20	3	30	70	0	0	0	0	0	0	0	0	0	0
2002	15	A	20	3	5	0	0	95	0	0	0	0	0	0	0	0
2002	15	B	20	3	10	0	50	0	0	40	0	0	0	0	0	0
2002	15	C	20	3	20	80	0	0	0	0	0	0	0	0	0	0
2002	16	A	20	3	300	10	60	0	0	0	0	0	0	0	0	0
2002	16	B	20	3	0	0	10	0	0	90	0	0	0	0	0	0
2002	16	C	20	3	20	80	0	0	0	0	0	0	0	0	0	0
2002	17	A	20	3	85	0	15	0	0	0	0	0	0	0	0	0
2002	17	B	20	3	0	0	0	0	0	100	0	0	0	0	0	0
2002	17	C	20	3	50	50	0	0	0	0	0	0	0	0	0	0
2002	18	A	20	3	75	0	20	0	0	5	0	0	0	0	0	0
2002	18	B	20	3	20	0	0	0	0	80	0	0	0	0	0	0
2002	18	C	20	3	0	95	0	0	5	0	0	0	0	0	0	0
2002	19	A	20	3	50	0	40	0	10	0	0	0	0	0	0	0
2002	19	B	20	3	10	0	0	0	0	90	0	0	0	0	0	0
2002	19	C	20	3	5	95	0	0	0	0	0	0	0	0	0	0
2002	0	A	20	6	0	0	70	0	0	0	0	0	30	0	0	0
2002	0	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2002	0	C	20	6	60	40	0	0	0	0	0	0	0	0	0	0
2002	1	A	20	6	0	0	85	0	0	0	0	0	15	0	0	0
2002	1	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2002	1	C	20	6	20	80	0	0	0	0	0	0	0	0	0	0
2002	2	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2002	2	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2002	2	C	20	6	70	30	0	0	0	0	0	0	0	0	0	0
2002	3	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2002	3	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2002	3	C	20	6	50	50	0	0	0	0	0	0	0	0	0	0
2002	4	A	20	6	0	0	95	0	0	0	0	0	0	0	5	0
2002	4	B	20	6	40	0	0	0	0	60	0	0	0	0	0	0
2002	4	C	20	6	0	70	0	0	20	0	0	0	0	0	0	0
2002	5	A	20	6	0	0	95	0	0	0	0	0	0	0	5	0
2002	5	B	20	6	0	0	0	0	0	100	0	0	0	0	0	0
2002	5	C	20	6	30	70	0	0	0	0	0	0	0	0	0	0
2002	6	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2002	6	B	20	6	0	0	0	0	0	100	0	0	0	0	0	0
2002	6	C	20	6	40	60	0	0	0	0	0	0	0	0	0	0
2002	7	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2002	7	B	20	6	0	5	0	0	0	95	0	0	0	0	0	0
2002	7	C	20	6	60	40	0	0	0	0	0	0	0	0	0	0
2002	8	A	20	6	30	0	70	0	0	0	0	0	0	0	0	0
2002	8	B	20	6	0	30	0	0	0	70	0	0	0	0	0	0
2002	8	C	20	6	10	90	0	0	0	0	0	0	0	0	0	0
2002	9	A	20	6	50	0	50	0	0	0	0	0	0	0	0	0
2002	9	B	20	6	0	25	0	0	0	75	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2002	9	C	20	6	10	90	0	0	0	0	0	0	0	0	0	0
2002	10	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2002	10	B	20	6	0	0	10	0	0	90	0	0	0	0	0	0
2002	10	C	20	6	90	10	0	0	0	0	0	0	0	0	0	0
2002	11	A	20	6	50	0	50	0	0	0	0	0	0	0	0	0
2002	11	B	20	6	0	0	80	0	0	20	0	0	0	0	0	0
2002	11	C	20	6	30	70	0	0	0	0	0	0	0	0	0	0
2002	12	A	20	6	60	0	30	0	0	10	0	0	0	0	0	0
2002	12	B	20	6	20	0	70	0	0	10	0	0	0	0	0	0
2002	12	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2002	13	A	20	6	50	0	50	0	0	0	0	0	0	0	0	0
2002	13	B	20	6	0	0	100	0	0	20	0	0	0	0	0	0
2002	13	C	20	6	40	60	0	0	0	0	0	0	0	0	0	0
2002	14	A	20	6	80	0	20	0	0	0	0	0	0	0	0	0
2002	14	B	20	6	0	0	50	0	0	55	0	0	0	0	0	0
2002	14	C	20	6	50	50	0	0	0	0	0	0	0	0	0	0
2002	15	A	20	6	90	0	10	0	0	0	0	0	0	0	0	0
2002	15	B	20	6	0	0	15	0	0	85	0	0	0	0	0	0
2002	15	C	20	6	70	30	0	0	0	0	0	0	0	0	0	0
2002	16	A	20	6	70	0	30	0	0	0	0	0	0	0	0	0
2002	16	B	20	6	0	40	0	0	0	60	0	0	0	0	0	0
2002	16	C	20	6	50	50	0	0	0	0	0	0	0	0	0	0
2002	17	A	20	6	20	0	80	0	0	0	0	0	0	0	0	0
2002	17	B	20	6	0	10	0	0	0	90	0	0	0	0	0	0
2002	17	C	20	6	10	60	0	0	30	0	0	0	0	0	0	0
2002	18	A	20	6	10	0	50	40	0	0	0	0	0	0	0	0
2002	18	B	20	6	0	25	0	0	0	75	0	0	0	0	0	0
2002	18	C	20	6	40	40	0	0	20	0	0	0	0	0	0	0
2002	19	A	20	6	20	0	30	50	0	0	0	0	0	0	0	0
2002	19	B	20	6	30	0	0	0	0	70	0	0	0	0	0	0
2002	19	C	20	6	0	95	0	0	5	0	0	0	0	0	0	0
2002	0	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2002	0	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2002	0	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2002	1	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2002	1	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2002	1	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2002	2	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2002	2	B	20	9	70	0	20	0	0	10	0	0	0	0	0	0
2002	2	C	20	9	90	10	0	0	0	0	0	0	0	0	0	0
2002	3	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2002	3	B	20	9	50	0	50	0	0	0	0	0	0	0	0	0
2002	3	C	20	9	10	70	0	0	10	0	0	0	0	10	0	0
2002	4	A	20	9	50	0	40	0	10	0	0	0	0	0	0	0
2002	4	B	20	9	50	0	50	0	0	0	0	0	0	0	0	0
2002	4	C	20	9	10	90	0	0	0	0	0	0	0	0	0	0
2002	5	A	20	9	10	0	90	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2002	5	B	20	9	30	0	70	0	0	0	0	0	0	0	0	0
2002	5	C	20	9	10	50	40	0	0	0	0	0	0	0	0	0
2002	6	A	20	9	20	0	80	0	0	0	0	0	0	0	0	0
2002	6	B	20	9	30	0	70	0	0	0	0	0	0	0	0	0
2002	6	C	20	9	30	70	0	0	0	0	0	0	0	0	0	0
2002	7	A	20	9	20	0	70	0	0	0	0	0	0	0	0	10
2002	7	B	20	9	40	0	60	0	0	0	0	0	0	0	0	0
2002	7	C	20	9	50	50	0	0	0	0	0	0	0	0	0	0
2002	8	A	20	9	10	0	80	0	10	0	0	0	0	0	0	0
2002	8	B	20	9	45	5	50	0	0	0	0	0	0	0	0	0
2002	8	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2002	9	A	20	9	5	0	95	0	0	0	0	0	0	0	0	0
2002	9	B	20	9	45	15	40	0	5	0	0	0	0	0	0	0
2002	9	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2002	10	A	20	9	70	0	30	0	0	0	0	0	0	0	0	0
2002	10	B	20	9	60	10	30	0	0	0	0	0	0	0	0	0
2002	10	C	20	9	60	40	0	0	0	0	0	0	0	0	0	0
2002	11	A	20	9	75	0	20	0	0	5	0	0	0	0	0	0
2002	11	B	20	9	0	30	20	0	0	5	0	0	0	0	0	0
2002	11	C	20	9	50	50	0	0	0	0	0	0	0	0	0	0
2002	12	A	20	9	45	0	50	0	0	5	0	0	0	0	0	0
2002	12	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2002	12	C	20	9	60	40	0	0	0	0	0	0	0	0	0	0
2002	13	A	20	9	70	0	30	0	0	0	0	0	0	0	0	0
2002	13	B	20	9	45	5	0	0	0	50	0	0	0	0	0	0
2002	13	C	20	9	30	0	0	0	70	0	0	0	0	0	0	0
2002	14	A	20	9	60	0	40	0	0	0	0	0	0	0	0	0
2002	14	B	20	9	0	5	0	0	0	100	0	0	0	0	0	0
2002	14	C	20	9	90	0	0	0	10	0	0	0	0	0	0	0
2002	15	A	20	9	70	0	30	0	0	0	0	0	0	0	0	0
2002	15	B	20	9	0	0	0	0	0	100	0	0	0	0	0	0
2002	15	C	20	9	50	0	0	0	50	0	0	0	0	0	0	0
2002	16	A	20	9	40	0	60	0	0	0	0	0	0	0	0	0
2002	16	B	20	9	0	0	0	0	0	100	0	0	0	0	0	0
2002	16	C	20	9	55	5	0	0	40	0	0	0	0	0	0	0
2002	17	A	20	9	10	0	90	0	0	0	0	0	0	0	0	0
2002	17	B	20	9	0	50	0	0	0	50	0	0	0	0	0	0
2002	17	C	20	9	85	15	0	0	0	0	0	0	0	0	0	0
2002	18	A	20	9	0	0	90	10	0	0	0	0	0	0	0	0
2002	18	B	20	9	0	10	0	0	0	90	0	0	0	0	0	0
2002	18	C	20	9	50	50	0	0	0	0	0	0	0	0	0	0
2002	19	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2002	19	B	20	9	0	0	0	0	0	100	0	0	0	0	0	0
2002	19	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2002	0	A	20	12	0	50	0	0	0	50	0	0	0	0	0	0
2002	0	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2002	0	C	20	12	5	95	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2002	1	A	20	12	0	30	5	0	0	65	0	0	0	0	0	0
2002	1	B	20	12	85	0	15	0	0	0	0	0	0	0	0	0
2002	1	C	20	12	20	80	0	0	0	0	0	0	0	0	0	0
2002	2	A	20	12	0	5	0	0	5	90	0	0	0	0	0	0
2002	2	B	20	12	15	15	70	0	0	0	0	0	0	0	0	0
2002	2	C	20	12	20	75	0	0	5	0	0	0	0	0	0	0
2002	3	A	20	12	0	40	0	0	0	60	0	0	0	0	0	0
2002	3	B	20	12	10	90	0	0	0	0	0	0	0	0	0	0
2002	3	C	20	12	5	90	0	0	0	0	0	0	0	5	0	0
2002	4	A	20	12	20	40	0	0	0	40	0	0	0	0	0	0
2002	4	B	20	12	15	0	85	0	0	0	0	0	0	0	0	0
2002	4	C	20	12	50	40	0	0	5	0	0	0	0	0	0	0
2002	5	A	20	12	15	25	0	0	0	60	0	0	0	0	0	0
2002	5	B	20	12	20	0	80	0	0	0	0	0	0	0	0	0
2002	5	C	20	12	50	50	0	0	0	0	0	0	0	0	0	0
2002	6	A	20	12	0	20	0	0	0	80	0	0	0	0	0	0
2002	6	B	20	12	30	0	70	0	0	0	0	0	0	0	0	0
2002	6	C	20	12	50	50	0	0	0	0	0	0	0	0	0	0
2002	7	A	20	12	0	15	0	0	0	85	0	0	0	0	0	0
2002	7	B	20	12	50	0	50	0	0	0	0	0	0	0	0	0
2002	7	C	20	12	80	20	0	0	0	0	0	0	0	0	0	0
2002	8	A	20	12	5	70	0	0	5	20	0	0	0	0	0	0
2002	8	B	20	12	40	30	30	0	0	0	0	0	0	0	0	0
2002	8	C	20	12	40	60	0	0	0	0	0	0	0	0	0	0
2002	9	A	20	12	0	100	0	0	0	0	0	0	0	0	0	0
2002	9	B	20	12	0	95	10	0	0	0	0	0	0	0	0	0
2002	9	C	20	12	75	25	0	0	0	0	0	0	0	0	0	0
2002	10	A	20	12	0	0	0	0	1	99	0	0	0	0	0	0
2002	10	B	20	12	0	100	0	0	0	0	0	0	0	0	0	0
2002	10	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2002	11	A	20	12	0	0	15	0	5	80	0	0	0	0	0	0
2002	11	B	20	12	70	15	15	0	0	0	0	0	0	0	0	0
2002	11	C	20	12	65	30	0	0	5	0	0	0	0	0	0	0
2002	12	A	20	12	0	0	50	0	0	50	0	0	0	0	0	0
2002	12	B	20	12	40	50	0	0	10	0	0	0	0	0	0	0
2002	12	C	20	12	20	70	0	0	0	0	10	0	0	0	0	0
2002	13	A	20	12	0	0	100	0	0	10	0	0	0	0	0	0
2002	13	B	20	12	25	75	0	0	0	0	0	0	0	0	0	0
2002	13	C	20	12	20	20	0	0	60	0	0	0	0	0	0	0
2002	14	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2002	14	B	20	12	95	5	0	0	0	0	0	0	0	0	0	0
2002	14	C	20	12	0	20	0	0	95	0	0	0	0	0	0	0
2002	15	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2002	15	B	20	12	30	70	0	0	0	0	0	0	0	0	0	0
2002	15	C	20	12	80	20	0	0	0	0	0	0	0	0	0	0
2002	16	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2002	16	B	20	12	60	20	0	0	20	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2002	16	C	20	12	20	80	0	0	0	0	0	0	0	0	0	0
2002	17	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2002	17	B	20	12	50	30	0	0	20	0	0	0	0	0	0	0
2002	17	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2002	18	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2002	18	B	20	12	80	0	0	0	0	20	0	0	0	0	0	0
2002	18	C	20	12	75	20	0	0	5	0	0	0	0	0	0	0
2002	19	A	20	12	0	0	100	0	10	0	0	0	0	0	0	0
2002	19	B	20	12	20	30	0	0	0	50	0	0	0	0	0	0
2002	19	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	0	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	0	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	0	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	1	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	1	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	1	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	2	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	2	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	2	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	3	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	3	B	20	3	85	0	15	0	0	0	0	0	0	0	0	0
2003	3	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	4	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	4	B	20	3	70	0	30	0	0	0	0	0	0	0	0	0
2003	4	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	5	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	5	B	20	3	40	0	60	0	0	0	0	0	0	0	0	0
2003	5	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	6	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	6	B	20	3	25	5	70	0	0	0	0	0	0	0	0	0
2003	6	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	7	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	7	B	20	3	50	0	50	0	0	0	0	0	0	0	0	0
2003	7	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	8	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	8	B	20	3	5	5	90	0	0	0	0	0	0	0	0	0
2003	8	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	9	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	9	B	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	9	C	20	3	80	0	0	0	0	0	0	0	0	0	20	0
2003	10	A	20	3	0	0	60	40	0	0	0	0	0	0	0	0
2003	10	B	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	10	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	11	A	20	3	0	0	10	90	0	0	0	0	0	0	0	0
2003	11	B	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	11	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	12	A	20	3	35	0	60	5	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2003	12	B	20	3	20	0	80	0	0	0	0	0	0	0	0	0
2003	12	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	13	A	20	3	50	0	35	15	0	0	0	0	0	0	0	0
2003	13	B	20	3	20	0	80	0	0	0	0	0	0	0	0	0
2003	13	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	14	A	20	3	20	0	60	20	0	0	0	0	0	0	0	0
2003	14	B	20	3	20	0	80	0	0	0	0	0	0	0	0	0
2003	14	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	15	A	20	3	20	0	50	30	0	0	0	0	0	0	0	0
2003	15	B	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	15	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	16	A	20	3	10	0	20	70	0	0	0	0	0	0	0	0
2003	16	B	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	16	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2003	17	A	20	3	10	0	85	5	0	0	0	0	0	0	0	0
2003	17	B	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2003	17	C	20	3	95	0	0	0	0	0	0	0	0	0	0	0
2003	18	A	20	3	20	0	80	0	0	0	0	0	0	0	0	0
2003	18	B	20	3	5	0	95	0	0	0	0	0	0	0	0	0
2003	18	C	20	3	20	0	0	80	0	0	0	0	0	0	0	0
2003	19	A	20	3	50	0	50	0	0	0	0	0	0	0	0	0
2003	19	B	20	3	60	0	40	0	0	0	0	0	0	0	0	0
2003	19	C	20	3	80	0	0	5	0	0	0	0	0	0	0	0
2003	0	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	0	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	0	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	1	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	1	B	20	6	95	0	5	0	0	0	0	0	0	0	0	0
2003	1	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	2	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	2	B	20	6	60	0	40	0	0	0	0	0	0	0	0	0
2003	2	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	3	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	3	B	20	6	40	0	60	0	0	0	0	0	0	0	0	0
2003	3	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	4	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	4	B	20	6	50	0	50	0	0	0	0	0	0	0	0	0
2003	4	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	5	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	5	B	20	6	70	0	30	0	0	0	0	0	0	0	0	0
2003	5	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	6	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	6	B	20	6	50	0	50	0	0	0	0	0	0	0	0	0
2003	6	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	7	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	7	B	20	6	40	0	60	0	0	0	0	0	0	0	0	0
2003	7	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2003	8	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	8	B	20	6	50	0	50	0	0	0	0	0	0	0	0	0
2003	8	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	9	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	9	B	20	6	10	5	85	0	0	0	0	0	0	0	0	0
2003	9	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	10	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	10	B	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	10	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	11	A	20	6	50	0	50	0	0	0	0	0	0	0	0	0
2003	11	B	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	11	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	12	A	20	6	60	0	40	0	0	0	0	0	0	0	0	0
2003	12	B	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	12	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	13	A	20	6	60	0	40	0	0	0	0	0	0	0	0	0
2003	13	B	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	13	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	14	A	20	6	50	0	50	0	0	0	0	0	0	0	0	0
2003	14	B	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	14	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	15	A	20	6	20	0	80	0	0	0	0	0	0	0	0	0
2003	15	B	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	15	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	16	A	20	6	30	0	70	0	0	0	0	0	0	0	0	0
2003	16	B	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2003	16	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	17	A	20	6	40	0	60	0	0	0	0	0	0	0	0	0
2003	17	B	20	6	5	0	95	0	0	0	0	0	0	0	0	0
2003	17	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	18	A	20	6	10	0	90	0	0	0	0	0	0	0	0	0
2003	18	B	20	6	40	0	60	0	0	0	0	0	0	0	0	0
2003	18	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	19	A	20	6	10	0	90	0	0	0	0	0	0	0	0	0
2003	19	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	19	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2003	0	A	20	9	0	0	90	0	0	0	0	0	10	0	0	0
2003	0	B	20	9	50	0	50	0	0	0	0	0	0	0	0	0
2003	0	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	1	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	1	B	20	9	20	0	80	0	0	0	0	0	0	0	0	0
2003	1	C	20	9	80	0	0	20	0	0	0	0	0	0	0	0
2003	2	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	2	B	20	9	10	0	90	0	0	0	0	0	0	0	0	0
2003	2	C	20	9	80	0	0	20	0	0	0	0	0	0	0	0
2003	3	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	3	B	20	9	30	0	70	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2003	3	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	4	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	4	B	20	9	50	0	50	0	0	0	0	0	0	0	0	0
2003	4	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	5	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	5	B	20	9	70	0	30	0	0	0	0	0	0	0	0	0
2003	5	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	6	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	6	B	20	9	90	0	10	0	0	0	0	0	0	0	0	0
2003	6	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	7	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	7	B	20	9	85	0	15	0	0	0	0	0	0	0	0	0
2003	7	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	8	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	8	B	20	9	75	0	25	0	0	0	0	0	0	0	0	0
2003	8	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	9	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	9	B	20	9	80	0	20	0	0	0	0	0	0	0	0	0
2003	9	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	10	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	10	B	20	9	50	0	50	0	0	0	0	0	0	0	0	0
2003	10	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	11	A	20	9	60	0	40	0	0	0	0	0	0	0	0	0
2003	11	B	20	9	50	0	50	0	0	0	0	0	0	0	0	0
2003	11	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	12	A	20	9	5	0	95	0	0	0	0	0	0	0	0	0
2003	12	B	20	9	50	0	50	0	0	0	0	0	0	0	0	0
2003	12	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	13	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	13	B	20	9	10	20	70	0	0	0	0	0	0	0	0	0
2003	13	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	14	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	14	B	20	9	25	20	55	0	0	0	0	0	0	0	0	0
2003	14	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	15	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	15	B	20	9	80	0	20	0	0	0	0	0	0	0	0	0
2003	15	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	16	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2003	16	B	20	9	95	0	5	0	0	0	0	0	0	0	0	0
2003	16	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	17	A	20	9	10	0	90	0	0	0	0	0	0	0	0	0
2003	17	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	17	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	18	A	20	9	10	0	80	0	0	0	0	0	0	0	0	0
2003	18	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	18	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	19	A	20	9	80	0	20	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2003	19	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2003	19	C	20	9	95	0	0	0	0	5	0	0	0	0	0	0
2003	0	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	0	B	20	12	20	0	80	0	0	0	0	0	0	0	0	0
2003	0	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	1	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	1	B	20	12	10	0	90	0	0	0	0	0	0	0	0	0
2003	1	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	2	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	2	B	20	12	80	0	20	0	0	0	0	0	0	0	0	0
2003	2	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	3	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	3	B	20	12	60	0	40	0	0	0	0	0	0	0	0	0
2003	3	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	4	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	4	B	20	12	80	0	20	0	0	0	0	0	0	0	0	0
2003	4	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	5	A	20	12	40	0	60	0	0	0	0	0	0	0	0	0
2003	5	B	20	12	75	0	25	0	0	0	0	0	0	0	0	0
2003	5	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	6	A	20	12	90	0	10	0	0	0	0	0	0	0	0	0
2003	6	B	20	12	50	0	50	0	0	0	0	0	0	0	0	0
2003	6	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	7	A	20	12	70	30	0	0	0	0	0	0	0	0	0	0
2003	7	B	20	12	40	0	60	0	0	0	0	0	0	0	0	0
2003	7	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	8	A	20	12	0	100	0	0	0	0	0	0	0	0	0	0
2003	8	B	20	12	50	0	50	0	0	0	0	0	0	0	0	0
2003	8	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	9	A	20	12	30	50	20	0	0	0	0	0	0	0	0	0
2003	9	B	20	12	20	50	30	0	0	0	0	0	0	0	0	0
2003	9	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	10	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	10	B	20	12	0	90	10	0	0	0	0	0	0	0	0	0
2003	10	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	11	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	11	B	20	12	5	15	80	0	0	0	0	0	0	0	0	0
2003	11	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	12	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	12	B	20	12	20	60	20	0	0	0	0	0	0	0	0	0
2003	12	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	13	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	13	B	20	12	50	0	50	0	0	0	0	0	0	0	0	0
2003	13	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	14	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	14	B	20	12	95	0	5	0	0	0	0	0	0	0	0	0
2003	14	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2003	15	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	15	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	15	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	16	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	16	B	20	12	80	20	0	0	0	0	0	0	0	0	0	0
2003	16	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	17	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	17	B	20	12	75	25	0	0	0	0	0	0	0	0	0	0
2003	17	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	18	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	18	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	18	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	19	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2003	19	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2003	19	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	0	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2004	0	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	0	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	1	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2004	1	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	1	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	2	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2004	2	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	2	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	3	A	20	3	0	0	0	0	0	0	0	0	0	0	0	0
2004	3	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	3	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	4	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2004	4	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	4	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	5	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2004	5	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	5	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	6	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2004	6	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	6	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	7	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2004	7	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	7	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	8	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2004	8	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	8	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	9	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2004	9	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	9	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	10	A	20	3	0	0	90	10	0	0	0	0	0	0	0	0
2004	10	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2004	10	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	11	A	20	3	0	0	80	20	0	0	0	0	0	0	0	0
2004	11	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	11	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	12	A	20	3	0	0	90	10	0	0	0	0	0	0	0	0
2004	12	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	12	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	13	A	20	3	0	0	20	80	0	0	0	0	0	0	0	0
2004	13	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	13	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	14	A	20	3	0	0	10	90	0	0	0	0	0	0	0	0
2004	14	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	14	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	15	A	20	3	0	0	5	90	0	0	0	0	0	0	0	0
2004	15	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	15	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	16	A	20	3	0	0	30	70	0	0	0	0	0	0	0	0
2004	16	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	16	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	17	A	20	3	30	0	70	0	0	0	0	0	0	0	0	0
2004	17	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	17	C	20	3	95	0	0	5	0	0	0	0	0	0	0	0
2004	18	A	20	3	0	0	100	0	0	0	0	0	0	0	0	0
2004	18	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	18	C	20	3	20	0	0	80	0	0	0	0	0	0	0	0
2004	19	A	20	3	10	0	90	0	0	0	0	0	0	0	0	0
2004	19	B	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	19	C	20	3	100	0	0	0	0	0	0	0	0	0	0	0
2004	0	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2004	0	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	0	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	1	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2004	1	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	1	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	2	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2004	2	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	2	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	3	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2004	3	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	3	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	4	A	20	6	20	0	80	0	0	0	0	0	0	0	0	0
2004	4	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	4	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	5	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2004	5	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	5	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	6	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2004	6	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	6	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	7	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2004	7	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	7	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	8	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2004	8	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	8	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	9	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2004	9	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	9	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	10	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2004	10	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	10	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	11	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2004	11	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	11	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	12	A	20	6	0	0	100	0	0	0	0	0	0	0	0	0
2004	12	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	12	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	13	A	20	6	10	0	90	0	0	0	0	0	0	0	0	0
2004	13	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	13	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	14	A	20	6	80	0	20	0	0	0	0	0	0	0	0	0
2004	14	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	14	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	15	A	20	6	20	0	80	0	0	0	0	0	0	0	0	0
2004	15	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	15	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	16	A	20	6	0	0	90	10	0	0	0	0	0	0	0	0
2004	16	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	16	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	17	A	20	6	0	0	50	50	0	0	0	0	0	0	0	0
2004	17	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	17	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	18	A	20	6	0	0	50	50	0	0	0	0	0	0	0	0
2004	18	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	18	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	19	A	20	6	0	0	20	80	0	0	0	0	0	0	0	0
2004	19	B	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	19	C	20	6	100	0	0	0	0	0	0	0	0	0	0	0
2004	0	A	20	9	10	0	90	0	0	0	0	0	0	0	0	0
2004	0	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	0	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	1	A	20	9	40	0	60	0	0	0	0	0	0	0	0	0
2004	1	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	1	C	20	9	95	0	0	5	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2004	2	A	20	9	20	0	80	0	0	0	0	0	0	0	0	0
2004	2	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	2	C	20	9	50	0	0	50	0	0	0	0	0	0	0	0
2004	3	A	20	9	70	0	30	0	0	0	0	0	0	0	0	0
2004	3	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	3	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	4	A	20	9	50	0	50	0	0	0	0	0	0	0	0	0
2004	4	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	4	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	5	A	20	9	20	0	80	0	0	0	0	0	0	0	0	0
2004	5	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	5	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	6	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2004	6	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	6	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	7	A	20	9	10	0	90	0	0	0	0	0	0	0	0	0
2004	7	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	7	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	8	A	20	9	20	0	80	0	0	0	0	0	0	0	0	0
2004	8	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	8	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	9	A	20	9	10	0	90	0	0	0	0	0	0	0	0	0
2004	9	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	9	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	10	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2004	10	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	10	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	11	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2004	11	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	11	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	12	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2004	12	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	12	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	13	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2004	13	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	13	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	14	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2004	14	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	14	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	15	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2004	15	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	15	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	16	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2004	16	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	16	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	17	A	20	9	0	0	100	0	0	0	0	0	0	0	0	0
2004	17	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2004	17	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	18	A	20	9	0	0	80	20	0	0	0	0	0	0	0	0
2004	18	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	18	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	19	A	20	9	10	0	90	0	0	0	0	0	0	0	0	0
2004	19	B	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	19	C	20	9	100	0	0	0	0	0	0	0	0	0	0	0
2004	0	A	20	12	0	0	99	0	0	0	0	0	1	0	0	0
2004	0	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	0	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	1	A	20	12	5	0	95	0	0	0	0	0	0	0	0	0
2004	1	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	1	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	2	A	20	12	5	0	95	0	0	0	0	0	0	0	0	0
2004	2	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	2	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	3	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2004	3	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	3	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	4	A	20	12	70	0	30	0	0	0	0	0	0	0	0	0
2004	4	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	4	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	5	A	20	12	90	0	10	0	0	0	0	0	0	0	0	0
2004	5	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	5	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	6	A	20	12	20	0	80	0	0	0	0	0	0	0	0	0
2004	6	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	6	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	7	A	20	12	20	0	80	0	0	0	0	0	0	0	0	0
2004	7	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	7	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	8	A	20	12	10	5	85	0	0	0	0	0	0	0	0	0
2004	8	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	8	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	9	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2004	9	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	9	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	10	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2004	10	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	10	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	11	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2004	11	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	11	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	12	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2004	12	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	12	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	13	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.5. (cont.) Kingman X20 Exclosure Species % Cover Between Meter Locations Along Transect Lines

Year	At (m)	Rep	Size	Transect	Mud	Pont	Sag	Pelt	Echin	Ludwig	Polyg	Potom	Tlata	Biden	Lyth	Leers
2004	13	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	13	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	14	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2004	14	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	14	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	15	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2004	15	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	15	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	16	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2004	16	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	16	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	17	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2004	17	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	17	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	18	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2004	18	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	18	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	19	A	20	12	0	0	100	0	0	0	0	0	0	0	0	0
2004	19	B	20	12	100	0	0	0	0	0	0	0	0	0	0	0
2004	19	C	20	12	100	0	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.6. Kingman Biomass x10 (grams/.25 m)

Year	Distar	Rep	Size	Transect	Elevat	Pont	Sag	Pelt	Echin	Ludwig	Polyg
2001		A1	10	3		0	0	0	0	0	0
2001		A2	10	3		0	0	0	0	0	0
2001		A3	10	3		0	0	0	0	0	0
2001		A4	10	3		0	0	0	0	0	0
2001		B1	10	3		0	0	0	0	0	0
2001		B2	10	3		0	0	0	0	0	0
2001		B3	10	3		0	0	0	0.95	17.48	0
2001		B4	10	3		0	0	0	0	66.01	0
2001		C1	10	3		0	0	0	0	0	0
2001		C2	10	3		0	0	0	0	0	0
2001		C3	10	3		37.1	0	0	0	0	0
2001		C4	10	3		99.46	0	0	0	0	0
2001		A1	10	6		0	0	0	0	0	0
2001		A2	10	6		0	0	0	0	0	0
2001		A3	10	6		0	0	0	0	0	0
2001		A4	10	6		0	0	0	0	0	0
2001		B1	10	6		0	0	0	0	0	10.4
2001		B2	10	6		0	0	0	0	0	0
2001		B3	10	6		59.64	0	0	0	19.3	0
2001		B4	10	6		0	13.42	0	0	39.8	0
2001		C1	10	6		0	0	0	0	0	0
2001		C2	10	6		0	0	0	0	0	0
2001		C3	10	6		3.97	0	0	0	0	0
2001		C4	10	6		0	0	0	0	0	0
2001		A1	10	9		0	0	0	0	0	0
2001		A2	10	9		0	0	0	0	0	0
2001		A3	10	9		0	0	0	0	0	0
2001		A4	10	9		0	0	0	0	0	0
2001		B1	10	9		8.85	0	0	0	0	0
2001		B2	10	9		0	0	0	0	0	0
2001		B3	10	9		0	0	0	0	0	0
2001		B4	10	9		12.63	42.09	0	0	8.14	0
2001		C1	10	9		0	0	0	0	0	0
2001		C2	10	9		0	0	0	0	0	0
2001		C3	10	9		0	0	0	0	0	0
2001		C4	10	9		0	0	0	0	0	0
2001		A1	10	12		0	0	0	0	0	0
2001		A2	10	12		0	0	0	0	0	0
2001		A3	10	12		0	0	0	0	0	0
2001		A4	10	12		0	0	0	0	0	0
2001		B1	10	12		48.05	0.24	0	47.31	0.74	0.27
2001		B2	10	12		29.54	0	0	112.08	0	0
2001		B3	10	12		78.5	0	0	0	0	0
2001		B4	10	12		0	0	0	0	0	0
2001		C1	10	12		0	0	0	0	0	0
2001		C2	10	12		0	0	0	0	0	0
2001		C3	10	12		0	0	0	0	0	0
2001		C4	10	12		18	0	0	0	0	0
2002		A1	10	3		0	0	0	0	0	0
2002		A2	10	3		0	0	0	0	0	0
2002		A3	10	3		0	0	0	0	0	0
2002		A4	10	3		0	0	0	0	0	0

Appendix B, Table 4.6. (cont.) Kingman Biomass x10 (grams/.25 m)

Year	Distar	Rep	Size	Transect	Elevat	Pont	Sag	Pelt	Echin	Ludwig	Polyg
2002		B1	10	3		0	0	0	0	65.66	0
2002		B2	10	3		0	0	0	0	0	0
2002		B3	10	3		0	17.86	0	0	75.87	0
2002		B4	10	3		0	7.34	0	0	45.66	0
2002		C1	10	3		0	0	0	0	0	0
2002		C2	10	3		105.26	0	0	0	0	0
2002		C3	10	3		0	4.43	0	0	12.94	0
2002		C4	10	3		47.42	0	0	0	19.09	0
2002		A1	10	6		0	0	0	0	0	0
2002		A2	10	6		0	0	0	0	0	0
2002		A3	10	6		0	0	0	0	0	0
2002		A4	10	6		0	0	0	0	0	0
2002		B1	10	6		0	0	0	0	37.94	0
2002		B2	10	6		0	0	0	0	33.81	0
2002		B3	10	6		0	62.17	0	0	5.29	0
2002		B4	10	6		0	62.21	0	0	0	0
2002		C1	10	6		0	0	0	0	0	0
2002		C2	10	6		12.98	10.73	0	0	0	0
2002		C3	10	6		29.37	0	0	0	0	0
2002		C4	10	6		0	0	0	0	0	0
2002		A1	10	9		0	0	0	0	0	0
2002		A2	10	9		0	0	0	0	0	0
2002		A3	10	9		0	0	0	0	0	0
2002		A4	10	9		0	0	0	0	0	0
2002		B1	10	9		0	16.1	0	0	56.98	0
2002		B2	10	9		0	35.43	0	0	34.21	0
2002		B3	10	9		0	50.37	0	0	0	0
2002		B4	10	9		0	50.78	0	0	0	0
2002		C1	10	9		0	0	0	0	0	0
2002		C2	10	9		40.87	0	0	0	0	0
2002		C3	10	9		20.25	0	0	0	0	0
2002		C4	10	9		22.35	0	0	0	0	0
2002		A1	10	12		0	0	0	0	0	0
2002		A2	10	12		0	0	0	0	0	0
2002		A3	10	12		0	0	0	0	0	0
2002		A4	10	12		0	0	0	0	0	0
2002		B1	10	12		0	0	0	0	50.96	0
2002		B2	10	12		0	0	0	0	51.76	0
2002		B3	10	12		28.97	0	0	0	29.31	0
2002		B4	10	12		0	0	0	0	61.38	0
2002		C1	10	12		0	0	0	0	0	0
2002		C2	10	12		0	0	0	0	0	0
2002		C3	10	12		87.84	0	0	0	0	0
2002		C4	10	12		99.98	0	0	0	0	0
2003		A1	10	3		0	0	0	0	0	0
2003		A2	10	3		0	0	0	0	0	0
2003		A3	10	3		0	0	0	0	0	0
2003		A4	10	3		0	0	0	0	0	0
2003		B1	10	3		0	11.28	0	0	0	0
2003		B2	10	3		0	0	0	0	0	0
2003		B3	10	3		0	10.86	0	0	0	0
2003		B4	10	3		0	31.51	0	0	0	0

Appendix B, Table 4.6. (cont.) Kingman Biomass x10 (grams/.25 m)

Year	Distar	Rep	Size	Transect	Elevat	Pont	Sag	Pelt	Echin	Ludwig	Polyg
2003		C1	10	3		0	0	0	0	0	0
2003		C2	10	3		15.07	0	0	0	0	0
2003		C3	10	3		0	0	0	0	0	0
2003		C4	10	3		0	0	0	0	0	0
2003		A1	10	6		0	0	0	0	0	0
2003		A2	10	6		0	0	0	0	0	0
2003		A3	10	6		0	0	0	0	0	0
2003		A4	10	6		0	0	0	0	0	0
2003		B1	10	6		0	7.68	0	0	0	0
2003		B2	10	6		0	35.68	0	0	0	0
2003		B3	10	6		0	18.02	0	0	0	0
2003		B4	10	6		0	0	0	0	0	0
2003		C1	10	6		0	0.19	0	0	0	0
2003		C2	10	6		0	0.35	0	0	0	0
2003		C3	10	6		0	0	0	0	0	0
2003		C4	10	6		0	0	0	0	0	0
2003		A1	10	9		0	0	0	0	0	0
2003		A2	10	9		0	0	0	0	0	0
2003		A3	10	9		0	0	0	0	0	0
2003		A4	10	9		0	0	0	0	0	0
2003		B1	10	9		0	10.48	0	0	0	0
2003		B2	10	9		0	33.4	0	0	0	0
2003		B3	10	9		0	10.53	0	0	0	0
2003		B4	10	9		0	33.63	0	0	0	0
2003		C1	10	9		0	0	0	0	0	0
2003		C2	10	9		0	0	0	0	0	0
2003		C3	10	9		0	0	0	0	0	0
2003		C4	10	9		4.34	0	0	0	0	0
2003		A1	10	12		0	0	0	0	0	0
2003		A2	10	12		0	0	220.3	0	0	0
2003		A3	10	12		0	0	0	0	0	0
2003		A4	10	12		0	0	418.3	0	0	0
2003		B1	10	12		0	0	0	0	0	0
2003		B2	10	12		0	0	0	0	0	0
2003		B3	10	12		28.49	6.88	0	0	0	0
2003		B4	10	12		0	30.47	0	0	0	0
2003		C1	10	12		0	0	0	0	0	0
2003		C2	10	12		0	0	0	0	0	0
2003		C3	10	12		0	0	0	0	0	0
2003		C4	10	12		0	0	0	0	3.15	0
2004		A1	10	3		0	0	0	0	0	0
2004		A2	10	3		0	0	0	0	0	0
2004		A3	10	3		0	0	0	0	0	0
2004		A4	10	3		0	0	0	0	0	0
2004		B1	10	3		0	31.79	0	0	0	0
2004		B2	10	3		0	7.14	0	0	0	0
2004		B3	10	3		0	43.42	0	0	0	0
2004		B4	10	3		0	0	0	0	0	0
2004		C1	10	3		0	0	0	0	0	0
2004		C2	10	3		0	0	0	0	0	0
2004		C3	10	3		0	0	0	0	0	0
2004		C4	10	3		0	0	0	0	0	0

Appendix B, Table 4.6. (cont.) Kingman Biomass x10 (grams/.25 m)

Year	Distar	Rep	Size	Transect	Elevat	Pont	Sag	Pelt	Echin	Ludwig	Polyg
2004		A1	10	6		0	0	0	0	0	0
2004		A2	10	6		0	0	0	0	0	0
2004		A3	10	6		0	0	0	0	0	0
2004		A4	10	6		0	0	0	0	0	0
2004		B1	10	6		0	0	0	0	0	0
2004		B2	10	6		0	0	0	0	0	0
2004		B3	10	6		0	0.85	0	0	0	0
2004		B4	10	6		0	2.37	0	0	0	0
2004		C1	10	6		0	0	0	0	0	0
2004		C2	10	6		0	0	0	0	0	0
2004		C3	10	6		0	0	0	0	0	0
2004		C4	10	6		0	0	0	0	0	0
2004		A1	10	9		0	0	0	0	0	0
2004		A2	10	9		0	0	0	0	0	0
2004		A3	10	9		0	0	0	0	0	0
2004		A4	10	9		0	0	0	0	0	0
2004		B1	10	9		0	0	0	0	0	0
2004		B2	10	9		0	0	0	0	0	0
2004		B3	10	9		0	0	0	0	0	0
2004		B4	10	9		0	0	0	0	0	0
2004		C1	10	9		0	0	0	0	0	0
2004		C2	10	9		0	0	0	0	0	0
2004		C3	10	9		0	0	0	0	0	0
2004		C4	10	9		0	0	0	0	0	0
2004		A1	10	12		0	0	0	0	0	0
2004		A2	10	12		0	0	0	0	0	0
2004		A3	10	12		0	0	0	0	0	0
2004		A4	10	12		0	0	0	0	0	0
2004		B1	10	12		0	0	0	0	0	0
2004		B2	10	12		0	0	0	0	0	0
2004		B3	10	12		0	24.3	141.3	0	0	0
2004		B4	10	12		0	0	0	0	0	0
2004		C1	10	12		0	0	0	0	0	0
2004		C2	10	12		0	0	0	0	0	0
2004		C3	10	12		0	0	0	0	0	0
2004		C4	10	12		0	0	0	0	0	0
						0	27.52	141.3	0	0	0

Appendix B, Table 4.7. Kingman Biomass X20 (grams/.25 m)

Year	Distance	Rep	Size	Transect	Elevation	Pont	Sag	Pelt	Echin	Ludwig
2001		A1	20	3		0	132.33	0	3.52	0
2001		A2	20	3		0.99	26.73	23.68	356.86	0
2001		A3	20	3		0	0	25.78	0	0
2001		A4	20	3		0	0	20.28	0	0
2001		B1	20	3		0	0	0	0	0
2001		B2	20	3		3.51	0	0	0	0
2001		B3	20	3		0	0	0	0	0
2001		B4	20	3		0	0	0	214.84	0
2001		C1	20	3		130.37	0	0	0	0
2001		C2	20	3		15.06	0	0	0	0
2001		C3	20	3		7.2	0	0	178.42	0
2001		C4	20	3		0	0	0	0	0
2001		A1	20	6		7.38	129.65	0	70.95	0
2001		A2	20	6		100.07	9.15	0	0	0
2001		A3	20	6		47.56	0	0	0	0
2001		A4	20	6		10.62	81.55	0	0	0
2001		B1	20	6		0	0	0	0	0
2001		B2	20	6		0	0	0	0	0
2001		B3	20	6		0	0	0	0	0
2001		B4	20	6		0	0	0	0	0
2001		C1	20	6		0	0	0	0	0
2001		C2	20	6		55.74	0	0	0	0
2001		C3	20	6		103.55	22.16	0	0	0
2001		C4	20	6		49.91	0	0	157.08	0
2001		A1	20	9		68.84	0	0	0	0
2001		A2	20	9		93.35	0	0	0	0
2001		A3	20	9		88.37	0	0	0	0
2001		A4	20	9		43.78	5.35	0	0	0
2001		B1	20	9		0	0	0	0	0
2001		B2	20	9		0	0	0	0	0
2001		B3	20	9		52.4	0	0	0	0
2001		B4	20	9		0	0	0	0	0
2001		C1	20	9		0	0	0	0	0
2001		C2	20	9		41.08	0	0	0	0
2001		C3	20	9		12.63	0	0	0	8.14
2001		C4	20	9		37.22	0	0	0	0
2001		A1	20	12		35.29	0	0	0	0
2001		A2	20	12		0	0	0	0	0
2001		A3	20	12		165.01	0	0	0	0
2001		A4	20	12		32.33	0	0	0	0
2001		B1	20	12		0	0	0	0	0
2001		B2	20	12		33.95	0	0	0	0
2001		B3	20	12		92.8	28.58	0	0	0
2001		B4	20	12		13.22	0	0	0	0
2001		C1	20	12		82.24	0	0	0	0
2001		C2	20	12		45.42	0	0	0	0
2001		C3	20	12		20.03	0	0	0	0
2001		C4	20	12		7.65	0	0	125.19	3.82
2002		A1	20	3		0	54.42	0	0	0
2002		A2	20	3		0	16.32	0	0	0
2002		A3	20	3		0	6.24	306.5	0	0
2002		A4	20	3		0	0	783.39	0	0

Appendix B, Table 4.7. (cont.) Kingman Biomass X20 (grams/.25 m)

Year	Distance	Rep	Size	Transect	Elevation	Pont	Sag	Pelt	Echin	Ludwig
2002		B1	20	3		0	0	0	0	72.28
2002		B2	20	3		0	63.48	0	0	0
2002		B3	20	3		0	96.08	0	0	0
2002		B4	20	3		0	76.29	0	0	13.44
2002		C1	20	3		40.12	0	0	1.51	20.51
2002		C2	20	3		27.25	0	0	0	0
2002		C3	20	3		19.17	0	0	0	0
2002		C4	20	3		26.28	0	0	0	0
2002		A1	20	6		0	146.85	0	0	0
2002		A2	20	6		0	111.12	0	11.61	0
2002		A3	20	6		0	32.28	0	0	0
2002		A4	20	6		0	9.2	0	0	0
2002		B1	20	6		0	0	0	0	80.62
2002		B2	20	6		0	0	0	0	0
2002		B3	20	6		0	0	0	0	0
2002		B4	20	6		0	0	0	0	25.25
2002		C1	20	6		29.92	0	0	0	0
2002		C2	20	6		41.42	0	0	1.93	0
2002		C3	20	6		31.35	0	0	13.36	0
2002		C4	20	6		56.44	0	0	23.45	0
2002		A1	20	9		0	133.82	0	0	0
2002		A2	20	9		0	22.5	0	0	0
2002		A3	20	9		0	49.51	0	18.28	0
2002		A4	20	9		0	12.95	0	0	0
2002		B1	20	9		0	0	0	0	14.85
2002		B2	20	9		0	58.89	0	0	0
2002		B3	20	9		0	17.03	0	0	4.03
2002		B4	20	9		14.45	0	0	0	49.62
2002		C1	20	9		0	0	0	0	0
2002		C2	20	9		26.77	0.13	0	0	0
2002		C3	20	9		17.45	0	0	0	0
2002		C4	20	9		85.21	0	0	0	0
2002		A1	20	12		0	8.15	0	0	52.81
2002		A2	20	12		3.82	45.71	0	0	0
2002		A3	20	12		0	0	0	0	0
2002		A4	20	12		0	0	0	0	60.12
2002		B1	20	12		0	58.65	0	0	0
2002		B2	20	12		0	39.64	0	0	0
2002		B3	20	12		0	19.71	0	0	0
2002		B4	20	12		73.01	0	0	0	0
2002		C1	20	12		52.07	0	0	3.47	0
2002		C2	20	12		18.76	0	0	0	0
2002		C3	20	12		17.43	0	0	41.5	0
2002		C4	20	12		63.48	0	0	0	0
2003		A1	20	3		0	293.93	0	0	0
2003		A2	20	3		0	229.98	0	0	0
2003		A3	20	3		0	153.15	0	0	0
2003		A4	20	3		0	149.23	87.85	0	0
2003		B1	20	3		0	25.64	0	0	0
2003		B2	20	3		0	118.4	0	0	0
2003		B3	20	3		0	62.72	0	0	0
2003		B4	20	3		0	37.38	0	0	0

Appendix B, Table 4.7. (cont.) Kingman Biomass X20 (grams/.25 m)

Year	Distance	Rep	Size	Transect	Elevation	Pont	Sag	Pelt	Echin	Ludwig
2003		C1	20	3		0	0	0	0	0
2003		C2	20	3		0	0	0	0	0
2003		C3	20	3		0	0	0	0	21.92
2003		C4	20	3		0	0	0	0	0
2003		A1	20	6		0	214.04	0	0	0
2003		A2	20	6		0	210.43	0	0	0
2003		A3	20	6		0	235.74	0	0	0
2003		A4	20	6		0	64.81	0	0	0
2003		B1	20	6		0	11.51	0	0	0
2003		B2	20	6		0	38.54	0	0	0
2003		B3	20	6		57.88	0	0	0	0
2003		B4	20	6		0	0	0	0	0
2003		C1	20	6		0	0	0	0	0
2003		C2	20	6		0	0	0	0	0
2003		C3	20	6		0	0	0	0	0
2003		C4	20	6		0	0	0	0	0
2003		A1	20	9		0	196.61	0	0	0
2003		A2	20	9		0	93.34	0	0	0
2003		A3	20	9		0	103.11	0	0	0
2003		A4	20	9		0	84.91	0	0	0
2003		B1	20	9		0	58.91	0	0	0
2003		B2	20	9		0	18.84	0	0	0
2003		B3	20	9		0	12.94	0	0	0
2003		B4	20	9		0	20.34	0	0	0
2003		C1	20	9		0	0	0	0	0
2003		C2	20	9		0	0	0	0	0
2003		C3	20	9		0	0	0	0	0
2003		C4	20	9		0	0	0	0	0
2003		A1	20	12		0	239.38	0	0	0
2003		A2	20	12		0	10.3	0	0	0
2003		A3	20	12		0	38.16	147.35	0	0
2003		A4	20	12		0	160.89	0	0	0
2003		B1	20	12		0	32.4	0	0	0
2003		B2	20	12		0	36.97	0	0	0
2003		B3	20	12		0	19.98	0	0	0
2003		B4	20	12		0	14.12	0	0	0
2003		C1	20	12		0	0	0	0	0
2003		C2	20	12		0	0	0	0	0
2003		C3	20	12		0	0	0	0	0
2003		C4	20	12		0	0	0	0	0
2004		A1	20	3		0	434.22	0	0	0
2004		A2	20	3		0	424.23	0	0	0
2004		A3	20	3		0	337.79	0	0	0
2004		A4	20	3		0	69.33	165.55	0	0
2004		B1	20	3		0	0	0	0	0
2004		B2	20	3		0	0	0	0	0
2004		B3	20	3		0	0	0	0	0
2004		B4	20	3		0	0	0	0	0
2004		C1	20	3		0	0	0	0	0
2004		C2	20	3		0	0	0	0	0
2004		C3	20	3		0	0	0	0	0
2004		C4	20	3		0	0	0	0	0

Appendix B, Table 4.7. (cont.) Kingman Biomass X20 (grams/.25 m)

Year	Distance	Rep	Size	Transect	Elevation	Pont	Sag	Pelt	Echin	Ludwig
2004		A1	20	6		0	326.46	0	0	0
2004		A2	20	6		0	257.17	0	0	0
2004		A3	20	6		0	241.34	0	0	0
2004		A4	20	6		0	126.38	0	0	0
2004		B1	20	6		0	0	0	0	0
2004		B2	20	6		0	0	0	0	0
2004		B3	20	6		0	0	0	0	0
2004		B4	20	6		0	0	0	0	0
2004		C1	20	6		0	0	0	0	0
2004		C2	20	6		0	0	0	0	0
2004		C3	20	6		0	0	0	0	0
2004		C4	20	6		0	0	0	0	0
2004		A1	20	9		0	417.03	0	0	0
2004		A2	20	9		0	248.72	0	0	0
2004		A3	20	9		0	269.07	0	0	0
2004		A4	20	9		0	369.27	0	0	0
2004		B1	20	9		0	0	0	0	0
2004		B2	20	9		0	0	0	0	0
2004		B3	20	9		0	0	0	0	0
2004		B4	20	9		0	0	0	0	0
2004		C1	20	9		0	0	0	0	0
2004		C2	20	9		0	0	0	0	0
2004		C3	20	9		0	0	0	0	0
2004		C4	20	9		0	0	0	0	0
2004		A1	20	12		0	196.76	0	0	0
2004		A2	20	12		0	181.87	0	0	0
2004		A3	20	12		0	251.4	0	0	0
2004		A4	20	12		0	284.47	0	0	0
2004		B1	20	12		0	0	0	0	0
2004		B2	20	12		0	0	0	0	0
2004		B3	20	12		0	0	0	0	0
2004		B4	20	12		0	0	0	0	0
2004		C1	20	12		0	0	0	0	0
2004		C2	20	12		0	0	0	0	0
2004		C3	20	12		0	0	0	0	0
2004		C4	20	12		0	0	0	0	0
						0	3169.94	0	0	0

Appendix B, Table 4.8. Kingman X10 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line.
Species data binary (presence 1/absence 0)

Year	At (m)	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Bidens	Polyg
2001	0	A	10	3	0	0	0	0	0	0	0	0	0
2001	0	B	10	3	50	0	1	0	0	0	0	0	0
2001	0	C	10	3	0	0	0	0	0	0	0	0	0
2001	1	A	10	3	0	0	0	0	0	0	0	0	0
2001	1	B	10	3	0	0	0	0	0	0	0	0	0
2001	1	C	10	3	0	0	0	0	0	0	0	0	0
2001	2	A	10	3	0	0	0	0	0	0	0	0	0
2001	2	B	10	3	0	0	0	0	0	0	0	0	0
2001	2	C	10	3	0	0	0	0	0	0	0	0	0
2001	3	A	10	3	0	0	0	0	0	0	0	0	0
2001	3	B	10	3	0	0	0	0	0	0	0	0	0
2001	3	C	10	3	60	0	1	0	0	0	0	0	0
2001	4	A	10	3	0	0	0	0	0	0	0	0	0
2001	4	B	10	3	0	0	0	0	0	0	0	0	0
2001	4	C	10	3	45	0	1	0	0	0	0	0	0
2001	5	A	10	3	0	0	0	0	0	0	0	0	0
2001	5	B	10	3	0	0	0	0	0	0	0	0	0
2001	5	C	10	3	40	0	1	0	0	0	0	0	0
2001	6	A	10	3	0	0	0	0	0	0	0	0	0
2001	6	B	10	3	65	0	0	0	0	1	0	0	0
2001	6	C	10	3	0	0	0	0	0	0	0	0	0
2001	7	A	10	3	0	0	0	0	0	0	0	0	0
2001	7	B	10	3	45	0	0	1	0	0	0	0	0
2001	7	C	10	3	0	0	0	0	0	0	0	0	0
2001	8	A	10	3	0	0	0	0	0	0	0	0	0
2001	8	B	10	3	25	0	1	0	0	0	0	0	0
2001	8	C	10	3	0	0	0	0	0	0	0	0	0
2001	9	A	10	3	0	0	0	0	0	0	0	0	0
2001	9	B	10	3	5	0	0	0	0	0	1	0	0
2001	9	C	10	3	50	0	1	0	0	0	0	0	0
2001	10	A	10	3	0	0	0	0	0	0	0	0	0
2001	10	B	10	3	0	0	0	0	0	0	0	0	0
2001	10	C	10	3	0	0	0	0	0	0	0	0	0
2001	0	A	10	6	0	0	0	0	0	0	0	0	0
2001	0	B	10	6	0	0	0	0	0	0	0	0	0
2001	0	C	10	6	0	0	0	0	0	0	0	0	0
2001	1	A	10	6	0	0	0	0	0	0	0	0	0
2001	1	B	10	6	0	0	0	0	0	0	0	0	0
2001	1	C	10	6	0	0	0	0	0	0	0	0	0
2001	2	A	10	6	0	0	0	0	0	0	0	0	0
2001	2	B	10	6	0	0	0	0	0	0	0	0	0
2001	2	C	10	6	0	0	0	0	0	0	0	0	0
2001	3	A	10	6	0	0	0	0	0	0	0	0	0
2001	3	B	10	6	0	0	0	0	0	0	0	0	0
2001	3	C	10	6	0	0	0	0	0	0	0	0	0
2001	4	A	10	6	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.8. (cont.) Kingman X10 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line.
Species data binary (presence 1/absence 0)

Year	At (m)	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Bidens	Polyg
2001	4	B	10	6	0	0	0	0	0	0	0	0	0
2001	4	C	10	6	0	0	0	0	0	0	0	0	0
2001	5	A	10	6	0	0	0	0	0	0	0	0	0
2001	5	B	10	6	25	0	1	0	0	0	0	0	0
2001	5	C	10	6	0	0	0	0	0	0	0	0	0
2001	6	A	10	6	0	0	0	0	0	0	0	0	0
2001	6	B	10	6	30	0	0	0	0	0	1	0	0
2001	6	C	10	6	0	0	0	0	0	0	0	0	0
2001	7	A	10	6	0	0	0	0	0	0	0	0	0
2001	7	B	10	6	60	0	0	1	0	0	1	0	0
2001	7	C	10	6	0	0	0	0	0	0	0	0	0
2001	8	A	10	6	0	0	0	0	0	0	0	0	0
2001	8	B	10	6	50	0	0	1	0	0	1	0	0
2001	8	C	10	6	0	0	0	0	0	0	0	0	0
2001	9	A	10	6	0	0	0	0	0	0	0	0	0
2001	9	B	10	6	0	0	0	0	0	0	0	0	0
2001	9	C	10	6	0	0	0	0	0	0	0	0	0
2001	10	A	10	6	0	0	0	0	0	0	0	0	0
2001	10	B	10	6	0	0	0	0	0	0	0	0	0
2001	10	C	10	6	0	0	0	0	0	0	0	0	0
2001	0	A	10	9	0	0	0	0	0	0	0	0	0
2001	0	B	10	9	60	0	1	0	0	0	0	0	0
2001	0	C	10	9	0	0	0	0	0	0	0	0	0
2001	1	A	10	9	0	0	0	0	0	0	0	0	0
2001	1	B	10	9	60	0	1	0	0	0	0	0	0
2001	1	C	10	9	0	0	0	0	0	0	0	0	0
2001	2	A	10	9	0	0	0	0	0	0	0	0	0
2001	2	B	10	9	55	0	1	0	0	0	0	0	0
2001	2	C	10	9	0	0	0	0	0	0	0	0	0
2001	3	A	10	9	0	0	0	0	0	0	0	0	0
2001	3	B	10	9	45	0	1	0	0	0	0	0	0
2001	3	C	10	9	0	0	0	0	0	0	0	0	0
2001	4	A	10	9	0	0	0	0	0	0	0	0	0
2001	4	B	10	9	0	0	0	0	0	0	0	0	0
2001	4	C	10	9	0	0	0	0	0	0	0	0	0
2001	5	A	10	9	0	0	0	0	0	0	0	0	0
2001	5	B	10	9	0	0	0	0	0	0	0	0	0
2001	5	C	10	9	0	0	0	0	0	0	0	0	0
2001	6	A	10	9	0	0	0	0	0	0	0	0	0
2001	6	B	10	9	0	0	0	0	0	0	0	0	0
2001	6	C	10	9	0	0	0	0	0	0	0	0	0
2001	7	A	10	9	0	0	0	0	0	0	0	0	0
2001	7	B	10	9	0	0	0	0	0	0	0	0	0
2001	7	C	10	9	0	0	0	0	0	0	0	0	0
2001	8	A	10	9	0	0	0	0	0	0	0	0	0
2001	8	B	10	9	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.8. (cont.) Kingman X10 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line.
Species data binary (presence 1/absence 0)

Year	At (m)	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Bidens	Polyg
2001	4	B	10	6	0	0	0	0	0	0	0	0	0
2001	4	C	10	6	0	0	0	0	0	0	0	0	0
2001	5	A	10	6	0	0	0	0	0	0	0	0	0
2001	5	B	10	6	25	0	1	0	0	0	0	0	0
2001	5	C	10	6	0	0	0	0	0	0	0	0	0
2001	6	A	10	6	0	0	0	0	0	0	0	0	0
2001	6	B	10	6	30	0	0	0	0	0	1	0	0
2001	6	C	10	6	0	0	0	0	0	0	0	0	0
2001	7	A	10	6	0	0	0	0	0	0	0	0	0
2001	7	B	10	6	60	0	0	1	0	0	1	0	0
2001	7	C	10	6	0	0	0	0	0	0	0	0	0
2001	8	A	10	6	0	0	0	0	0	0	0	0	0
2001	8	B	10	6	50	0	0	1	0	0	1	0	0
2001	8	C	10	6	0	0	0	0	0	0	0	0	0
2001	9	A	10	6	0	0	0	0	0	0	0	0	0
2001	9	B	10	6	0	0	0	0	0	0	0	0	0
2001	9	C	10	6	0	0	0	0	0	0	0	0	0
2001	10	A	10	6	0	0	0	0	0	0	0	0	0
2001	10	B	10	6	0	0	0	0	0	0	0	0	0
2001	10	C	10	6	0	0	0	0	0	0	0	0	0
2001	0	A	10	9	0	0	0	0	0	0	0	0	0
2001	0	B	10	9	60	0	1	0	0	0	0	0	0
2001	0	C	10	9	0	0	0	0	0	0	0	0	0
2001	1	A	10	9	0	0	0	0	0	0	0	0	0
2001	1	B	10	9	60	0	1	0	0	0	0	0	0
2001	1	C	10	9	0	0	0	0	0	0	0	0	0
2001	2	A	10	9	0	0	0	0	0	0	0	0	0
2001	2	B	10	9	55	0	1	0	0	0	0	0	0
2001	2	C	10	9	0	0	0	0	0	0	0	0	0
2001	3	A	10	9	0	0	0	0	0	0	0	0	0
2001	3	B	10	9	45	0	1	0	0	0	0	0	0
2001	3	C	10	9	0	0	0	0	0	0	0	0	0
2001	4	A	10	9	0	0	0	0	0	0	0	0	0
2001	4	B	10	9	0	0	0	0	0	0	0	0	0
2001	4	C	10	9	0	0	0	0	0	0	0	0	0
2001	5	A	10	9	0	0	0	0	0	0	0	0	0
2001	5	B	10	9	0	0	0	0	0	0	0	0	0
2001	5	C	10	9	0	0	0	0	0	0	0	0	0
2001	6	A	10	9	0	0	0	0	0	0	0	0	0
2001	6	B	10	9	0	0	0	0	0	0	0	0	0
2001	6	C	10	9	0	0	0	0	0	0	0	0	0
2001	7	A	10	9	0	0	0	0	0	0	0	0	0
2001	7	B	10	9	0	0	0	0	0	0	0	0	0
2001	7	C	10	9	0	0	0	0	0	0	0	0	0
2001	8	A	10	9	0	0	0	0	0	0	0	0	0
2001	8	B	10	9	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.8. (cont.) Kingman X10 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line.
Species data binary (presence 1/absence 0)

Year	At (m)	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Bidens	Polyg
2001	4	B	10	6	0	0	0	0	0	0	0	0	0
2001	4	C	10	6	0	0	0	0	0	0	0	0	0
2001	5	A	10	6	0	0	0	0	0	0	0	0	0
2001	8	C	10	9	0	0	0	0	0	0	0	0	0
2001	9	A	10	9	0	0	0	0	0	0	0	0	0
2001	9	B	10	9	0	0	0	0	0	0	0	0	0
2001	9	C	10	9	35	0	1	0	0	0	0	0	0
2001	10	A	10	9	0	0	0	0	0	0	0	0	0
2001	10	B	10	9	0	0	0	0	0	0	0	0	0
2001	10	C	10	9	0	0	0	0	0	0	0	0	0
2001	0	A	10	12	0	0	0	0	0	0	0	0	0
2001	0	B	10	12	75	0	1	0	0	0	0	0	0
2001	0	C	10	12	0	0	0	0	0	0	0	0	0
2001	1	A	10	12	0	0	0	0	0	0	0	0	0
2001	1	B	10	12	75	0	0	0	0	1	0	0	0
2001	1	C	10	12	0	0	0	0	0	0	0	0	0
2001	2	A	10	12	50	0	1	0	0	0	0	0	0
2001	2	B	10	12	60	0	1	0	0	1	0	0	0
2001	2	C	10	12	0	0	0	0	0	0	0	0	0
2001	3	A	10	12	0	0	0	0	0	0	0	0	0
2001	3	B	10	12	70	0	1	0	0	1	0	0	0
2001	3	C	10	12	0	0	0	0	0	0	0	0	0
2001	4	A	10	12	0	0	0	0	0	0	0	0	0
2001	4	B	10	12	65	0	1	0	0	1	0	0	0
2001	4	C	10	12	0	0	0	0	0	0	0	0	0
2001	5	A	10	12	0	0	0	0	0	0	0	0	0
2001	5	B	10	12	40	0	1	0	0	1	0	0	0
2001	5	C	10	12	0	0	0	0	0	0	0	0	0
2001	6	A	10	12	0	0	0	0	0	0	0	0	0
2001	6	B	10	12	60	0	1	0	0	1	0	0	0
2001	6	C	10	12	0	0	0	0	0	0	0	0	0
2001	7	A	10	12	0	0	0	0	0	0	0	0	0
2001	7	B	10	12	60	0	1	0	0	1	0	0	0
2001	7	C	10	12	0	0	0	0	0	0	0	0	0
2001	8	A	10	12	0	0	0	0	0	0	0	0	0
2001	8	B	10	12	60	0	0	0	0	1	0	0	0
2001	8	C	10	12	0	0	0	0	0	0	0	0	0
2001	9	A	10	12	0	0	0	0	0	0	0	0	0
2001	9	B	10	12	40	0	0	0	1	0	0	0	0
2001	9	C	10	12	0	0	0	0	0	0	0	0	0
2001	10	A	10	12	0	0	0	0	0	0	0	0	0
2001	10	B	10	12	0	0	0	0	0	0	0	0	0
2001	10	C	10	12	0	0	0	0	0	0	0	0	0
2002	0	A	10	3	0	0	0	0	0	0	0	0	0
2002	0	B	10	3	50	0	0	0	0	0	1	0	0
2002	0	C	10	3	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.8. (cont.) Kingman X10 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line.
Species data binary (presence 1/absence 0)

Year	At (m)	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Bidens	Polyg
2002	1	A	10	3	0	0	0	0	0	0	0	0	0
2002	1	B	10	3	30	0	0	0	0	0	1	0	0
2002	1	C	10	3	0	0	0	0	0	0	0	0	0
2002	2	A	10	3	0	0	0	0	0	0	0	0	0
2002	2	B	10	3	30	0	0	0	0	0	0	1	0
2002	2	C	10	3	0	0	0	0	0	0	0	0	0
2002	3	A	10	3	0	0	0	0	0	0	0	0	0
2002	3	B	10	3	35	0	0	0	0	0	1	0	0
2002	3	C	10	3	35	0	1	0	0	0	0	0	0
2002	4	A	10	3	0	0	0	0	0	0	0	0	0
2002	4	B	10	3	30	0	0	0	0	0	1	0	0
2002	4	C	10	3	40	0	1	0	0	0	0	0	0
2002	5	A	10	3	0	0	0	0	0	0	0	0	0
2002	5	B	10	3	30	0	0	0	0	0	1	0	0
2002	5	C	10	3	40	0	1	0	0	0	0	0	0
2002	6	A	10	3	0	0	0	0	0	0	0	0	0
2002	6	B	10	3	55	0	0	0	0	0	1	0	0
2002	6	C	10	3	0	0	0	0	0	0	0	0	0
2002	7	A	10	3	0	0	0	0	0	0	0	0	0
2002	7	B	10	3	45	0	0	0	0	0	1	0	0
2002	7	C	10	3	0	0	0	0	0	0	0	0	0
2002	8	A	10	3	0	0	0	0	0	0	0	0	0
2002	8	B	10	3	45	0	0	1	0	0	1	0	0
2002	8	C	10	3	0	0	0	0	0	0	0	0	0
2002	9	A	10	3	0	0	0	0	0	0	0	0	0
2002	9	B	10	3	55	0	0	1	0	0	1	0	0
2002	9	C	10	3	35	0	1	0	0	0	0	0	0
2002	10	A	10	3	0	0	0	0	0	0	0	0	0
2002	10	B	10	3	40	0	0	1	0	0	0	0	0
2002	10	C	10	3	0	0	0	0	0	0	0	0	0
2002	0	A	10	6	0	0	0	0	0	0	0	0	0
2002	0	B	10	6	60	0	0	0	0	0	1	0	0
2002	0	C	10	6	0	0	0	0	0	0	0	0	0
2002	1	A	10	6	0	0	0	0	0	0	0	0	0
2002	1	B	10	6	30	0	0	0	0	0	1	0	0
2002	1	C	10	6	0	0	0	0	0	0	0	0	0
2002	2	A	10	6	0	0	0	0	0	0	0	0	0
2002	2	B	10	6	35	0	0	0	0	0	1	0	0
2002	2	C	10	6	0	0	0	0	0	0	0	0	0
2002	3	A	10	6	0	0	0	0	0	0	0	0	0
2002	3	B	10	6	30	0	0	0	0	0	1	0	0
2002	3	C	10	6	0	0	0	0	0	0	0	0	0
2002	4	A	10	6	0	0	0	0	0	0	0	0	0
2002	4	B	10	6	45	0	0	0	0	0	1	0	0
2002	4	C	10	6	50	0	0	1	0	0	0	0	0
2002	5	A	10	6	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.8. (cont.) Kingman X10 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line.
Species data binary (presence 1/absence 0)

Year	At (m)	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Bidens	Polyg
2002	5	B	10	6	55	0	0	1	0	0	1	0	0
2002	5	C	10	6	50	0	0	1	0	0	0	0	0
2002	6	A	10	6	0	0	0	0	0	0	0	0	0
2002	6	B	10	6	50	0	0	1	0	0	0	0	0
2002	6	C	10	6	0	0	0	0	0	0	0	0	0
2002	7	A	10	6	0	0	0	0	0	0	0	0	0
2002	7	B	10	6	45	0	0	1	0	0	0	0	0
2002	7	C	10	6	35	0	0	1	0	0	0	0	0
2002	8	A	10	6	0	0	0	0	0	0	0	0	0
2002	8	B	10	6	40	0	0	1	0	0	0	0	0
2002	8	C	10	6	0	0	0	0	0	0	0	0	0
2002	9	A	10	6	0	0	0	0	0	0	0	0	0
2002	9	B	10	6	40	0	0	1	0	0	0	0	0
2002	9	C	10	6	30	0	1	0	0	0	0	0	0
2002	10	A	10	6	0	0	0	0	0	0	0	0	0
2002	10	B	10	6	40	0	0	1	0	0	0	0	0
2002	10	C	10	6	0	0	0	0	0	0	0	0	0
2002	0	A	10	9	0	0	0	0	0	0	0	0	0
2002	0	B	10	9	60	0	0	0	0	0	1	0	0
2002	0	C	10	9	0	0	0	0	0	0	0	0	0
2002	1	A	10	9	0	0	0	0	0	0	0	0	0
2002	1	B	10	9	55	0	0	0	0	0	1	0	0
2002	1	C	10	9	0	0	0	0	0	0	0	0	0
2002	2	A	10	9	0	0	0	0	0	0	0	0	0
2002	2	B	10	9	55	0	0	0	0	0	1	0	0
2002	2	C	10	9	0	0	0	0	0	0	0	0	0
2002	3	A	10	9	0	0	0	0	0	0	0	0	0
2002	3	B	10	9	55	0	0	0	0	0	1	0	0
2002	3	C	10	9	0	0	0	0	0	0	0	0	0
2002	4	A	10	9	0	0	0	0	0	0	0	0	0
2002	4	B	10	9	50	0	0	0	0	0	1	0	0
2002	4	C	10	9	0	0	0	0	0	0	0	0	0
2002	5	A	10	9	0	0	0	0	0	0	0	0	0
2002	5	B	10	9	45	0	0	1	0	0	0	0	0
2002	5	C	10	9	0	0	0	0	0	0	0	0	0
2002	6	A	10	9	0	0	0	0	0	0	0	0	0
2002	6	B	10	9	55	0	0	1	0	0	0	0	0
2002	6	C	10	9	0	0	0	0	0	0	0	0	0
2002	7	A	10	9	0	0	0	0	0	0	0	0	0
2002	7	B	10	9	55	0	0	1	0	0	0	0	0
2002	7	C	10	9	0	0	0	0	0	0	0	0	0
2002	8	A	10	9	0	0	0	0	0	0	0	0	0
2002	8	B	10	9	50	0	0	1	0	0	0	0	0
2002	8	C	10	9	0	0	0	0	0	0	0	0	0
2002	9	A	10	9	0	0	0	0	0	0	0	0	0
2002	9	B	10	9	45	0	0	1	0	0	0	0	0

Appendix B, Table 4.8. (cont.) Kingman X10 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line.
Species data binary (presence 1/absence 0)

Year	At (m)	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Bidens	Polyg
2002	9	C	10	9	30	0	1	0	0	0	0	0	0
2002	10	A	10	9	0	0	0	0	0	0	0	0	0
2002	10	B	10	9	40	0	0	1	0	0	0	0	0
2002	10	C	10	9	30	0	1	0	0	0	0	0	0
2002	0	A	10	12	0	0	0	0	0	0	0	0	0
2002	0	B	10	12	50	0	1	0	0	0	1	0	1
2002	0	C	10	12	0	0	0	0	0	0	0	0	0
2002	1	A	10	12	0	0	0	0	0	0	0	0	0
2002	1	B	10	12	45	0	0	0	0	1	1	0	0
2002	1	C	10	12	0	0	0	0	0	0	0	0	0
2002	2	A	10	12	45	0	1	0	0	0	0	0	0
2002	2	B	10	12	45	0	0	0	0	0	1	0	0
2002	2	C	10	12	0	0	0	0	0	0	0	0	0
2002	3	A	10	12	0	0	0	0	0	0	0	0	0
2002	3	B	10	12	50	0	1	0	0	0	1	0	0
2002	3	C	10	12	0	0	0	0	0	0	0	0	0
2002	4	A	10	12	0	0	0	0	0	0	0	0	0
2002	4	B	10	12	45	0	0	0	0	0	1	0	0
2002	4	C	10	12	0	0	0	0	0	0	0	0	0
2002	5	A	10	12	0	0	0	0	0	0	0	0	0
2002	5	B	10	12	45	0	1	0	0	1	1	0	0
2002	5	C	10	12	0	0	0	0	0	0	0	0	0
2002	6	A	10	12	0	0	0	0	0	0	0	0	0
2002	6	B	10	12	40	0	0	0	0	1	1	0	0
2002	6	C	10	12	0	0	0	0	0	0	0	0	0
2002	7	A	10	12	0	0	0	0	0	0	0	0	0
2002	7	B	10	12	45	0	0	0	0	0	1	0	0
2002	7	C	10	12	0	0	0	0	0	0	0	0	0
2002	8	A	10	12	0	0	0	0	0	0	0	0	0
2002	8	B	10	12	45	0	1	0	0	0	1	0	0
2002	8	C	10	12	0	0	0	0	0	0	0	0	0
2002	9	A	10	12	0	0	0	0	0	0	0	0	0
2002	9	B	10	12	40	0	1	0	0	0	1	0	0
2002	9	C	10	12	35	0	1	0	0	0	0	0	0
2002	10	A	10	12	0	0	0	0	0	0	0	0	0
2002	10	B	10	12	40	0	1	0	0	0	0	0	0
2002	10	C	10	12	0	0	0	0	0	0	0	0	0
2003	0	A	10	3	0	0	0	0	0	0	0	0	0
2003	0	B	10	3	0	0	0	0	0	0	0	0	0
2003	0	C	10	3	0	0	0	0	0	0	0	0	0
2003	1	A	10	3	0	0	0	0	0	0	0	0	0
2003	1	B	10	3	0	0	0	0	0	0	0	0	0
2003	1	C	10	3	0	0	0	0	0	0	0	0	0
2003	2	A	10	3	0	0	0	0	0	0	0	0	0
2003	2	B	10	3	0	0	0	0	0	0	0	0	0
2003	2	C	10	3	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.8. (cont.) Kingman X10 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line.
Species data binary (presence 1/absence 0)

Year	At (m)	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Bidens	Polyg
2003	3	A	10	3	0	0	0	0	0	0	0	0	0
2003	3	B	10	3	0	0	0	0	0	0	0	0	0
2003	3	C	10	3	0	0	0	0	0	0	0	0	0
2003	4	A	10	3	0	0	0	0	0	0	0	0	0
2003	4	B	10	3	0	0	0	0	0	0	0	0	0
2003	4	C	10	3	0	0	0	0	0	0	0	0	0
2003	5	A	10	3	0	0	0	0	0	0	0	0	0
2003	5	B	10	3	0	0	0	0	0	0	0	0	0
2003	5	C	10	3	0	0	0	0	0	0	0	0	0
2003	6	A	10	3	0	0	0	0	0	0	0	0	0
2003	6	B	10	3	0	0	0	0	0	0	0	0	0
2003	6	C	10	3	0	0	0	0	0	0	0	0	0
2003	7	A	10	3	0	0	0	0	0	0	0	0	0
2003	7	B	10	3	50	0	0	1	0	0	0	0	0
2003	7	C	10	3	0	0	0	0	0	0	0	0	0
2003	8	A	10	3	0	0	0	0	0	0	0	0	0
2003	8	B	10	3	20	0	0	1	0	0	0	0	0
2003	8	C	10	3	0	0	0	0	0	0	0	0	0
2003	9	A	10	3	0	0	0	0	0	0	0	0	0
2003	9	B	10	3	0	0	0	0	0	0	0	0	0
2003	9	C	10	3	0	0	0	0	0	0	0	0	0
2003	10	A	10	3	0	0	0	0	0	0	0	0	0
2003	10	B	10	3	0	0	0	0	0	0	0	0	0
2003	10	C	10	3	0	0	0	0	0	0	0	0	0
2003	0	A	10	6	0	0	0	0	0	0	0	0	0
2003	0	B	10	6	0	0	0	0	0	0	0	0	0
2003	0	C	10	6	0	0	0	0	0	0	0	0	0
2003	1	A	10	6	0	0	0	0	0	0	0	0	0
2003	1	B	10	6	0	0	0	0	0	0	0	0	0
2003	1	C	10	6	0	0	0	0	0	0	0	0	0
2003	2	A	10	6	0	0	0	0	0	0	0	0	0
2003	2	B	10	6	0	0	0	0	0	0	0	0	0
2003	2	C	10	6	0	0	0	0	0	0	0	0	0
2003	3	A	10	6	0	0	0	0	0	0	0	0	0
2003	3	B	10	6	35	0	0	1	0	0	0	0	0
2003	3	C	10	6	0	0	0	0	0	0	0	0	0
2003	4	A	10	6	0	0	0	0	0	0	0	0	0
2003	4	B	10	6	0	0	0	0	0	0	0	0	0
2003	4	C	10	6	0	0	0	0	0	0	0	0	0
2003	5	A	10	6	0	0	0	0	0	0	0	0	0
2003	5	B	10	6	0	0	0	0	0	0	0	0	0
2003	5	C	10	6	0	0	0	0	0	0	0	0	0
2003	6	A	10	6	0	0	0	0	0	0	0	0	0
2003	6	B	10	6	0	0	0	0	0	0	0	0	0
2003	6	C	10	6	20	0	0	1	0	0	0	0	0
2003	7	A	10	6	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.8. (cont.) Kingman X10 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line.
Species data binary (presence 1/absence 0)

Year	At (m)	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Bidens	Polyg
2003	7	B	10	6	0	0	0	0	0	0	0	0	0
2003	7	C	10	6	0	0	0	0	0	0	0	0	0
2003	8	A	10	6	0	0	0	0	0	0	0	0	0
2003	8	B	10	6	35	0	0	1	0	0	0	0	0
2003	8	C	10	6	0	0	0	0	0	0	0	0	0
2003	9	A	10	6	0	0	0	0	0	0	0	0	0
2003	9	B	10	6	40	0	0	1	0	0	0	0	0
2003	9	C	10	6	0	0	0	0	0	0	0	0	0
2003	10	A	10	6	0	0	0	0	0	0	0	0	0
2003	10	B	10	6	0	0	0	0	0	0	0	0	0
2003	10	C	10	6	0	0	0	0	0	0	0	0	0
2003	0	A	10	9	0	0	0	0	0	0	0	0	0
2003	0	B	10	9	0	0	0	0	0	0	0	0	0
2003	0	C	10	9	0	0	0	0	0	0	0	0	0
2003	1	A	10	9	0	0	0	0	0	0	0	0	0
2003	1	B	10	9	0	0	0	0	0	0	0	0	0
2003	1	C	10	9	0	0	0	0	0	0	0	0	0
2003	2	A	10	9	0	0	0	0	0	0	0	0	0
2003	2	B	10	9	0	0	0	0	0	0	0	0	0
2003	2	C	10	9	0	0	0	0	0	0	0	0	0
2003	3	A	10	9	0	0	0	0	0	0	0	0	0
2003	3	B	10	9	0	0	0	0	0	0	0	0	0
2003	3	C	10	9	0	0	0	0	0	0	0	0	0
2003	4	A	10	9	0	0	0	0	0	0	0	0	0
2003	4	B	10	9	30	0	0	1	0	0	0	0	0
2003	4	C	10	9	0	0	0	0	0	0	0	0	0
2003	5	A	10	9	0	0	0	0	0	0	0	0	0
2003	5	B	10	9	25	0	0	1	0	0	0	0	0
2003	5	C	10	9	0	0	0	0	0	0	0	0	0
2003	6	A	10	9	0	0	0	0	0	0	0	0	0
2003	6	B	10	9	30	0	0	1	0	0	0	0	0
2003	6	C	10	9	0	0	0	0	0	0	0	0	0
2003	7	A	10	9	0	0	0	0	0	0	0	0	0
2003	7	B	10	9	0	0	0	0	0	0	0	0	0
2003	7	C	10	9	0	0	0	0	0	0	0	0	0
2003	8	A	10	9	0	0	0	0	0	0	0	0	0
2003	8	B	10	9	0	0	0	0	0	0	0	0	0
2003	8	C	10	9	0	0	0	0	0	0	0	0	0
2003	9	A	10	9	0	0	0	0	0	0	0	0	0
2003	9	B	10	9	40	0	0	1	0	0	0	0	0
2003	9	C	10	9	0	0	0	0	0	0	0	0	0
2003	10	A	10	9	0	0	0	0	0	0	0	0	0
2003	10	B	10	9	0	0	0	0	0	0	0	0	0
2003	10	C	10	9	0	0	0	0	0	0	0	0	0
2003	0	A	10	12	0	0	0	0	0	0	0	0	0
2003	0	B	10	12	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.8. (cont.) Kingman X10 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line.
Species data binary (presence 1/absence 0)

Year	At (m)	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Bidens	Polyg
2003	0	C	10	12	0	0	0	0	0	0	0	0	0
2003	1	A	10	12	0	0	0	0	0	0	0	0	0
2003	1	B	10	12	0	0	0	0	0	0	0	0	0
2003	1	C	10	12	0	0	0	0	0	0	0	0	0
2003	2	A	10	12	0	0	0	0	0	0	0	0	0
2003	2	B	10	12	0	0	0	0	0	0	0	0	0
2003	2	C	10	12	0	0	0	0	0	0	0	0	0
2003	3	A	10	12	0	0	0	0	0	0	0	0	0
2003	3	B	10	12	0	0	0	0	0	0	0	0	0
2003	3	C	10	12	0	0	0	0	0	0	0	0	0
2003	4	A	10	12	0	0	0	0	0	0	0	0	0
2003	4	B	10	12	0	0	0	0	0	0	0	0	0
2003	4	C	10	12	0	0	0	0	0	0	0	0	0
2003	5	A	10	12	65	0	0	0	1	0	0	0	0
2003	5	B	10	12	0	0	0	0	0	0	0	0	0
2003	5	C	10	12	0	0	0	0	0	0	0	0	0
2003	6	A	10	12	0	0	0	0	0	0	0	0	0
2003	6	B	10	12	65	0	0	0	1	0	0	0	0
2003	6	C	10	12	0	0	0	0	0	0	0	0	0
2003	7	A	10	12	0	0	0	0	0	0	0	0	0
2003	7	B	10	12	0	0	0	0	0	0	0	0	0
2003	7	C	10	12	0	0	0	0	0	0	0	0	0
2003	8	A	10	12	0	0	0	0	0	0	0	0	0
2003	8	B	10	12	40	0	1	0	0	0	0	0	0
2003	8	C	10	12	0	0	0	0	0	0	0	0	0
2003	9	A	10	12	80	0	0	0	1	0	0	0	0
2003	9	B	10	12	40	0	0	1	0	0	0	0	0
2003	9	C	10	12	0	0	0	0	0	0	0	0	0
2003	10	A	10	12	50	0	0	1	0	0	0	0	0
2003	10	B	10	12	0	0	0	0	0	0	0	0	0
2003	10	C	10	12	0	0	0	0	0	0	0	0	0
2004	0	A	10	3	0	0	0	0	0	0	0	0	0
2004	0	B	10	3	0	0	0	0	0	0	0	0	0
2004	0	C	10	3	0	0	0	0	0	0	0	0	0
2004	1	A	10	3	0	0	0	0	0	0	0	0	0
2004	1	B	10	3	0	0	0	0	0	0	0	0	0
2004	1	C	10	3	0	0	0	0	0	0	0	0	0
2004	2	A	10	3	0	0	0	0	0	0	0	0	0
2004	2	B	10	3	100	0	0	1	0	0	0	0	0
2004	2	C	10	3	0	0	0	0	0	0	0	0	0
2004	3	A	10	3	0	0	0	0	0	0	0	0	0
2004	3	B	10	3	0	0	0	0	0	0	0	0	0
2004	3	C	10	3	0	0	0	0	0	0	0	0	0
2004	4	A	10	3	0	0	0	0	0	0	0	0	0
2004	4	B	10	3	0	0	0	0	0	0	0	0	0
2004	4	C	10	3	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.8. (cont.) Kingman X10 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line.
Species data binary (presence 1/absence 0)

Year	At (m)	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Bidens	Polyg
2004	5	A	10	3	0	0	0	0	0	0	0	0	0
2004	5	B	10	3	0	0	0	0	0	0	0	0	0
2004	5	C	10	3	0	0	0	0	0	0	0	0	0
2004	6	A	10	3	0	0	0	0	0	0	0	0	0
2004	6	B	10	3	0	0	0	0	0	0	0	0	0
2004	6	C	10	3	0	0	0	0	0	0	0	0	0
2004	7	A	10	3	0	0	0	0	0	0	0	0	0
2004	7	B	10	3	0	0	0	0	0	0	0	0	0
2004	7	C	10	3	0	0	0	0	0	0	0	0	0
2004	8	A	10	3	0	0	0	0	0	0	0	0	0
2004	8	B	10	3	0	0	0	0	0	0	0	0	0
2004	8	C	10	3	0	0	0	0	0	0	0	0	0
2004	9	A	10	3	0	0	0	0	0	0	0	0	0
2004	9	B	10	3	0	0	0	0	0	0	0	0	0
2004	9	C	10	3	0	0	0	0	0	0	0	0	0
2004	10	A	10	3	0	0	0	0	0	0	0	0	0
2004	10	B	10	3	0	0	0	0	0	0	0	0	0
2004	10	C	10	3	0	0	0	0	0	0	0	0	0
2004	0	A	10	6	0	0	0	0	0	0	0	0	0
2004	0	B	10	6	0	0	0	0	0	0	0	0	0
2004	0	C	10	6	0	0	0	0	0	0	0	0	0
2004	1	A	10	6	0	0	0	0	0	0	0	0	0
2004	1	B	10	6	0	0	0	0	0	0	0	0	0
2004	1	C	10	6	0	0	0	0	0	0	0	0	0
2004	2	A	10	6	0	0	0	0	0	0	0	0	0
2004	2	B	10	6	0	0	0	0	0	0	0	0	0
2004	2	C	10	6	0	0	0	0	0	0	0	0	0
2004	3	A	10	6	0	0	0	0	0	0	0	0	0
2004	3	B	10	6	0	0	0	0	0	0	0	0	0
2004	3	C	10	6	0	0	0	0	0	0	0	0	0
2004	4	A	10	6	0	0	0	0	0	0	0	0	0
2004	4	B	10	6	0	0	0	0	0	0	0	0	0
2004	4	C	10	6	0	0	0	0	0	0	0	0	0
2004	5	A	10	6	0	0	0	0	0	0	0	0	0
2004	5	B	10	6	0	0	0	0	0	0	0	0	0
2004	5	C	10	6	0	0	0	0	0	0	0	0	0
2004	6	A	10	6	0	0	0	0	0	0	0	0	0
2004	6	B	10	6	0	0	0	0	0	0	0	0	0
2004	6	C	10	6	0	0	0	0	0	0	0	0	0
2004	7	A	10	6	0	0	0	0	0	0	0	0	0
2004	7	B	10	6	0	0	0	0	0	0	0	0	0
2004	7	C	10	6	0	0	0	0	0	0	0	0	0
2004	8	A	10	6	0	0	0	0	0	0	0	0	0
2004	8	B	10	6	0	0	0	0	0	0	0	0	0
2004	8	C	10	6	0	0	0	0	0	0	0	0	0
2004	9	A	10	6	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.8. (cont.) Kingman X10 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line.
Species data binary (presence 1/absence 0)

Year	At (m)	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Bidens	Polyg
2004	9	B	10	6	0	0	0	0	0	0	0	0	0
2004	9	C	10	6	0	0	0	0	0	0	0	0	0
2004	10	A	10	6	0	0	0	0	0	0	0	0	0
2004	10	B	10	6	0	0	0	0	0	0	0	0	0
2004	10	C	10	6	0	0	0	0	0	0	0	0	0
2004	0	A	10	9	0	0	0	0	0	0	0	0	0
2004	0	B	10	9	0	0	0	0	0	0	0	0	0
2004	0	C	10	9	0	0	0	0	0	0	0	0	0
2004	1	A	10	9	0	0	0	0	0	0	0	0	0
2004	1	B	10	9	0	0	0	0	0	0	0	0	0
2004	1	C	10	9	0	0	0	0	0	0	0	0	0
2004	2	A	10	9	0	0	0	0	0	0	0	0	0
2004	2	B	10	9	0	0	0	0	0	0	0	0	0
2004	2	C	10	9	0	0	0	0	0	0	0	0	0
2004	3	A	10	9	0	0	0	0	0	0	0	0	0
2004	3	B	10	9	0	0	0	0	0	0	0	0	0
2004	3	C	10	9	0	0	0	0	0	0	0	0	0
2004	4	A	10	9	0	0	0	0	0	0	0	0	0
2004	4	B	10	9	0	0	0	0	0	0	0	0	0
2004	4	C	10	9	0	0	0	0	0	0	0	0	0
2004	5	A	10	9	0	0	0	0	0	0	0	0	0
2004	5	B	10	9	0	0	0	0	0	0	0	0	0
2004	5	C	10	9	0	0	0	0	0	0	0	0	0
2004	6	A	10	9	0	0	0	0	0	0	0	0	0
2004	6	B	10	9	0	0	0	0	0	0	0	0	0
2004	6	C	10	9	0	0	0	0	0	0	0	0	0
2004	7	A	10	9	0	0	0	0	0	0	0	0	0
2004	7	B	10	9	0	0	0	0	0	0	0	0	0
2004	7	C	10	9	0	0	0	0	0	0	0	0	0
2004	8	A	10	9	0	0	0	0	0	0	0	0	0
2004	8	B	10	9	0	0	0	0	0	0	0	0	0
2004	8	C	10	9	0	0	0	0	0	0	0	0	0
2004	9	A	10	9	0	0	0	0	0	0	0	0	0
2004	9	B	10	9	0	0	0	0	0	0	0	0	0
2004	9	C	10	9	0	0	0	0	0	0	0	0	0
2004	10	A	10	9	0	0	0	0	0	0	0	0	0
2004	10	B	10	9	0	0	0	0	0	0	0	0	0
2004	10	C	10	9	0	0	0	0	0	0	0	0	0
2004	0	A	10	12	0	0	0	0	0	0	0	0	0
2004	0	B	10	12	0	0	0	0	0	0	0	0	0
2004	0	C	10	12	0	0	0	0	0	0	0	0	0
2004	1	A	10	12	0	0	0	0	0	0	0	0	0
2004	1	B	10	12	0	0	0	0	0	0	0	0	0
2004	1	C	10	12	0	0	0	0	0	0	0	0	0
2004	2	A	10	12	0	0	0	0	0	0	0	0	0
2004	2	B	10	12	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.8. (cont.) Kingman X10 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line.
Species data binary (presence 1/absence 0)

Year	At (m)	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Bidens	Polyg
2004	2	C	10	12	0	0	0	0	0	0	0	0	0
2004	3	A	10	12	0	0	0	0	0	0	0	0	0
2004	3	B	10	12	0	0	0	0	0	0	0	0	0
2004	3	C	10	12	0	0	0	0	0	0	0	0	0
2004	4	A	10	12	0	0	0	0	0	0	0	0	0
2004	4	B	10	12	0	0	0	0	0	0	0	0	0
2004	4	C	10	12	0	0	0	0	0	0	0	0	0
2004	5	A	10	12	70	0	0	0	1	0	0	0	0
2004	5	B	10	12	0	0	0	0	0	0	0	0	0
2004	5	C	10	12	0	0	0	0	0	0	0	0	0
2004	6	A	10	12	0	0	0	0	0	0	0	0	0
2004	6	B	10	12	65	0	0	0	1	0	0	0	0
2004	6	C	10	12	0	0	0	0	0	0	0	0	0
2004	7	A	10	12	0	0	0	0	0	0	0	0	0
2004	7	B	10	12	0	0	0	0	0	0	0	0	0
2004	7	C	10	12	0	0	0	0	0	0	0	0	0
2004	8	A	10	12	0	0	0	0	0	0	0	0	0
2004	8	B	10	12	0	0	0	0	0	0	0	0	0
2004	8	C	10	12	0	0	0	0	0	0	0	0	0
2004	9	A	10	12	90	0	0	0	1	0	0	0	0
2004	9	B	10	12	0	0	0	0	0	0	0	0	0
2004	9	C	10	12	0	0	0	0	0	0	0	0	0
2004	10	A	10	12	0	0	0	0	0	0	0	0	0
2004	10	B	10	12	0	0	0	0	0	0	0	0	0
2004	10	C	10	12	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2001	0	A	20	3	100	0	0	1	0	1	0	0	0	0
2001	0	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	0	C	20	3	50	0	1	0	0	0	0	0	0	0
2001	1	A	20	3	115	0	0	1	0	1	0	0	0	0
2001	1	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	1	C	20	3	0	0	0	0	0	0	0	0	0	0
2001	2	A	20	3	105	0	0	1	0	1	0	0	0	0
2001	2	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	2	C	20	3	0	0	0	0	0	0	0	0	0	0
2001	3	A	20	3	125	0	0	1	0	0	0	0	0	0
2001	3	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	3	C	20	3	35	0	1	0	0	0	0	0	0	0
2001	4	A	20	3	120	0	0	1	0	0	0	0	0	0
2001	4	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	4	C	20	3	40	0	1	0	0	0	0	0	0	0
2001	5	A	20	3	120	0	0	1	0	1	0	0	0	0
2001	5	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	5	C	20	3	65	0	1	0	0	0	0	0	0	0
2001	6	A	20	3	120	0	0	0	0	1	0	0	0	0
2001	6	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	6	C	20	3	75	0	1	0	0	1	0	0	0	0
2001	7	A	20	3	100	0	1	0	0	1	0	0	0	0
2001	7	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	7	C	20	3	80	0	1	0	0	0	0	0	0	0
2001	8	A	20	3	90	0	1	0	0	0	0	0	0	0
2001	8	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	8	C	20	3	80	0	0	0	0	1	0	0	0	0
2001	9	A	20	3	90	0	1	1	0	0	0	0	0	0
2001	9	B	20	3	45	0	1	0	0	0	0	0	0	0
2001	9	C	20	3	45	0	1	1	0	0	0	0	0	0
2001	10	A	20	3	90	0	1	0	0	0	0	0	0	0
2001	10	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	10	C	20	3	0	0	0	0	0	0	0	0	0	0
2001	11	A	20	3	100	0	1	1	0	0	0	0	0	0
2001	11	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	11	C	20	3	0	0	0	0	0	0	0	0	0	0
2001	12	A	20	3	80	0	0	0	0	1	0	0	0	0
2001	12	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	12	C	20	3	50	0	1	0	0	0	0	0	0	0
2001	13	A	20	3	55	0	1	0	0	1	0	0	0	0
2001	13	B	20	3	50	0	0	1	0	0	0	0	0	0
2001	13	C	20	3	40	0	1	0	0	0	0	0	0	0
2001	14	A	20	3	0	0	0	0	0	0	0	0	0	0
2001	14	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	14	C	20	3	40	0	1	0	0	0	0	0	0	0
2001	15	A	20	3	50	0	0	0	1	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2001	15	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	15	C	20	3	40	0	1	0	0	0	0	0	0	0
2001	16	A	20	3	0	0	0	0	0	0	0	0	0	0
2001	16	B	20	3	50	0	0	0	0	1	0	0	0	0
2001	16	C	20	3	40	0	1	0	0	0	0	0	0	0
2001	17	A	20	3	0	0	0	0	0	0	0	0	0	0
2001	17	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	17	C	20	3	40	0	1	0	0	0	0	0	0	0
2001	18	A	20	3	0	0	0	0	0	0	0	0	0	0
2001	18	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	18	C	20	3	45	0	1	0	0	0	0	0	0	0
2001	19	A	20	3	0	0	0	0	0	0	0	0	0	0
2001	19	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	19	C	20	3	40	0	1	0	0	0	0	0	0	0
2001	20	A	20	3	0	0	0	0	0	0	0	0	0	0
2001	20	B	20	3	0	0	0	0	0	0	0	0	0	0
2001	20	C	20	3	0	0	0	0	0	0	0	0	0	0
2001	0	A	20	6	50	0	1	0	0	0	0	0	0	0
2001	0	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	0	C	20	6	0	0	0	0	0	0	0	0	0	0
2001	1	A	20	6	100	0	0	0	0	0	0	1	0	0
2001	1	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	1	C	20	6	40	0	1	0	0	0	0	0	0	0
2001	2	A	20	6	100	0	0	1	0	1	0	0	0	0
2001	2	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	2	C	20	6	40	0	1	0	0	0	0	0	0	0
2001	3	A	20	6	100	0	1	0	0	0	0	0	0	0
2001	3	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	3	C	20	6	0	0	0	0	0	0	0	0	0	0
2001	4	A	20	6	105	0	1	1	0	0	0	0	0	0
2001	4	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	4	C	20	6	60	0	1	0	0	1	0	0	0	0
2001	5	A	20	6	130	0	1	1	0	1	0	0	0	0
2001	5	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	5	C	20	6	50	0	1	0	0	0	0	0	0	0
2001	6	A	20	6	95	0	0	1	0	0	0	0	1	0
2001	6	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	6	C	20	6	70	0	1	0	0	1	0	0	0	0
2001	7	A	20	6	65	0	0	1	0	1	0	0	0	0
2001	7	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	7	C	20	6	75	0	1	0	0	1	0	0	0	0
2001	8	A	20	6	70	0	1	0	0	0	0	0	0	0
2001	8	B	20	6	50	0	1	0	0	0	0	0	0	0
2001	8	C	20	6	65	0	1	0	0	1	0	0	0	0
2001	9	A	20	6	60	0	1	0	0	0	0	0	0	0
2001	9	B	20	6	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2001	9	C	20	6	55	0	1	0	0	0	0	0	0	0
2001	10	A	20	6	0	0	0	0	0	0	0	0	0	0
2001	10	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	10	C	20	6	0	0	0	0	0	0	0	0	0	0
2001	11	A	20	6	50	0	1	0	0	0	0	0	0	0
2001	11	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	11	C	20	6	0	0	0	0	0	0	0	0	0	0
2001	12	A	20	6	60	0	1	0	0	0	0	0	0	0
2001	12	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	12	C	20	6	0	0	0	0	0	0	0	0	0	0
2001	13	A	20	6	0	0	0	0	0	0	0	0	0	0
2001	13	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	13	C	20	6	0	0	0	0	0	0	0	0	0	0
2001	14	A	20	6	55	0	1	0	0	0	0	0	0	0
2001	14	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	14	C	20	6	30	0	0	1	0	0	0	0	0	0
2001	15	A	20	6	0	0	0	0	0	0	0	0	0	0
2001	15	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	15	C	20	6	25	0	1	0	0	0	0	0	0	0
2001	16	A	20	6	0	0	0	0	0	0	0	0	0	0
2001	16	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	16	C	20	6	0	0	0	0	0	0	0	0	0	0
2001	17	A	20	6	0	0	0	0	0	0	0	0	0	0
2001	17	B	20	6	50	0	1	0	0	0	0	0	0	0
2001	17	C	20	6	40	0	1	0	0	0	0	0	0	0
2001	18	A	20	6	55	0	1	0	0	0	0	0	0	0
2001	18	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	18	C	20	6	40	0	0	0	0	1	0	0	0	0
2001	19	A	20	6	0	0	0	0	0	0	0	0	0	0
2001	19	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	19	C	20	6	20	0	1	0	0	0	0	0	0	0
2001	20	A	20	6	0	0	0	0	0	0	0	0	0	0
2001	20	B	20	6	0	0	0	0	0	0	0	0	0	0
2001	20	C	20	6	0	0	0	0	0	0	0	0	0	0
2001	0	A	20	9	85	0	1	0	0	0	0	0	0	0
2001	0	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	0	C	20	9	0	0	0	0	0	0	0	0	0	0
2001	1	A	20	9	75	0	1	1	0	1	0	0	0	0
2001	1	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	1	C	20	9	0	0	0	0	0	0	0	0	0	0
2001	2	A	20	9	85	0	1	1	0	0	0	0	0	0
2001	2	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	2	C	20	9	0	0	0	0	0	0	0	0	0	0
2001	3	A	20	9	75	0	1	0	0	0	0	0	0	0
2001	3	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	3	C	20	9	75	0	1	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2001	4	A	20	9	0	0	1	0	0	0	0	0	0	0
2001	4	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	4	C	20	9	80	0	1	0	0	0	0	0	0	0
2001	5	A	20	9	65	0	1	0	0	0	0	0	0	0
2001	5	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	5	C	20	9	75	0	1	0	0	0	0	0	0	0
2001	6	A	20	9	80	0	1	0	0	1	0	0	0	0
2001	6	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	6	C	20	9	80	0	1	0	0	0	0	0	0	0
2001	7	A	20	9	75	0	1	0	0	0	0	0	0	0
2001	7	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	7	C	20	9	80	0	1	1	0	1	0	0	0	0
2001	8	A	20	9	80	0	1	0	0	0	0	0	0	0
2001	8	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	8	C	20	9	80	0	1	0	0	1	0	0	0	0
2001	9	A	20	9	75	0	1	0	0	0	0	0	0	0
2001	9	B	20	9	80	0	0	0	0	1	0	0	0	0
2001	9	C	20	9	70	0	0	1	0	1	0	0	0	0
2001	10	A	20	9	75	0	1	0	0	0	0	0	0	0
2001	10	B	20	9	60	0	0	0	0	1	0	0	0	0
2001	10	C	20	9	50	0	0	1	0	1	0	0	0	0
2001	11	A	20	9	65	0	1	0	0	0	0	0	0	0
2001	11	B	20	9	45	0	1	0	0	0	0	0	0	0
2001	11	C	20	9	70	0	1	0	0	1	0	0	0	0
2001	12	A	20	9	85	0	0	1	0	0	0	0	0	0
2001	12	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	12	C	20	9	0	0	0	0	0	0	0	0	0	0
2001	13	A	20	9	95	0	0	1	0	0	0	0	0	0
2001	13	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	13	C	20	9	0	0	0	0	0	0	0	0	0	0
2001	14	A	20	9	80	0	0	1	0	0	0	0	0	0
2001	14	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	14	C	20	9	120	0	0	1	0	1	0	0	0	0
2001	15	A	20	9	80	0	0	1	0	0	0	0	0	0
2001	15	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	15	C	20	9	120	0	0	0	0	1	0	0	0	0
2001	16	A	20	9	75	0	1	0	0	0	0	0	0	0
2001	16	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	16	C	20	9	80	0	0	0	0	1	0	0	0	0
2001	17	A	20	9	80	0	1	0	0	0	0	0	0	0
2001	17	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	17	C	20	9	0	0	0	0	0	0	0	0	0	0
2001	18	A	20	9	75	0	1	0	0	0	0	0	0	0
2001	18	B	20	9	40	0	1	0	0	0	0	0	0	0
2001	18	C	20	9	65	0	1	0	0	1	0	0	0	0
2001	19	A	20	9	65	0	0	1	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2001	19	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	19	C	20	9	0	0	0	0	0	0	0	0	0	0
2001	20	A	20	9	0	0	0	0	0	0	0	0	0	0
2001	20	B	20	9	0	0	0	0	0	0	0	0	0	0
2001	20	C	20	9	0	0	0	0	0	0	0	0	0	0
2001	0	A	20	12	0	0	0	0	0	0	0	0	0	0
2001	0	B	20	12	0	0	0	0	0	0	0	0	0	0
2001	0	C	20	12	0	0	0	0	0	0	0	0	0	0
2001	1	A	20	12	75	0	1	0	0	0	0	0	0	0
2001	1	B	20	12	0	0	0	0	0	0	0	0	0	0
2001	1	C	20	12	0	0	0	0	0	0	0	0	0	0
2001	2	A	20	12	75	0	1	0	0	0	0	0	0	0
2001	2	B	20	12	0	0	0	0	0	0	0	0	0	0
2001	2	C	20	12	0	0	0	0	0	0	0	0	0	0
2001	3	A	20	12	70	0	1	0	0	0	0	0	0	0
2001	3	B	20	12	60	0	1	0	0	0	0	0	0	0
2001	3	C	20	12	70	0	1	0	0	1	0	0	0	0
2001	4	A	20	12	60	0	0	0	1	0	0	0	0	0
2001	4	B	20	12	0	0	0	0	0	0	0	0	0	0
2001	4	C	20	12	60	0	1	0	0	0	0	0	0	0
2001	5	A	20	12	60	0	1	0	0	0	0	0	0	0
2001	5	B	20	12	0	0	0	0	0	0	0	0	0	0
2001	5	C	20	12	70	0	1	0	0	0	0	0	0	0
2001	6	A	20	12	75	0	1	0	0	0	0	0	0	0
2001	6	B	20	12	75	0	1	1	0	0	0	0	0	0
2001	6	C	20	12	75	0	1	0	0	0	0	0	0	0
2001	7	A	20	12	60	0	1	0	0	0	0	0	0	0
2001	7	B	20	12	55	0	1	1	0	0	0	0	0	1
2001	7	C	20	12	65	0	1	1	0	1	0	0	0	0
2001	8	A	20	12	60	0	1	0	0	0	0	0	0	0
2001	8	B	20	12	60	0	1	0	0	0	0	0	0	0
2001	8	C	20	12	65	0	0	1	0	1	0	0	0	0
2001	9	A	20	12	55	0	1	0	0	0	0	0	0	0
2001	9	B	20	12	80	0	1	0	0	0	0	0	0	0
2001	9	C	20	12	0	0	0	0	0	0	0	0	0	0
2001	10	A	20	12	80	0	1	0	0	0	0	0	0	0
2001	10	B	20	12	75	0	1	0	0	1	0	0	0	0
2001	10	C	20	12	85	0	0	0	0	1	0	0	0	0
2001	11	A	20	12	75	0	1	0	0	0	0	0	0	0
2001	11	B	20	12	0	0	0	0	0	0	0	0	0	0
2001	11	C	20	12	90	0	0	1	0	1	0	0	0	0
2001	12	A	20	12	75	0	1	0	0	0	0	0	0	0
2001	12	B	20	12	70	0	1	0	0	0	0	0	0	0
2001	12	C	20	12	50	0	1	0	0	0	0	0	0	0
2001	13	A	20	12	75	0	1	0	0	0	0	0	0	0
2001	13	B	20	12	65	0	1	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2001	13	C	20	12	0	0	0	0	0	0	0	0	0	0
2001	14	A	20	12	80	0	1	1	0	0	0	0	0	0
2001	14	B	20	12	0	0	0	0	0	0	0	0	0	0
2001	14	C	20	12	130	0	0	0	0	1	0	0	0	0
2001	15	A	20	12	50	0	1	0	0	0	0	0	0	0
2001	15	B	20	12	70	0	1	0	0	0	0	0	0	1
2001	15	C	20	12	70	0	0	0	0	1	0	0	0	0
2001	16	A	20	12	70	0	1	0	0	0	0	0	0	0
2001	16	B	20	12	80	0	0	0	0	1	0	0	0	0
2001	16	C	20	12	60	0	1	0	0	0	0	0	0	0
2001	17	A	20	12	75	0	1	0	0	0	1	0	0	0
2001	17	B	20	12	55	0	1	0	0	0	0	0	0	0
2001	17	C	20	12	70	0	1	0	0	0	0	0	0	0
2001	18	A	20	12	85	0	1	1	0	0	0	0	0	0
2001	18	B	20	12	85	0	0	0	0	1	0	0	0	0
2001	18	C	20	12	0	0	0	0	0	0	0	0	0	0
2001	19	A	20	12	50	0	1	0	0	0	0	0	0	0
2001	19	B	20	12	50	0	0	0	0	1	0	0	0	0
2001	19	C	20	12	0	0	0	0	0	0	0	0	0	0
2001	20	A	20	12	0	0	0	0	0	0	0	0	0	0
2001	20	B	20	12	0	0	0	0	0	0	0	0	0	0
2001	20	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	0	A	20	3	150	0	0	1	0	0	0	0	0	0
2002	0	B	20	3	0	0	0	0	0	0	0	0	0	0
2002	0	C	20	3	40	0	0	0	0	0	1	0	0	0
2002	1	A	20	3	120	0	0	1	0	0	0	0	0	0
2002	1	B	20	3	0	0	0	0	0	0	0	0	0	0
2002	1	C	20	3	40	0	1	0	0	0	1	0	0	0
2002	2	A	20	3	100	0	0	1	0	0	0	0	0	0
2002	2	B	20	3	0	0	0	0	0	0	0	0	0	0
2002	2	C	20	3	20	0	0	0	0	0	1	0	0	0
2002	3	A	20	3	100	0	0	1	0	0	0	0	0	0
2002	3	B	20	3	0	0	0	0	0	0	0	0	0	0
2002	3	C	20	3	20	0	0	0	0	0	1	0	0	0
2002	4	A	20	3	100	0	0	1	0	0	0	0	0	0
2002	4	B	20	3	5	0	0	0	0	0	1	0	0	0
2002	4	C	20	3	35	0	1	0	0	1	1	0	0	0
2002	5	A	20	3	120	0	0	1	0	0	0	0	0	0
2002	5	B	20	3	20	0	0	0	0	0	1	0	0	0
2002	5	C	20	3	35	0	1	0	0	0	0	0	0	0
2002	6	A	20	3	110	0	0	1	0	0	0	0	0	0
2002	6	B	20	3	25	0	0	0	0	0	1	0	0	0
2002	6	C	20	3	35	0	1	0	0	0	0	0	0	0
2002	7	A	20	3	120	0	0	1	0	0	0	0	0	0
2002	7	B	20	3	35	0	0	0	0	0	1	0	0	0
2002	7	C	20	3	40	0	1	0	0	1	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2002	8	A	20	3	80	0	0	1	0	0	0	0	0	0
2002	8	B	20	3	45	0	1	0	0	0	0	0	0	0
2002	8	C	20	3	35	0	1	0	0	0	0	0	0	0
2002	9	A	20	3	70	0	0	0	1	0	0	0	0	0
2002	9	B	20	3	60	0	0	0	0	1	0	0	0	0
2002	9	C	20	3	0	0	0	0	0	0	0	0	0	0
2002	10	A	20	3	30	0	0	0	1	0	0	0	0	0
2002	10	B	20	3	75	0	0	1	0	0	0	0	0	0
2002	10	C	20	3	35	0	1	0	0	0	0	0	0	0
2002	11	A	20	3	60	0	0	0	1	0	0	0	0	0
2002	11	B	20	3	80	0	0	1	0	0	0	0	0	0
2002	11	C	20	3	40	0	1	0	0	0	0	0	0	0
2002	12	A	20	3	35	0	0	1	0	0	0	0	0	0
2002	12	B	20	3	75	0	0	1	0	0	0	0	0	0
2002	12	C	20	3	50	0	1	0	0	0	0	0	0	0
2002	13	A	20	3	30	0	0	1	0	0	0	0	0	0
2002	13	B	20	3	90	0	0	1	0	0	0	0	0	0
2002	13	C	20	3	35	0	1	0	0	0	0	0	0	0
2002	14	A	20	3	50	0	0	1	1	0	0	0	0	0
2002	14	B	20	3	80	0	0	1	0	0	0	0	0	0
2002	14	C	20	3	40	0	1	0	0	0	0	0	0	0
2002	15	A	20	3	45	0	0	0	1	0	0	0	0	0
2002	15	B	20	3	75	0	0	1	0	0	0	0	0	0
2002	15	C	20	3	45	0	1	0	0	0	0	0	0	0
2002	16	A	20	3	70	0	0	0	1	0	0	0	0	0
2002	16	B	20	3	40	0	0	1	0	0	0	0	0	0
2002	16	C	20	3	25	0	1	0	0	0	0	0	0	0
2002	17	A	20	3	55	0	0	1	0	0	0	0	0	0
2002	17	B	20	3	25	0	0	0	0	0	1	0	0	0
2002	17	C	20	3	40	0	1	0	0	0	0	0	0	0
2002	18	A	20	3		0	0	0	0	0	0	0	0	0
2002	18	B	20	3	20	0	0	0	0	0	1	0	0	0
2002	18	C	20	3	40	0	1	0	0	0	0	0	0	0
2002	19	A	20	3	65	0	0	1	0	0	0	0	0	0
2002	19	B	20	3	20	0	0	0	0	0	1	0	0	0
2002	19	C	20	3	50	0	1	0	0	0	0	0	0	0
2002	20	A	20	3	0	0	0	0	0	0	0	0	0	0
2002	20	B	20	3	50	0	0	0	0	0	1	0	0	0
2002	20	C	20	3	0	0	0	0	0	0	0	0	0	0
2002	0	A	20	6	170	0	0	1	0	0	0	1	0	0
2002	0	B	20	6	0	0	0	0	0	0	0	0	0	0
2002	0	C	20	6	0	0	0	0	0	0	0	0	0	0
2002	1	A	20	6	160	0	0	1	0	0	0	1	0	0
2002	1	B	20	6	0	0	0	0	0	0	0	0	0	0
2002	1	C	20	6	40	0	1	0	0	0	0	0	0	0
2002	2	A	20	6	130	0	0	1	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2002	2	B	20	6	0	0	0	0	0	0	0	0	0	0
2002	2	C	20	6	50	0	1	0	0	0	0	0	0	0
2002	3	A	20	6	130	0	0	1	0	0	0	0	0	0
2002	3	B	20	6	0	0	0	0	0	0	0	0	0	0
2002	3	C	20	6	0	0	0	0	0	0	0	0	0	0
2002	4	A	20	6	125	0	0	1	0	0	0	0	0	0
2002	4	B	20	6	0	0	0	0	0	0	0	0	0	0
2002	4	C	20	6	0	0	0	0	0	0	0	0	0	0
2002	5	A	20	6	110	0	0	1	0	0	0	0	0	0
2002	5	B	20	6	20	0	0	0	0	0	1	0	0	0
2002	5	C	20	6	40	0	1	0	0	0	0	0	0	0
2002	6	A	20	6	125	0	0	1	0	0	0	0	0	0
2002	6	B	20	6	20	0	0	0	0	0	1	0	0	0
2002	6	C	20	6	40	0	1	0	0	0	0	0	0	0
2002	7	A	20	6	90	0	0	1	0	0	0	0	0	0
2002	7	B	20	6	30	0	0	0	0	0	1	0	0	0
2002	7	C	20	6	45	0	1	0	0	0	0	0	0	0
2002	8	A	20	6	55	0	0	1	0	0	0	0	0	0
2002	8	B	20	6	35	0	1	0	0	0	0	0	0	0
2002	8	C	20	6	30	0	1	0	0	0	0	0	0	0
2002	9	A	20	6	45	0	0	1	0	0	0	0	0	0
2002	9	B	20	6	30	0	0	0	0	0	1	0	0	0
2002	9	C	20	6	40	0	1	0	0	0	0	0	0	0
2002	10	A	20	6	35	0	0	1	0	0	0	0	0	0
2002	10	B	20	6	40	0	0	0	0	0	1	0	0	0
2002	10	C	20	6	0	0	0	0	0	0	0	0	0	0
2002	11	A	20	6	0	0	0	0	0	0	0	0	0	0
2002	11	B	20	6	55	0	0	0	0	0	1	0	0	0
2002	11	C	20	6	0	0	0	0	0	0	0	0	0	0
2002	12	A	20	6	35	0	0	1	0	0	0	0	0	0
2002	12	B	20	6	20	0	0	0	0	0	1	0	0	0
2002	12	C	20	6	0	0	0	0	0	0	0	0	0	0
2002	13	A	20	6	25	0	0	1	0	0	0	0	0	0
2002	13	B	20	6	85	0	0	1	0	0	0	0	0	0
2002	13	C	20	6	0	0	0	0	0	0	0	0	0	0
2002	14	A	20	6	25	0	0	1	0	0	0	0	0	0
2002	14	B	20	6	90	0	0	1	0	0	0	0	0	0
2002	14	C	20	6	30	0	1	0	0	0	0	0	0	0
2002	15	A	20	6	0	0	0	0	0	0	0	0	0	0
2002	15	B	20	6	55	0	0	1	0	0	0	0	0	0
2002	15	C	20	6	35	0	1	0	0	0	0	0	0	0
2002	16	A	20	6	30	0	0	1	0	0	0	0	0	0
2002	16	B	20	6	50	0	0	0	0	0	1	0	0	0
2002	16	C	20	6	0	0	0	0	0	0	0	0	0	0
2002	17	A	20	6	50	0	0	1	0	0	0	0	0	0
2002	17	B	20	6	50	0	0	0	0	0	1	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2002	17	C	20	6	35	0	1	0	0	0	0	0	0	0
2002	18	A	20	6	80	0	0	1	0	0	0	0	0	0
2002	18	B	20	6	55	0	0	0	0	0	1	0	0	0
2002	18	C	20	6	45	0	0	0	0	1	0	0	0	0
2002	19	A	20	6	100	0	0	1	1	0	0	0	0	0
2002	19	B	20	6	30	0	0	0	0	0	1	0	0	0
2002	19	C	20	6	40	0	1	0	0	0	0	0	0	0
2002	20	A	20	6	90	0	0	1	0	0	0	0	0	0
2002	20	B	20	6	60	0	0	0	0	0	1	0	0	0
2002	20	C	20	6	0	0	0	0	0	0	0	0	0	0
2002	0	A	20	9	100	0	0	1	0	0	0	0	0	0
2002	0	B	20	9	0	0	0	0	0	0	0	0	0	0
2002	0	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	1	A	20	9	90	0	0	1	0	0	0	0	0	0
2002	1	B	20	9	0	0	0	0	0	0	0	0	0	0
2002	1	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	2	A	20	9	55	0	0	1	0	0	0	0	0	0
2002	2	B	20	9	2	0	0	0	0	0	1	0	0	0
2002	2	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	3	A	20	9	85	0	0	1	0	0	0	0	0	0
2002	3	B	20	9	40	0	0	1	0	0	0	0	0	0
2002	3	C	20	9	35	0	1	0	0	0	0	0	0	0
2002	4	A	20	9	60	0	0	1	0	0	0	0	0	0
2002	4	B	20	9	50	0	0	1	0	0	0	0	0	0
2002	4	C	20	9	35	0	1	0	0	0	0	0	0	0
2002	5	A	20	9	45	0	0	1	0	0	0	0	0	0
2002	5	B	20	9	40	0	0	1	0	0	0	0	0	0
2002	5	C	20	9	45	0	1	0	0	0	0	0	0	0
2002	6	A	20	9	45	0	0	1	0	0	0	0	0	0
2002	6	B	20	9	35	0	0	1	0	0	0	0	0	0
2002	6	C	20	9	40	0	1	0	0	0	0	0	0	0
2002	7	A	20	9	50	0	0	1	0	0	0	0	0	0
2002	7	B	20	9	35	0	0	1	0	0	0	0	0	0
2002	7	C	20	9	25	0	1	0	0	0	0	0	0	0
2002	8	A	20	9	0	0	0	0	0	0	0	0	0	0
2002	8	B	20	9	30	0	0	1	0	0	0	0	0	0
2002	8	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	9	A	20	9	30	0	0	1	0	0	0	0	0	0
2002	9	B	20	9	40	0	1	0	0	0	0	0	0	0
2002	9	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	10	A	20	9	50	0	0	1	0	0	0	0	0	0
2002	10	B	20	9	0	0	0	0	0	0	0	0	0	0
2002	10	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	11	A	20	9	0	0	0	0	0	0	0	0	0	0
2002	11	B	20	9	40	0	1	0	0	0	0	0	0	0
2002	11	C	20	9	30	0	1	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2002	12	A	20	9	0	0	0	0	0	0	0	0	0	0
2002	12	B	20	9	0	0	0	0	0	0	0	0	0	0
2002	12	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	13	A	20	9	25	0	0	1	0	0	0	0	0	0
2002	13	B	20	9	0	0	0	0	0	0	0	0	0	0
2002	13	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	14	A	20	9	35	0	0	1	0	0	0	0	0	0
2002	14	B	20	9	20	0	0	0	0	0	1	0	0	0
2002	14	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	15	A	20	9	30	0	0	1	0	0	0	0	0	0
2002	15	B	20	9	25	0	0	0	0	0	1	0	0	0
2002	15	C	20	9	55	0	0	0	0	1	0	0	0	0
2002	16	A	20	9	40	0	0	1	0	0	0	0	0	0
2002	16	B	20	9	30	0	0	0	0	0	1	0	0	0
2002	16	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	17	A	20	9	50	0	0	1	0	0	0	0	0	0
2002	17	B	20	9	40	0	0	0	0	0	1	0	0	0
2002	17	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	18	A	20	9	100	0	0	1	0	0	0	0	0	0
2002	18	B	20	9	50	0	1	0	0	0	0	0	0	0
2002	18	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	19	A	20	9	110	0	0	1	0	0	0	0	0	0
2002	19	B	20	9	30	0	0	0	0	0	1	0	0	0
2002	19	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	20	A	20	9	110	0	0	1	0	0	0	0	0	0
2002	20	B	20	9	70	0	0	0	0	0	1	0	0	0
2002	20	C	20	9	0	0	0	0	0	0	0	0	0	0
2002	0	A	20	12	45	0	0	0	0	0	1	0	0	0
2002	0	B	20	12	0	0	0	0	0	0	0	0	0	0
2002	0	C	20	12	35	0	1	0	0	0	0	0	0	0
2002	1	A	20	12	55	0	1	0	0	0	1	0	0	0
2002	1	B	20	12	0	0	0	0	0	0	0	0	0	0
2002	1	C	20	12	45	0	1	0	0	0	0	0	0	0
2002	2	A	20	12	55	0	0	0	0	1	1	0	0	0
2002	2	B	20	12	35	0	0	1	0	0	0	0	0	0
2002	2	C	20	12	45	0	1	0	0	0	0	0	0	0
2002	3	A	20	12	35	0	0	0	0	0	1	0	0	0
2002	3	B	20	12	30	0	0	1	0	0	0	0	0	0
2002	3	C	20	12	40	0	1	0	0	0	0	0	0	0
2002	4	A	20	12	20	0	0	0	0	0	1	0	0	0
2002	4	B	20	12	65	0	0	1	0	0	0	0	0	0
2002	4	C	20	12	45	0	1	0	0	0	0	0	0	0
2002	5	A	20	12	0	0	0	0	0	0	0	0	0	0
2002	5	B	20	12	35	0	0	1	0	0	0	0	0	0
2002	5	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	6	A	20	12	40	0	1	0	0	0	1	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2002	6	B	20	12	30	0	0	1	0	0	0	0	0	0
2002	6	C	20	12	35	0	1	0	0	0	0	0	0	0
2002	7	A	20	12	20	0	0	0	0	0	1	0	0	0
2002	7	B	20	12	30	0	0	1	0	0	0	0	0	0
2002	7	C	20	12	50	0	1	0	0	0	0	0	0	0
2002	8	A	20	12	45	0	1	0	0	1	1	0	0	0
2002	8	B	20	12	25	0	0	1	0	0	0	0	0	0
2002	8	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	9	A	20	12	80	0	1	0	0	0	0	0	0	0
2002	9	B	20	12	40	0	1	0	0	0	0	0	0	0
2002	9	C	20	12	30	0	1	0	0	0	0	0	0	0
2002	10	A	20	12	25	0	0	0	0	0	1	0	0	0
2002	10	B	20	12	120	0	1	0	0	0	0	0	0	0
2002	10	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	11	A	20	12	30	0	0	0	0	1	1	0	0	0
2002	11	B	20	12	35	0	1	0	0	0	0	0	0	0
2002	11	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	12	A	20	12	35	0	0	1	0	0	1	0	0	0
2002	12	B	20	12	40	0	1	0	0	0	0	0	0	0
2002	12	C	20	12	35	0	1	0	0	0	0	0	0	0
2002	13	A	20	12	85	0	0	1	0	0	1	0	0	0
2002	13	B	20	12	35	0	1	0	0	0	0	0	0	0
2002	13	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	14	A	20	12	120	0	0	1	0	0	0	0	0	0
2002	14	B	20	12	0	0	0	0	0	0	0	0	0	0
2002	14	C	20	12	70	0	0	0	0	1	0	0	0	0
2002	15	A	20	12	140	0	0	1	0	0	0	0	0	0
2002	15	B	20	12	35	0	1	0	0	0	0	0	0	0
2002	15	C	20	12	40	0	1	0	0	0	0	0	0	0
2002	16	A	20	12	120	0	0	1	0	0	0	0	0	0
2002	16	B	20	12	40	0	1	0	0	0	0	0	0	0
2002	16	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	17	A	20	12	75	0	0	1	0	0	0	0	0	0
2002	17	B	20	12	30	0	1	0	0	1	0	0	0	0
2002	17	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	18	A	20	12	45	0	0	1	0	0	0	0	0	0
2002	18	B	20	12	0	0	0	0	0	0	0	0	0	0
2002	18	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	19	A	20	12	100	0	0	1	0	0	0	0	0	0
2002	19	B	20	12	10	0	0	0	0	0	1	0	0	0
2002	19	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	20	A	20	12	100	0	0	1	0	0	0	0	0	0
2002	20	B	20	12	50	0	1	0	0	0	1	0	0	1
2002	20	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	0	A	20	3	200	0	0	0	0	0	0	1	0	0
2003	0	B	20	3	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2002	6	B	20	12	30	0	0	1	0	0	0	0	0	0
2002	6	C	20	12	35	0	1	0	0	0	0	0	0	0
2002	7	A	20	12	20	0	0	0	0	0	1	0	0	0
2002	7	B	20	12	30	0	0	1	0	0	0	0	0	0
2002	7	C	20	12	50	0	1	0	0	0	0	0	0	0
2002	8	A	20	12	45	0	1	0	0	1	1	0	0	0
2002	8	B	20	12	25	0	0	1	0	0	0	0	0	0
2002	8	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	9	A	20	12	80	0	1	0	0	0	0	0	0	0
2002	9	B	20	12	40	0	1	0	0	0	0	0	0	0
2002	9	C	20	12	30	0	1	0	0	0	0	0	0	0
2002	10	A	20	12	25	0	0	0	0	0	1	0	0	0
2002	10	B	20	12	120	0	1	0	0	0	0	0	0	0
2002	10	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	11	A	20	12	30	0	0	0	0	1	1	0	0	0
2002	11	B	20	12	35	0	1	0	0	0	0	0	0	0
2002	11	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	12	A	20	12	35	0	0	1	0	0	1	0	0	0
2002	12	B	20	12	40	0	1	0	0	0	0	0	0	0
2002	12	C	20	12	35	0	1	0	0	0	0	0	0	0
2002	13	A	20	12	85	0	0	1	0	0	1	0	0	0
2002	13	B	20	12	35	0	1	0	0	0	0	0	0	0
2002	13	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	14	A	20	12	120	0	0	1	0	0	0	0	0	0
2002	14	B	20	12	0	0	0	0	0	0	0	0	0	0
2002	14	C	20	12	70	0	0	0	0	1	0	0	0	0
2002	15	A	20	12	140	0	0	1	0	0	0	0	0	0
2002	15	B	20	12	35	0	1	0	0	0	0	0	0	0
2002	15	C	20	12	40	0	1	0	0	0	0	0	0	0
2002	16	A	20	12	120	0	0	1	0	0	0	0	0	0
2002	16	B	20	12	40	0	1	0	0	0	0	0	0	0
2002	16	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	17	A	20	12	75	0	0	1	0	0	0	0	0	0
2002	17	B	20	12	30	0	1	0	0	1	0	0	0	0
2002	17	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	18	A	20	12	45	0	0	1	0	0	0	0	0	0
2002	18	B	20	12	0	0	0	0	0	0	0	0	0	0
2002	18	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	19	A	20	12	100	0	0	1	0	0	0	0	0	0
2002	19	B	20	12	10	0	0	0	0	0	1	0	0	0
2002	19	C	20	12	0	0	0	0	0	0	0	0	0	0
2002	20	A	20	12	100	0	0	1	0	0	0	0	0	0
2002	20	B	20	12	50	0	1	0	0	0	1	0	0	1
2002	20	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	0	A	20	3	200	0	0	0	0	0	0	1	0	0
2003	0	B	20	3	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2003	0	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	1	A	20	3	130	0	0	1	0	0	0	0	0	0
2003	1	B	20	3	0	0	0	0	0	0	0	0	0	0
2003	1	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	2	A	20	3	150	0	0	1	0	0	0	0	0	0
2003	2	B	20	3	0	0	0	0	0	0	0	0	0	0
2003	2	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	3	A	20	3	150	0	0	1	0	0	0	0	0	0
2003	3	B	20	3	0	0	0	0	0	0	0	0	0	0
2003	3	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	4	A	20	3	150	0	0	1	0	0	0	0	0	0
2003	4	B	20	3	0	0	0	0	0	0	0	0	0	0
2003	4	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	5	A	20	3	140	0	0	1	0	0	0	0	0	0
2003	5	B	20	3	25	0	0	1	0	0	0	0	0	0
2003	5	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	6	A	20	3	60	0	0	1	0	0	0	0	0	0
2003	6	B	20	3	30	0	1	0	0	0	0	0	0	0
2003	6	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	7	A	20	3	65	0	0	1	0	0	0	0	0	0
2003	7	B	20	3	20	0	0	1	0	0	0	0	0	0
2003	7	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	8	A	20	3	100	0	0	1	0	0	0	0	0	0
2003	8	B	20	3	45	0	1	1	0	0	0	0	0	0
2003	8	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	9	A	20	3	100	0	0	1	0	0	0	0	0	0
2003	9	B	20	3	55	0	0	1	0	0	0	0	0	0
2003	9	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	10	A	20	3	100	0	0	1	0	0	0	0	0	0
2003	10	B	20	3	100	0	0	1	0	0	0	0	0	0
2003	10	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	11	A	20	3	85	0	0	0	1	0	0	0	0	0
2003	11	B	20	3	60	0	0	1	0	0	0	0	0	0
2003	11	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	12	A	20	3	85	0	0	1	1	0	0	0	0	0
2003	12	B	20	3	70	0	0	1	0	0	0	0	0	0
2003	12	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	13	A	20	3	50	0	0	1	1	0	0	0	0	0
2003	13	B	20	3	50	0	0	1	0	0	0	0	0	0
2003	13	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	14	A	20	3	50	0	0	1	1	0	0	0	0	0
2003	14	B	20	3	0	0	0	0	0	0	0	0	0	0
2003	14	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	15	A	20	3	50	0	0	1	1	0	0	0	0	0
2003	15	B	20	3	65	0	0	1	0	0	0	0	0	0
2003	15	C	20	3	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2003	0	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	1	A	20	3	130	0	0	1	0	0	0	0	0	0
2003	1	B	20	3	0	0	0	0	0	0	0	0	0	0
2003	1	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	2	A	20	3	150	0	0	1	0	0	0	0	0	0
2003	2	B	20	3	0	0	0	0	0	0	0	0	0	0
2003	2	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	3	A	20	3	150	0	0	1	0	0	0	0	0	0
2003	3	B	20	3	0	0	0	0	0	0	0	0	0	0
2003	3	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	4	A	20	3	150	0	0	1	0	0	0	0	0	0
2003	4	B	20	3	0	0	0	0	0	0	0	0	0	0
2003	4	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	5	A	20	3	140	0	0	1	0	0	0	0	0	0
2003	5	B	20	3	25	0	0	1	0	0	0	0	0	0
2003	5	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	6	A	20	3	60	0	0	1	0	0	0	0	0	0
2003	6	B	20	3	30	0	1	0	0	0	0	0	0	0
2003	6	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	7	A	20	3	65	0	0	1	0	0	0	0	0	0
2003	7	B	20	3	20	0	0	1	0	0	0	0	0	0
2003	7	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	8	A	20	3	100	0	0	1	0	0	0	0	0	0
2003	8	B	20	3	45	0	1	1	0	0	0	0	0	0
2003	8	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	9	A	20	3	100	0	0	1	0	0	0	0	0	0
2003	9	B	20	3	55	0	0	1	0	0	0	0	0	0
2003	9	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	10	A	20	3	100	0	0	1	0	0	0	0	0	0
2003	10	B	20	3	100	0	0	1	0	0	0	0	0	0
2003	10	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	11	A	20	3	85	0	0	0	1	0	0	0	0	0
2003	11	B	20	3	60	0	0	1	0	0	0	0	0	0
2003	11	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	12	A	20	3	85	0	0	1	1	0	0	0	0	0
2003	12	B	20	3	70	0	0	1	0	0	0	0	0	0
2003	12	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	13	A	20	3	50	0	0	1	1	0	0	0	0	0
2003	13	B	20	3	50	0	0	1	0	0	0	0	0	0
2003	13	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	14	A	20	3	50	0	0	1	1	0	0	0	0	0
2003	14	B	20	3	0	0	0	0	0	0	0	0	0	0
2003	14	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	15	A	20	3	50	0	0	1	1	0	0	0	0	0
2003	15	B	20	3	65	0	0	1	0	0	0	0	0	0
2003	15	C	20	3	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2003	16	A	20	3	70	0	0	1	1	0	0	0	0	0
2003	16	B	20	3	110	0	0	1	0	0	0	0	0	0
2003	16	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	17	A	20	3	80	0	0	1	1	0	0	0	0	0
2003	17	B	20	3	100	0	0	1	0	0	0	0	0	0
2003	17	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	18	A	20	3	80	0	0	1	0	0	0	0	0	0
2003	18	B	20	3	90	0	0	1	0	0	0	0	0	0
2003	18	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	19	A	20	3	55	0	0	1	0	0	0	0	0	0
2003	19	B	20	3	40	0	0	1	0	0	0	0	0	0
2003	19	C	20	3	15	0	0	0	1	0	0	0	0	0
2003	20	A	20	3	35	0	0	1	0	0	0	0	0	0
2003	20	B	20	3	0	0	0	0	0	0	0	0	0	0
2003	20	C	20	3	0	0	0	0	0	0	0	0	0	0
2003	0	A	20	6	120	0	0	1	0	0	0	0	0	0
2003	0	B	20	6	0	0	0	0	0	0	0	0	0	0
2003	0	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	1	A	20	6	150	0	0	1	0	0	0	0	0	0
2003	1	B	20	6	0	0	0	0	0	0	0	0	0	0
2003	1	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	2	A	20	6	150	0	0	1	0	0	0	0	0	0
2003	2	B	20	6	0	0	0	0	0	0	0	0	0	0
2003	2	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	3	A	20	6	150	0	0	1	0	0	0	0	0	0
2003	3	B	20	6	40	0	0	1	0	0	0	0	0	0
2003	3	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	4	A	20	6	150	0	0	1	0	0	0	0	0	0
2003	4	B	20	6	50	0	0	1	0	0	0	0	0	0
2003	4	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	5	A	20	6	140	0	0	1	0	0	0	0	0	0
2003	5	B	20	6	35	0	0	1	0	0	0	0	0	0
2003	5	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	6	A	20	6	105	0	0	1	0	0	0	0	0	0
2003	6	B	20	6	40	0	0	1	0	0	0	0	0	0
2003	6	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	7	A	20	6	90	0	0	1	0	0	0	0	0	0
2003	7	B	20	6	40	0	0	1	0	0	0	0	0	0
2003	7	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	8	A	20	6	100	0	0	1	0	0	0	0	0	0
2003	8	B	20	6	25	0	0	1	0	0	0	0	0	0
2003	8	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	9	A	20	6	90	0	0	1	0	0	0	0	0	0
2003	9	B	20	6	60	0	0	1	0	0	0	0	0	0
2003	9	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	10	A	20	6	130	0	0	1	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2003	10	B	20	6	65	0	0	1	0	0	0	0	0	0
2003	10	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	11	A	20	6	80	0	0	1	0	0	0	0	0	0
2003	11	B	20	6	70	0	0	1	0	0	0	0	0	0
2003	11	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	12	A	20	6	25	0	0	1	0	0	0	0	0	0
2003	12	B	20	6	70	0	0	1	0	0	0	0	0	0
2003	12	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	13	A	20	6	40	0	0	1	0	0	0	0	0	0
2003	13	B	20	6	85	0	0	1	0	0	0	0	0	0
2003	13	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	14	A	20	6	35	0	0	1	0	0	0	0	0	0
2003	14	B	20	6	100	0	0	1	0	0	0	0	0	0
2003	14	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	15	A	20	6	30	0	0	1	0	0	0	0	0	0
2003	15	B	20	6	100	0	0	1	0	0	0	0	0	0
2003	15	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	16	A	20	6	90	0	0	1	0	0	0	0	0	0
2003	16	B	20	6	95	0	0	1	0	0	0	0	0	0
2003	16	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	17	A	20	6	0	0	0	0	0	0	0	0	0	0
2003	17	B	20	6	90	0	0	1	0	0	0	0	0	0
2003	17	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	18	A	20	6	0	0	0	0	0	0	0	0	0	0
2003	18	B	20	6	55	0	0	1	0	0	0	0	0	0
2003	18	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	19	A	20	6	100	0	0	1	0	0	0	0	0	0
2003	19	B	20	6	0	0	0	0	0	0	0	0	0	0
2003	19	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	20	A	20	6	35	0	0	1	0	0	0	0	0	0
2003	20	B	20	6	0	0	0	0	0	0	0	0	0	0
2003	20	C	20	6	0	0	0	0	0	0	0	0	0	0
2003	0	A	20	9	200	0	0	1	0	0	0	1	0	0
2003	0	B	20	9	20	0	0	1	0	0	0	0	0	0
2003	0	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	1	A	20	9	115	0	0	1	0	0	0	0	0	0
2003	1	B	20	9	30	0	0	1	0	0	0	0	0	0
2003	1	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	2	A	20	9	125	0	0	1	0	0	0	0	0	0
2003	2	B	20	9	45	0	0	1	0	0	0	0	0	0
2003	2	C	20	9	80	0	0	0	1	0	0	0	0	0
2003	3	A	20	9	85	0	0	1	0	0	0	0	0	0
2003	3	B	20	9	40	0	0	1	0	0	0	0	0	0
2003	3	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	4	A	20	9	50	0	0	1	0	0	0	0	0	0
2003	4	B	20	9	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2003	4	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	5	A	20	9	50	0	0	1	0	0	0	0	0	0
2003	5	B	20	9	35	0	0	1	0	0	0	0	0	0
2003	5	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	6	A	20	9	50	0	0	1	0	0	0	0	0	0
2003	6	B	20	9	0	0	0	0	0	0	0	0	0	0
2003	6	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	7	A	20	9	60	0	0	1	0	0	0	0	0	0
2003	7	B	20	9	0	0	0	0	0	0	0	0	0	0
2003	7	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	8	A	20	9	55	0	0	1	0	0	0	0	0	0
2003	8	B	20	9	30	0	0	1	0	0	0	0	0	0
2003	8	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	9	A	20	9	100	0	0	1	0	0	0	0	0	0
2003	9	B	20	9	30	0	0	1	0	0	0	0	0	0
2003	9	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	10	A	20	9	80	0	0	1	0	0	0	0	0	0
2003	10	B	20	9	0	0	0	0	0	0	0	0	0	0
2003	10	C	20	9		0	0	0	0	0	0	0	0	0
2003	11	A	20	9	0	0	0	1	0	0	0	0	0	0
2003	11	B	20	9	45	0	0	1	0	0	0	0	0	0
2003	11	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	12	A	20	9	50	0	0	1	0	0	0	0	0	0
2003	12	B	20	9	35	0	0	1	0	0	0	0	0	0
2003	12	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	13	A	20	9	70	0	0	1	0	0	0	0	0	0
2003	13	B	20	9	0	0	0	0	0	0	0	0	0	0
2003	13	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	14	A	20	9	90	0	0	1	0	0	0	0	0	0
2003	14	B	20	9	50	0	1	0	0	0	0	0	0	0
2003	14	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	15	A	20	9	85	0	0	1	0	0	0	0	0	0
2003	15	B	20	9	0	0	0	0	0	0	0	0	0	0
2003	15	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	16	A	20	9	90	0	0	1	0	0	0	0	0	0
2003	16	B	20	9	0	0	0	0	0	0	0	0	0	0
2003	16	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	17	A	20	9	80	0	0	1	0	0	0	0	0	0
2003	17	B	20	9	0	0	0	0	0	0	0	0	0	0
2003	17	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	18	A	20	9	90	0	0	1	0	0	0	0	0	0
2003	18	B	20	9	0	0	0	0	0	0	0	0	0	0
2003	18	C	20	9	0	0	0	0	0	0	0	0	0	0
2003	19	A	20	9	0	0	0	0	0	0	0	0	0	0
2003	19	B	20	9	0	0	0	0	0	0	0	0	0	0
2003	19	C	20	9	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2003	20	A	20	9	0	0	0	0	0	0	0	0	0	0
2003	20	B	20	9	0	0	0	0	0	0	0	0	0	0
2003	20	C	20	9	5	0	0	0	0	0	1	0	0	0
2003	0	A	20	12	100	0	0	1	0	0	0	0	0	0
2003	0	B	20	12	30	0	0	1	0	0	0	0	0	0
2003	0	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	1	A	20	12	100	0	0	1	0	0	0	0	0	0
2003	1	B	20	12	30	0	0	1	0	0	0	0	0	0
2003	1	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	2	A	20	12	65	0	0	1	0	0	0	0	0	0
2003	2	B	20	12	50	0	0	1	0	0	0	0	0	0
2003	2	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	3	A	20	12	40	0	0	1	0	0	0	0	0	0
2003	3	B	20	12	30	0	0	1	0	0	0	0	0	0
2003	3	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	4	A	20	12	85	0	0	1	0	0	0	0	0	0
2003	4	B	20	12	30	0	0	1	0	0	0	0	0	0
2003	4	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	5	A	20	12	100	0	0	1	0	0	0	0	0	0
2003	5	B	20	12	30	0	0	1	0	0	0	0	0	0
2003	5	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	6	A	20	12	65	0	0	1	0	0	0	0	0	0
2003	6	B	20	12	35	0	0	1	0	0	0	0	0	0
2003	6	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	7	A	20	12	0	0	0	0	0	0	0	0	0	0
2003	7	B	20	12	40	0	0	1	0	0	0	0	0	0
2003	7	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	8	A	20	12	100	0	1	0	0	0	0	0	0	0
2003	8	B	20	12	25	0	0	1	0	0	0	0	0	0
2003	8	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	9	A	20	12	100	0	1	0	0	0	0	0	0	0
2003	9	B	20	12	40	0	0	1	0	0	0	0	0	0
2003	9	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	10	A	20	12	50	0	0	1	0	0	0	0	0	0
2003	10	B	20	12	90	0	1	1	0	0	0	0	0	0
2003	10	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	11	A	20	12	100	0	0	1	0	0	0	0	0	0
2003	11	B	20	12	100	0	1	1	0	0	0	0	0	0
2003	11	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	12	A	20	12	80	0	0	1	0	0	0	0	0	0
2003	12	B	20	12	50	0	1	1	0	0	0	0	0	0
2003	12	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	13	A	20	12	95	0	0	1	0	0	0	0	0	0
2003	13	B	20	12	40	0	0	1	0	0	0	0	0	0
2003	13	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	14	A	20	12	130	0	0	1	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2003	14	B	20	12	0	0	0	0	0	0	0	0	0	0
2003	14	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	15	A	20	12	90	0	0	1	0	0	0	0	0	0
2003	15	B	20	12	0	0	0	0	0	0	0	0	0	0
2003	15	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	16	A	20	12	100	0	0	1	0	0	0	0	0	0
2003	16	B	20	12	0	0	0	0	0	0	0	0	0	0
2003	16	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	17	A	20	12	65	0	0	1	0	0	0	0	0	0
2003	17	B	20	12	40	0	1	0	0	0	0	0	0	0
2003	17	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	18	A	20	12	50	0	0	1	0	0	0	0	0	0
2003	18	B	20	12	0	0	0	0	0	0	0	0	0	0
2003	18	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	19	A	20	12	110	0	0	1	0	0	0	0	0	0
2003	19	B	20	12	0	0	0	0	0	0	0	0	0	0
2003	19	C	20	12	0	0	0	0	0	0	0	0	0	0
2003	20	A	20	12	0	0	0	1	0	0	0	0	0	0
2003	20	B	20	12	0	0	0	0	0	0	0	0	0	0
2003	20	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	0	A	20	3	130	0	0	1	0	0	0	0	0	0
2004	0	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	0	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	1	A	20	3	100	0	0	1	0	0	0	0	0	0
2004	1	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	1	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	2	A	20	3	40	0	0	1	0	0	0	0	0	0
2004	2	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	2	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	3	A	20	3	70	0	0	1	0	0	0	0	0	0
2004	3	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	3	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	4	A	20	3	140	0	0	1	0	0	0	0	0	0
2004	4	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	4	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	5	A	20	3	100	0	0	1	0	0	0	0	0	0
2004	5	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	5	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	6	A	20	3	85	0	0	1	0	0	0	0	0	0
2004	6	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	6	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	7	A	20	3	90	0	0	1	0	0	0	0	0	0
2004	7	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	7	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	8	A	20	3	70	0	0	1	0	0	0	0	0	0
2004	8	B	20	3	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2004	8	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	9	A	20	3	70	0	0	1	0	0	0	0	0	0
2004	9	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	9	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	10	A	20	3	75	0	0	1	0	0	0	0	0	0
2004	10	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	10	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	11	A	20	3	130	0	0	1	0	0	0	0	0	0
2004	11	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	11	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	12	A	20	3	100	0	0	1	0	0	0	0	0	0
2004	12	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	12	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	13	A	20	3	110	0	0	1	1	0	0	0	0	0
2004	13	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	13	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	14	A	20	3	70	0	0	1	1	0	0	0	0	0
2004	14	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	14	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	15	A	20	3	65	0	0	0	1	0	0	0	0	0
2004	15	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	15	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	16	A	20	3	80	0	0	0	1	0	0	0	0	0
2004	16	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	16	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	17	A	20	3	85	0	0	1	0	0	0	0	0	0
2004	17	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	17	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	18	A	20	3	90	0	0	1	0	0	0	0	0	0
2004	18	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	18	C	20	3	60	0	0	0	1	0	0	0	0	0
2004	19	A	20	3	100	0	0	1	0	0	0	0	0	0
2004	19	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	19	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	20	A	20	3	100	0	0	1	0	0	0	0	0	0
2004	20	B	20	3	0	0	0	0	0	0	0	0	0	0
2004	20	C	20	3	0	0	0	0	0	0	0	0	0	0
2004	0	A	20	6	120	0	0	1	0	0	0	0	0	0
2004	0	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	0	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	1	A	20	6	135	0	0	1	0	0	0	0	0	0
2004	1	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	1	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	2	A	20	6	100	0	0	1	0	0	0	0	0	0
2004	2	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	2	C	20	6	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2004	3	A	20	6	110	0	0	1	0	0	0	0	0	0
2004	3	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	3	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	4	A	20	6	100	0	0	1	0	0	0	0	0	0
2004	4	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	4	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	5	A	20	6	90	0	0	1	0	0	0	0	0	0
2004	5	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	5	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	6	A	20	6	110	0	0	1	0	0	0	0	0	0
2004	6	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	6	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	7	A	20	6	80	0	0	1	0	0	0	0	0	0
2004	7	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	7	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	8	A	20	6	110	0	0	1	0	0	0	0	0	0
2004	8	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	8	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	9	A	20	6	120	0	0	1	0	0	0	0	0	0
2004	9	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	9	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	10	A	20	6	130	0	0	1	0	0	0	0	0	0
2004	10	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	10	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	11	A	20	6	125	0	0	1	0	0	0	0	0	0
2004	11	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	11	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	12	A	20	6	110	0	0	1	0	0	0	0	0	0
2004	12	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	12	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	13	A	20	6	90	0	0	1	0	0	0	0	0	0
2004	13	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	13	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	14	A	20	6	30	0	0	1	0	0	0	0	0	0
2004	14	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	14	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	15	A	20	6	0	0	0	0	0	0	0	0	0	0
2004	15	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	15	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	16	A	20	6	100	0	0	1	0	0	0	0	0	0
2004	16	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	16	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	17	A	20	6	130	0	0	1	1	0	0	0	0	0
2004	17	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	17	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	18	A	20	6	110	0	0	1	1	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2004	3	A	20	6	110	0	0	1	0	0	0	0	0	0
2004	3	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	3	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	4	A	20	6	100	0	0	1	0	0	0	0	0	0
2004	4	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	4	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	5	A	20	6	90	0	0	1	0	0	0	0	0	0
2004	5	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	5	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	6	A	20	6	110	0	0	1	0	0	0	0	0	0
2004	6	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	6	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	7	A	20	6	80	0	0	1	0	0	0	0	0	0
2004	7	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	7	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	8	A	20	6	110	0	0	1	0	0	0	0	0	0
2004	8	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	8	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	9	A	20	6	120	0	0	1	0	0	0	0	0	0
2004	9	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	9	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	10	A	20	6	130	0	0	1	0	0	0	0	0	0
2004	10	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	10	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	11	A	20	6	125	0	0	1	0	0	0	0	0	0
2004	11	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	11	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	12	A	20	6	110	0	0	1	0	0	0	0	0	0
2004	12	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	12	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	13	A	20	6	90	0	0	1	0	0	0	0	0	0
2004	13	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	13	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	14	A	20	6	30	0	0	1	0	0	0	0	0	0
2004	14	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	14	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	15	A	20	6	0	0	0	0	0	0	0	0	0	0
2004	15	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	15	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	16	A	20	6	100	0	0	1	0	0	0	0	0	0
2004	16	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	16	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	17	A	20	6	130	0	0	1	1	0	0	0	0	0
2004	17	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	17	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	18	A	20	6	110	0	0	1	1	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2004	18	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	18	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	19	A	20	6	100	0	0	0	1	0	0	0	0	0
2004	19	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	19	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	20	A	20	6	100	0	0	0	1	0	0	0	0	0
2004	20	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	20	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	0	A	20	9	80	0	0	1	0	0	0	0	0	0
2004	0	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	0	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	1	A	20	9	85	0	0	1	0	0	0	0	0	0
2004	1	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	1	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	2	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	2	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	2	C	20	9	70	0	0	0	1	0	0	0	0	0
2004	3	A	20	9	75	0	0	1	0	0	0	0	0	0
2004	3	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	3	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	4	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	4	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	4	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	5	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	5	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	5	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	6	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	6	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	6	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	7	A	20	9	110	0	0	1	0	0	0	0	0	0
2004	7	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	7	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	8	A	20	9	95	0	0	1	0	0	0	0	0	0
2004	8	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	8	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	9	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	9	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	9	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	10	A	20	9	110	0	0	11	0	0	0	0	0	0
2004	10	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	10	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	11	A	20	9	110	0	0	1	0	0	0	0	0	0
2004	11	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	11	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	12	A	20	9	120	0	0	1	0	0	0	0	0	0
2004	12	B	20	9	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2004	18	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	18	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	19	A	20	6	100	0	0	0	1	0	0	0	0	0
2004	19	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	19	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	20	A	20	6	100	0	0	0	1	0	0	0	0	0
2004	20	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	20	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	0	A	20	9	80	0	0	1	0	0	0	0	0	0
2004	0	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	0	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	1	A	20	9	85	0	0	1	0	0	0	0	0	0
2004	1	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	1	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	2	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	2	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	2	C	20	9	70	0	0	0	1	0	0	0	0	0
2004	3	A	20	9	75	0	0	1	0	0	0	0	0	0
2004	3	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	3	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	4	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	4	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	4	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	5	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	5	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	5	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	6	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	6	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	6	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	7	A	20	9	110	0	0	1	0	0	0	0	0	0
2004	7	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	7	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	8	A	20	9	95	0	0	1	0	0	0	0	0	0
2004	8	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	8	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	9	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	9	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	9	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	10	A	20	9	110	0	0	11	0	0	0	0	0	0
2004	10	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	10	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	11	A	20	9	110	0	0	1	0	0	0	0	0	0
2004	11	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	11	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	12	A	20	9	120	0	0	1	0	0	0	0	0	0
2004	12	B	20	9	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2004	18	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	18	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	19	A	20	6	100	0	0	0	1	0	0	0	0	0
2004	19	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	19	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	20	A	20	6	100	0	0	0	1	0	0	0	0	0
2004	20	B	20	6	0	0	0	0	0	0	0	0	0	0
2004	20	C	20	6	0	0	0	0	0	0	0	0	0	0
2004	0	A	20	9	80	0	0	1	0	0	0	0	0	0
2004	0	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	0	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	1	A	20	9	85	0	0	1	0	0	0	0	0	0
2004	1	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	1	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	2	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	2	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	2	C	20	9	70	0	0	0	1	0	0	0	0	0
2004	3	A	20	9	75	0	0	1	0	0	0	0	0	0
2004	3	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	3	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	4	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	4	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	4	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	5	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	5	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	5	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	6	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	6	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	6	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	7	A	20	9	110	0	0	1	0	0	0	0	0	0
2004	7	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	7	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	8	A	20	9	95	0	0	1	0	0	0	0	0	0
2004	8	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	8	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	9	A	20	9	100	0	0	1	0	0	0	0	0	0
2004	9	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	9	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	10	A	20	9	110	0	0	11	0	0	0	0	0	0
2004	10	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	10	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	11	A	20	9	110	0	0	1	0	0	0	0	0	0
2004	11	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	11	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	12	A	20	9	120	0	0	1	0	0	0	0	0	0
2004	12	B	20	9	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2004	12	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	13	A	20	9	140	0	0	1	0	0	0	0	0	0
2004	13	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	13	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	14	A	20	9	140	0	0	1	0	0	0	0	0	0
2004	14	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	14	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	15	A	20	9	150	0	0	1	0	0	0	0	0	0
2004	15	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	15	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	16	A	20	9	150	0	0	1	0	0	0	0	0	0
2004	16	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	16	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	17	A	20	9	140	0	0	1	0	0	0	0	0	0
2004	17	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	17	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	18	A	20	9	140	0	0	1	0	0	0	0	0	0
2004	18	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	18	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	19	A	20	9	125	0	0	1	0	0	0	0	0	0
2004	19	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	19	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	20	A	20	9	0	0	0	0	0	0	0	0	0	0
2004	20	B	20	9	0	0	0	0	0	0	0	0	0	0
2004	20	C	20	9	0	0	0	0	0	0	0	0	0	0
2004	0	A	20	12	130	0	0	1	0	0	0	0	0	0
2004	0	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	0	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	1	A	20	12	95	0	0	1	0	0	0	0	0	0
2004	1	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	1	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	2	A	20	12	80	0	0	1	0	0	0	0	0	0
2004	2	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	2	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	3	A	20	12	100	0	0	1	0	0	0	0	0	0
2004	3	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	3	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	4	A	20	12	110	0	0	1	0	0	0	0	0	0
2004	4	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	4	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	5	A	20	12	0	0	0	0	0	0	0	0	0	0
2004	5	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	5	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	6	A	20	12	80	0	0	1	0	0	0	0	0	0
2004	6	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	6	C	20	12	0	0	0	0	0	0	0	0	0	0

Appendix B, Table 4.9. Cont. Kingman X20 Exclosure Quantitative Transects for Species Presence and Height at Meter Location on Transect Line
Species data binary (presence 1/absence 0)

Year	Distance	Rep	Size	Transect	Height cm	Mud	Pont	Sag	Pelt	Echin	Ludwig	Typha l.	Bidens	Polyg
2004	7	A	20	12	70	0	0	1	0	0	0	0	0	0
2004	7	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	7	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	8	A	20	12	100	0	0	1	0	0	0	0	0	0
2004	8	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	8	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	9	A	20	12	70	0	0	1	0	0	0	0	0	0
2004	9	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	9	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	10	A	20	12	110	0	0	1	0	0	0	0	0	0
2004	10	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	10	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	11	A	20	12	115	0	0	1	0	0	0	0	0	0
2004	11	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	11	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	12	A	20	12	110	0	0	1	0	0	0	0	0	0
2004	12	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	12	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	13	A	20	12	110	0	0	1	0	0	0	0	0	0
2004	13	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	13	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	14	A	20	12	85	0	0	1	0	0	0	0	0	0
2004	14	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	14	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	15	A	20	12	105	0	0	1	0	0	0	0	0	0
2004	15	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	15	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	16	A	20	12	120	0	0	1	0	0	0	0	0	0
2004	16	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	16	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	17	A	20	12	105	0	0	1	0	0	0	0	0	0
2004	17	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	17	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	18	A	20	12	110	0	0	1	0	0	0	0	0	0
2004	18	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	18	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	19	A	20	12	100	0	0	1	0	0	0	0	0	0
2004	19	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	19	C	20	12	0	0	0	0	0	0	0	0	0	0
2004	20	A	20	12	0	0	0	0	0	0	0	0	0	0
2004	20	B	20	12	0	0	0	0	0	0	0	0	0	0
2004	20	C	20	12	0	0	0	0	0	0	0	0	0	0

Appendix C – Kingman Fisheries Emergy Analysis Tables

Appendix C, Footnotes to Emergy Analysis Table 5.1

Note				
5	**WAVES:**			
	Total area open water at high tide with marsh:	3.16E+05	m^2	
	High tide open water w/o marsh:	4.46E+05	m^2	
	Low tide open water w/and w/o marsh:	1.58E+05	m^2	
	Density of water:	1000	kg/m^3	
	Wave amplitude:	0.05	m	Assume minimal wave ht
	Energy at high tide w/Marsh:	(0.5 for tide) * (open water area,m^2) * (water density,kg/m^3) * (gravity,m^2/s) * (wave amplitude)^2		
	=	3.87E+06	J	
	Energy at high tide w/o Marsh: =	5.46E+06	J	
	Energy at low tide open water w/and w/o marsh:	1.94E+06	J	
	Transformity:	3.06E+04	sej/J	(Odum 1996)
6	**TIDAL ENERGY:**			
	Total area open water at high tide with marsh:	3.16E+05	m^2	
	HT open water area w/o marsh:	4.46E+05	m^2	
	Open water area at low tide w/&w/o marsh:	1.58E+05	m^2	
	Tides per year (lunar, semi-diurnal)	706	estimated 2 tides/24.83 hr in one year	
	Average tide range:	0.91	m	
	Density of water:	1000	kg/m^3	
	Percent absorbed (with marsh):	20%	estimated	
	Percent absorbed (w/o marsh):	2%	estimated	
	Energy at high tide w/marsh:	(avg tide) * (open water area) * (water density) * (gravity) * (tides) * (tidal range)^2 * (% absorbed)		
	=	3.30E+11	J	
	Energy at high tide w/o marsh: =	4.65E+10	J	
	Energy at low tide w&w/o marsh: =	1.65E+10	J	
	Transformity:	1.68E+04	sej/J	(Odum, 1996)
7	**RIVERINE WATER USED - MUDFLAT / OPEN WATER**			
	Total area open water at high tide with marsh:	3.16E+05	m^2	
	HT open water w/o marsh:	4.46E+05	m^2	
	Transpiration rate in open water:	0.866	m/yr	(Abtew and Obeysekera, 1995) from (Martin, 2002)
	Density of water:	1.00E+06	g/m^3	
	Gibbs free energy:	4.94	J/g	(change in enthalpy)
	Energy without marsh:	(area open water,mudflat without marsh,m^2)*(total transpiration)*(density of river water)*(gibbs free energy)		
	=	1.91E+12	J	
	Energy mudflat/open water w/marsh:	(area open water,mudflat with marsh,m^2)*(total transpiration)*(density of river water)*(gibbs free energy)		
	=	1.35E+12	J	
	Transformity:	4.11E+04	sej/J	(Odum et al., 1987b)

Appendix C, Footnotes to Emergy Analysis Table 5.1cont.

Note			
8	**RIVERINE WATER USED - MARSH**		
	Total area marsh:	1.30E+05 m^2	
	Transpiration rate in marsh:	2 m/yr	(Abtew and Obeysekera, 1995)
	Energy marsh water used:	(area marsh,m^2)*(total evapotranspiration,m/yr)*(density of river water)*(gibbs free energy)	
	=	1.28E+12 J	
	Transformity:	4.11E+04 sej/J	(Odum et al., 1987b)
9	**RIVERINE SEDIMENTS CAPTURED:**		
	Annual flow of TSS Anacostia River:	4.82E+10 g	(Warner et al., 1997)
	Average volume Anacostia River:	1.18E+07 m^3	
	Average Annual River flow:	1.20E+08 m^3/yr	
	% of Anacostia River into Kingman:	1.83%	
	% Sediment captured in TFW marsh:	5-11%	(Stevenson et al., 1988; based on Officer et al., 1984)
	Average deposition on marsh:	0.025 m	(assume annual average dep at marsh SET 2.4 NGVD'29, Hammerschlag personal communication, 3 SET measures)
	Average deposition on mudflat:	0.033 m	(assume annual average dep at mudflat SET 1.7 NGVD'29, Hammerschlag personal communication, 3 SET measures)(assume plus open water)
	Anacostia sediment bulk density:	1.50E+06 g/m^3	assumed (Mandel et al., 2007)
	Marsh area sediment deposition:	3.25E+03 m^3	(marsh area deposition,m)*(marsh area,m^2)
	Mudflat +openwater deposition:	1.04E+04 m^3	(mudflat+openwater deposition,m) * (mudflat+openwater area w/marsh, m^2)
	Total sed. deposition in Kingman w/marsh:	1.37E+04 m^3	(added from above)
	Total sed. deposition in Kingman w/o marsh:	1.47E+04 m^3	(mudflat+openwater deposition,m) * (mudflat+openwater area w/o marsh, m^2) *approximately smaller proportion of sed inputs trapped by marsh compared to subtidal (Stevenson et al., 1988)
	% Anacostia sediment captured in Kingman with marsh:	(total sed. dep. in Kingman w/marsh m^3)*(sediment bulk density g/m^3) / (annual Anacostia TSS g) 4.26E-01 %	
	% Anacostia sediment captured in Kingman w/o marsh:	(total sed. dep. in Kingman w/o marsh m^3)*(sediment bulk density g/m^3) / (annual Anacostia TSS g) 4.58E-01 %	
	Kingman with marsh (sediments captured):	(annual TSS Anacostia river,g)*(%River into Kingman)*(% total sed. dep. in Kingman w/marsh)	
	=	3.75E+08 g	
	Kingman without marsh (sediments captured):	(annual TSS Anacostia river,g)*(%River into Kingman)*(% total sed. dep. in Kingman w/o marsh)	
		4.04E+08 g	
	Transformity: see table 2	8.51E+08 sej/g	

Appendix C, Footnotes to Emergy Analysis Table 5.1cont.

Note	Item	Value		Source
10	**RIVER SEDIMENTS STORED:**			
	Subsidence rate:	0.002 m/yr		(Kearney and Stevenson, 1991 from Holdahl and Morrison, 1974; and Brown, 1978)
	Bulk density sediments:	1.50E+06 g/m^3		assumed (Mandel et al., 2007)
	% Soil organic matter:	5.0%		assumed (Neff, 2002)
	Kingman with marsh (sediments stored):	(Kingman with marsh, sediments stored,g) - (Subsidence rate,m/yr * Bulk density sediments,g/m^3 * % Soil organic matter)		
		3.75E+08 g		
	Kingman without marsh (sediments stored):	(Kingman w/o marsh, sediments stored,g) - (Subsidence rate,m/yr * Bulk density sediments,g/m^3 * % Soil organic matter)		
		4.04E+08 g		
	Transformity: see table 2	8.51E+08 sej/g		
	IMPORTS			
11	**CONSTRUCTION**			Data from US ACOE Kingman Marsh restoration project, 2004
	Management and Design Costs			
	Technical Management	$49,643.34		
	PED Design	$321,315.37		
	Real Estate Activities	$2,487.82		
	Project Cooperation Agreement	$20,190.66		
	Financing Plan	$33,556.83		
	Surveys and Mapping	$75,255.45		
	Plans and Specifications	$138,485.21		
	Contract Award Activities	$13,262.11		
	Project Management	$169,434.03		
	Construction Management	$194,766.95		
	Physical Construction			
	Engineering During Construction	$9,677.72		
	Mobilization and Demobilization	$904,287.00		
	New Work/Maintenance Dredging	$1,381,928.00		
	Water Tube Dike Construction	$350,000.00		
	8-Foot Water Tubes	$7,000.00		
	Tidal Gut and Lagoon Construction	$80,805.00		
	Contractor Surveys	$25,000.00		
	Trash and Debris Removal	$40,000.00		
	Project Sign	$3,000.00		
	Photographic Coverage	$10,000.00		
	CONSTRUCTION TOTAL COSTS	$3,830,095.49		
	Year One Amoritized Cost over 50 years	$76,601.91	($ Total) * (1/50 yrs)	50 years based on relative age of Dueling mature marsh condition
	Emergy per dollar ratio (2000 $):	1.00E+12 sej/$		(Odum, 2000)

Appendix C, Footnotes to Emergy Analysis Table 5.1cont.

Note						
12	**DREDGED RIVER SEDIMENTS**					
	Anacostia River sediment bulk density:	1.50E+06	g/m^3			assumed (Mandel et al., 2007)
	Total volume river dredge sediments imported	1.86E+05	yd^3			
		1.42E+05	m^3			
	Total weight river sediments imported	2.13E+11	g			
	Year one weight of sediments imported	4.27E+09	g	(volume imported sediments, g)*(1/50 yrs)		
	Emergy per mass: see table 2	8.51E+08	sej/g			
13	**PLANTINGS**					
	Initial Wetland Planting	$837,500.00				
	Year One Amoritized Cost over 50 years	$16,750.00		($ Total)	* (1/50 yrs)	50 years based on relative age of Dueling mature marsh condition
	Emergy per dollar ratio (2000 $):	1.00E+12	sej/$			(Odum, 2000)
14	**FENCING**					
	Goose Fencing, Cell I	$23,400.00				
	Goose Fencing, Cell II	$76,176.00				
	Goose Fencing Removal	$32,500.00				
	New Goose Fencing + Replanting	$192,693.50				
	2003 Goose Fencing	$35,435.00				
	2005 Goose Fencing Removal	$30,000.00				
	FENCING TOTAL COSTS	$390,204.50				
	Year One Amoritized Cost over 50 years	$7,804.09		($ Total)	* (1/50 yrs)	50 years based on relative age of Dueling mature marsh condition
	Emergy per dollar ratio (2000 $):	1.00E+12	sej/$			(Odum, 2000)
15	**MONITORING AND MAINTENANCE**					
	Enviro Compliance and Monitoring	$657,337.02				
	Year One Amoritized Cost over 50 years	$13,146.74		($ Total)	* (1/50 yrs)	50 years based on relative age of Dueling mature marsh condition
	Emergy per dollar ratio (2000 $):	1.00E+12	sej/$			(Odum, 2000)
	TOTAL IMPORT COSTS	**$5,715,137.01**	**2000$**			
	# of hectares of Marsh Created, Cells I & II	13	ha			
	Total Unit Cost / ha for Marsh Restoration	$439,625.92	per ha restored			
	Total Unit Cost / ac for Marsh Restoration	$177,911.29	per ac restored			
	Year One Amoritized Cost over 50 years	$114,302.74		($ Total)	* (1/50 yrs)	50 years based on relative age of Dueling mature marsh condition
	Year One Amoritized Unit Cost / ha for Restoration	$8,792.52	per ha restored			
	Year One Amoritized Unit Cost / ac for Restoration	$273.71	per ac restored			
	Emergy per dollar ratio (2000 $):	1.00E+12	sej/$			(Odum, 2000)

Appendix C, Footnotes to Emergy Analysis Table 5.1cont.

Note			
	EXPORTS		
16	**NET PRIMARY PRODUCTION - WITHOUT RESTORED MARSH: ALL MUDFLAT / OPEN WATER**		
	Total area open water at low tide w/o marsh:	1.58E+05 m^2	calcs consider pre dredgefill conditions
	Total area mudflat at low tide w/o marsh:	2.88E+05 m^2	
	Annual NPP open water (phytoplankton):	63.1 g C/m^2/yr	Phytoplankton Productivity Rate from MD DNR Avg data for TFW Potomac
	Annual NPP epibenthic mud algae:	190 g C/m^2/yr	Assume same as saltmarsh mudflat, (Pomeroy and Wiegert, 1981)
	Annual NPP open water exported:	100 %	Assume all water / phytoplankton exported annually
	Annual NPP epibenthic mud algae exported:	100 %	Assume all mudflat epibenthic algae exported annually
	Annual NPP open water (phytoplankton):	4.98E+06 g C/yr	(NPP g C/m^2/yr)*(area m^2)*(% exported)/2 : Assume water only in Kingman half of year
	Energy:	2.09E+11 J	1g phyto C=10 Kcal (Odum, 1971) (Total area NPP g C/yr)*(__Kcal/g C)*(4186 J/Kcal)
	Annual NPP epibenthic mud algae:	5.47E+07 g C/yr	Algae production rate measured for combined high and low tide
	Energy:	1.12E+12 J	1g algae C=4.9 Kcal (Odum, 1971)
	Total energy annual primary production:	1.33E+12 J	(Sum NPP)
	Transformity:	4.70E+03 sej/J	(Odum 1996)
17	**NET PRIMARY PRODUCTION - WITH RESTORED MARSH AND MUDFLAT / OPEN WATER**		
	Total area marsh 2000/2001	1.30E+05 m^2	
	Total area open water at low tide with marsh:	1.58E+05 m^2	
	Total area mudflat at low tide with marsh:	1.58E+05 m^2	
	Annual emergent marsh NPP TFW marsh:	2347 g/m^2/yr	Est. inc. muliple sp. peak biomass, leaf mortality & below ground biomass (Whigham et al. 197
	Annual NPP open water:	63.1 g C/m^2/yr	Phytoplankton Productivity Rate from MD DNR Avg data for TFW Potomac*
	Annual NPP epibenthic mud algae:	190 g C/m^2/yr	Assume same as saltmarsh bare creekbank, (Pomeroy and Wiegert, 1981)
	Annual emergent marsh NPP exported:	80 %	(Odum and Heywood, 1978 from Good, Whigham, Simpson 1978)
	Annual open water NPP exported:	100 %	Assume all water / phytoplankton exported annually
	Annual NPP epibenthic mud algae exported:	100 %	Assume all mudflat epibenthic algae exported annually
	Total annual NPP emergent marsh:	2.44E+08 g /yr	(NPP g/m^2/yr)*(Area m^2)*(% exported)
			assume 1g dry wt. marsh =3.5 Kcal: from 4.5 Kcal/g dry wt. terrestrial plants (Odum, 1971)
	Energy:	3.58E+12 J	(Total area NPP g /yr)*(__Kcal/g)*(4186 J/Kcal)
	Total annual NPP open water (phytoplankton):	2.49E+06 g C/yr	Assume water only in Kingman half of year
	Energy:	1.04E+11 J	1g phyto C=10 Kcal (Odum, 1971) (Total area NPP g C/yr)*(__Kcal/g C)*(4186 J/Kcal)
	Total annual NPP epibenthic mud algae:	3.00E+07 g C/yr	Mudflat algae production rate measured for high and low tide
	Energy:	6.16E+11 J	1g algae C=4.9 Kcal (Odum, 1971)
	Total annual primary production mudflat / open wate	7.20E+11 J	
	Total annual primary production marsh:	3.58E+12 J	
	Transformity:	6.96E+03 sej/J	(Odum 1996)

Appendix C, Footnotes to Emergy Analysis Table 5.1cont.

Note			
18	**FISHERIES - Without Marsh**		
	Total fishery useable area at high tide w/o marsh:	4.50E+05 m^2	
	Annual fishery yield (with catfish):	6.75 g dry wt/m^2/yr	From fish Table x, Kingman mudflat condition
		3.04E+06 g dry wt /yr	(g dry wt/m^2/yr)*(area m^2)
		5.72E+10 J	(g dry wt/yr)*(4.5 Kcal/g)*(4186 J/Kcal)
	Annual fishery yield (without catfish):	0.7 g dry wt/m^2/yr	From fish Table xx, Kingman mudflat condition
		3.15E+05 g dry wt /yr	
		5.93E+09 J	
	Transformity:	3.07E+06 sej/J	From fish Table Y (Bahr et al., 1982)
	FISHERIES - With Marsh		
	Total area marsh (year 2000)	1.30E+05 m^2	
	Total fishery useable area at high tide with marsh:	3.16E+05 m^2	
	Annual fishery yield:	2.91 g dry wt/m^2/yr	From fish Table x, assume Kingman with a Kenilworth type marsh fish production
	(newly restored marsh with catfish)	9.20E+05 g dry wt/yr	(g dry wt/m^2/yr)*(area m^2)
	Energy:	1.73E+10 J	(g dry wt/yr)*(4.5 Kcal/g)*(4186 J/Kcal)
	Annual fishery yield:	0.73 g dry wt/m^2/yr	From fish Table xx, assume Kingman with a Kenilworth type marsh fish production
	(newly restored marsh without catfish)	2.31E+05 g dry wt/yr	
	Energy:	4.35E+09 J	
	Annual fishery yield :	3.18 g dry wt/m^2/yr	From fish Table x, assume Kingman with a Dueling type mature marsh fish production
	(mature marsh with catfish)	1.00E+06 g dry wt/yr	
	Energy:	1.89E+10 J	
	Annual fishery yield:	2.04 g dry wt/m^2/yr	From fish Table xx, assume Kingman with a Dueling type mature marsh fish production
	(mature marsh without catfish)	6.45E+05 g dry wt/yr	
	Energy:	1.21E+10 J	
	Transformity:	3.07E+06 sej/J	From fish Table Y (Bahr et al., 1982)

Appendix C. Table 5-2. U.S. Army Corps of Engineers Kingman Marsh Restoration Construction Costs

KINGMAN LAKE PROJECT CALCULATIONS: Expenditures: through 11 Aug

	PROJECTED REQUIRED FUNDS	PROJECT FUNDS EXPENDED TO DATE	FUNDS REMAINING
Technical Management	$49,643.34	$49,643.34	$0.00
PED Design	$321,315.37	$321,315.37	$0.00
Real Estate Activities	$2,487.82	$2,487.82	$0.00
Construction Contract Earnings	$4,311,268.25	$4,286,168.25	$25,100.00
Project Cooperation Agreement	$20,190.66	$20,190.66	$0.00
Financing Plan	$33,556.83	$33,556.83	$0.00
Surveys and Mapping	$75,255.45	$75,255.45	$0.00
Plans and Specifications	$138,485.21	$138,485.21	$0.00
Environmental Compliance and Monitoring	$657,337.02	$568,244.19	$89,092.83
Contract Award Activities	$13,262.11	$13,262.11	$0.00
Engineering During Construction	$9,677.72	$9,677.72	$0.00
Sponsor Coordination (In-kind contributions)	$0.00	$0.00	$0.00
Construction Management	$194,766.95	$194,766.95	$0.00
Project Management	$169,434.03	$157,795.22	$11,638.81
Contingency	$3,319.24	$0.00	$3,319.24
Total Project	$6,000,000.00	$5,870,849.12	$129,150.88

ALLOCATION OF FUNDS

Total Project Funds	$6,000,000.00				
Betterment (1 acre for PG County)	$93,200.00	Current estimated based on construction activities completed and 33.28 acres constructed			
Total Project Funds w/o Betterment	$5,906,800.00	Federal Share	Non-Federal Share	Total	
Allocation of Project (75-25 cost-sharing)		$4,430,100.00	$1,476,700.00	$5,906,800.00	
Betterment (100% DCEHA cost)			$93,200.00	$93,200.00	
Final Cost Allocation		$4,430,100.00	$1,569,900.00	$6,000,000.00	
Anticipated In-Kind Services			$0.00	Funds Received	Funds to Be Paid
Non-Federal Cash Required			$1,569,900.00	$1,475,000.00	$94,900.00

Appendix C, Table 5-2. cont. U.S. Army Corps of Engineers Kingman Marsh Restoration Construction Costs

CALCULATION OF WETLAND BETTERMENT COST

CONTRACT LINE ITEMS

No.	Description	Original Contract	Obligated Amount	Estimated Final Amount	Included in Wetland Betterment	Amount to be Deobligated		Uninvoiced Amount	
0001	Mobilization and Demobilization	$904,287.00	$904,287.00	$904,287.00	$0.00				
0002	New Work/Maintenance Dredging	$1,488,408.00	$1,488,408.00	$1,435,168.00	$1,435,168.00	$53,240.00	Yardage not dredged		
0003	Water Tube Dike Construction	$350,000.00	$350,000.00	$350,000.00	$350,000.00				
0004	Tidal Gut and Lagoon Construction	$80,805.00	$80,805.00	$80,805.00	$80,805.00				
0005	Contractor Surveys	$25,000.00	$25,000.00	$25,000.00	$0.00				
0006	Trash and Debris Removal	$40,000.00	$40,000.00	$40,000.00	$0.00				
0007	Wetland Planting	$837,500.00	$837,500.00	$837,500.00	$837,500.00				
0008	Stormwater Outfall	$15,000.00	$8,000.00	$0.00	$0.00	$8,000.00	Removed from contract		
0009	Project Sign	$3,000.00	$3,000.00	$3,000.00	$0.00				
0010	Photographic Coverage	$10,000.00	$10,000.00	$10,000.00	$0.00				
0011	Goose Fencing, Cell I		$23,400.00	$23,400.00	$23,400.00				
0012	Goose Fencing, Cell II		$76,176.00	$76,176.00	$76,176.00				
0013	8-Foot Water Tubes		$7,000.00	$7,000.00	$7,000.00				
0014	Reforestation		$210,061.06	$210,161.06	$0.00			$100.00	Keeping contract ope
0015	Goose Fencing Removal		$32,500.00	$32,500.00	$32,500.00				
0016	Reforestation Goose/Construction Fencing (Meadow Area)		$12,800.00	$12,800.00	$0.00				
0018	New Goose Fencing + Replanting		$192,693.50	$192,694.00	$192,694.00				
0019	Earth Day Clean-Up and Plants		$9,188.80	$9,288.80	$0.00			$100.00	Keeping contract ope
0020	2003 Goose Fencing		$0.00	$35,435.00	$35,435.00				
0021	2005? Goose Fencing Removal			$30,000.00	$30,000.00	Estimated value			
	Total Contract	$3,754,000.00	$4,310,819.36	$4,315,214.86	$3,100,678.00	$61,240.00		$200.00	

Number of Acres of Wetland Created, Cells I and II	33.28
Unit Cost per Acre for Wetland Creation	$93,200.00

Appendix C, Table 5.3. Sportfishery Biomass (With Catfish) to Energy and Emergy Equivalent Comparisons Between 2 Marsh and 2 Mudflat Survey Areas

	A	B	C:(A/B)	D	E:(CxD).2	F	G:(ExF)	H	I:(GxH)	J	K:(IxJ)	L	M:(KxL)
Marsh: Kenilworth MF1 & MF:	**Avg wet wt* (g)**	**Sample Area m^2**	**Avg Biomass g/m^2**	**Avg P/B****	**Avg dry wt *** g/m^2/yr**	**Caloric Coefficient********	**Production Kcal/m^2/yr**	**J/Kcal**	**Energy J/m^2/yr**	**Total Fishery Area m^2**	**Area Energy J/yr**	**Transformity***** sej/J**	**Fish Emergy sej/yr**
Brown bullhead	3438.4	500	6.88	1.5	2.06	4.5	9.28	4186	38861.48	9900	3.85E+08	3.02E+06	1.16E+15
White catfish	12.0	500	0.02	1.5	0.01	4.5	0.03	4186	135.63	9900	1.34E+06	3.02E+06	4.05E+12
Channel catfish	170.4	500	0.34	1.5	0.10	4.5	0.46	4186	1925.89	9900	1.91E+07	3.02E+06	5.76E+13
Yellow perch	37.0	500	0.07	1.5	0.02	4.5	0.10	4186	418.18	9900	4.14E+06	3.02E+06	1.25E+13
White perch	1004.3	500	2.01	1.5	0.60	4.5	2.71	4186	11350.80	9900	1.12E+08	3.02E+06	3.39E+14
Striped bass	2.0	500	0.00	1.5	0.00	4.5	0.01	4186	22.38	9900	2.22E+05	3.02E+06	6.69E+11
Pumpkinseed	93.8	500	0.19	1.5	0.06	4.5	0.25	4186	1060.15	9900	1.05E+07	3.02E+06	3.17E+13
Largemouth bass	84.7	500	0.17	1.5	0.05	4.5	0.23	4186	957.30	9900	9.48E+06	3.48E+06	3.30E+13
Bluegill	2.1	500	0.00	1.5	0.00	4.5	0.01	4186	23.17	9900	2.29E+05	3.02E+06	6.93E+11
	4844.6		**9.69**		**2.91**		**13.08**	4186	**5.48E+04**		**5.42E+08**		**1.64E+15**
Marsh: Dueling Creek													
Brown bullhead	1119.3	500	2.24	1.5	0.67	4.5	3.02	4186	12650.55	1000	1.27E+07	3.02E+06	3.82E+13
White catfish	0.0	500	0.00	1.5	0.00	4.5	0.00	4186	0.00	1000	0.00E+00	3.02E+06	0.00E+00
Channel catfish	786.6	500	1.57	1.5	0.47	4.5	2.12	4186	8890.31	1000	8.89E+06	3.02E+06	2.68E+13
Yellow perch	269.4	500	0.54	1.5	0.16	4.5	0.73	4186	3044.81	1000	3.04E+06	3.02E+06	9.20E+12
White perch	1373.7	500	2.75	1.5	0.82	4.5	3.71	4186	15525.83	1000	1.55E+07	3.02E+06	4.69E+13
Striped bass	2.7	500	0.01	1.5	0.00	4.5	0.01	4186	30.52	1000	3.05E+04	3.02E+06	9.22E+10
Pumpkinseed	651.0	500	1.30	1.5	0.39	4.5	1.76	4186	7357.73	1000	7.36E+06	3.02E+06	2.22E+13
Largemouth bass	1070.4	500	2.14	1.5	0.64	4.5	2.89	4186	12097.87	1000	1.21E+07	3.48E+06	4.21E+13
Bluegill	34.2	500	0.07	1.5	0.02	4.5	0.09	4186	386.54	1000	3.87E+05	3.02E+06	1.17E+12
	5307.3		**10.61**		**3.18**		**14.33**	4186	**6.00E+04**		**6.00E+07**		**1.87E+14**
Mudflat: Kenilworth MF3													
Brown bullhead	3112.2	500	6.22	1.5	1.87	4.5	8.40	4186	35174.71	19481	6.85E+08	3.02E+06	2.07E+15
White catfish	0.0	500	0.00	1.5	0.00	4.5	0.00	4186	0.00	19481	0.00E+00	3.02E+06	0.00E+00
Channel catfish	393.3	500	0.79	1.5	0.24	4.5	1.06	4186	4445.16	19481	8.66E+07	3.02E+06	2.62E+14
Yellow perch	42.1	500	0.08	1.5	0.03	4.5	0.11	4186	475.82	19481	9.27E+06	3.02E+06	2.80E+13
White perch	367.2	500	0.73	1.5	0.22	4.5	0.99	4186	4150.17	19481	8.08E+07	3.02E+06	2.44E+14
Striped bass	1.4	500	0.00	1.5	0.00	4.5	0.00	4186	15.26	19481	2.97E+05	3.02E+06	8.98E+11
Pumpkinseed	260.7	500	0.52	1.5	0.16	4.5	0.70	4186	2946.48	19481	5.74E+07	3.02E+06	1.73E+14
Largemouth bass	0.0	500	0.00	1.5	0.00	4.5	0.00	4186	0.00	19481	0.00E+00	3.48E+06	0.00E+00
Bluegill	17.1	500	0.03	1.5	0.01	4.5	0.05	4186	193.27	19481	3.77E+06	3.02E+06	1.14E+13
	4194.0		**8.39**		**2.52**		**11.32**	4186	**4.74E+04**		**9.23E+08**		**2.79E+15**
Mudflat: Kingman TG1 & TG2													
Brown bullhead	9418.5	500	18.84	1.5	5.65	4.5	25.43	4186	106449.77	445000	4.74E+10	3.02E+06	1.43E+17
White catfish	0.0	500	0.00	1.5	0.00	4.5	0.00	4186	0.00	445000	0.00E+00	3.02E+06	0.00E+00
Channel catfish	655.5	500	1.31	1.5	0.39	4.5	1.77	4186	7408.59	445000	3.30E+09	3.02E+06	9.96E+15
Yellow perch	101.0	500	0.20	1.5	0.06	4.5	0.27	4186	1141.52	445000	5.08E+08	3.02E+06	1.53E+15
White perch	624.2	500	1.25	1.5	0.37	4.5	1.69	4186	7055.29	445000	3.14E+09	3.02E+06	9.48E+15
Striped bass	1.4	500	0.00	1.5	0.00	4.5	0.00	4186	15.26	445000	6.79E+06	3.02E+06	2.05E+13
Pumpkinseed	414.0	500	0.83	1.5	0.25	4.5	1.12	4186	4678.66	445000	2.08E+09	3.02E+06	6.29E+15
Largemouth bass	0.0	500	0.00	1.5	0.00	4.5	0.00	4186	0.00	445000	0.00E+00	3.48E+06	0.00E+00
Bluegill	27.4	500	0.05	1.5	0.02	4.5	0.07	4186	309.23	445000	1.38E+08	3.02E+06	4.16E+14
	11241.9		**22.48**		**6.75**		**30.35**		**1.27E+05**		**5.65E+10**		**1.71E+17**

*** Average total wet weights from Appendix C. Table 5.5**
**** Averaged from ratios in (Chapman, 1978; and Wetzel, 1983)**
***** Assume dry wt is 20% of wet wt (Waters, 1977)**
****** Coloric coefficient 4.5 Kcal per g dry wt (Bahr et al., 1982)**
******* Solar emjoule (sej) transformity of fish biomass calculated from (Bahr et al., 1982)**

Appendix C, Table 5.4. Sportfishery Biomass (Without Catfish) to Energy and Emergy Equivalent Calculations Between 2 Marsh and 2 Mudflat Systems

	A	B	C:(A/B)	D	E:(CxD).2	F	G:(ExF)	H	I:(GxH)	J	K:(IxJ)	L	M:(KxL)
	Avg wet wt*	**Sample Area**	**Avg Biomass**	**Avg P/B****	**Avg dry wt *****	**Caloric**	**Production**	**J/Kcal**	**Energy**	**Total Fishery**	**Area Energy**	**Transformity*******	**Fish Emergy**
Marsh: Kenilworth MF1 & MF2	**(g)**	**m^2**	**g/m^2**		**g/m^2/yr**	**Coefficient*******	**Kcal/m^2/yr**		**J/m^2/yr**	**Area m^2**	**J/yr**	**sej/J**	**sej/yr**
Yellow perch	37.0	500	0.07	1.5	0.02	4.5	0.10	4186	418.2	9900	4.14E+06	3.02E+06	1.25E+13
White perch	1004.3	500	2.01	1.5	0.60	4.5	2.71	4186	11350.8	9900	1.12E+08	3.02E+06	3.39E+14
Striped bass	2.0	500	0.00	1.5	0.00	4.5	0.01	4186	22.4	9900	2.22E+05	3.02E+06	6.69E+11
Pumpkinseed	93.8	500	0.19	1.5	0.06	4.5	0.25	4186	1060.1	9900	1.05E+07	3.02E+06	3.17E+13
Largemouth bass	84.7	500	0.17	1.5	0.05	4.5	0.23	4186	957.3	9900	9.48E+06	3.48E+06	3.30E+13
Bluegill	2.1	500	0.00	1.5	0.00	4.5	0.01	4186	23.2	9900	2.29E+05	3.02E+06	6.93E+11
	1223.8		**2.45**		**0.73**		**3.30**	4186	**1.38E+04**		**1.37E+08**		**4.18E+14**
Marsh: Dueling Creek													
Yellow perch	269.4	500	0.54	1.5	0.16	4.5	0.73	4186	3044.8	1000	3.04E+06	3.02E+06	9.20E+12
White perch	1373.7	500	2.75	1.5	0.82	4.5	3.71	4186	15525.8	1000	1.55E+07	3.02E+06	4.69E+13
Striped bass	2.7	500	0.01	1.5	0.00	4.5	0.01	4186	30.5	1000	3.05E+04	3.02E+06	9.22E+10
Pumpkinseed	651.0	500	1.30	1.5	0.39	4.5	1.76	4186	7357.7	1000	7.36E+06	3.02E+06	2.22E+13
Largemouth bass	1070.4	500	2.14	1.5	0.64	4.5	2.89	4186	12097.9	1000	1.21E+07	3.48E+06	4.21E+13
Bluegill	34.2	500	0.07	1.5	0.02	4.5	0.09	4186	386.5	1000	3.87E+05	3.02E+06	1.17E+12
	3401.4		**6.80**		**2.04**		**9.18**	4186	**3.84E+04**		**3.84E+07**		**1.22E+14**
Mudflat: Kenilworth MF3													
Yellow perch	42.1	500	0.08	1.5	0.03	4.5	0.11	4186	475.8	19481	9.27E+06	3.02E+06	2.80E+13
White perch	367.2	500	0.73	1.5	0.22	4.5	0.99	4186	4150.2	19481	8.08E+07	3.02E+06	2.44E+14
Striped bass	1.4	500	0.00	1.5	0.00	4.5	0.00	4186	15.3	19481	2.97E+05	3.02E+06	8.98E+11
Pumpkinseed	260.7	500	0.52	1.5	0.16	4.5	0.70	4186	2946.5	19481	5.74E+07	3.02E+06	1.73E+14
Largemouth bass	0.0	500	0.00	1.5	0.00	4.5	0.00	4186	0.0	19481	0.00E+00	3.48E+06	0.00E+00
Bluegill	17.1	500	0.03	1.5	0.01	4.5	0.05	4186	193.3	19481	3.77E+06	3.02E+06	1.14E+13
	688.5		**1.38**		**0.41**		**1.86**	4186	**7.78E+03**		**1.52E+08**		**4.58E+14**
Mudflat: Kingman TG1 & TG2													
Yellow perch	101.0	500	0.20	1.5	0.06	4.5	0.27	4186	1141.5	445000	5.08E+08	3.02E+06	1.53E+15
White perch	624.2	500	1.25	1.5	0.37	4.5	1.69	4186	7055.3	445000	3.14E+09	3.02E+06	9.48E+15
Striped bass	1.4	500	0.00	1.5	0.00	4.5	0.00	4186	15.3	445000	6.79E+06	3.02E+06	2.05E+13
Pumpkinseed	414.0	500	0.83	1.5	0.25	4.5	1.12	4186	4678.7	445000	2.08E+09	3.02E+06	6.29E+15
Largemouth bass	0.0	500	0.00	1.5	0.00	4.5	0.00	4186	0.0	445000	0.00E+00	3.48E+06	0.00E+00
Bluegill	27.4	500	0.05	1.5	0.02	4.5	0.07	4186	309.2	445000	1.38E+08	3.02E+06	4.16E+14
	1167.9		**2.34**		**0.70**		**3.15**		**1.32E+04**		**5.87E+09**		**1.77E+16**

*** Average total wet weights from Appendix C. Table 5.5**
**** Averaged from ratios in (Chapman, 1978; and Wetzel, 1983)**
***** Assume dry wt is 20% of wet wt (Waters, 1977)**
****** Coloric coefficient 4.5 Kcal per g dry wt (Bahr et al., 1982)**
******* Solar emjoule (sej) transformity of fish biomass calculated from (Bahr et al., 1982)**

Appendix C, Table 5.5. Sportfish Abundance and Biomass Comparisons Between Marsh and Mudflat Systems

		Total # Fish				Avgerage # Fish / Shocking Event				* Avgerage total wt (g) / sp.				
Total Catch With Catfish		Marsh		Mudflat		Marsh		Mudflat		Marsh		Mudflat		
		MF1 & MF2	Dueling	MF3	Kingman	MF1 & MF2	Dueling	MF3	Kingman	MF1 & MF2	Dueling	MF3	Kingman	
Ictaluridae	**Bullhead catfishes**													
Ameiurus nebulosus	Brown bullhead	403	41	91	414	25.2	8.2	22.8	69.0	3438.4	1119.3	3112.2	9418.5	
Ameiurus catus	White catfish	1	0	0	0	0.1	0.0	0.0	0.0	12.0	0.0	0.0	0.0	
Ictalurus punctatus	Channel catfish	2	3	1	3	0.1	0.6	0.3	0.5	170.4	786.6	393.3	655.5	
Percidae	**Perches**													
Perca flavescens	Yellow perch	7	16	2	7	0.4	3.2	0.5	1.2	37.0	269.4	42.1	101.0	
Moronidae	**Temperate basses**													
Morone americana	White perch	175	308	16	41	10.9	61.6	4.0	6.8	1004.3	1373.7	367.2	624.2	
Morone saxatilis	Striped bass	7	3	1	2	0.4	0.6	0.3	0.3	2.0	2.7	1.4	1.4	
Centrarchidae	**Sunfishes**													
Lepomis gibbosus	Pumpkinseed	95	206	66	175	5.9	41.2	16.5	26.2	93.8	651.0	260.7	414.0	
Micropterus salmoides	Largemouth bass	6	24	0	0	0.4	4.8	0.0	0.0	84.7	1070.4	0.0	0.0	
Lepomis macrochirus	Bluegill	1	5	2	5	0.1	1.0	0.5	0.8	2.1	34.2	17.1	27.4	
		697	**606**	**179**	**647**	**43.5**	**121.2**	**44.8**	**104.9**	**4844.6**	**5307.3**	**4194.0**	**11241.9**	
										9.7	10.6	8.4	22.5	**g/m^2 fish**

Total Catch Without Catfish		Marsh		Mudflat		Marsh		Mudflat		Marsh		Mudflat		
		MF1 & MF2	Dueling	MF3	Kingman	MF1 & MF2	Dueling	MF3	Kingman	MF1 & MF2	Dueling	MF3	Kingman	
Percidae	**Perches**													
Perca flavescens	Yellow perch	7	16	2	7	0.4	3.2	0.5	1.2	37.0	269.4	42.1	101.0	
Moronidae	**Temperate basses**													
Morone americana	White perch	175	308	16	41	10.9	61.6	4.0	6.8	1004.3	1373.7	367.2	624.2	
Morone saxatilis	Striped bass	7	3	1	2	0.4	0.6	0.3	0.3	2.0	2.7	1.4	1.4	
Centrarchidae	**Sunfishes**													
Lepomis gibbosus	Pumpkinseed	95	206	66	175	5.9	41.2	16.5	26.2	93.8	651.0	260.7	414.0	
Micropterus salmoides	Largemouth bass	6	24	0	0	0.4	4.8	0.0	0.0	84.7	1070.4	0.0	0.0	
Lepomis macrochirus	Bluegill	1	5	2	5	0.1	1.0	0.5	0.8	2.1	34.2	17.1	27.4	
		291	**562**	**87**	**230**	**18.2**	**112.4**	**21.8**	**35.4**	**1223.8**	**3401.4**	**688.5**	**1167.9**	
										2.5	6.8	1.4	2.3	**g/m^2 fish**

* Average individual fish wet weights from Appendix C, Table 5.6

Appendix C, Table 5.6. Fish Average Weights and References

		Avg wt (g)	# sampled	
Cyprinidae	**Carps and Minnows**			
Cyprinus carpio	Common carp	2260	1	May's electrofishing survey data
Carassius auratus	Goldfish	1200	1	May's electrofishing survey data
Hybognathus regius	Eastern silvery minnow	7.2	4	Rozas and Odum, 1987 - Rozas et al., 1988
Notemigonus crysoleucas	Golden shiner	13.2	33	Rozas and Odum, 1987 - Rozas et al., 1989
Notropis hudsonius	Spottail shiner	3.5	255	Rozas and Odum, 1987 - Rozas et al., 1990
Cyprinella spiloptera	Spotfin shiner	3.5		Assume same as Spottail shiner - Rozas and Odum, 1987 - Rozas et al., 1990
Notropis procne	Swallowtail shiner	3.5		Assume same as Spottail shiner - Rozas and Odum, 1987 - Rozas et al., 1990
Anguillidae	**Freshwater eels**			
Anguilla rostrata	American eel	178.5	4	Rozas and Odum, 1987
Antherinidae	**Silversides**			
Menidia beryilina	Atlantic silversides	0.57	556	Rozas and Odum, 1987 - Rozas et al., 1988
Fundulidae	**Killifishes**			
Fundulus diaphanus	Banded killifish	0.57	1941	Rozas and Odum, 1987 - Rozas et al., 1988
Fundulus heteroclitus	Mummichog killifish	0.66	3952	Rozas and Odum, 1987 - Rozas et al., 1988
Clupeidae	**Herrings**			
Dorosoma cepedianum	Gizzard shad	216		Kilambi and Baglin, 1969
Alosa aestivalis	Blueback herring	0.1		Assume same as Alewife
Alosa pseudoharengus	Alewife herring	0.1	1	Rozas and Odum, 1987 - Rozas et al., 1988
Alosa sapidissima	American shad	0.1		Assume same as Alewife
Ictaluridae	**Bullhead catfishes**			
Ameiurus nebulosus	Brown bullhead	136.5	73	May's electrofishing survey data
Ameiurus catus	White catfish	200	1	Assume same weight as same sized Brown bullhead collected by May 240mm=200g
Ictalurus punctatus	Channel catfish	1311	3	May's electrofishing survey data
Castomomidae	**Suckers**			
Carpiodes cyprinus	Quillback carpsucker	23.6	33	White sucker used as sub FFON, 2005
Moxostoma erythrurum	Golden redhorse	24	3	Silver redhorse used as sub FFON, 2004
Moxostoma macrolepidotum	Shorthead redhorse	24	3	Silver redhorse used as sub FFON, 2004
Percidae	**Perches**			
Perca flavescens	Yellow perch	84.2	19	May's electrofishing survey data
Poeciliidae	**Livebearers**			
Gambusia affinis	Mosquitofish	0.24	293	Rozas and Odum, 1987 - Rozas et al., 1988
Moronidae	**Temperate basses**			
Morone americana	White perch	91.8	11	May's electrofishing survey data
Morone saxatilis	Striped bass	4.5	320	Juvenile striped bass, Cooper et al.,1998
Centrarchidae	**Sunfishes**			
Lepomis gibbosus	Pumpkinseed	15.8	348	Rozas and Odum, 1987 - Rozas et al., 1988
Micropterus salmoides	Largemouth bass	223	19	May's electrofishing survey data
Lepomis macrochirus	Bluegill	34.2	48	Rozas and Odum, 1987 - Rozas et al., 1988

Appendix C, Table 5.7. 2004 District of Columbia Shoreline Angler Survey Results and Economic Estimates

Estimated # of annual DC wide shore fishing trips	34257	Byers, 2005
Fishery Value	$1,027,710.00	Assume all anglers accept $30 to stop fishing for the day (Cummins and Rockland, 1987;Byers, 2005)
License fees	$83,037.00	Assume same as 2001 DC fish license sales (Byers, 2005)
Cost per trip	$240,827.00	Assume all anglers pay an average of $7 per trip (Cummins and Rockland, 1987)
	$1,351,574.00	2004 total DC fishery economic value
Estimated total DC catch (lbs) May-Nov, 2004	2004.2	Byers, 2005 (Assume this is total annual catch)

Relative abundance and weight of fish caught in a survey of 143 anglers (Byers, 2005)

	Total # caught	% Relative abundance	Total lbs caught	% Relative weight	Estimated Annual catch (lbs)	Estimated Annual Catch (g)
Brown bullhead	7	3%	11	6%	122.5	5.56E+04
White catfish	0	0%	0	0%	0.0	0.00E+00
Channel catfish	42	16%	68	38%	757.0	3.43E+05
Yellow perch	14	5%	4	2%	44.5	2.02E+04
White perch	63	25%	33	18%	367.4	1.67E+05
Striped bass	2	1%	1	1%	11.0	5.00E+03
Pumpkinseed	24	9%	8	4%	89.0	4.04E+04
Largemouth bass	17	6%	15	8%	166.9	7.57E+04
Bluegill	87	34%	40	22%	445.3	2.02E+05
Total	**256**	**99%**	**180**	**100%**	**2003.7**	**9.09E+05**
		% Catfish	lbs Catfish	% Catfish weight	Catfish	Catfish
		19%	79	44%	879.5	3.99E+05

Total DC fishery catch:	g wet wt	g dry wt
1g wet wt = .2g dry wt	9.09E+05	1.82E+05

Appendix D – Examples of SAS Code

Appendix D, Figure 3.1. Example of Algae SAS Code.

```
title1 Algae;

PROC IMPORT OUT= WORK.alg
            DATAFILE= "C:\SAS Algae 97-98 Rework.xls"
            DBMS=EXCEL REPLACE;
     SHEET="Sheet1$";
RUN;
data alg;
set alg;
if date = '.' then delete;
run;
proc print data=alg;
quit;

title1 Means across dates;
proc sort data=alg;
by repetition excl_type;
quit;
proc means data=alg NOPRINT;
by repetition excl_type ;
var __Algae_Cover;
output out=means mean=meanalg;
quit;

title1 Mean BY Season;
proc sort data=alg;
by repetition excl_type season;
proc means data=alg NOPRINT;
by repetition excl_type season;
var __Algae_cover;
output out = seasonal mean=meanalg;
quit;

title1 SEASONAL Mixed;
proc mixed data=seasonal;
class excl_type repetition season;
model meanalg = excl_type|season/ ddfm=kr outp=resids;
random repetition;
repeated season / type=cs;

lsmeans excl_type season / pdiff; → no diff w/ TUKEY
quit;

PROC SORT DATA=RESIDS;
BY EXCL_TYPE;
proc univariate data=resids plot normal;
BY EXCL_TYPE;
var resid;
quit;
```

Appendix D Figure 3.2 Example of Invertebrate SAS code for BA exclosure using a Chi Square in creating a frequency for each treatment repetition to remove significant differences between blocks giving an average percentage of each invert by exclosure type.

```
title1 Invertebrates;
data bugs;
input Excl$ Repetition$  Invert$  count;
datalines;
BA    A      Oligo 34
BA    B      Oligo 40
BA    C      Oligo 60
.
.
.
;
run;
proc sort data=bugs;
by repetition;

proc freq data=bugs noprint;
by repetition;
tables excl*invert / chisq out=tables_rep outpct;
weight count;
quit;

proc freq data=tables_rep;
tables excl*invert / chisq out=tables_all;
weight pct_row;
quit;
```

Appendix D, Figure 4.1. Example of Kingman SAS biomass code.

```
title1 King Biomass Data1;

PROC IMPORT OUT= WORK.biomass
            DATAFILE= "C:\SAS Kng Biomass.xls"
            DBMS=EXCEL REPLACE;
     SHEET="all$";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
RUN;
data biomass;
set biomass;
mass = pont+sag+pelt+echin+ludwig;
run;

proc sort data=biomass;
by  block size year;
proc means data=biomass noprint;
by  block size year;
var mass;
output out = means mean=meanmass;
quit;

data means;
set means;
if Block = 'A' and size= 20 then elevation=1.77;
if Block = 'A' and size = 10 then elevation=1.35;
if Block = 'B' and size = 20 then elevation=1.63;
if Block = 'B' and size = 10 then elevation=1.73;
if Block = 'C' and size = 20 then elevation = 1.54;
if Block = 'C' and size=10 then elevation = 1.4;
run;


Title1 Total Biomass;
*There is no significant different between years F (3,16) = 0.03, P=
.9942 AND no interaction
of size component and year with equally small F and equally unlikely p
value;

proc mixed data=means;
class  size year block;
model meanmass = size elevation size*elevation / ddfm=kr outp=residK;

random block;
lsmeans size / at elevation= 1.55;
```

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