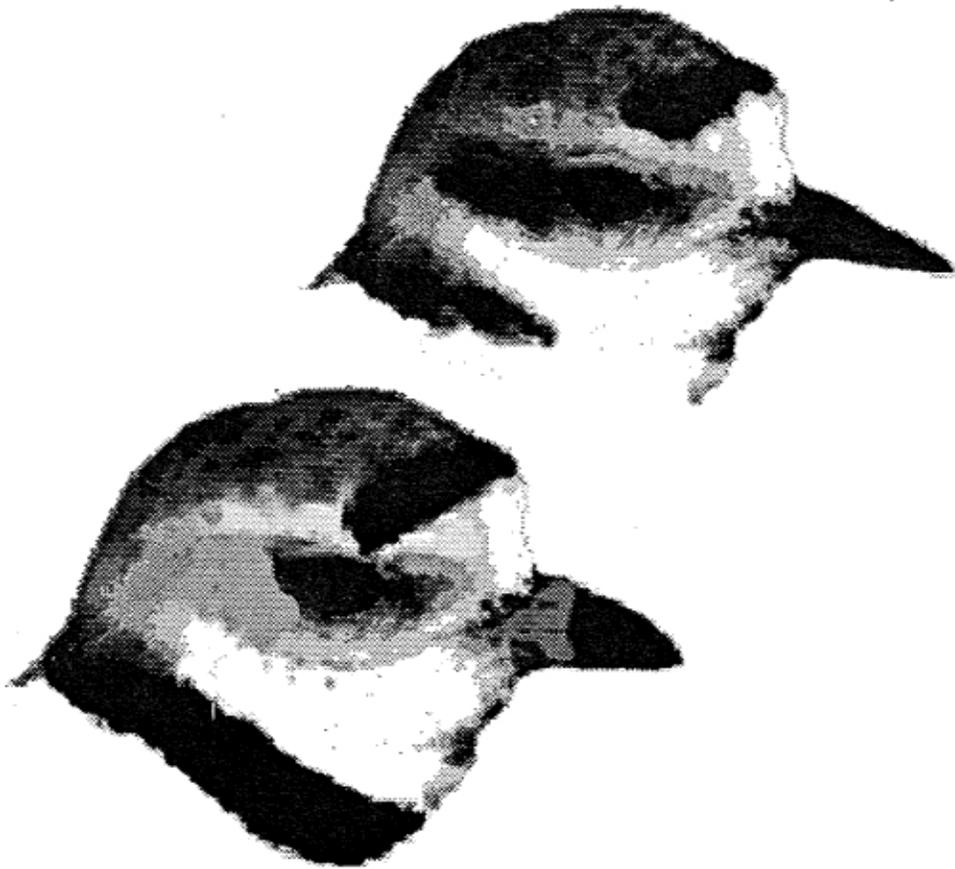


**The Effects of Dredged Material on Piping Plovers  
(*Charadrius melodus*) and Snowy Plovers (*C. alexandrinus*)  
in the lower Laguna Madre of Texas**

**Final Report for the 1997/1998 Season**



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## **FINAL REPORT (1997/1998 Season)**

### **PROJECT TITLE**

The Effects of Dredged Material on Piping Plovers (*Charadrius melodus*) and Snowy Plovers (*C. alexandrinus*) in the lower Laguna Madre of Texas

### **RESPONSIBLE ORGANIZATION**

National Audubon Society

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### **PROJECT OVERVIEW AND RATIONALE**

We investigated the effects of dredged material placement areas (DMPAs) on the ecology of the federally-threatened Piping Plover (*Charadrius melodus*) (U.S. Fish and Wildlife Service 1985) and the Snowy Plover (*C. alexandrinus*). Snowy Plovers are not currently listed as threatened or endangered in Texas, however, the Pacific Coast population was recently protected under the Endangered Species Act (U.S. Fish and Wildlife Service 1993). Furthermore, the Texas Gulf Coast Snowy Plover population is threatened by many of the same factors that required the listing of the Pacific Coast population (e.g., human disturbance, nest failure resulting from anthropogenically-expanded predator populations, habitat destruction and alteration, see U.S. Fish and Wildlife Service 1993, Page et al. 1995) (Zonick 1996, 1997).

Understanding how Piping and Snowy Plovers use coastal habitats that are influenced by DMPAs might substantially reduce the potentially detrimental effects of dredged material to these species. Furthermore, if managed wisely, DMPAs might offer habitat for one or both of these species.

We used radiotelemetry and color-banding techniques to study the following aspects of Piping and Snowy Plovers ecology along the Texas lower Laguna Madre from August 1997 - May 1998.

### **1. Locations and microhabitat characteristics of plover roosting sites.**

Radiotelemetry can provide a useful tool for identifying roost sites used by Piping and Snowy Plovers. Although a few regularly used roost locations have been identified (Zonick 1994, 1996, 1997a), and these sites are used by large groups of plovers, many more roost sites undoubtedly exist but have yet to be mapped. Degradation of roost sites can have negative impacts on shorebird use of an area causing birds to stop using adjacent foraging areas (Burton et al. 1996). Therefore, protection of roost sites may play an important role in the conservation of both species. Additionally, identifying these sites will prevent their loss due to unguided placement of dredged material and/or other anthropogenic activities. We investigated roosting ecology of Piping and Snowy Plovers by observing marked and unmarked plovers, and recording habitat and environmental parameters most likely to affect plover roosting behavior (e.g., macrohabitat and microhabitat features of roost sites, bayshore tidal amplitude and distance to water).

### **2. Home ranges and site fidelity of plovers throughout the winter period.**

#### **Winter Home Range.**

The Laguna Madre's wind-tidal flat system appears expansive; however, this may not be the case. Tidal shifts caused by the passing of winter cold fronts may cause plovers and other birds to cycle among multiple sites throughout the nonbreeding period. Only a fraction of the seemingly vast wind-tidal flat system may provide suitable shorebird habitat at any given time. Shorebirds can deplete the available food resources within

localized areas on non-breeding habitats (Goss-Custard 1977, Evans et al. 1979, Schneider and Harrington 1981, Myers 1983, Withers 1994). Shorebird movements occur in response to unpredictable local prey populations (Pienkowski and Clark 1979, Myers 1983), tidal conditions (Burger et al. 1977, Zonick 1994, 1996) or other factors that affect food availability or the availability of suitable roost habitat (Burton et al 1996). Hypersalinity, wind-tides, and the presence of broad mainland tidal flats are among the features that characterize bayshore habitat in the Laguna Madre ecosystem and distinguish the Laguna Madre from other bays along the Texas coast. These factors also influence prey availability to plovers. For example, Zonick (1996) reported prey density to be substantially lower at many of the Laguna Madre tidal flats used by Piping Plovers relative to tidal flats used by plovers along the central and upper Texas Coast (Zonick 1996). We predicted plovers would exhibit broad winter movements in response to the sporadic availability of foraging and/or roost sites in the lower Laguna Madre. We determined home range size (i.e., the amount of area birds used throughout the during the period they were monitored) of Piping Plovers by monitoring movements of radio-fitted and color banded birds.

*Site Fidelity.* Another question associated with these species is the degree to which they exhibit site fidelity (remaining in a specified area) throughout the nonbreeding season. Determining the degree to which Piping Plovers exhibit site fidelity will enhance the interpretation of plover census data, and help appraise the extent to which local plover populations might be affected by the loss or degradation of winter sites. Tidal flats along the Texas Coast have been directly impacted in areas where dredged material has been deposited onto tidal flats or eroded onto adjacent tidal flats. DMPAs impact tidal flat habitats both directly and indirectly by prohibiting a normal tidal regime of inundation and exposure, resulting in vegetated areas. Characterizing the habitat use, site fidelity, and movements of radioed and color-banded plovers prior to alteration of tidal flats is an important step in determining the effects of winter habitats loss to Piping Plover populations. Similar studies completed after alteration of tidal flats would provide comparative data to analyze impacts of alteration. Monitoring movements of radio-fitted Piping Plovers allowed us to address this goal.

### **3. DMPAs as nesting sites for Snowy Plovers and members of the Flat Nesting Guild.**

Snowy Plover nesting habitat along the Texas Coast has been described as wind-tidal flats and related habitats that exhibit scattered, sparse vegetation, that are rarely flooded, with preference for flats and shorelines located near broad, shallow pools of water (Page and Stenzel 1981, Zonick 1994, Zonick 1996). This habitat description includes most washover passes, bayshore tidal flats, and lagoons, but also extends beyond natural habitats to include many man-made impoundments and basins, including DMPAs. Snowy Plovers have been observed nesting at DMPAs (Zonick 1996). In fact, a guild including several species of shorebirds and other birds with similar habitat requirements is regularly associated with DMPAs and DMPA-like habitat. The guild, described as the flat-nesting guild (FNG; Zonick 1996) because of the link between this guild and tidal flat-associated habitat, includes species such as the Least Tern (*Sterna antillarum*), Snowy Plover, Wilson's Plover (*Charadrius wilsonia*), Killdeer (*C. vociferus*), Black Skimmer (*Rynchops niger*), Black-necked Stilt (*Himantopus mexicanus*), American Avocet (*Recurvirostra americana*), and Horned Lark (*Eremophila alpestris*). Several of these species (e.g., Snowy Plover, Least Tern, Wilson's Plover, Horned Lark) have been identified as "priority species" by Texas Partners in Flight (TPIF; 1996). TPIF distinguished these birds as species that deserve very high concern and are likely in need of management and/or monitoring.

We investigated use of DMPAs and other man-made habitats with similar designs (e.g., cooling ponds, settling ponds) by Snowy Plovers and the FNG. We report factors that were most strongly associated with nesting birds at these habitats, and propose features that might be optimized to enhance existing DMPAs as FNG habitat.

#### **STUDY AREA**

Most research presented in this report was conducted along the lower Laguna Madre in Cameron and Willacy Counties. The majority of radiotelemetry work was conducted on South Padre Island, however, data were collected at other locations including wetlands

associated with South Bay, Brazos Island, Laguna Atascosa National Wildlife Refuge and mainland tidal flats adjacent to the Laguna Madre. We conducted research addressing use of DMPA habitat by Snowy Plovers and FNG colonies at numerous sites, all of which occurred south of Copano Bay.

## **METHODS**

### **Movement Patterns and Roosting Ecology.**

Initially, we proposed to use Snowy Plovers as a surrogate species to describe the effects of dredged material on Piping Plovers. Piping and Snowy Plovers exhibit relatively broad niche overlap, often foraging and roosting together in mixed flocks (Zonick 1994, 1996), therefore, this approach was justifiable. However, after modifying our banding and radio-fitting methods to reduce the likelihood of adversely affecting birds, we were permitted by the U.S. Fish and Wildlife Service and Texas Parks and Wildlife Department to work directly with Piping Plovers. In addition, we banded and radio-fitted Snowy Plovers during the project, however, most of our efforts were directed at trapping and monitoring Piping Plovers.

We captured plovers using leg-hold noose mats (Bub 1991) and mist nets from January 1997 - February 1998 primarily on South Padre Island. Each bird was banded with a unique color band combination that included a red/white bi-colored identifier band and 2 additional color bands. In addition to color bands, we also banded Snowy Plovers with a stainless steel U.S. Fish and Wildlife Service band. To reduce the potential for band-induced leg injuries, we did not use metal bands on Piping Plovers. Furthermore, we did not stack colored leg bands and avoided use of flagged bands to further reduce the risk of band-related injuries.

We fitted Piping Plovers with a 1.2g radio transmitter (Holohil Systems Ltd., Ontario Canada, Model BD-2G) epoxied to the feathers in the interscapular region (see Knopf and Rupert 1995). Radiotransmitters had an active lifespan of approximately 8 weeks. Color band sequences were unique to individual birds to permit continued monitoring of plovers throughout the study. We recorded the following morphometric measurements of

each bird: weight (g), wing cord (mm), tarsus length (mm), bill length (mm), and an estimate of furcular fat deposits. Birds were released < 15 minutes after capture.

We monitored movements of radio-fitted plovers using receivers (ATS model R2100, Advanced Telemetry Systems, Isanti, MN, and WMI model TRX-1000S, Wildlife Materials Inc., Carbondale, IL) and 3-element Yagi antennas. Radioed plovers were monitored from the ground 5-6 days/week using 4-wheel drive vehicles and ATVs, throughout the life of the radios (average = 58 days). When we were unable to locate radioed plovers from the ground aerial telemetry was used to locate birds. During ground searches for radioed birds, observations of color-banded birds, in which radios had failed, were also recorded. Searches for radioed birds were conducted throughout the diel period, however, most of our efforts focused on the daylight period.

Upon locating marked plovers, we recorded the following variables: date, time, location (location was determined using global positioning system equipment), habitat type, distance to water, behavior of plovers at the time of relocation (foraging or roosting), and tidal amplitude. We estimated tidal amplitude as the distance (in meters) of the waterline from the mean high tide line. Mean high tide line was generally easily discernible as the boundary between lower sand flat habitat and the waterward edge of algal flat habitat.

In addition to our observations of marked (i.e., banded or radio-fitted) plovers, we also searched the study area for unmarked roosting plovers. When roosting birds were found, we recorded features of the roost site including microhabitat and macrohabitat type, distance from water, and tidal amplitude. To determine microhabitat variables plovers selected for when roosting, we compared microhabitat components (e.g., % depressions, % debris, % water, and % vegetation within 1 m<sup>2</sup> of roost location) of roost sites to those at random sites. Random sites were located 50 m from the roost site in a random direction.

### **Use of DMPAs by Nesting Snowy Plovers.**

We visited over 25 sites to investigate use of DMPAs by Snowy Plovers and other members of the FNG. Sites were visited from 1 June 1997 - 1 August 1997 and from 1 March 1998 - 1 June 1998. Twelve of the sites were DMPAs along the lower reach of the Gulf Intracoastal Waterway (GIWW). The remaining sites were either DMPAs along channels other than the GIWW (n = 12), or DMPA-like sites that featured habitat structure very similar to that typically found at DMPAs (e.g., sites with high flat habitat or shell/gravel berms juxtaposed with low flat habitat and/or shallow pool habitat; such as cooling ponds, or settling ponds; n = 5). Some of the sites were privately owned, and were visited through agreements that required confidentiality; therefore, site locations are not described in this report.

During visits, we surveyed the entire area of each site for the presence of adult Snowy Plovers and other members of the FNG, and searched suitable nesting habitat for the presence of nests and chicks. Several microhabitat features were recorded at nest sites including substrate type, nest lining, distance to nearest vegetation, and distance to nearest water. Additionally, information was collected on the presence and area of dense vegetation, pools of standing water, levee slopes, and surface shell/gravel cover.

### **Data Analyses.**

Statistical analyses were performed using JMP (SAS Institute Inc., 1995). Home ranges were estimated from all relocations (i.e., relocations of birds with active radios using radiotelemetry and visual relocations of color-banded birds) using Home range (R. Huber, University of California - San Diego, San Diego, CA). Home ranges were estimated as convex polygons (i.e., the smallest polygon created by connecting all peripheral relocation points). Relocations were incorporated into the Piping Plover Geographic Information System (GIS) layer being developed by the Texas Parks and Wildlife Department using the Arcview Geographic Information System (Environmental Systems Research Institute, Inc., Redlands, CA).

## RESULTS

### Capture and Banding Results

We trapped 49 Piping Plovers and 32 Snowy Plovers between 1 January 1997 - 29 March 1998. We fitted all plovers with unique color band combinations and attached 49 transmitters to Piping Plovers and 5 transmitters to Snowy Plovers. One Piping Plover was trapped twice during the study and fitted with a radiotransmitter on both occasions (Radio frequencies 301/687).

Three Piping Plovers we captured had been previously banded (Radio frequencies: 384, 871, and 882). Two plovers were originally banded in Canada (871 - Alberta, 882 - Saskatchewan), and one plover was an endangered Great Lakes bird (384 - Michigan). The Great Lakes plover had four color-bands when we captured it, thus, it was fitted only with a radiotransmitter and released. This plover was resighted at its former breeding site in Michigan in 1998 (pers. comm., F. Cuthbert, University of Minnesota). The other 2 plovers each had a U.S. Fish and Wildlife band and one color band when we captured them. We added our identifier band (red/white bi-colored band) to each of these plovers, as well as two additional color-bands to permit individual recognition.

Piping Plover body mass ranged from 48 g to 71 g (average = 54.1 g). Furcular fat stores ranged from 0 (lowest range; no fat deposits) to 5 (highest rank, extensive fat reserves) averaging of 2.6. Fat stores correlated positively ( $P = 0.0208$ ) with body mass for Piping Plovers. Snowy Plover body mass ranged from 33 g to 50 g (average = 43.7 g). Furcular fat stores ranged from 0 (lowest range; no fat deposits) to 5 (highest rank, extensive fat reserves) averaging 2.7. Snowy Plovers fat stores correlated positively ( $P = 0.0002$ ) with body mass. Similarly, White and Mitchell (1990) observed positive relationships between fat stores and body mass in Long-billed Dowitchers (*Limnodromus scolopaceus*), Western Sandpipers (*Calidris mauri*), and American Avocets collected within our study area.

### **Movement Patterns of Piping and Snowy Plovers**

A relocation map and accompanying relocation data summary for each marked Piping Plover is presented in the Appendix. Snowy Plover relocation data are summarized collectively.

Color-bands facilitated collection of additional data beyond the lifespan of radiotransmitters. Most plovers (95.9%) were visually relocated after their radiotransmitters had become inactive. Marked Piping Plovers exhibited high site fidelity (89.7%) in the lower Laguna Madre throughout the study.

### **Habitat Use**

All marked Piping Plovers used > 2 habitat types during the study (Appendix). All but one of the Piping Plovers (frequency 778; Appendix) used both high flat habitat (Table 1; primarily upper sand flats and algal flats) and low flat habitat (Table 1; primarily lower sand flats). Ten of the Piping Plovers used beach habitat in addition to high flat and/or low flat habitat (Appendix). Over half of the marked Piping Plovers (n = 26) used washover pass habitat in addition to high flat and/or low flat habitat (Appendix).

### **Winter Ranges**

Home range estimates indicated that Piping Plovers used a relatively large area throughout the nonbreeding season (Figure 1). Home range estimates for marked Piping Plovers ranged from 230 ha to 27,351 ha with a mean of 5,027 ha.

A few plovers were consistently relocated within a relatively small area (e.g., radio frequencies 177, 248; Appendix). However, most plovers moved among widely spaced locations throughout the nonbreeding period. The small ranges estimated for plovers 177, 248 and other plovers caught early in the year must be evaluated with caution, as birds tracked in early fall generally exhibited a more restricted range than did those tracked later in the year when winter cold fronts began influencing local habitat conditions. For instance, we relocated 177 during March and April ~ 20 km north of its

fall home range. In addition, 686 and 301 (same bird) had different home range sizes during fall and winter, further supporting season variations in home range size.

### **Time of Day**

Most Piping Plovers were associated with high flats and washover passes at night. However, because most nocturnal relocations were triangulated, exact habitat associations often could not be determined. Evaluation of relocation maps presented in the Appendix suggests that many of the nocturnal relocations of radioed Piping Plovers occurred on higher tidal flats closer to the Gulf relative to diurnal relocations. However, because nocturnal relocations must be triangulated, exact habitat types could not always be determined. These data suggest that plovers used the same general locations at night that were used during the day, but moved to higher areas. Thus, the nocturnal behavior of roosting Piping Plovers was similar to diurnal roosting behavior; which we describe in the Roost Ecology section of this report.

### **Use of Mainland Tidal Flats**

Twenty-one Piping Plovers (42.8%) used both mainland and barrier island sites. . Use of mainland tidal flats appeared to be strongly linked to the arrival of north fronts throughout the early winter period (i.e., November and December). North fronts generally cause high bayshore tides on South Padre Island while exposing tidal flat habitat along the mainland coast. However, by January, plover movements to the mainland did not appear to be correlated with arrival of north fronts or changes in bayshore tidal amplitude on South Padre Island.

### **Use of DMPAs by radioed Piping Plovers**

Radioed Piping Plovers rarely used DMPAs. Only 2% (5 out of 242) of aerial telemetry relocations found Piping Plovers using DMPAs. Furthermore, plovers using mainland habitats did not use areas adjacent to DMPA islands and impoundments. This was likely due to conversion of habitats from low tidal flat to upper flat through encroachment by saltwart (*Batis maritima*) and other secondary vegetation. Piping Plovers avoid vegetated areas while roosting (e.g., of 357 roost plots % vegetation averaged < 0.34%) and were

never observed foraging in vegetated areas. Piping Plover winter habitat must include normal periods of tidal inundation and exposure. Thus, manipulations to DMPAs would need to allow tidal inundation and exposure to be beneficial to wintering Piping Plovers.

### **Conclusions & Management Recommendations**

Our findings further support the importance of preserving large tracts of bayshore tidal flat habitat for Piping Plovers. Our findings support previous work demonstrating the importance of the broad tidal flats on South Padre Island to Piping Plovers and Snowy Plovers (Zonick 1994, 1996). This study also supports earlier studies describing the importance of washover passes, and mainland tidal flats to Piping and Snowy Plovers wintering along the lower Laguna Madre (Zonick 1997a, 1997b). These tidal flats and washover passes provide critical feeding and roosting sites for plovers throughout the non-breeding season.

This study demonstrated that most plovers used island and mainland sites throughout the winter. Mainland sites appeared to be used during periods when the barrier island experiences high bayshore tides, particularly during the early winter period. These findings confirmed our initial hypothesis that plovers visit, and probably require, multiple sites throughout the winter period.

The use of mainland habitat by Piping Plovers along the lower Laguna Madre is very similar to their use of beach habitat along the mid and upper Texas coast. Zonick (1994) reported that Piping Plovers regularly moved between bayshore tidal flats and beach habitat at more northerly sites along the Texas Coast. In this region, beach habitat was used primarily as a secondary habitat when bayshore foraging areas were submerged. Preference for bayshore habitat over beach habitat north of the Laguna Madre was apparently due to higher energy requirements to gather the same quantity of prey at beach habitat relative to bayshore habitat (Zonick 1994). Despite the apparent preference by Piping Plovers for bayshore habitat, local Piping Plover abundance was most strongly affected by availability of high quality beach habitat (Zonick 1994).

Piping Plovers we monitored appeared to prefer mainland areas and washover passes to beaches as a secondary habitat. These results are supported by other surveys of beach habitat on South Padre Island that found very low use by Piping Plovers relative to beach habitat along other regions of the Texas Coast (Nicholls and Baldassarre 1990, Haig and Plissner 1993, Zonick 1994). The importance of washover passes to Piping Plovers, Snowy Plovers (especially breeding Snowy Plover populations), and other waterbirds has already been documented (Zonick 1997a, 1997b), as has the extensive use of mainland habitat by Snowy Plovers and occasional large flocks (>100 birds) of Piping Plovers (Zonick 1994, Brush 1995). Maintaining healthy Piping Plover populations along the lower Laguna Madre may require more than the protection of barrier island habitat. Our findings further support the need to protect mainland tidal flats and barrier island washover pass habitat in addition to barrier island bayshore tidal flats.

Very few marked Piping Plovers were observed using DMPAs during the winter portion of the study. Low use of these areas suggests DMPAs do not provide suitable habitat for Piping Plovers. Furthermore, DMPAs have a detrimental effect on the quality of mainland tidal flats along the GIWW between the Ship Channel to Harlingen and northern boundaries of Laguna Atascosa National Wildlife Refuge (~ latitude 26°29'). In this region, previously isolated DMPA islands have coalesced to form a long barrier between large tracts of mainland tidal flats and the Laguna Madre. Other DMPAs along the Ship Channel to Harlingen have divided a large tidal flat complex at Laguna Atascosa National Wildlife Refuge, and have nearly removed the southern portion of this tidal flat complex from the tidal regime. Consequently, tidal flats in these regions have begun successional conversion to upland habitat (e.g., encroachment of *Salicornia bigelovii*, *Batis maritima* and other vascular plants). These areas supported large Piping Plover populations as recently as 1991-1994 (Zonick 1994), but as the tidal flats in this region have become more densely vegetated, they have become less attractive to Piping and Snowy Plovers (Brush 1995). For these reasons, we recommend that measures be taken to restore a more natural tidal regime to the mainland tidal flat complex in the lower Laguna Madre (e.g., by creating and maintaining gaps in the DMPA barriers).

## **Roost Ecology of Piping and Snowy Plovers**

Only a small proportion of the plovers we marked (radio-fitted and/or color-banded) were engaged in roosting behavior when relocated (Appendix). Piping Plovers were roosting during 7.3% (91/1249) of all relocations, and Snowy Plovers were roosting during 8.1% (7/86) of all relocations. Using only radiotelemetry relocations, however, a higher proportion of Piping Plovers were roosting when relocated (9.8%; 87/889). Furthermore, despite efforts to minimize the effects of our activities on bird behavior, many plovers may have been disturbed from roosts during our surveys and consequently documented as foraging birds. Therefore, we believe these findings represent conservative estimates of the proportion of roosting relocations.

### **Roosting Habitat**

Marked Piping Plovers roosted primarily within high flat habitat (BEG layer HF, Table 1); however, washover passes and low tidal flats were also used as roost sites (Appendix). Marked Piping Plovers roosted more often when tides rose above the mean high tide line ( $P = 0.0110$ , Figure 2), and roosting Piping Plovers occurred farther from water than did foraging Piping Plovers ( $P < 0.0001$ , Figure 3). On average, marked Piping Plovers roosted 53.1 m from water when tides covered 29.0 m of flats above the mean high tide line (Appendix).

Marked Snowy Plovers roosted exclusively within high flat habitat (BEG layer HF, Table 1; Appendix). Roosting Snowy Plovers occurred farther from water than did foraging Snowy Plovers ( $P = 0.0305$ , Figure 4), however, in contrast to Piping Plovers, Snowy Plovers were just as likely to roost during periods of low bayshore tides as during periods of high bayshore tides ( $P = 0.2231$ , Figure 5). On average, marked Snowy Plovers roosted 52.2 m from water when the tide had fallen to a level that exposed 69.3 m of flats below the mean high tide line (Appendix).

Observations of unmarked plovers closely matched those of marked plovers. Unmarked Piping Plovers roosted away from water during high bayshore tides. On average, unmarked Piping Plovers roosted 35.9 m from water when the tides had risen to cover

55.9 m of flats above the mean high tide line (Figure 6). Most unmarked Snowy Plovers roosted away from water, but without apparent regard to tide level. On average, unmarked Snowy Plovers roosted 74.1 m from water when the tide had fallen to a level that exposed 35.9 m of flats below the mean high tide line (Figure 7).

Plovers exhibited strong selection for high flats as roosting habitat. Most (91.5%) roost sites occurred on high flat habitat (i.e., high sand flats and algal flats) with a small percentage of roost sites occurring on lower flats (7.4%) and washovers (1.1%). Similarly, plovers exhibit strong preference for microhabitat variables within roost sites. Compared to random plots, roost plots had a higher percent cover of depressions ( $P < 0.0001$ ) and debris ( $P < 0.0001$ ), greater mean depression depth ( $P < 0.0001$ ), less percent water coverage ( $P < 0.001$ ), and were closer to the water's edge (primary foraging area;  $P = 0.0261$ ). Therefore, our results suggest that plovers are selecting roost sites based on microhabitat components.

### **Conclusions & Management Recommendations**

Piping and Snowy Plovers used multiple roost sites throughout the nonbreeding period. Roosts were discovered primarily in regions of high flat habitat (higher algal flats and sand flats) adjacent to recently used feeding areas. Because shorebird distribution coincides with distributions of their prey (Colwell and Landrum 1993, Mercier and McNeil 1994), plovers presumably used multiple roost sites because they move among multiple foraging sites following ephemeral prey populations.

Our data indicate that plovers moved among different feeding areas; thus, they likely select roost sites based on the presence local of microhabitat features such as small depressions and accumulation of seagrass and/or other wrack material. Habitat selection involves the choice of a particular habitat from available habitats resulting in non-random distribution of animals (Burger 1987). Components within roosts have a role in attractiveness of a site as a roost area (Burton et al. 1996). The selection of microclimates by roosting birds may be important from a thermoregulatory standpoint

and habitat components at roosts may assist birds in concealment from predators (Walsberg and King 1980).

Piping and Snowy Plovers have been observed to congregate in large roosting flocks at some sites along parts of the Texas coast (e.g., Newport Pass, Bolivar Flats, San Luis Pass, Big Reef; Zonick 1994, 1997a). Along the lower Laguna Madre, large roosting flocks have been documented at washover passes on Brazos Island and South Padre Island (Zonick 1997a). However, plovers appear to use these sites less frequently than do plover using sites north of the lower Laguna Madre. Most of the radioed Piping Plovers we monitored were observed to roost alone or in small flocks (< 5 plovers) and used multiple roost sites.

Differences in flock size at roost sites is likely driven by availability of habitat. Roost sites at some locations (e.g., Newport Pass and Bolivar Flats) are used by large plover flocks several times during the year, and have been used by plovers every year since they were documented, whereas roost sites along the lower Laguna Madre appears to be less predictable. For example, a washover pass on Brazos Island that supported large roosting flocks of Piping Plovers on several occasions from 1991-1994 (U.S. Fish and Wildlife Service 1989, Zonick 1996, 1997a) was used less frequently in 1996-1998 based on our observations and those reported by Zonick (1997a). The most recent observation of a large roosting flock of plovers at this site coincided with the extreme high tides associated with tropical storm Josephine in 1996 (Zonick 1997a).

#### **The use of DMPAs by Breeding Snowy Plovers and the FNG**

DMPAs and DMPA-like sites were used as nesting habitat by Snowy Plovers and several other members of the FNG. We found no Snowy Plover nests, broods or adults at any of the 12 DMPAs along the GIWW. However, we detected adults and either nests with eggs or broods at all of the DMPAs that were not located along the GIWW, and all of the DMPA-like sites. Together, a total of 144 Snowy Plover nests were found at these sites. Because nests and chicks were well camouflaged and sometimes difficult to locate, it is likely that more nests were present at these sites but were not detected.

### **Nest Habitat at DMPAs**

All but one of the Snowy Plover nests (99.2%), and 15 of the FNG nests (96.6%, including Snowy Plover nests) were associated with "beaches and berms" and "high sand and mud flats" as these habitats are described by "Submerged Lands of Texas" maps developed by University of Texas at Austin's Bureau of Economic Geology (BEG; Tables 1 and 2). Koenen et al. (1996) also reported that Snowy Plovers and Least Terns selected berm habitat in Oklahoma.

Berms at DMPA and DMPA-like sites occurred as perimeter levees, blind-ending berms (projecting from perimeter levees into the impoundment), and mounds of dredged material or shell/caliche accumulations. Many Snowy Plover nests occurred near the top few meters of berms (mean = 4.9 m from top, SE = 3.6, N = 65), although nests rarely occurred on the top surface of the berm. Nests were as likely to occur on the outer side of the perimeter berm (n = 30) as on the interior side of the berm (n = 35). Most of the berms had been scoured by rain, leaving a rough surface of high ridges flanked by eroded drainage channels (Figure 8). All Snowy Plover nests found on such berms occurred on the high ridges, which often exhibited accumulations of stones and shell fragments (Figure 8).

### **Shallow Pool Habitat**

The presence of a sheltered water body appeared to be an important factor in attracting nesting Snowy Plovers. Most Snowy Plover nests were found within 100 m of some permanent or semi-permanent water source (i.e., lasting at least the length of incubation for Snowy Plovers; Table 2). The primary water sources near most nests were shallow pools or small lakes located near the center of the site. This habitat type is described as shallow subaqueous flats habitat in the BEG layer (Table 1).

### **Habitat Juxtaposition**

All of the sites used by Snowy Plovers exhibited a mix of the 4 habitat types described in Table 1. These habitats were often closely juxtaposed to one another. All of the used

sites exhibited a berm or levee (BEG layer BB) that graded as a shallow slope into shallow subaqueous flat habitat (BEG layer W, Figure 9). Between the BB and W habitats were zones of high flat habitat (BEG layer HF, Figure 9) and low flat habitat (BEG layer LF, Figure 9). This mix of habitat types may be preferred by Snowy Plovers because it provided suitable nesting habitat (i.e., layers BB and HF; higher areas safe from flooding) in close proximity to brood-rearing habitat (layers LF and W; wetter areas where prey populations were more abundant).

Another landscape exhibiting a similar combination of these habitat layers is the complex of washover passes that occur naturally on many south Texas barrier islands (Zonick 1996, 1997a, 1997b). Washover passes support some of the largest and most dense populations of Snowy Plovers along the Texas Gulf Coast, further supporting the apparent preference by this species for regions where high flats, low flats and shallow lakes occur together. The physical and chemical properties of shallow lake habitat at the nesting sites are not well known, however, salinity does not appear to be a major factor influencing use by Snowy Plovers because we observed nests around lakes that ranged in salinity from near brackish (e.g., Sunset Lake) to marine (e.g., Barney M. Davis Cooling Ponds) to hypersaline (e.g., most washover pass lakes).

### **Microhabitat Features Affecting Nest Density**

*Vegetation.* Most Snowy Plovers nested within berm or high flat habitat. Several microhabitat features associated with these habitats appeared to affect local nesting density, and may have affected nesting at the site level. One of these features was vegetation density. Most nests were within a few meters of some type of vegetation (Table 2), however, no nests were detected in densely-vegetated habitats (Figure 10). This may have been a significant factor limiting the use of GIWW DMPAs. Although many GIWW sites exhibited high flat or berm habitat, most of the BB and HF habitat at these sites was heavily overgrown with vegetation, and therefore was unavailable as nesting habitat for Snowy Plovers.

*Surface Features.* Another microhabitat feature that appeared to affect Snowy Plover nesting density was the presence of shell fragments, stones or similar surface features. Whereas Snowy Plover nests were observed on a wide variety of base substrate types (e.g., sand, mud, spoil), all of the nests were lined with small stones or fragments of shell or algal mat, and nearly all of the nests were established in areas where these materials were common (Figure 11). Nests situated in microhabitats where shell pieces or stones were present appeared to be much better camouflaged, and consequently may have been harder for predators to detect. Snowy Plovers also exhibited an apparent preference for shell fields when selecting nest sites within washover pass habitat, however, there was some evidence that predators cued in on this microhabitat feature when searching for nests (Zonick 1997a).

*Berm Slope.* A third microhabitat feature that apparently affected local Snowy Plover nesting density was slope of berm and shoreline habitats. Snowy Plover's only rarely nested on steep berms ( $> 35^\circ$ ). In areas with steep berms, but otherwise suitable habitat (e.g., sparsely vegetated zones with surface stones/shell and shallow pool habitat located nearby), Snowy Plover nests were often found at the top of the berm, or at the base of the berm near the HF/BB boundary.

### **Conclusions & Management Recommendations**

Our findings demonstrate many DMPAs currently provide breeding habitat for Snowy Plovers and other members of the flat-nesting guild (FNG). However, breeding habitat for this guild might be improved at many DMPAs. The factors that appeared to most strongly affect breeding density at DMPAs were the presence of suitable nesting and brood-rearing habitat. Snowy Plovers prefer to nest in open, sparsely-vegetated areas that are above the mean high tide line, and are therefore relatively safe from flooding (e.g., the HF, BB layers described in Table 1). They also prefer areas covered with small stones and/or shell fragments. The proximity of a shallow pool of water ( $< 100$  m; i.e., the W layer described in Table 1) to potential nesting sites also appeared to influence Snowy Plover nesting density. Pools of water, and their surrounding shorelines (LF habitat, Table 1), provide ideal brood-rearing habitat for Snowy Plovers.

At DMPAs, nesting habitat can be maintained as berms that are kept free of dense vegetation. The berms should not have a steep slope, but should grade at a relatively shallow angle ( $\leq 35^\circ$ ). When possible, water should be present within the DMPA during early nesting season (i.e., February - June). The proximity of water may be a critical consideration for plovers seeking safe nesting sites located near brood-rearing habitat. Berms can be improved by topping them with shell/stones where possible.

Timing of addition of dredge material into DMPAs may be an critical factor affecting the value of these areas to Snowy Plovers and the FNG. Once nests have been established (i.e., March - August), addition of dredge material can have deleterious effects (e.g., flooding nests, covering brood-rearing habitat). However, if dredged material is placed in the DMPA between nesting periods (i.e., September - February), its effects may be positive by creating shallow pools during at least the early nesting period.

Another management practice recommended to improve Snowy Plover nest success at DMPAs is the use of predator exclosures around heavily used nest sites. Predator exclosures have been highly effective in reducing depredation of plover nests (Koenen et al., 1996, B. Murphy, U.S. Fish and Wildlife Service, Kenmare, ND, pers. comm.). Rather than deploying individual exclosures around a single nest, we recommend the use of electrified fence exclosures around larger areas of the DMPA. Berm landscapes are relatively easy and inexpensive to surround with electric fencing. Sections of existing berms could be managed by removing vegetation, top-dressing with shell and stones and surrounding with electrified fence exclosures. When possible, blind-ending berms projecting from the perimeter of the DMPA into a shallow pool of water should be incorporated. These berms can be isolated from predators with only a very short fence positioned at the junction of the blind-ending berm and perimeter berm. These steps will benefit not only Snowy Plovers, but Wilson's Plovers, Least Terns, Black-necked Stilts and other members of the FNG, and should not greatly impair the intended use of DMPAs.

Finally, the potentially deleterious effects associated with heavy metal poisoning and other chemical hazards to birds that nest at DMPAs along the Texas Coast have not been adequately investigated. Snowy Plovers and other members of the FNG raise precocial young that feed at the nesting site. These birds may bioaccumulate heavy metals and other biotoxins that might be present at some DMPAs. The potential exists for creating “attractive nuisances” if DMPAs that contain contaminated sediments are managed to attract FNG colonies. Therefore, we recommend that future research investigate the influences of hazardous chemicals on nesting populations of birds using DMPAs. This study will determine, not only the relative health of existing DMPA nesting colonies, but whether these colonies should be encouraged to expand, or should be encouraged to relocate at safer locations away from DMPAs.

#### **ACKNOWLEDGEMENTS**

We thank Tim Cooper, Steve Labuda, and the rest of the staff at Laguna Atascosa National Wildlife Refuge for their support during this study and their ongoing commitment to the conservation of Piping Plovers, Snowy Plovers and the vast number of other wildlife species relying upon healthy coastal habitats in south Texas. We were fortunate to have the support and camaraderie of Anse Windham, one of the finest and most knowledgeable pilots along the Texas coast. We are also extremely grateful to Tammy White (Texas Parks and Wildlife Department), who provided tireless support toward the generation of the relocation maps presented in the report. We sincerely appreciate the support of Martin Arhelger and Espey Huston and Associates, Inc. for their help in administering this project. We would also like to acknowledge the support of Compaq Computer Corporation and Texas Partners in Flight for providing the valuable use of a laptop computer during the study. Finally, we thank Nell McPhillips, Anne Hect, Casey Kruse, Francie Cuthbert, Bob Murphy, Jonathan Plissner and all of the other dedicated shorebird biologists in North America that contributed guidance and professional support to this project.

Primary support for this research was provided by the U.S. Army Corps of Engineers through the lower Laguna Madre Interagency Coordination Team. Additional support

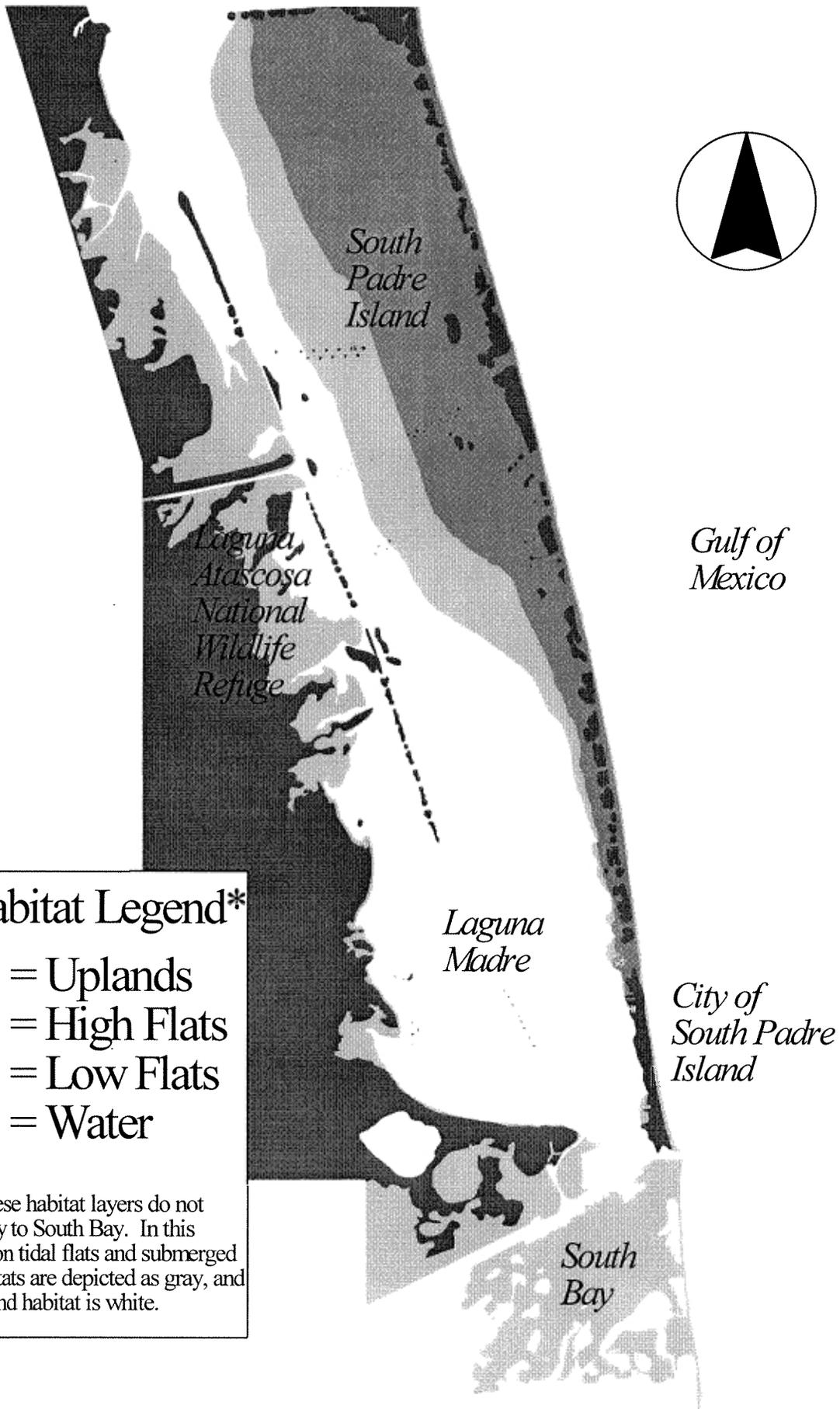
was provided by the U.S. Fish and Wildlife Service, the U.S. Geological Survey – Biological Resources Division, Forest and Rangeland Ecosystem Science Center, the National Audubon Society, and the Caesar Kleberg Wildlife Research Institute at Texas A&M University-Kingsville.

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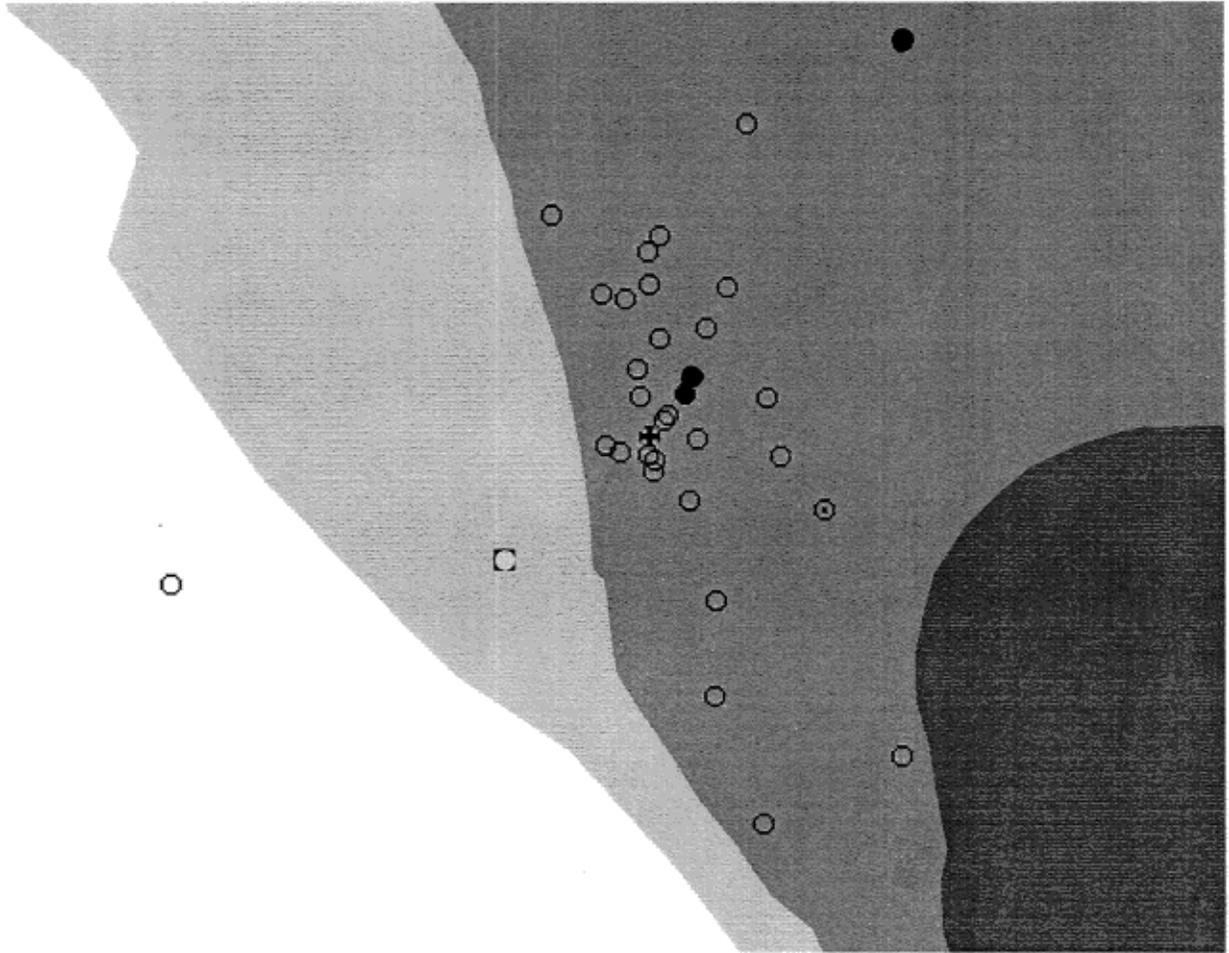
**Habitat Legend\***

-  = Uplands
-  = High Flats
-  = Low Flats
-  = Water

\*These habitat layers do not apply to South Bay. In this region tidal flats and submerged habitats are depicted as gray, and upland habitat is white.



**Study Area**



**Symbols Legend:**

**Trap Site**



**Foraging Bird**



**Roosting Bird**

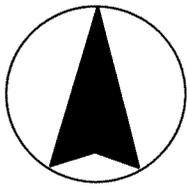
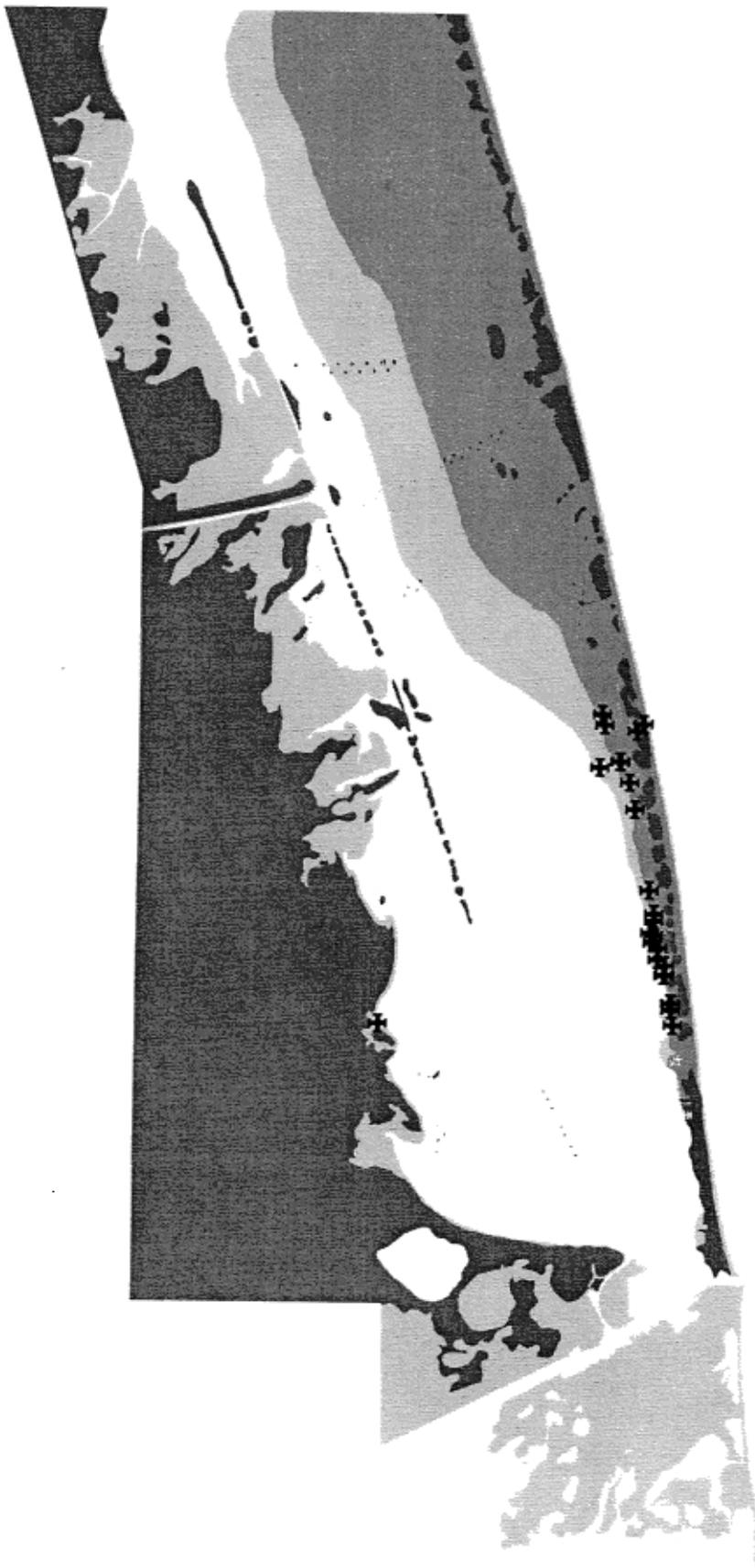


**Unknown Behavior**



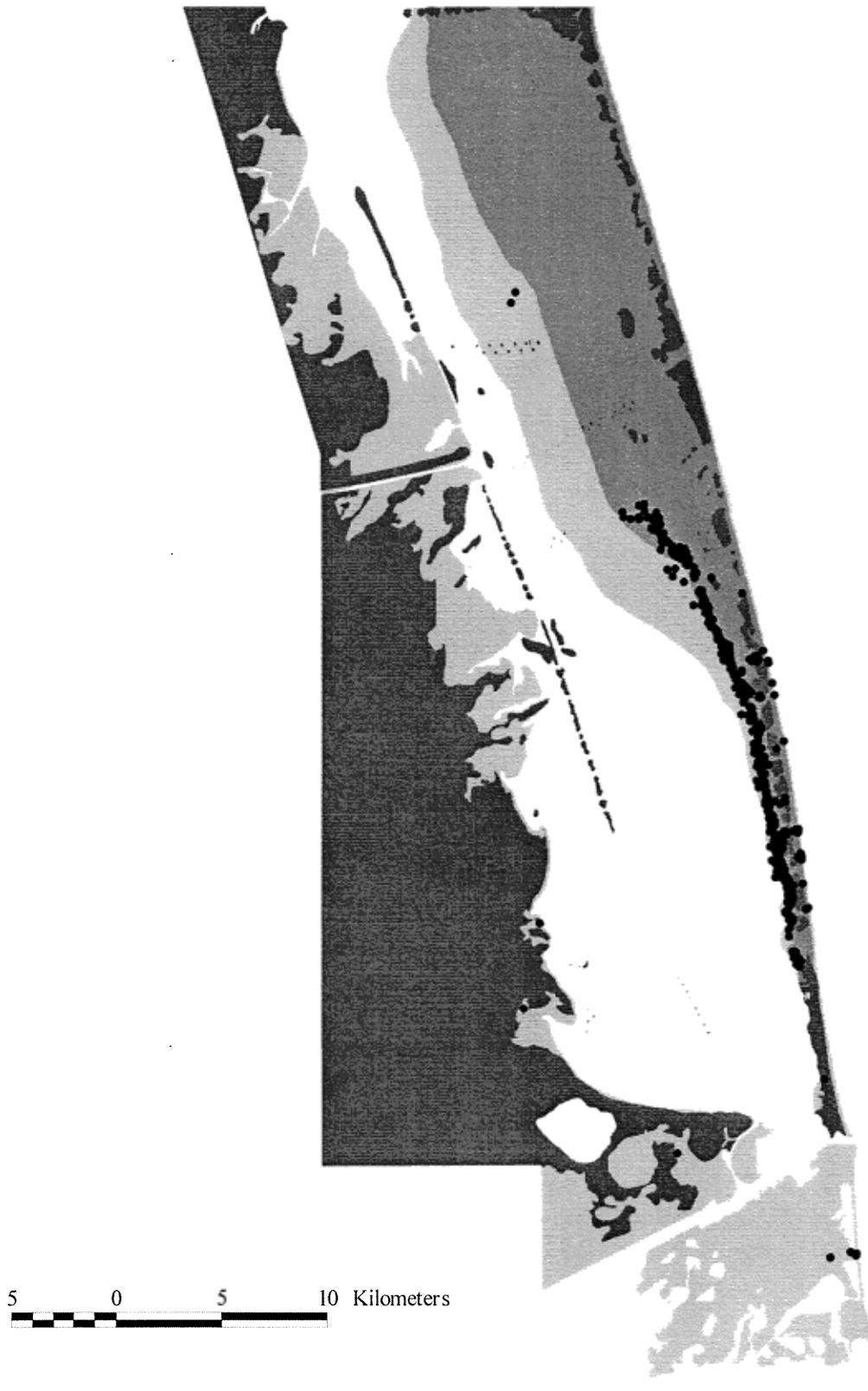
**Nocturnal Relocation**



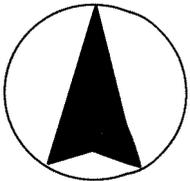
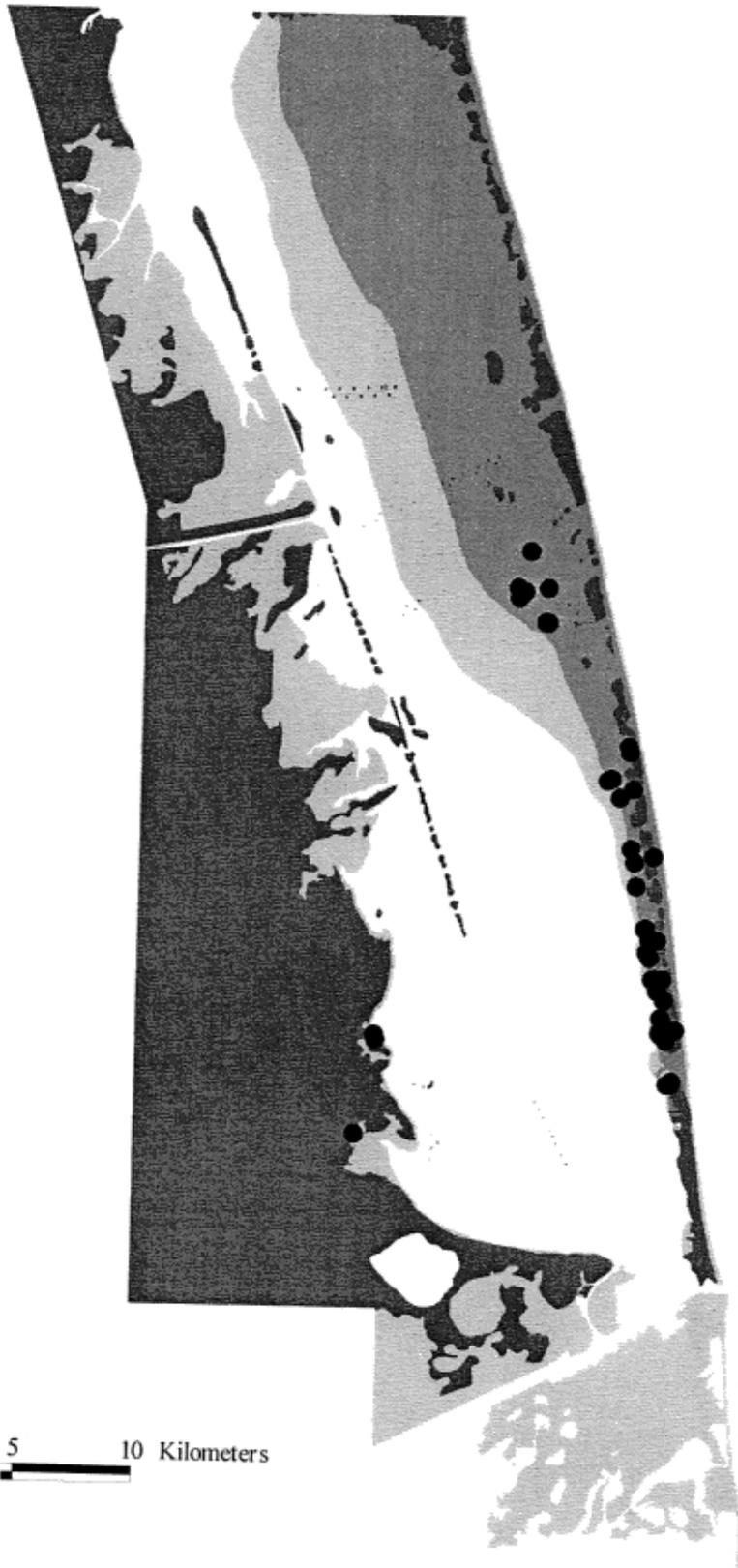


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**Trap Sites**

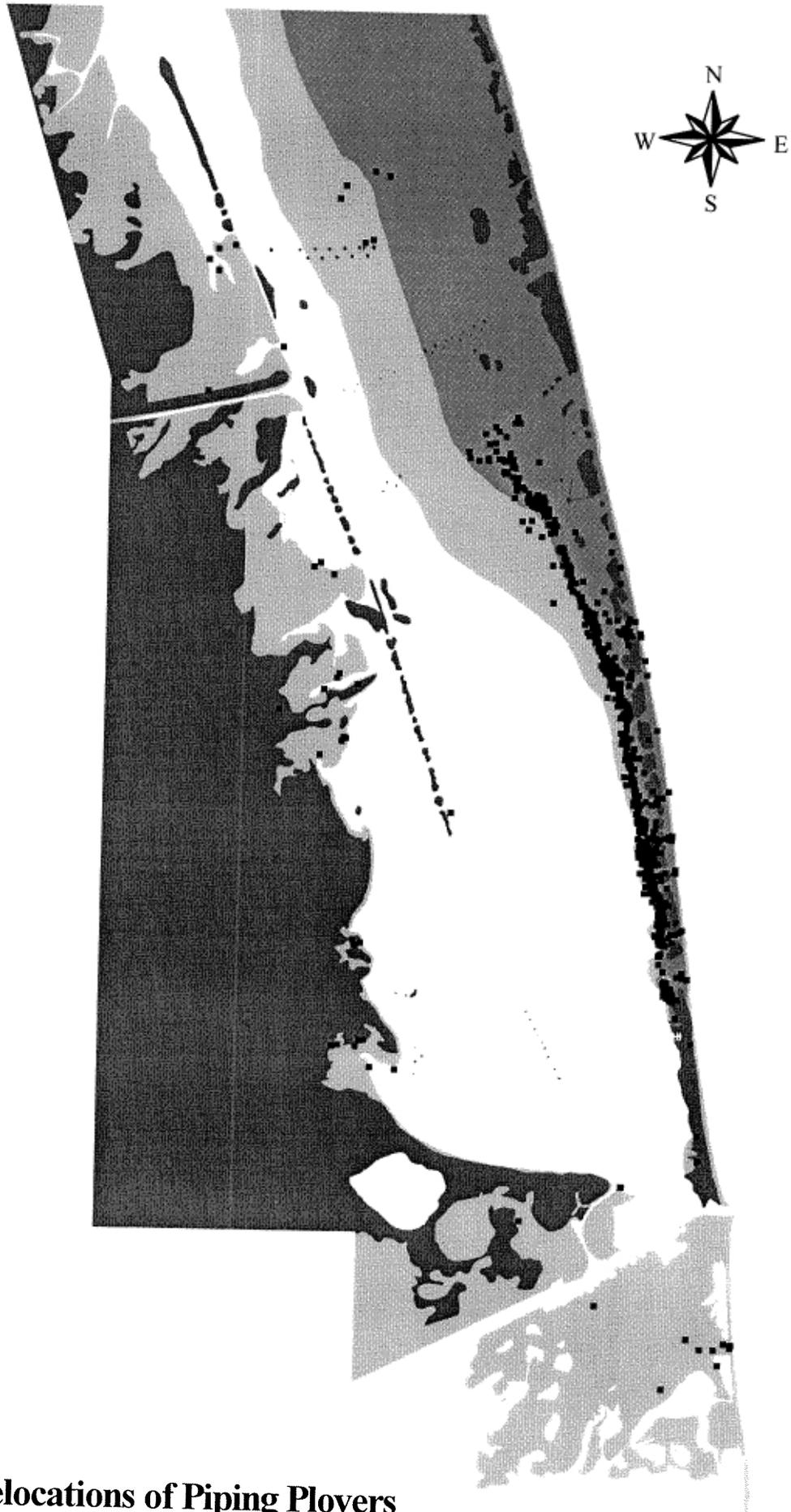


**Relocations of Foraging Piping Plovers**

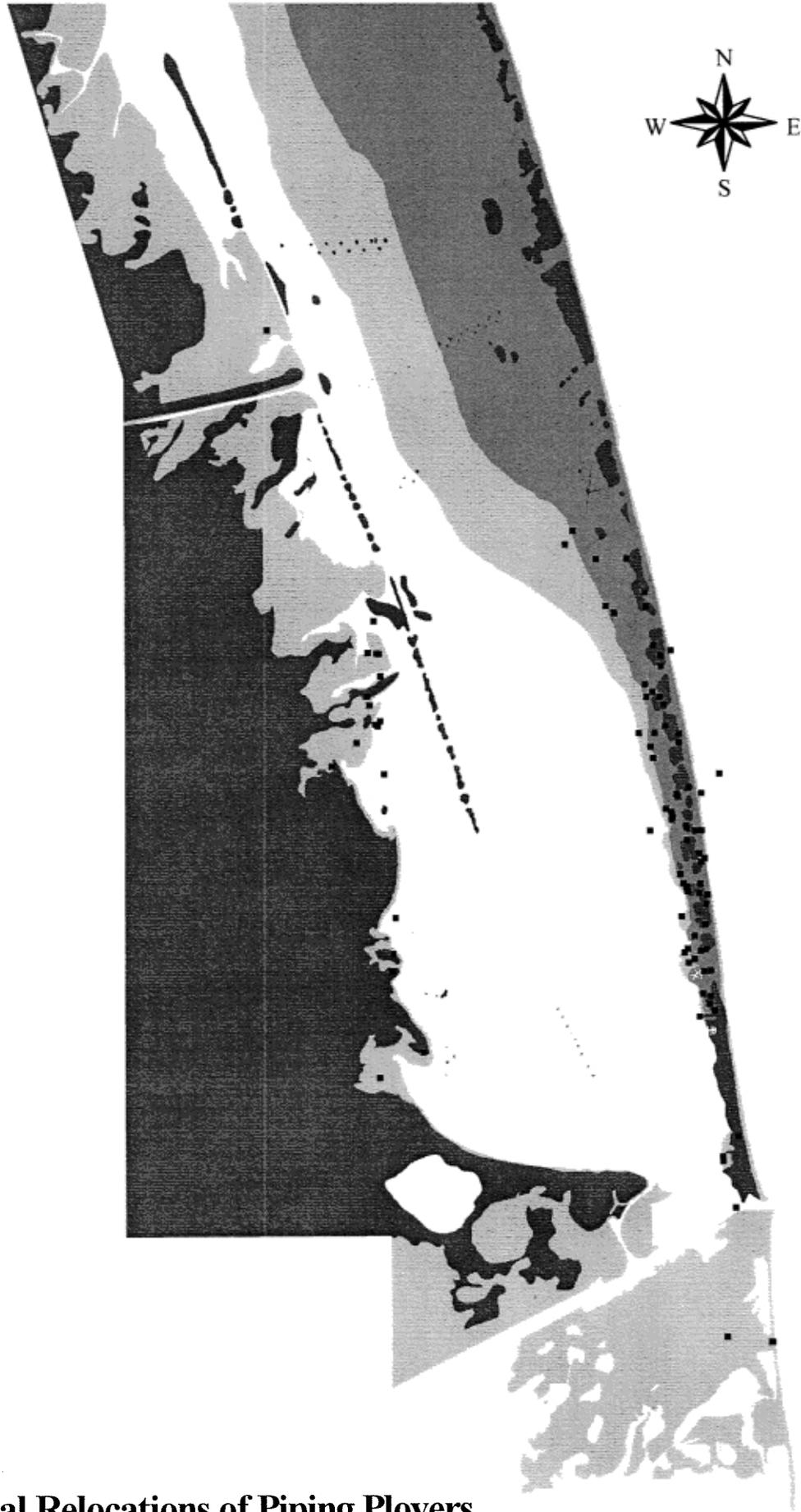


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**Relocations of Roosting Piping Plovers**



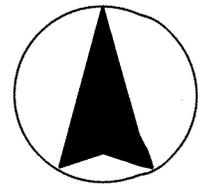
**All Diurnal Relocations of Piping Plovers**



**All Nocturnal Relocations of Piping Plovers**



**Relocations of Foraging Snowy Plovers**



5 0 5 10 Kilometers

A horizontal scale bar with alternating black and white segments, marked with the numbers 5, 0, 5, and 10, representing kilometers.

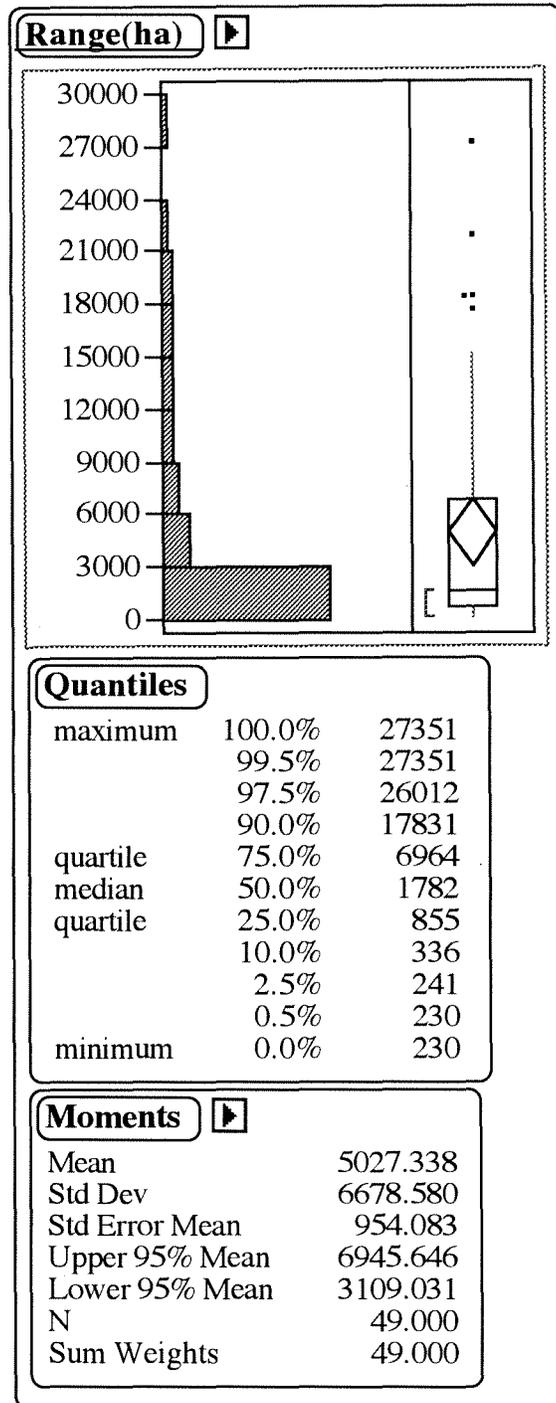
## Relocations of Roosting Snowy Plovers

**Table 1.** Descriptions of the 4 habitat layers, delineated in the “Submerged Lands of Texas” maps developed by University of Texas - Austin’s Bureau of Economic Geology, that best describe macrohabitat types associated with wintering Piping Plovers and Snowy Plovers, and nesting Snowy Plovers and the flat-nesting guild.

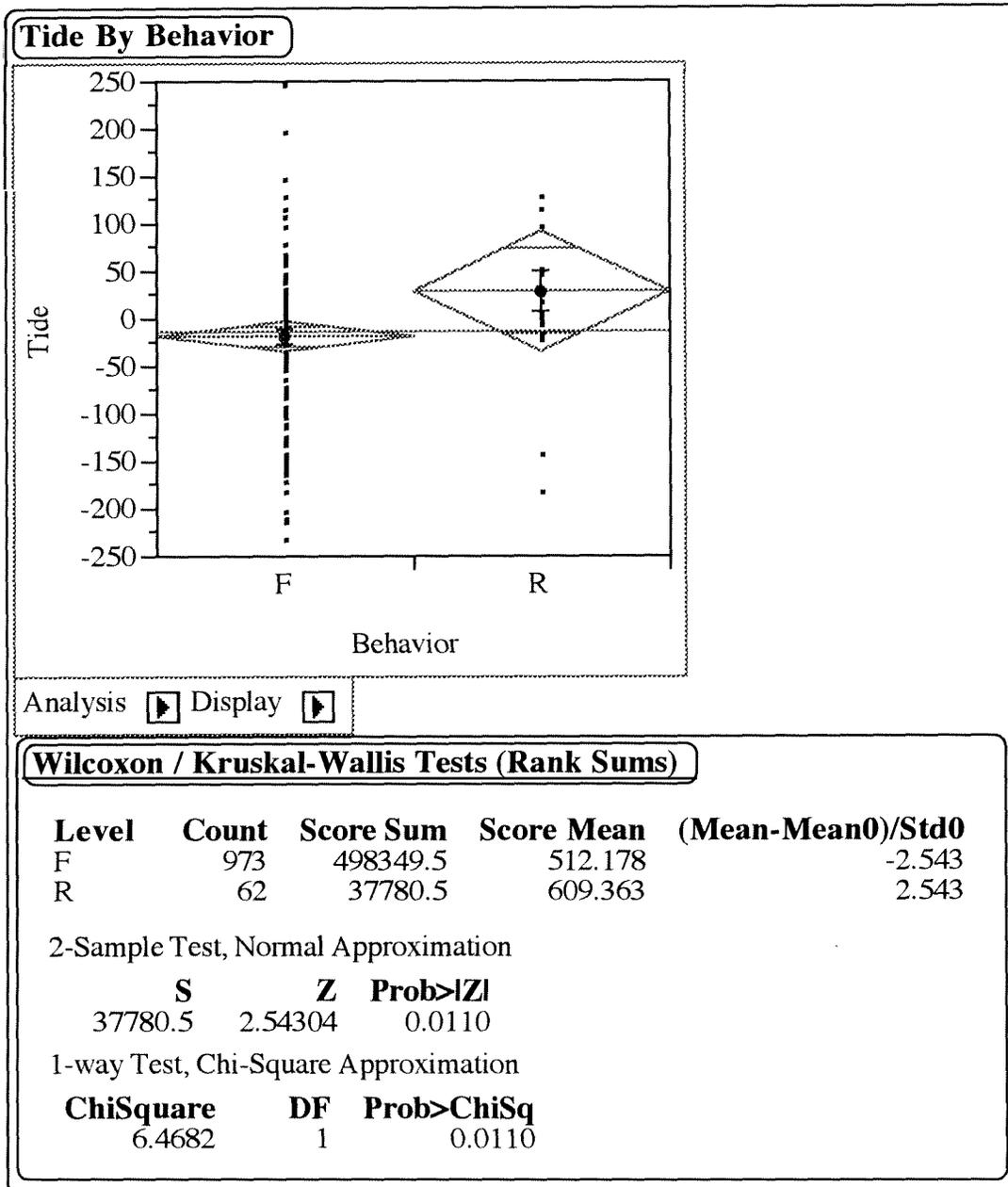
<b>Layer Code</b>	<b>Layer Name and Description</b>
<b>BB</b>	<b>Beaches and Berms:</b> Bay-estuary-lagoon margin, sand and shell, generally barren, locally scattered salt marsh vegetation.
<b>HF</b>	<b>High Sand and Mud Flats:</b> Topographically high wind-tidal flats, less frequent flooding than lower flats, local scattered vegetation; also flats not affected by tides, and channel margins and bars along streams and stream valleys; locally grade into upland areas, predominantly sand on the barrier islands and mud on the mainlands.
<b>LF</b>	<b>Low Sand and Mud Flats:</b> Wind-tidal, relatively frequent flooding, algal mats common, locally scattered vegetation, predominantly sand on the barrier islands and mud on the mainland.
<b>W</b>	<b>Shallow Subaqueous Flats, Tidal Pools, Inland Reservoirs and Ponds, and Natural and Dredged Channels:</b> Flats and pools affected by wind tides, coastal water bodies saline to brackish, inland water bodies fresh, locally fringed by water-tolerant plants.

**Table 2.** The spatial relationships between nests of Snowy Plovers and other FNG members and the nearest source of water and vegetation. Distance to nearest water source (DTW) and nearest vegetation (DTV) are reported in meters as means for all nests. Standard errors (SE) for each mean and maximum distance to each of the habitat features are also reported.

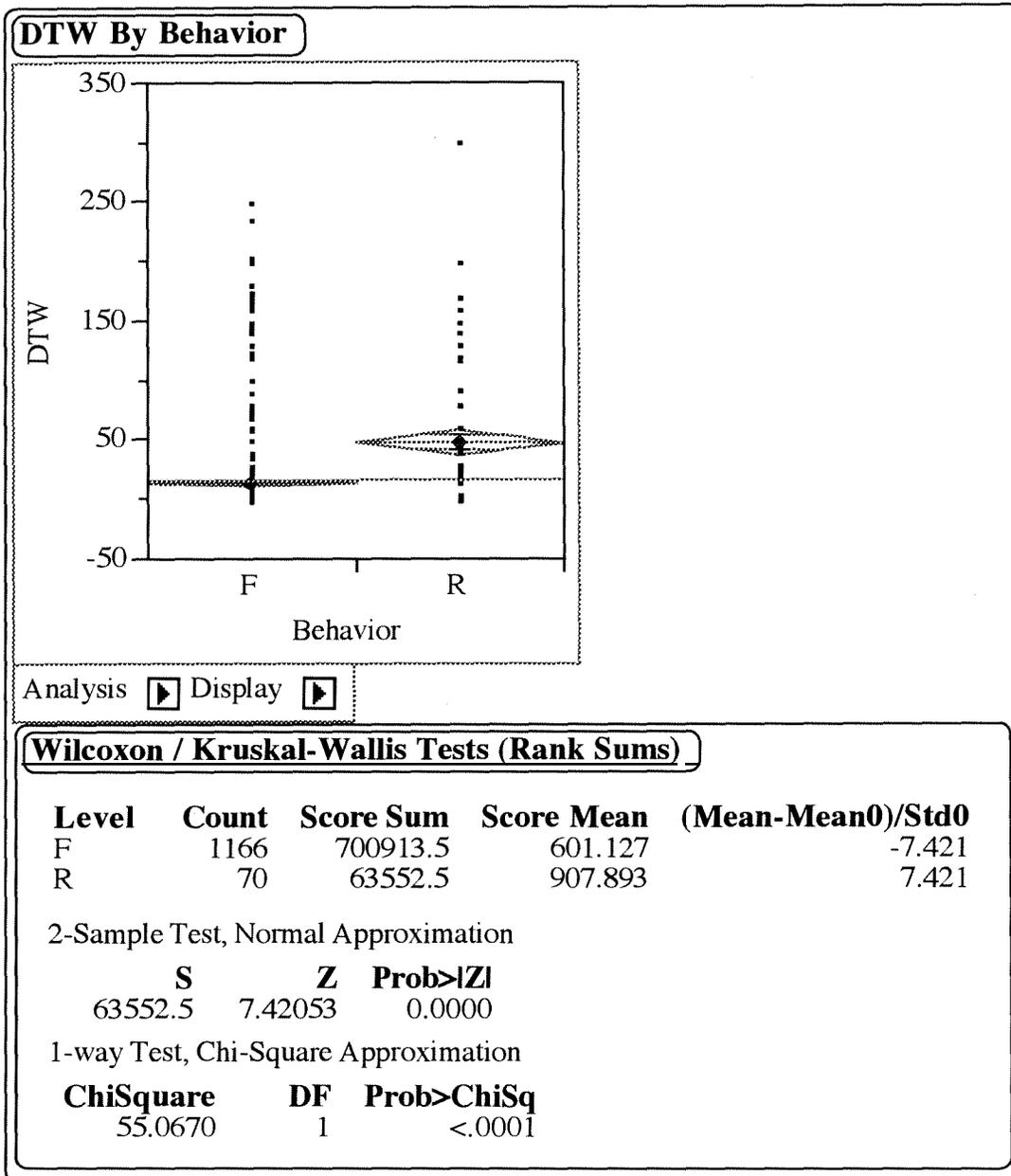
Species	N	DTW			DTV		
		Mean	SE	Max.	Mean	SE	Max.
Snowy Plover	144	62.3	12.5	>1000	2.8	0.4	14
Wilson's Plover	22	33.5	8.5	85	4.0	3.9	8
Killdeer	19	35.6	7.3	65	2.2	1.7	12
Least Tern	99	150.6	27.8	>1000	5.1	0.9	25
Willet	1	35	--	--	0	--	--
Horned Lark	3	86.4	26.3	150	0	0.0	0
Common Nighthawk	1	18	--	--	4	--	--
Black-necked Stilt	23	23.6	9.4	75	1.5	1.5	3



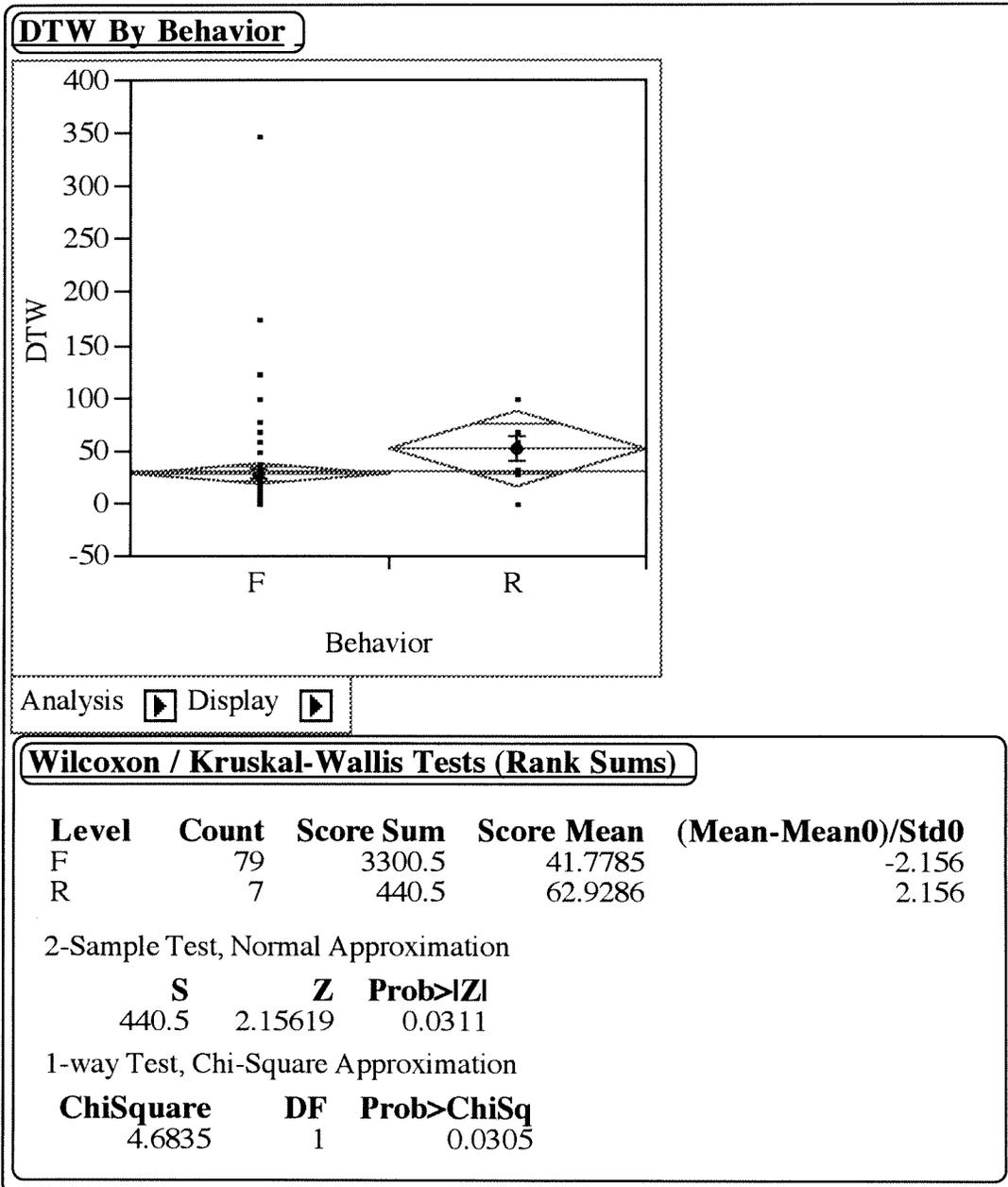
**Figure 1.** Home range estimate distributions for all marked Piping Plovers. Home ranges for each plover were estimated in hectares as convex polygons from all relocations (i.e., telemetry and visual).



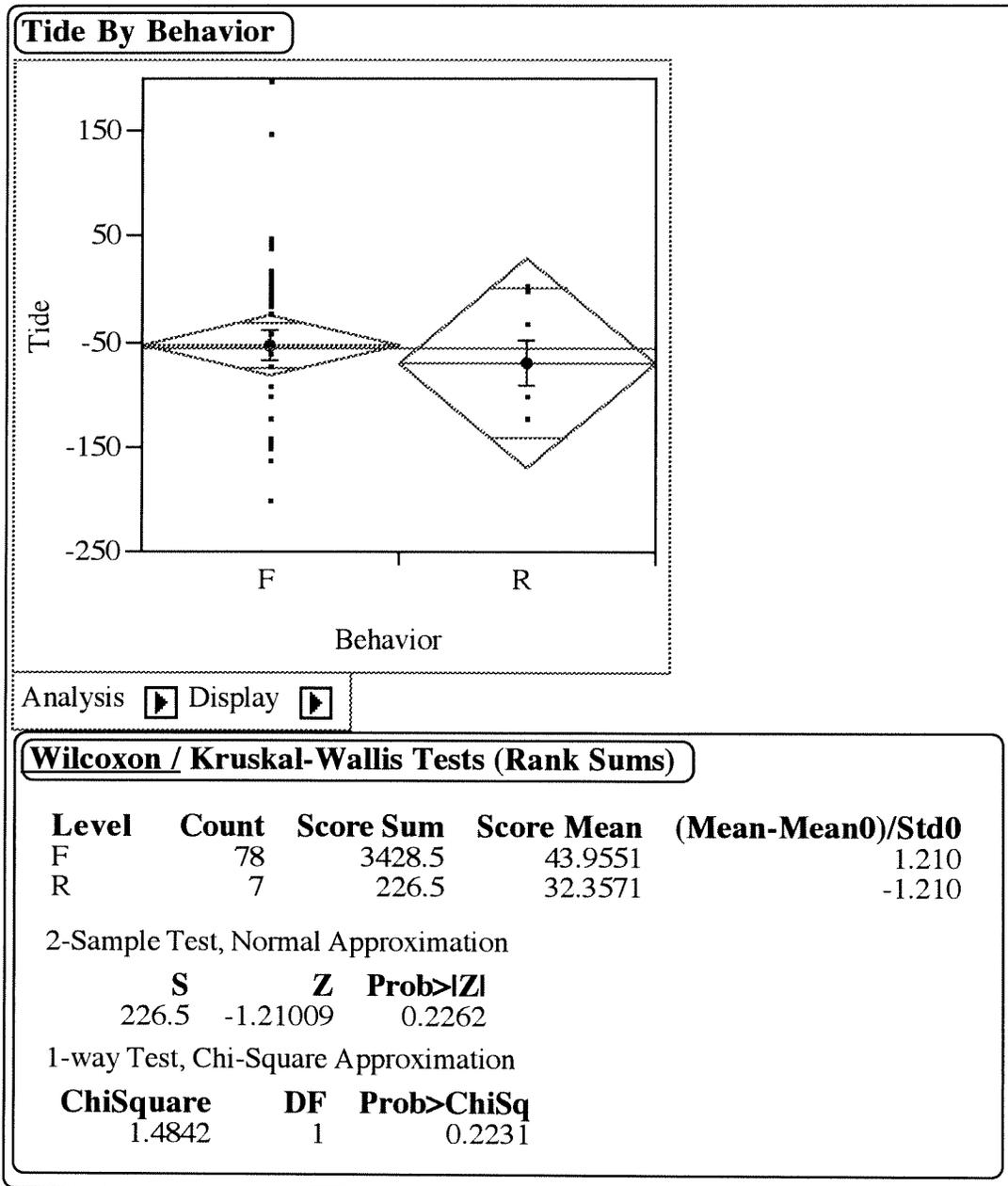
**Figure 2.** The effect of bayshore tidal amplitude (# meters of inundation above the mean high tide line) on Piping Plover behavior.



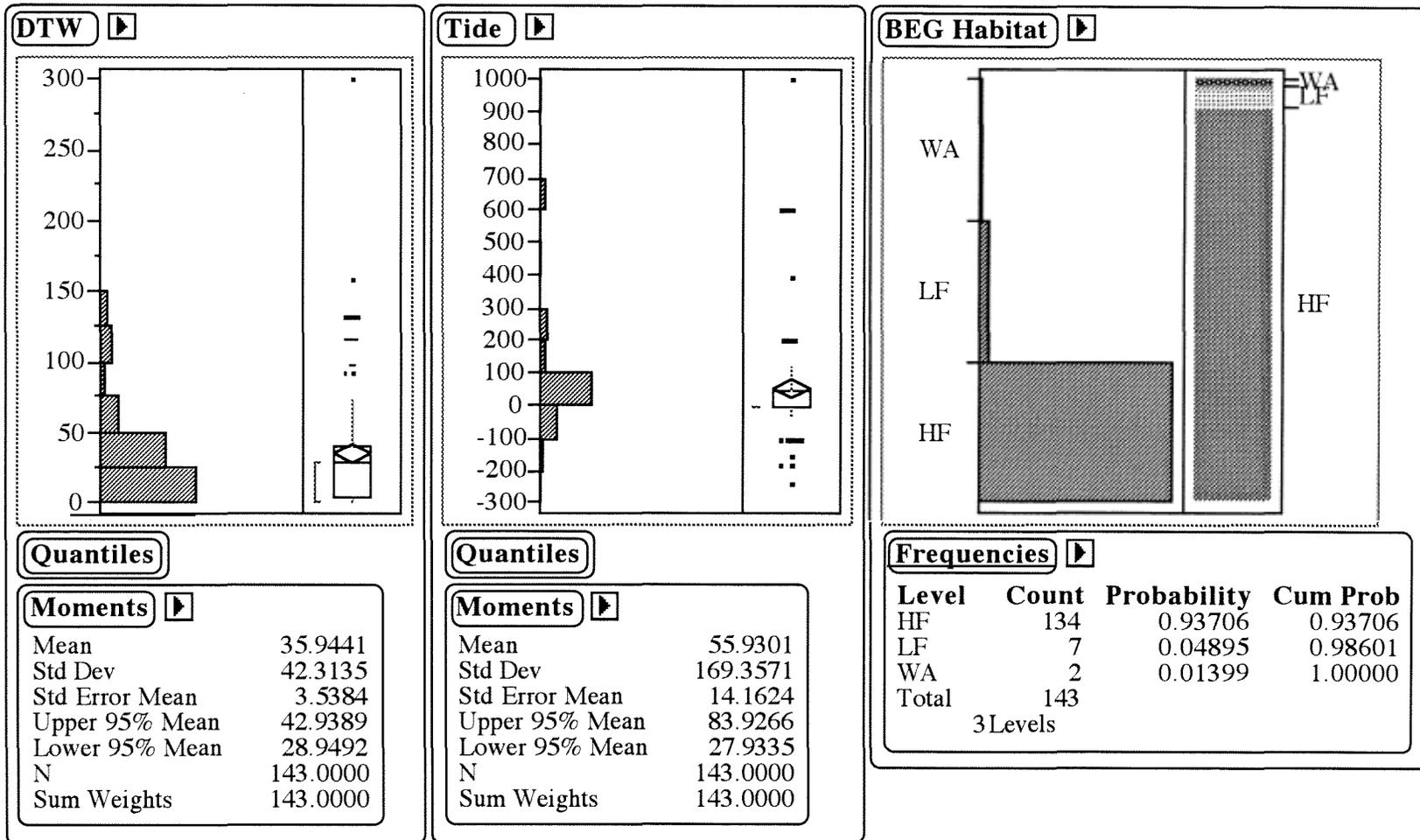
**Figure 3.** The relationship between behavior and distance to water for marked Piping Plovers.



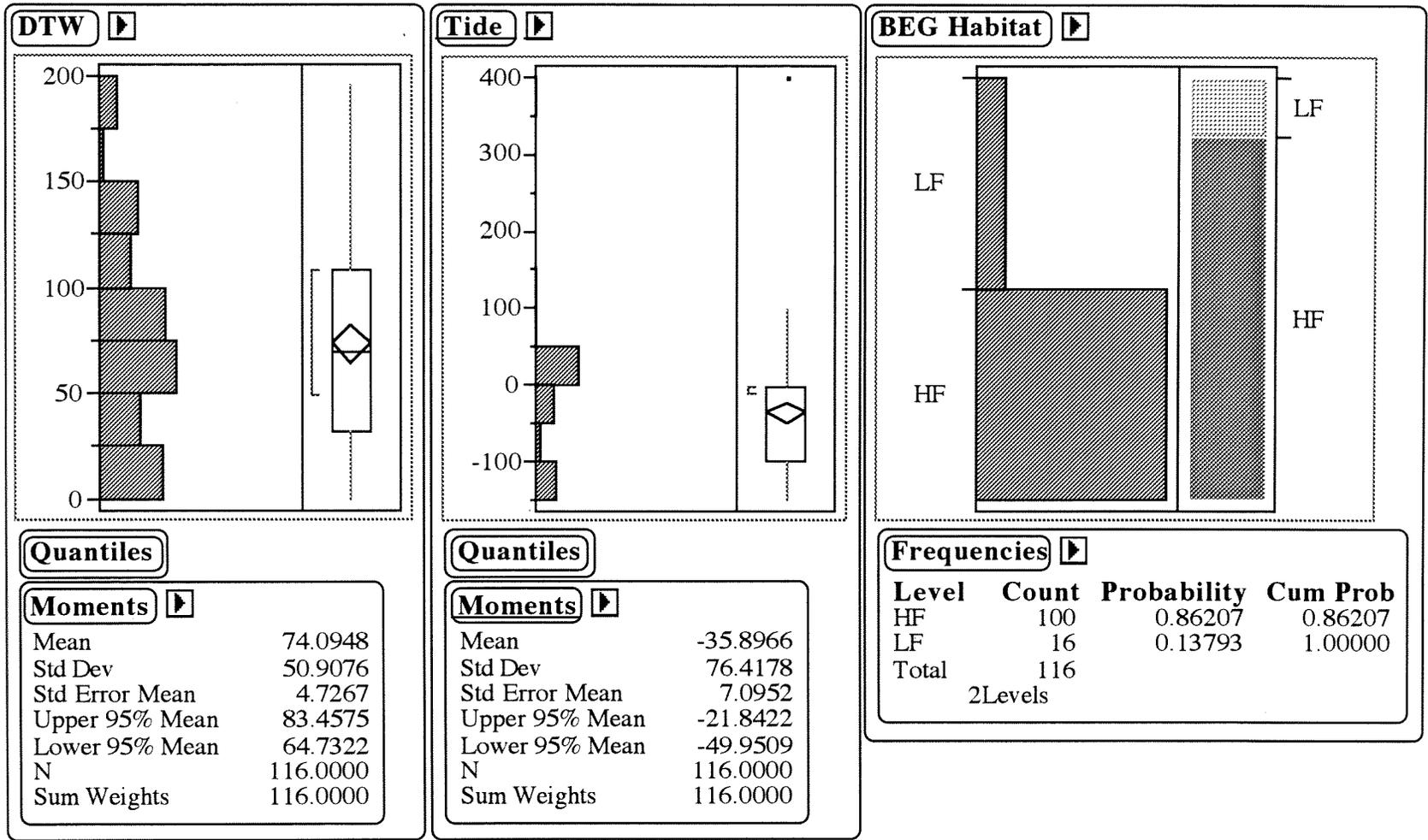
**Figure 4.** The relationship between behavior and distance to water for marked Snowy Plovers.



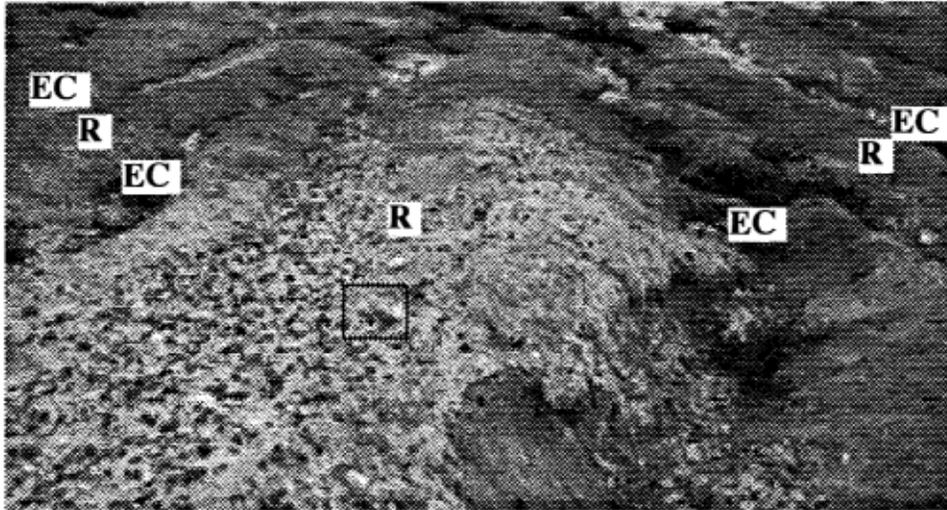
**Figure 5.** The effect of bayshore tidal amplitude on the behavior of marked Snowy Plovers.



**Figure 6.** Distance to water ([DTW]meters), bayshore tidal amplitude (# meters of inundation above the mean high tide line), and habitat usage for unmarked roosting Piping Plovers.



**Figure 7.** Distance to water ([DTW]meters), bayshore tidal amplitude (# meters of inundation above the mean high tide line), and habitat usage for unmarked roosting Snowy Plovers.



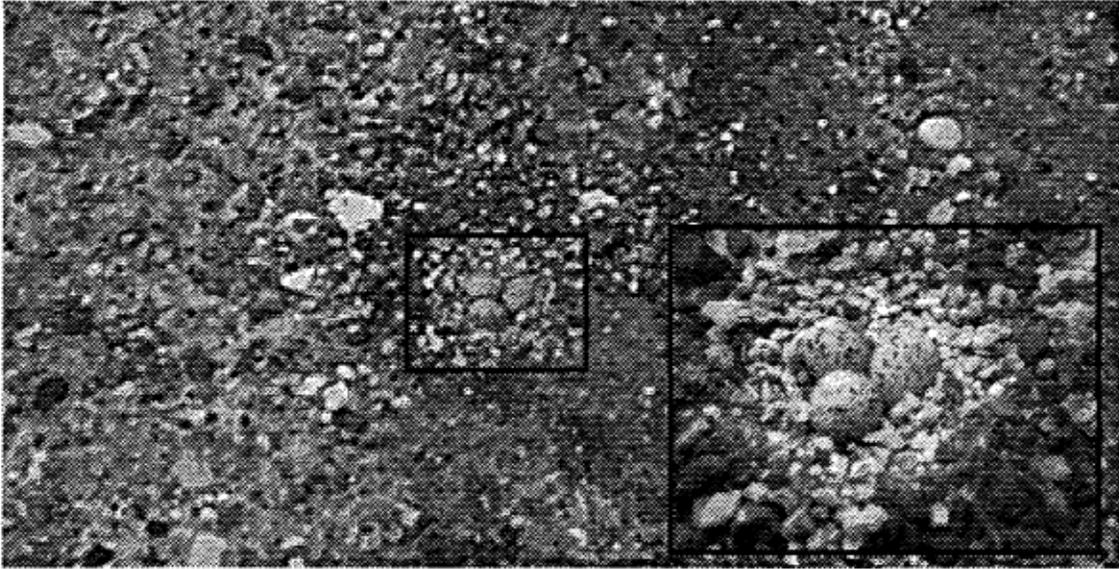
**Figure 8.** This photo depicts a view from the top of a typical berm found at DMPA and DMPA-like sites. Several erosion channels (EC), and ridges (R) are labelled in the photo. Accumulations of stones and other material can be seen along the large central ridge. A snowy Plover nest was located on this ridge. It's position is indicated by the framed area.



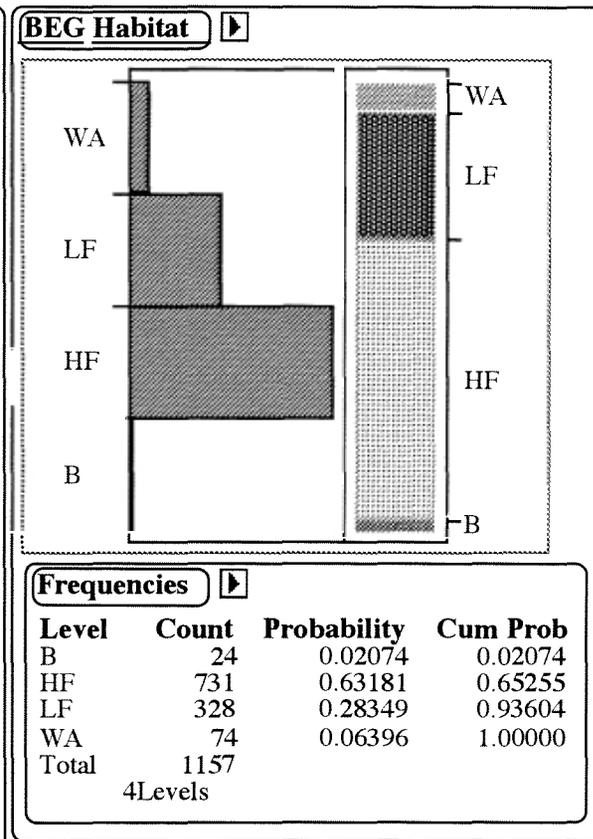
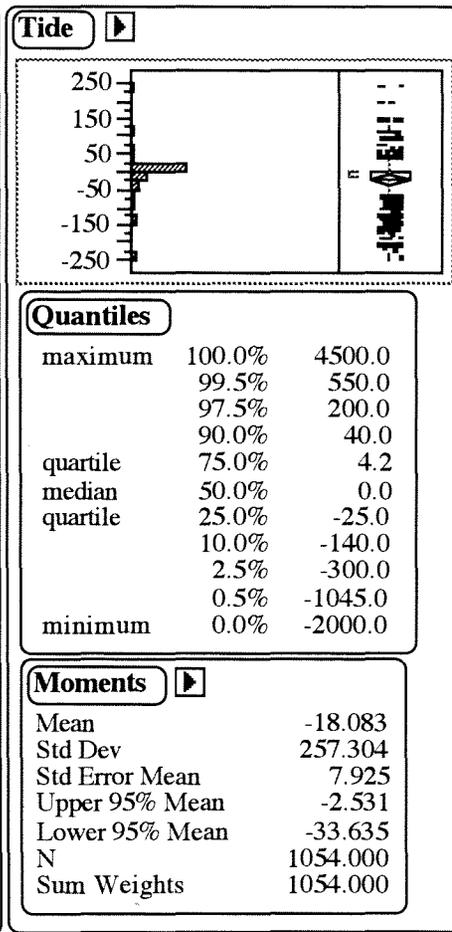
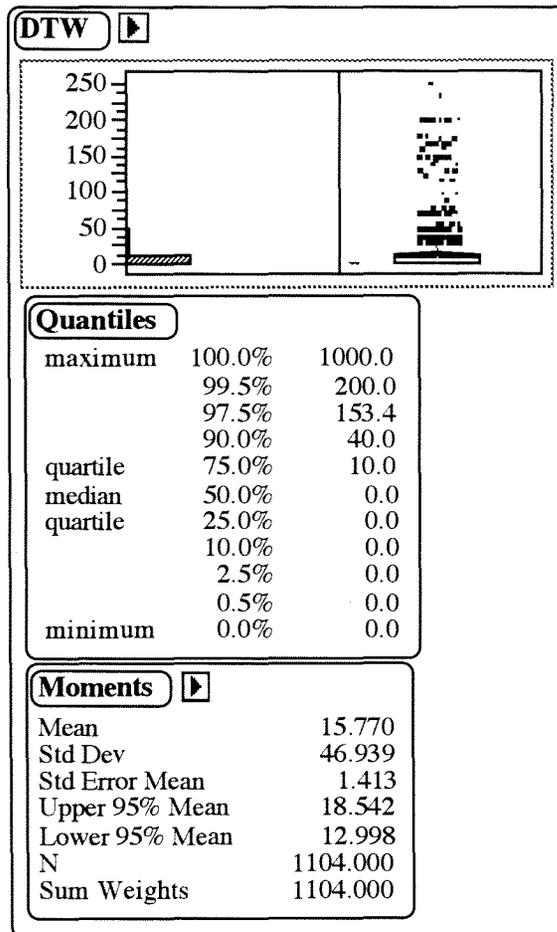
**Figure 9.** Picture from atop a perimeter berm looking into a DMPA-like site showing the juxtaposition of the berm (BB), high flat (HF), low flat (LF), and shallow pool (W) habitat zones. Most Snowy Plover nest occurred within the BB and HF zones, whereas most broods were observed in the HF, and LF zones and along the LF/BB margin.



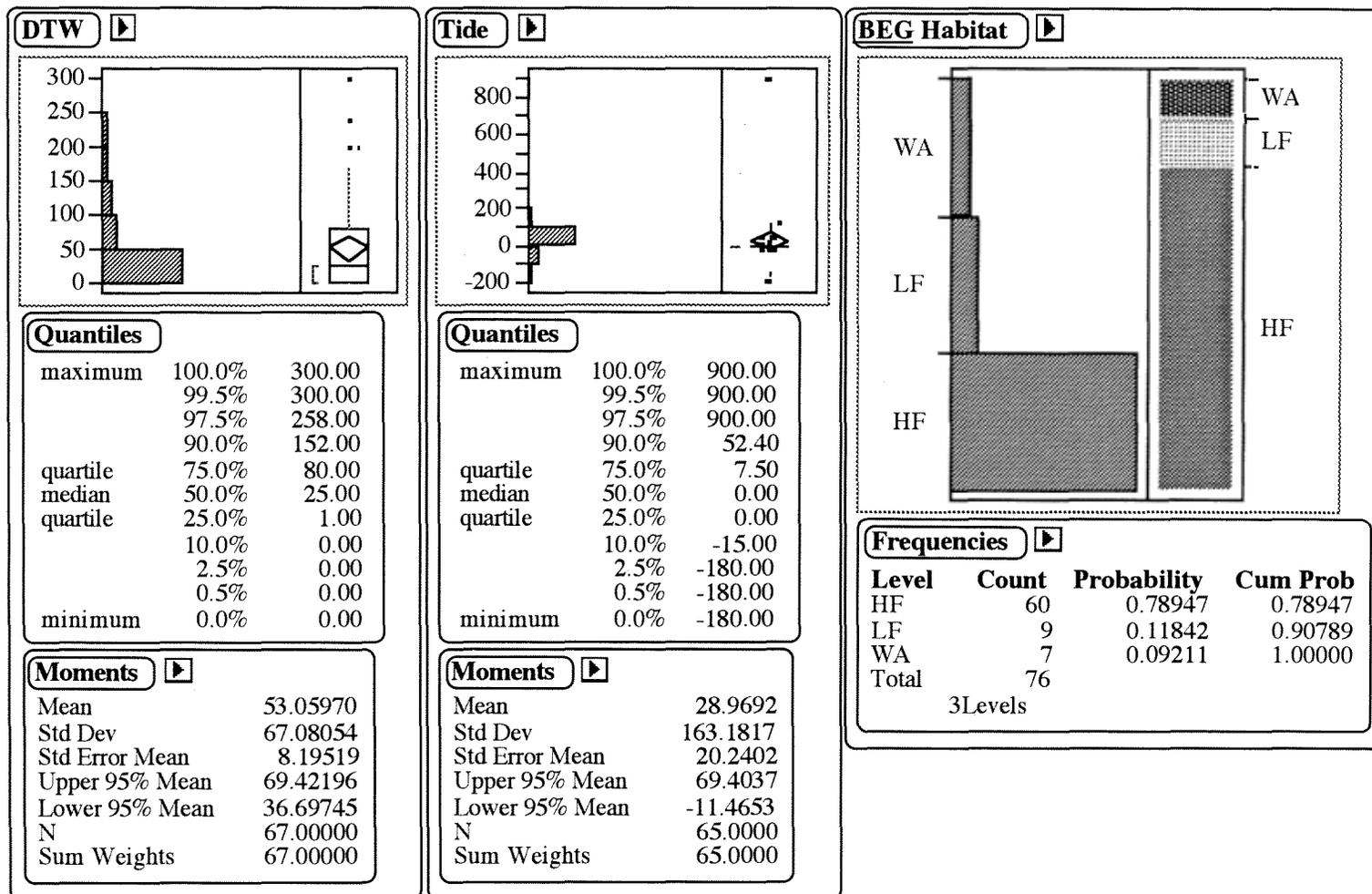
**Figure 10.** A section of perimeter berm at a DMPA-like site that had become overgrown with vegetation. This was one of the few sections of berm at this site that did not support Snowy Plover nests.



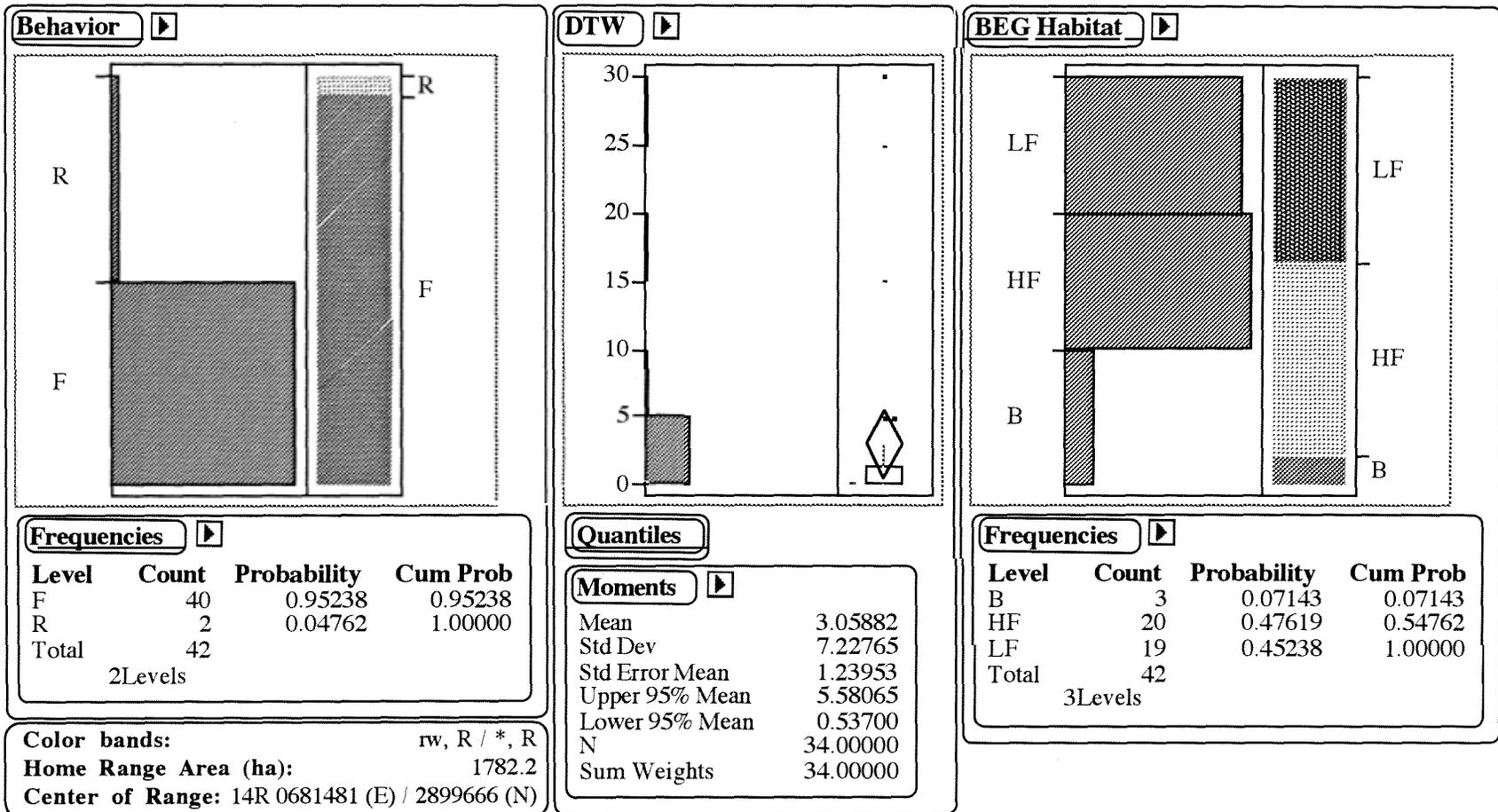
**Figure 11.** A Snowy Plover nest containing 3 eggs. The nest is located near the center of this photo (within the small black frame). A magnified view of the same nest is shown in the inset image at the lower right. The nest was lined with small stones and shell fragments. This nest was typical of most Snowy Plover nests discovered at DMPAs and DMPA-like sites. It was constructed within a portion of a berm that had a gradual incline. The berm was within 100 m of a shallow pond, was relatively free of vegetation, and was covered with stones, shell and other surface materials.



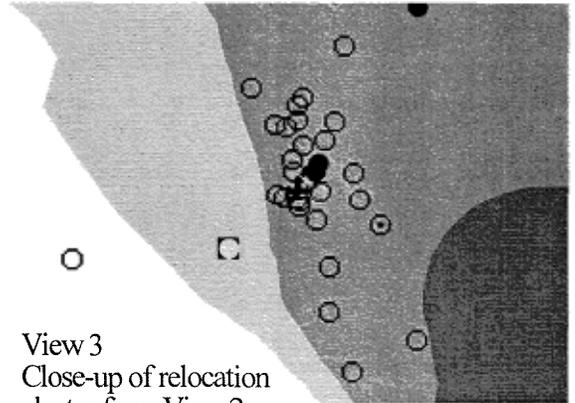
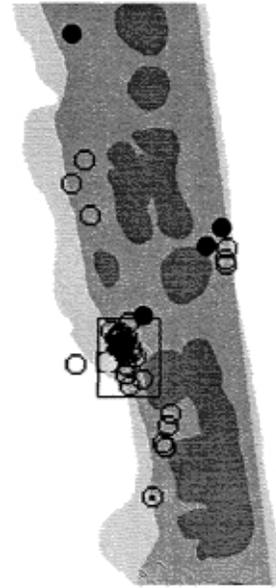
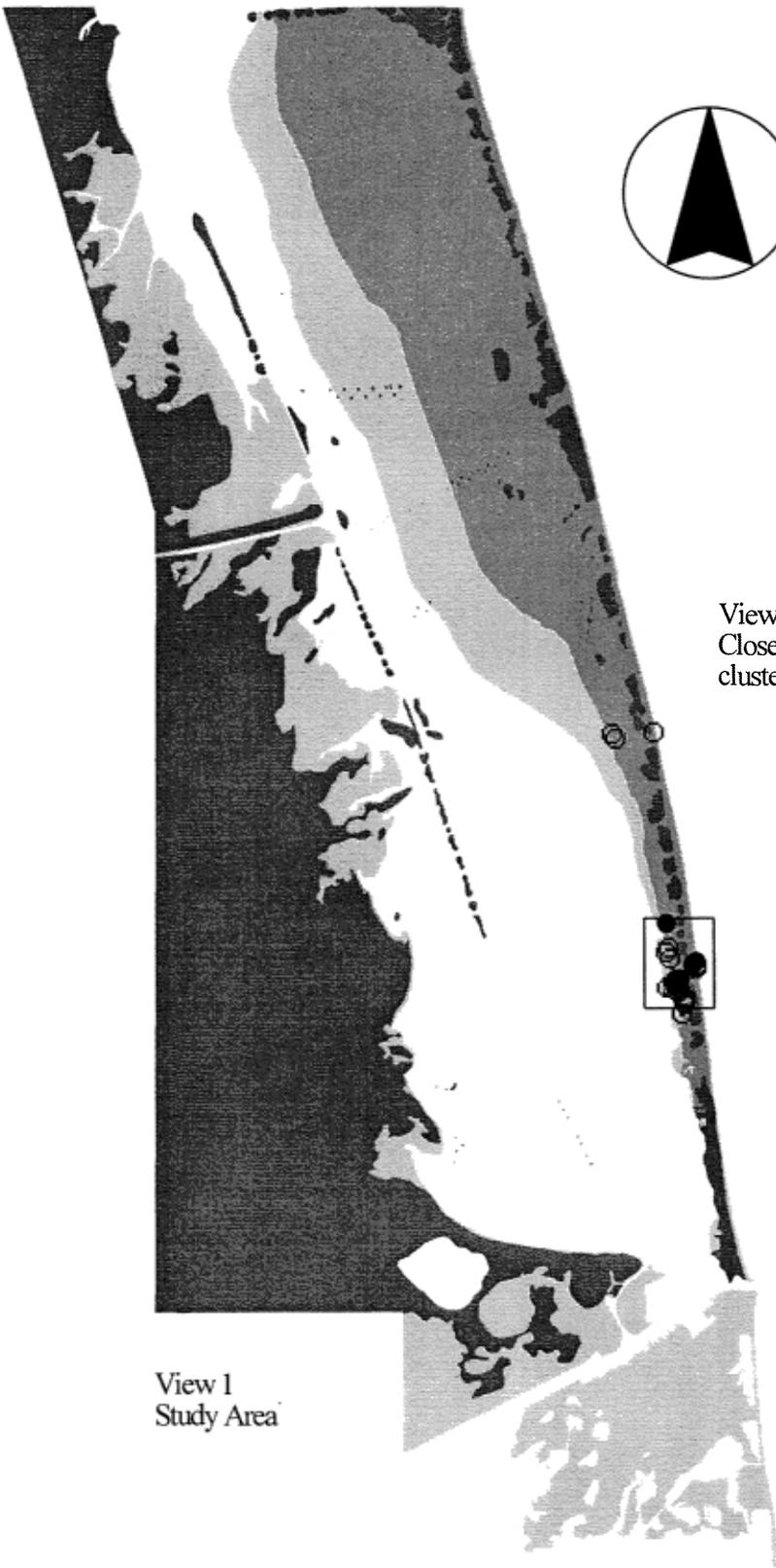
**All Foraging Piping Plovers.** The distance to water (DTW [meters]), bayshore tidal amplitude (# meters inundated above the mean high tide line) and habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]) history for all marked Piping Plovers engaged in foraging behavior when relocated.

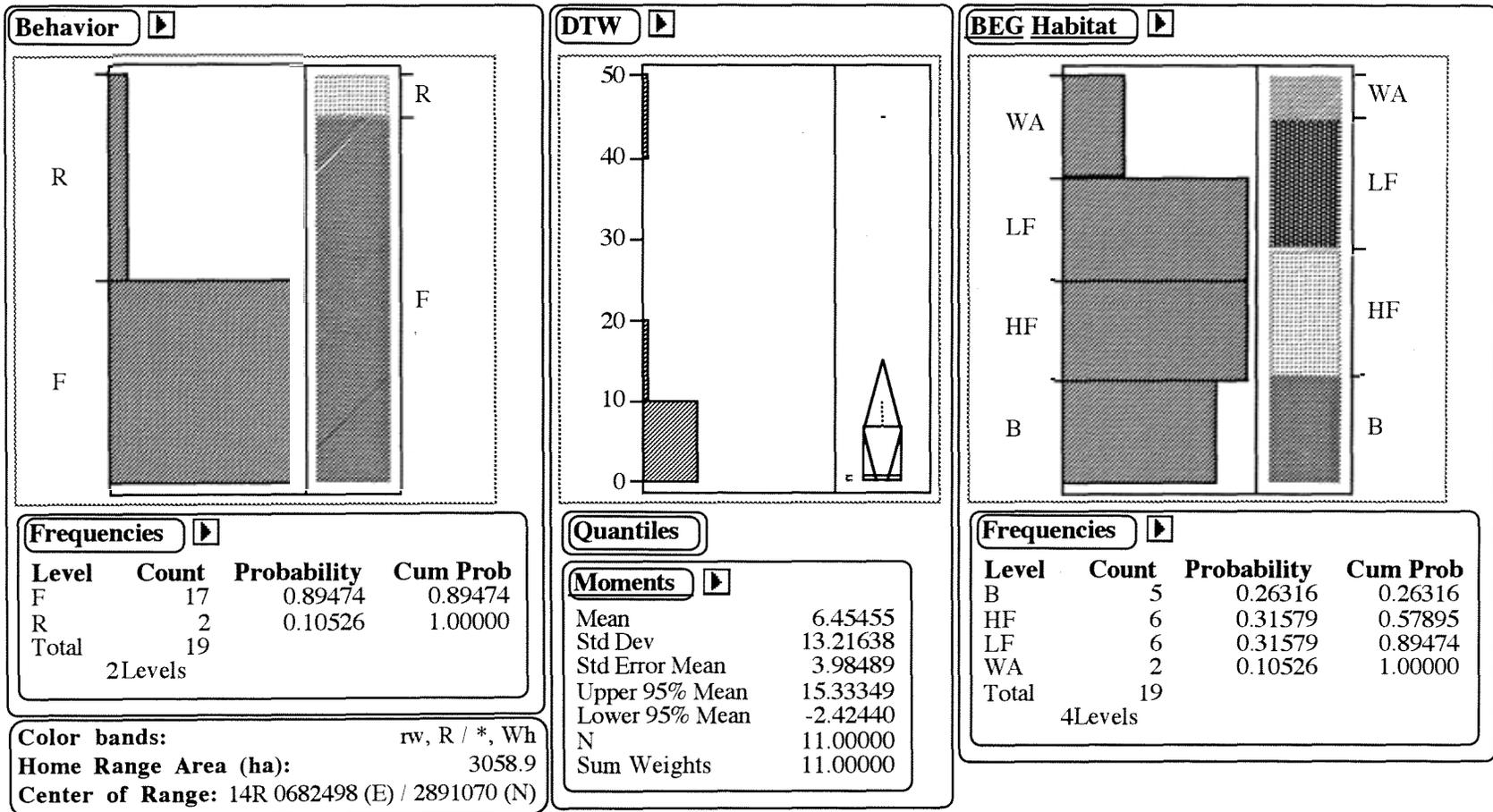


**All Roosting Piping Plovers.** The distance to water (DTW [meters]), bayshore tidal amplitude (# meters inundated above the mean high tide line) and habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]) history for all marked Piping Plovers engaged in roosting behavior when relocated.

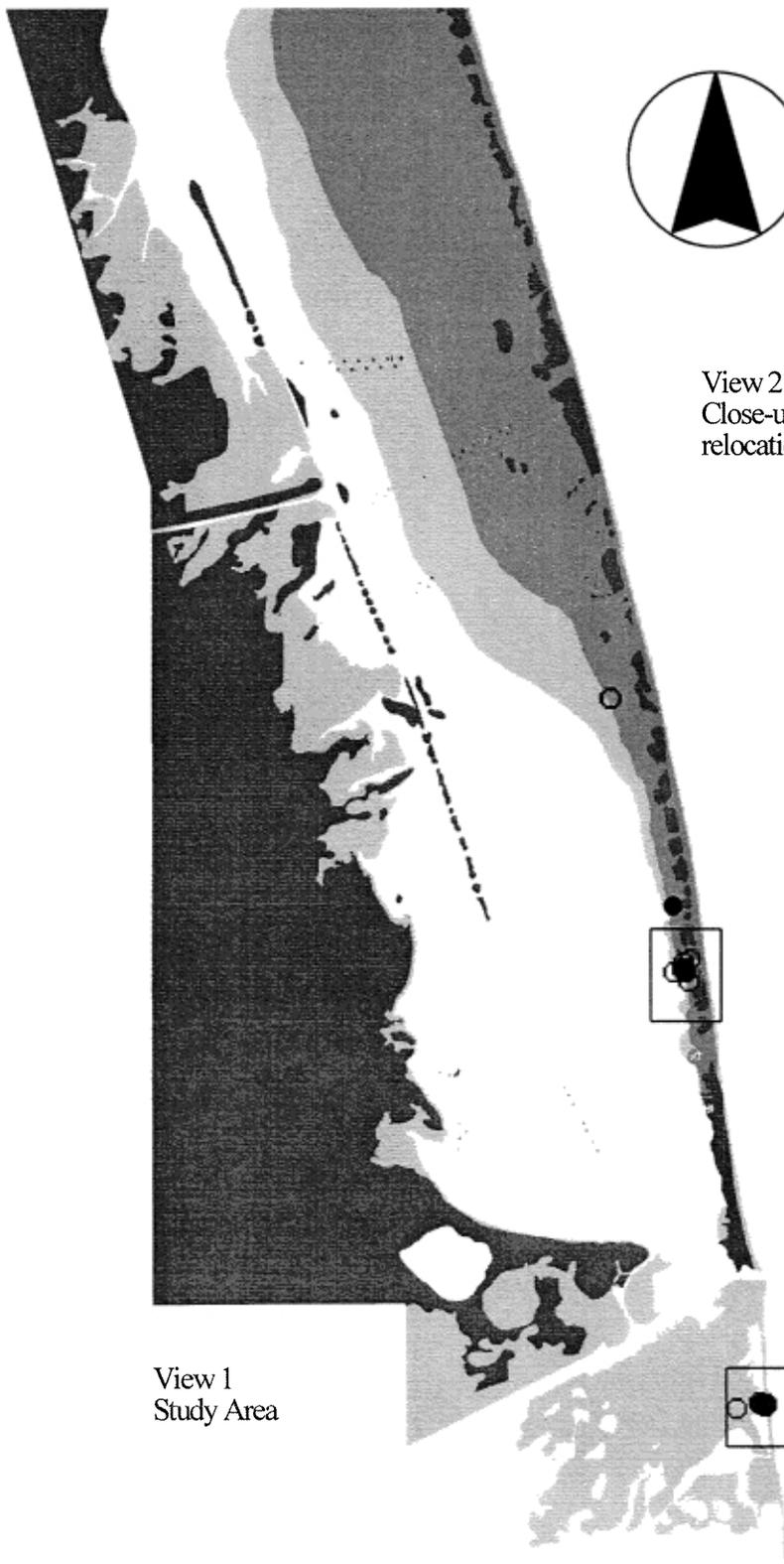


**Radiofrequency 177 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.





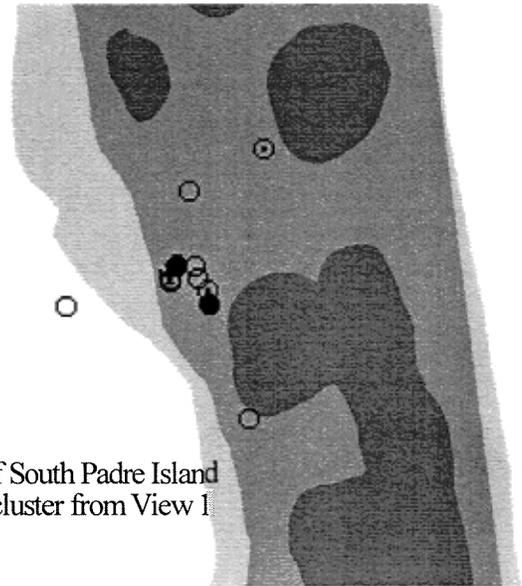
**Radiofrequency 219 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



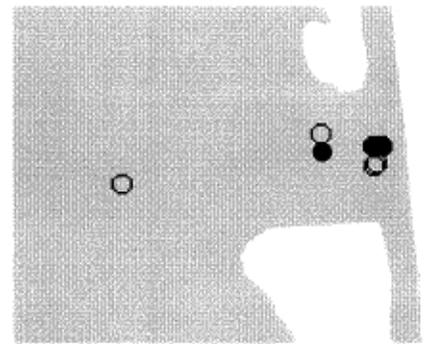
View 1  
Study Area



View 2  
Close-up of South Padre Island  
relocation cluster from View 1



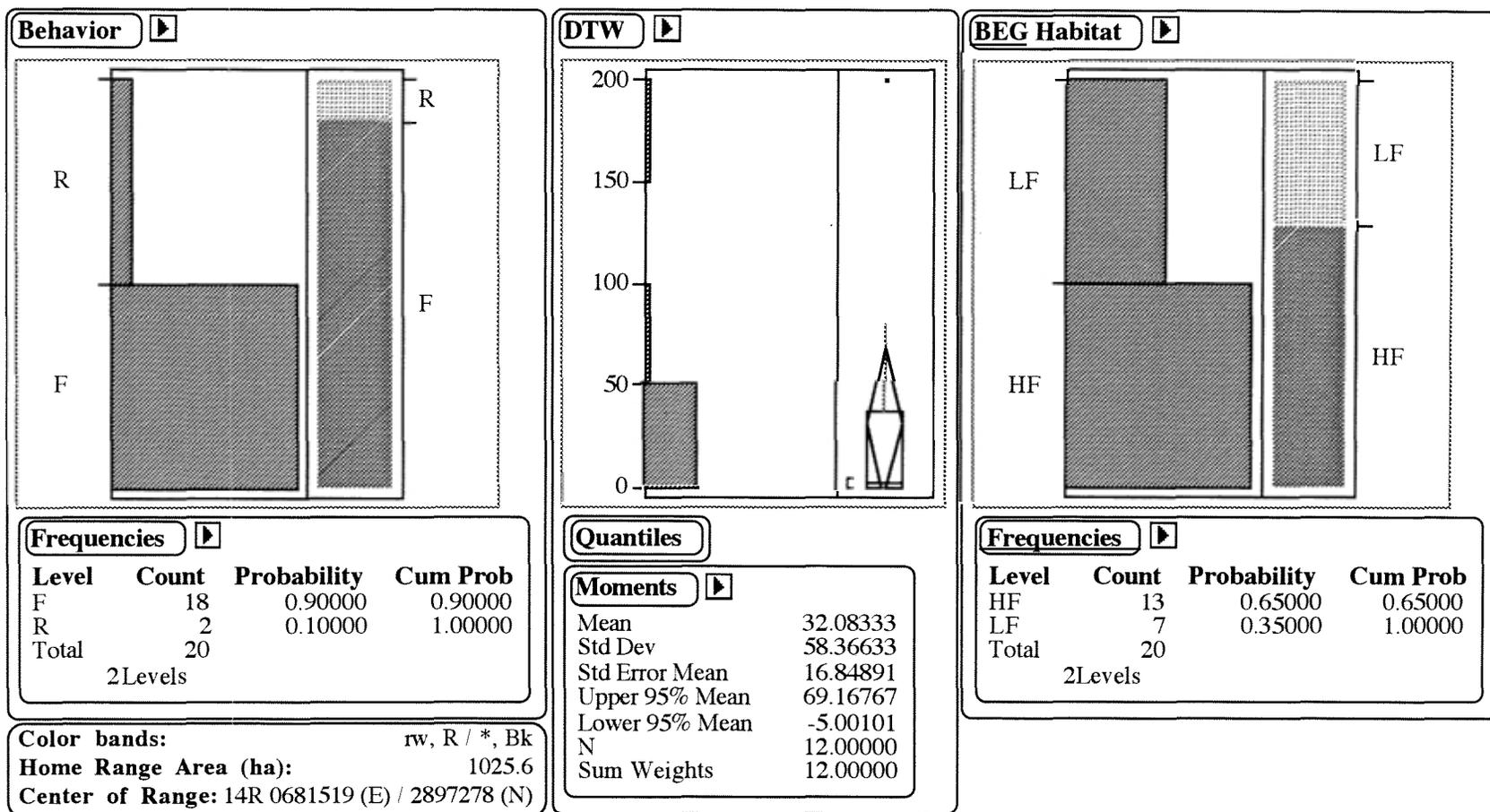
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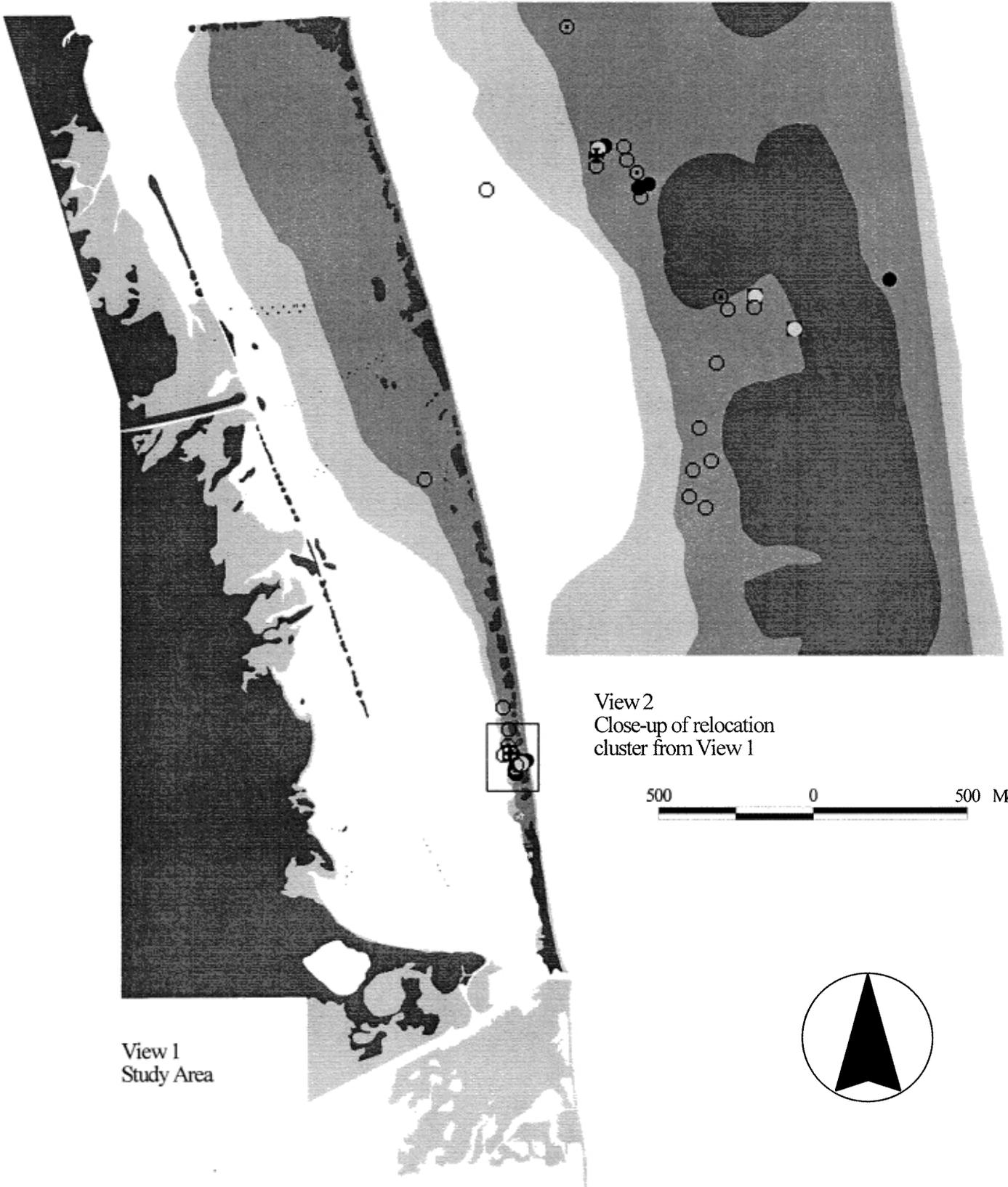
View 3  
Close-up of Brazos Island  
relocation cluster from View 1

250 0 250 500 Meters

5 0 5 10 15 20 Kilometers

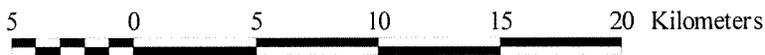
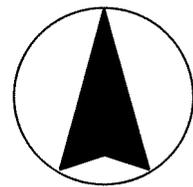


**Radiofrequency 248 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.

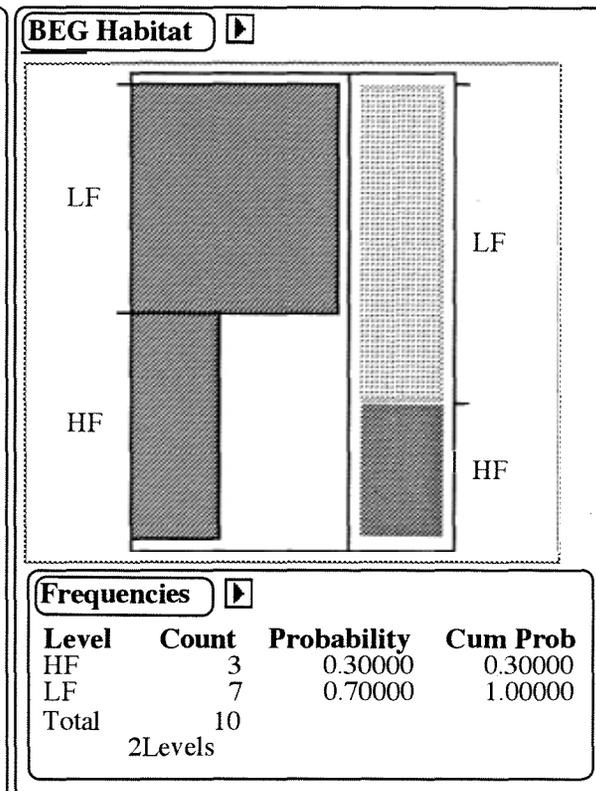
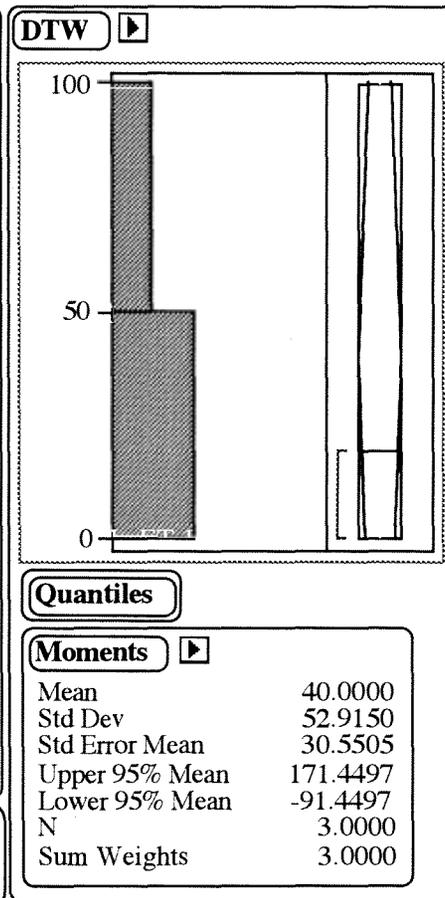
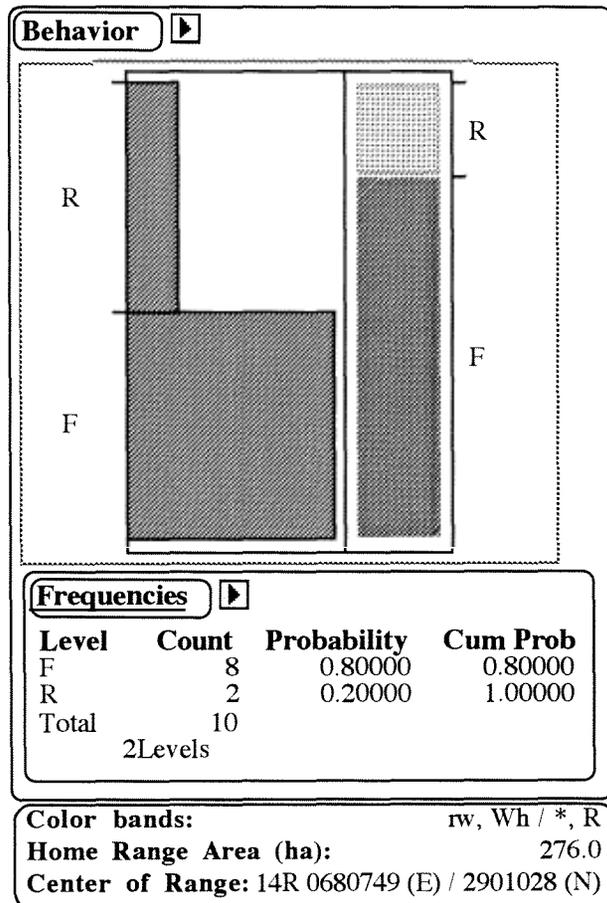


View 1  
Study Area

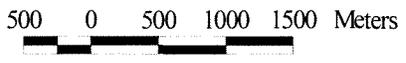
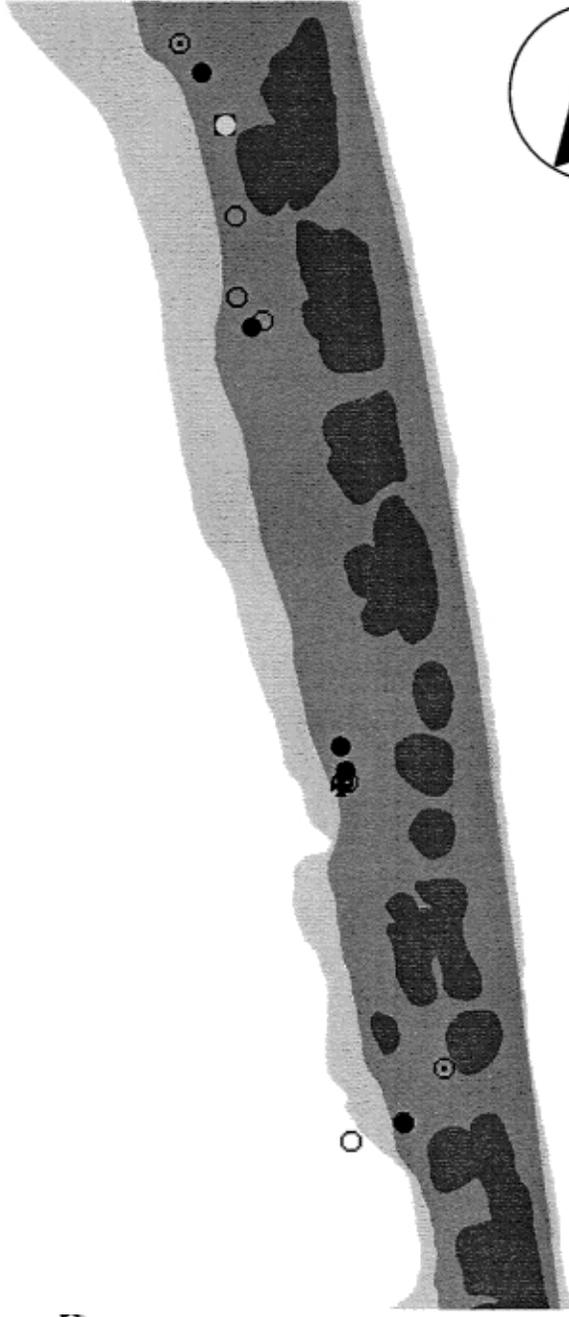
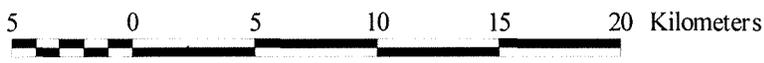
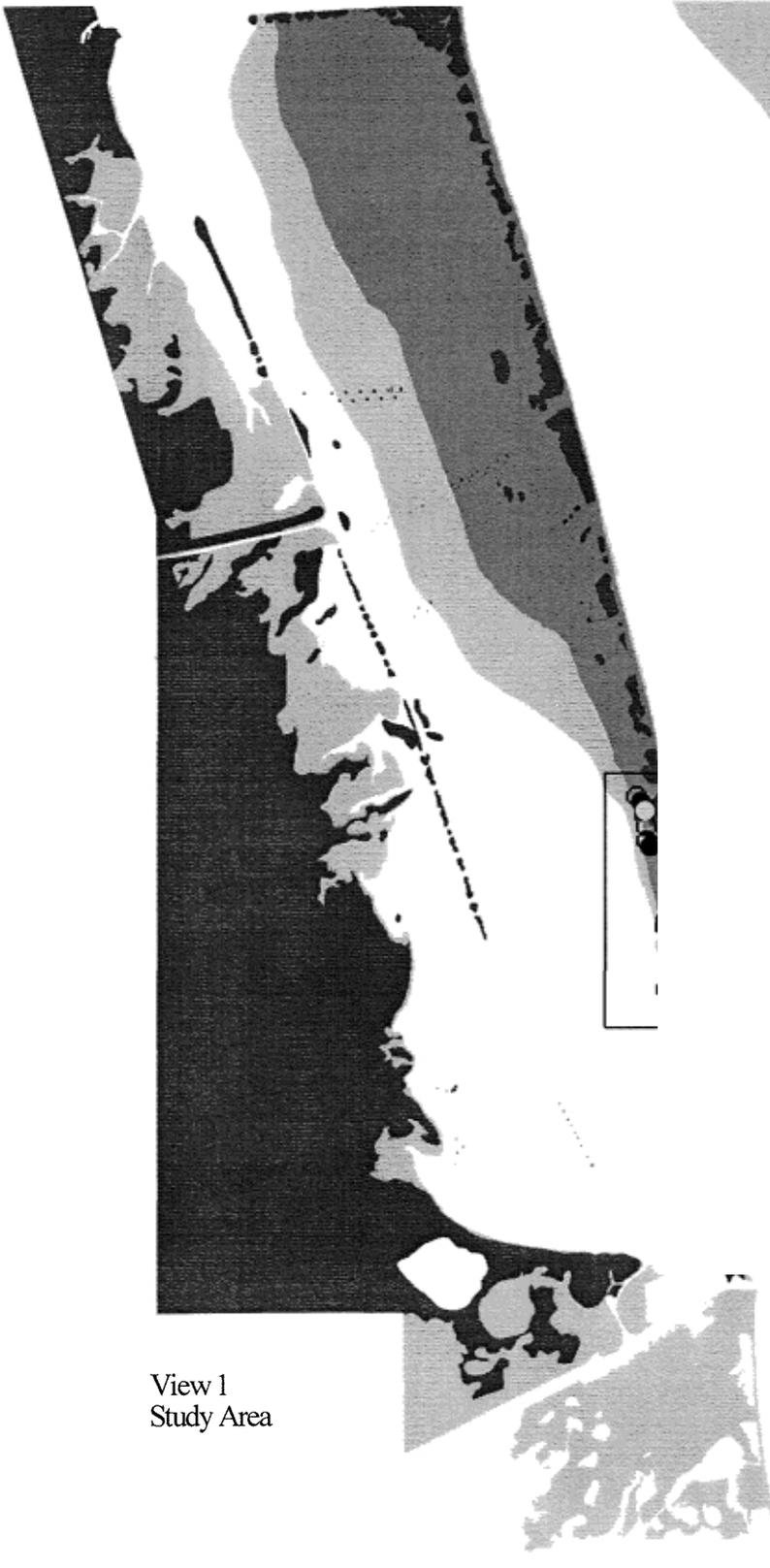
View 2  
Close-up of relocation  
cluster from View 1



## Radiofrequencies 248



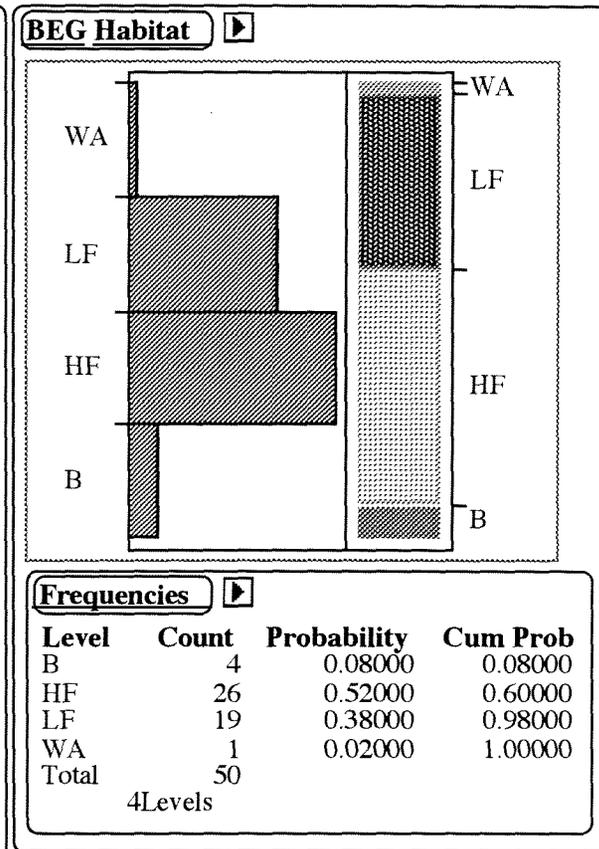
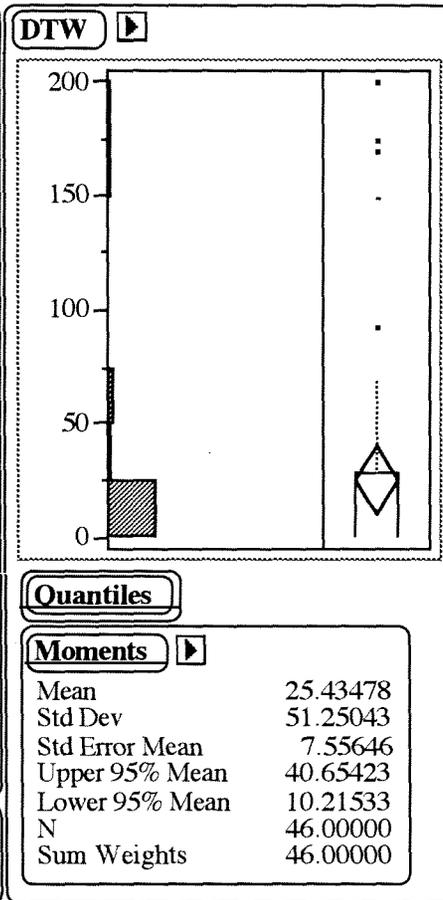
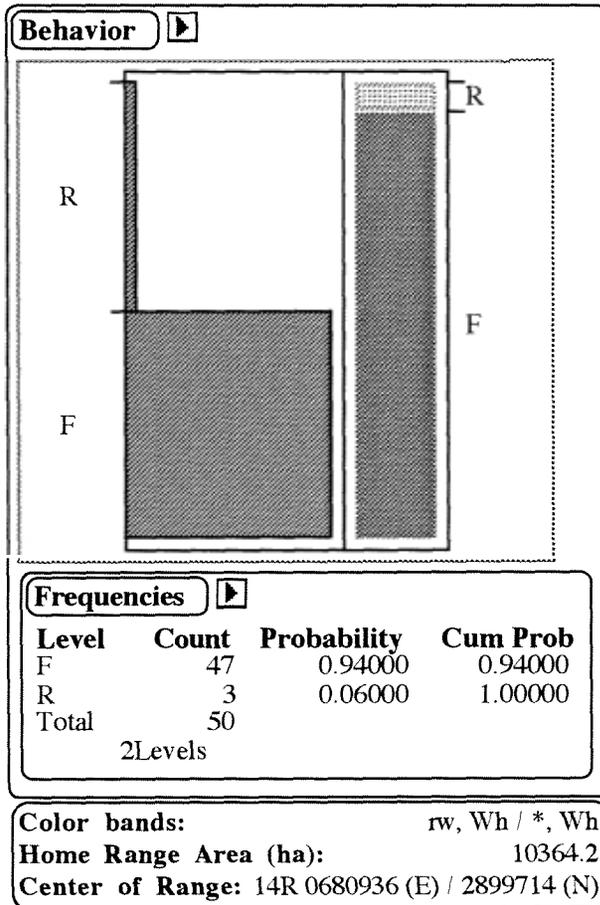
**Radiofrequency 274 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



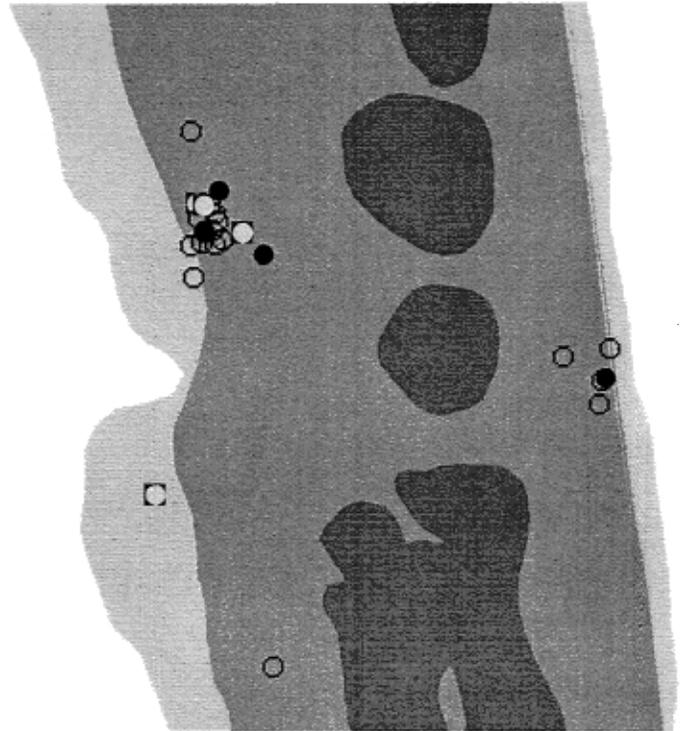
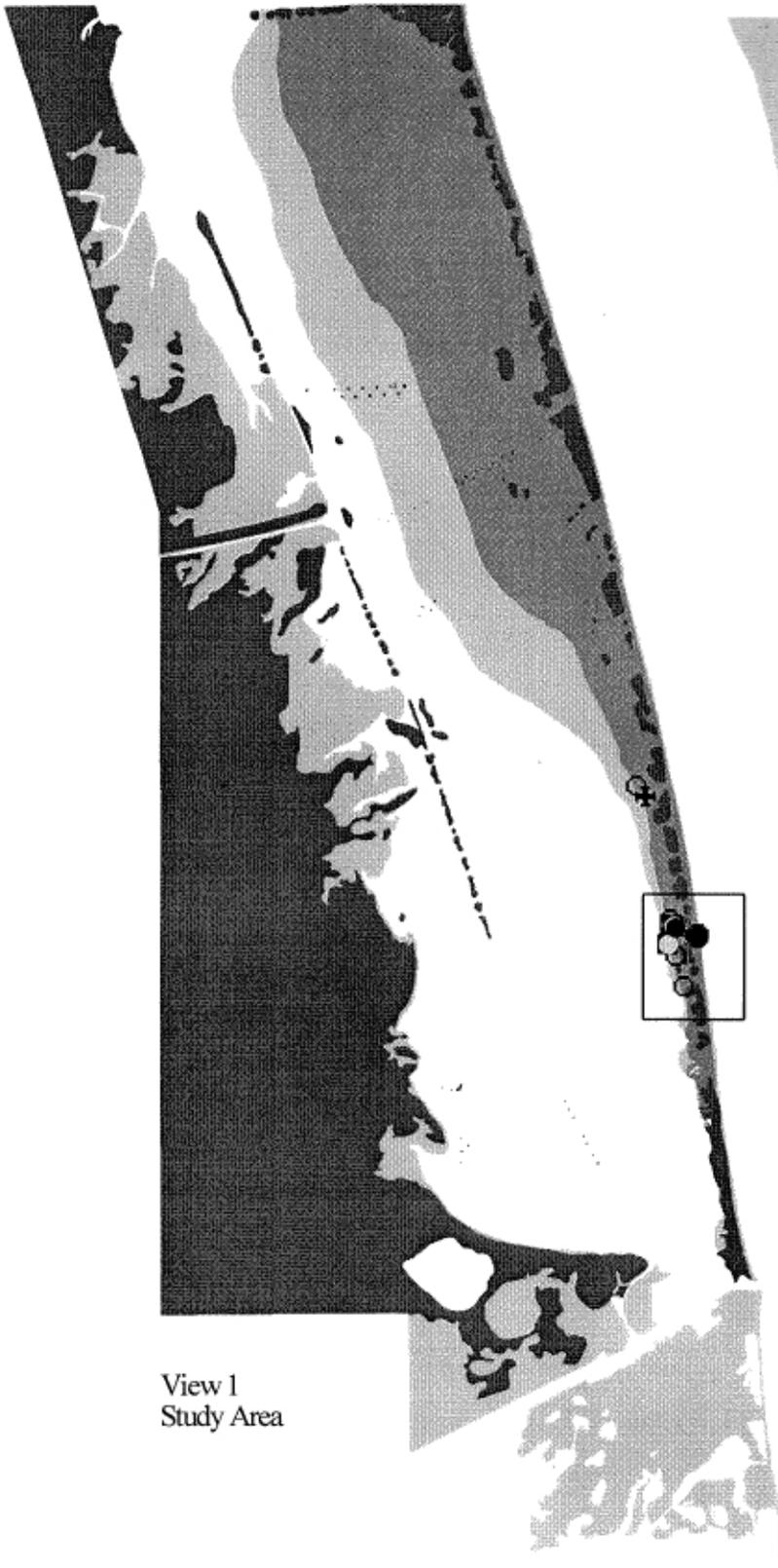
View 2  
Close-up of South Padre Island  
relocation cluster from View 1



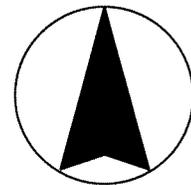
**Radiofrequency 274 (PIPL)**



**Radiofrequency 301 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.

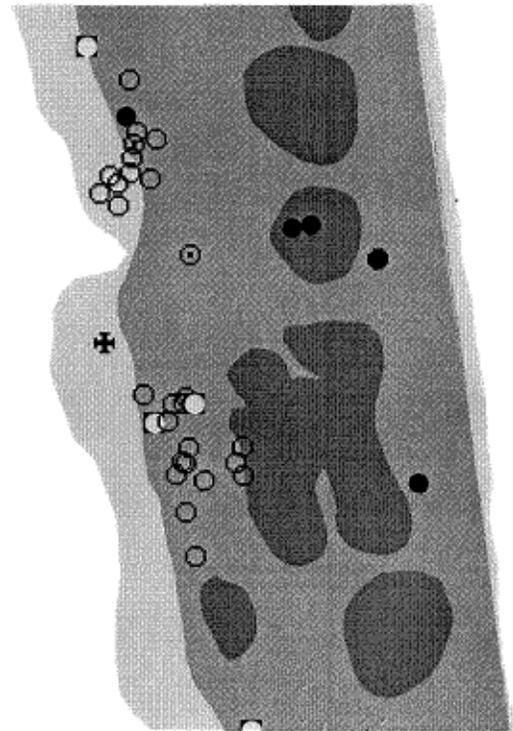
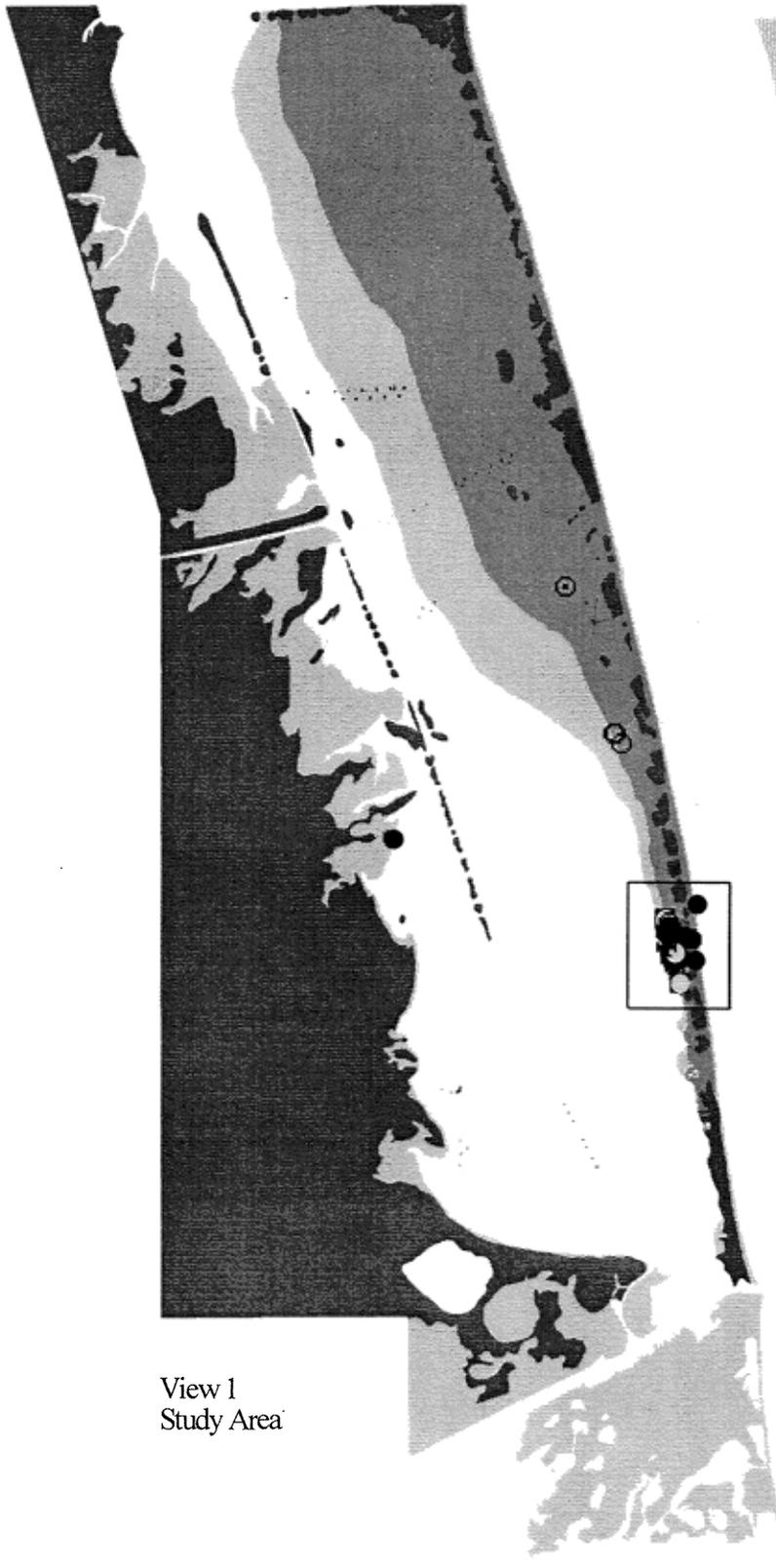


200 0 200 400 Meters

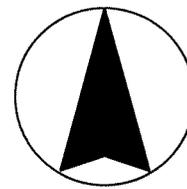


5 0 5 10 15 20 Kilometers

**Radiofrequency 301 (PIPL)**

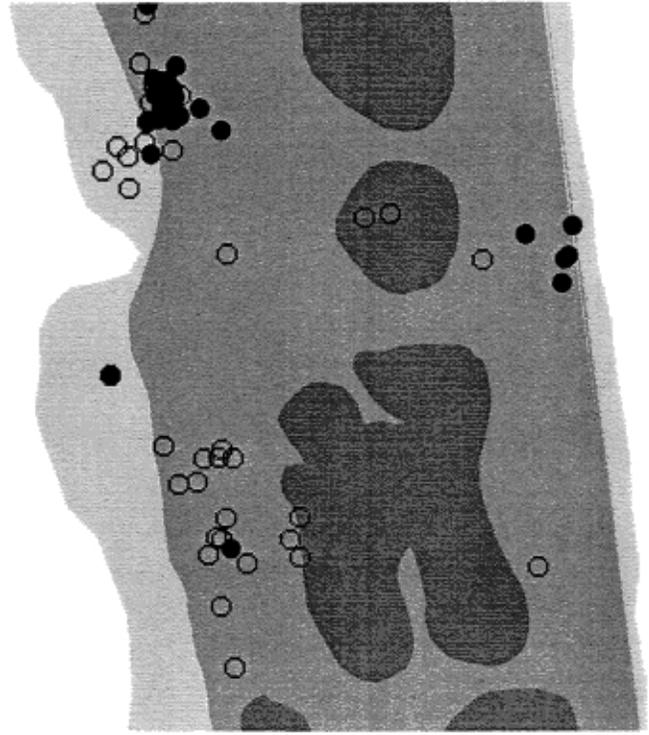


250 0 250 500 Meters



5 0 5 10 15 20 Kilometers

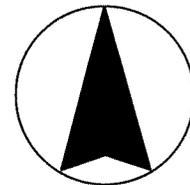
**Radiofrequency 687 (PIPL)**



View 2  
Close-up of relocation  
cluster from View 1

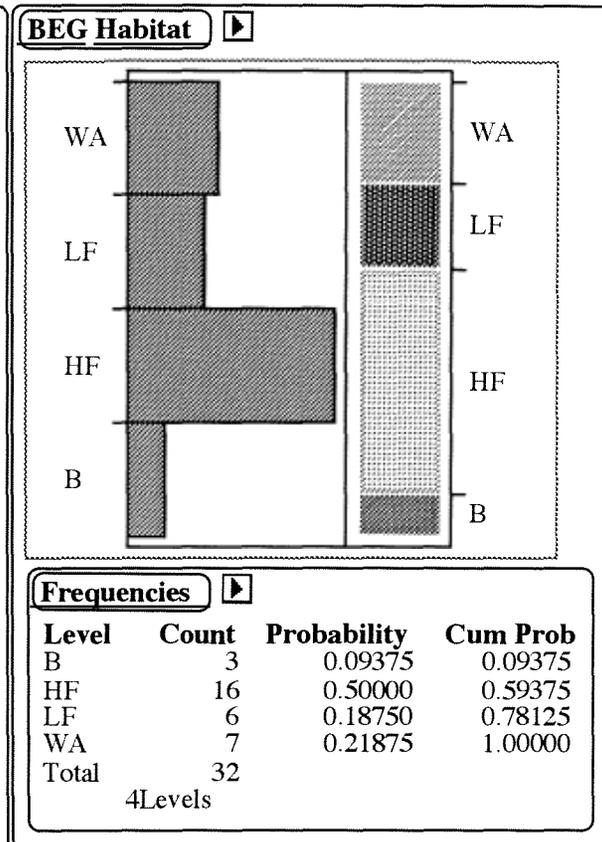
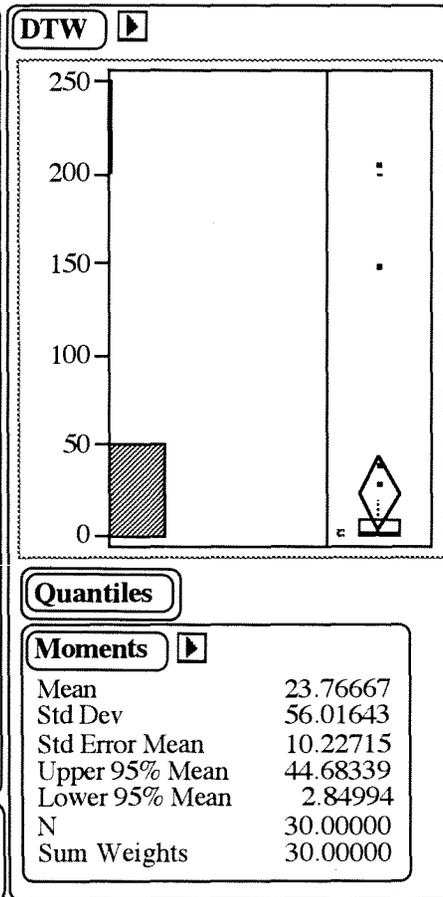
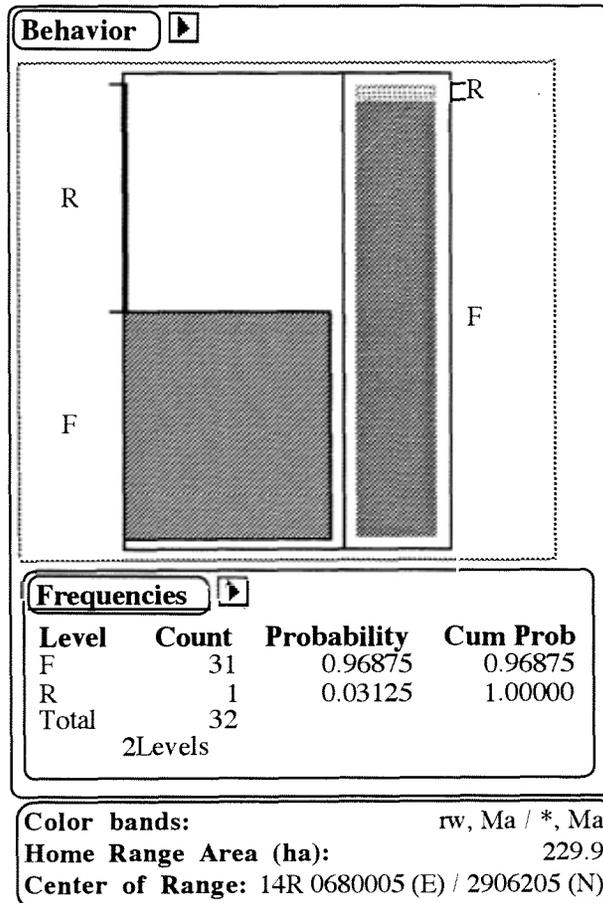
200 0 200 400 Meters

● = 301 (8/16/97 - 12/30/97)  
○ = 687 (1/1/98 - 4/20/98)

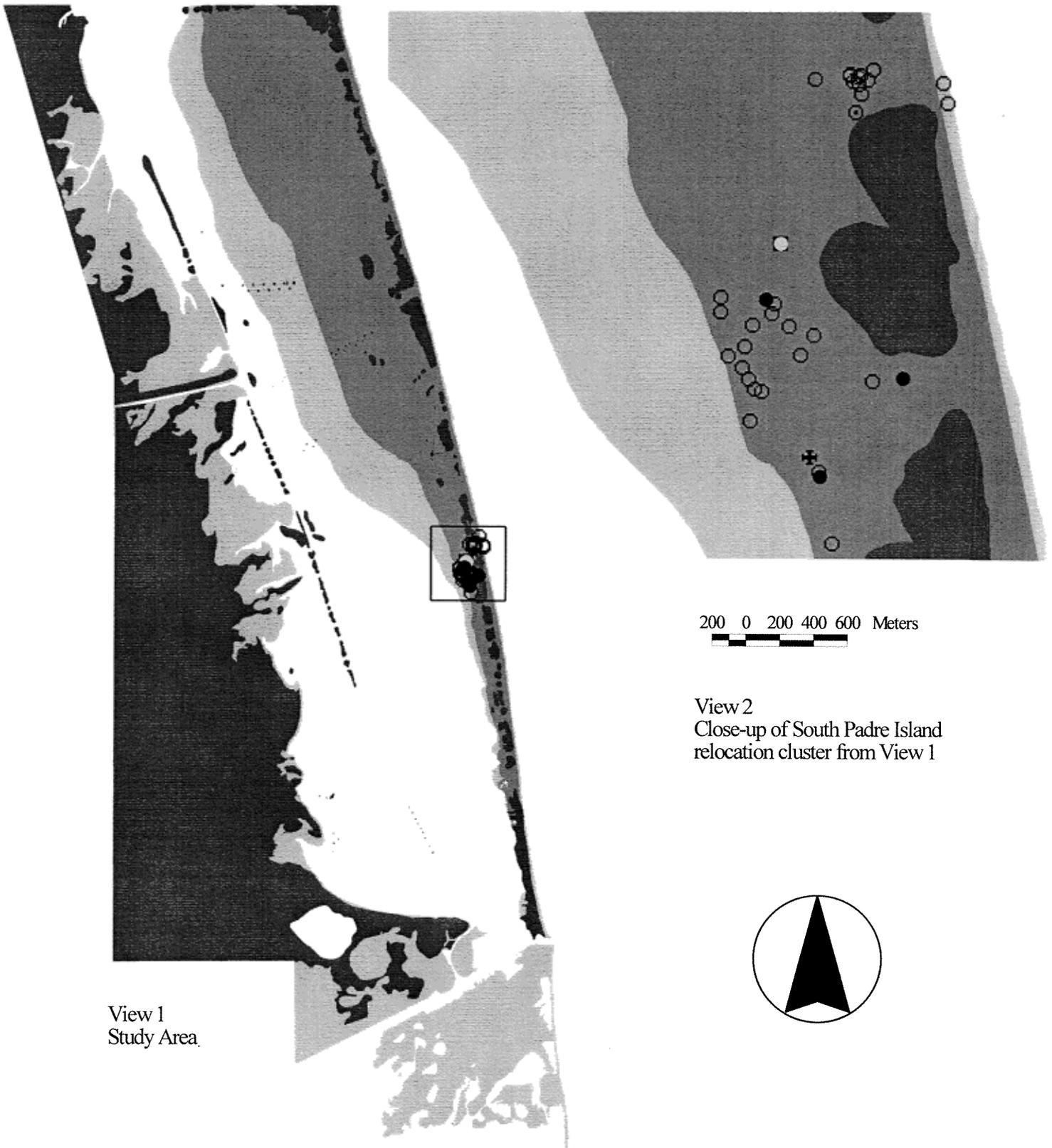


5 0 5 10 15 20 Kilometers

**Radiofrequencies 301/687  
(Same PIPL trapped and radioed twice)**



**Radiofrequency 342 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



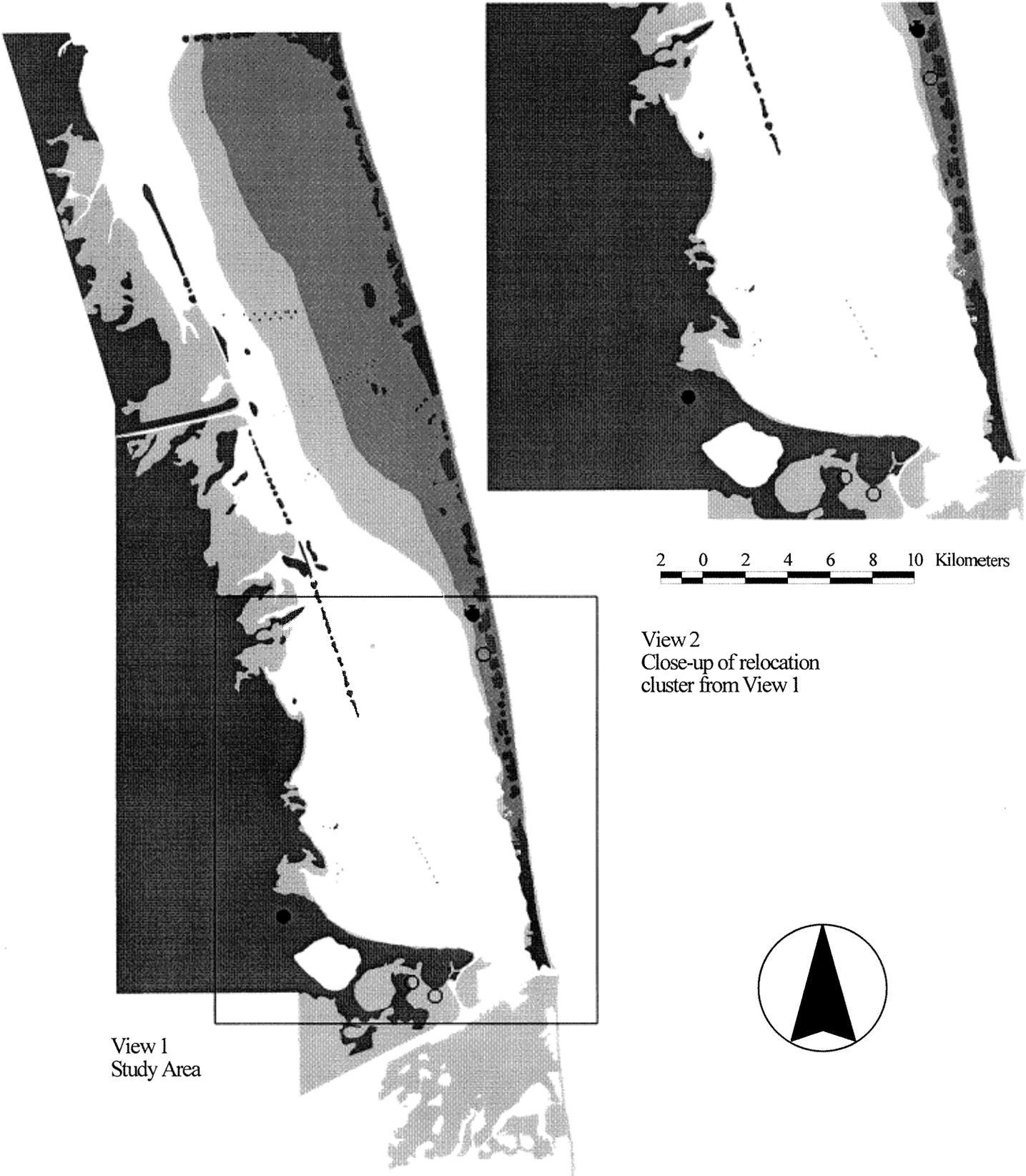
View 1  
Study Area

200 0 200 400 600 Meters

View 2  
Close-up of South Padre Island  
relocation cluster from View 1

4.9 0 4.9 9.8 14.7 19.6 Kilometers

## Radiofrequency 342 (PIPL)



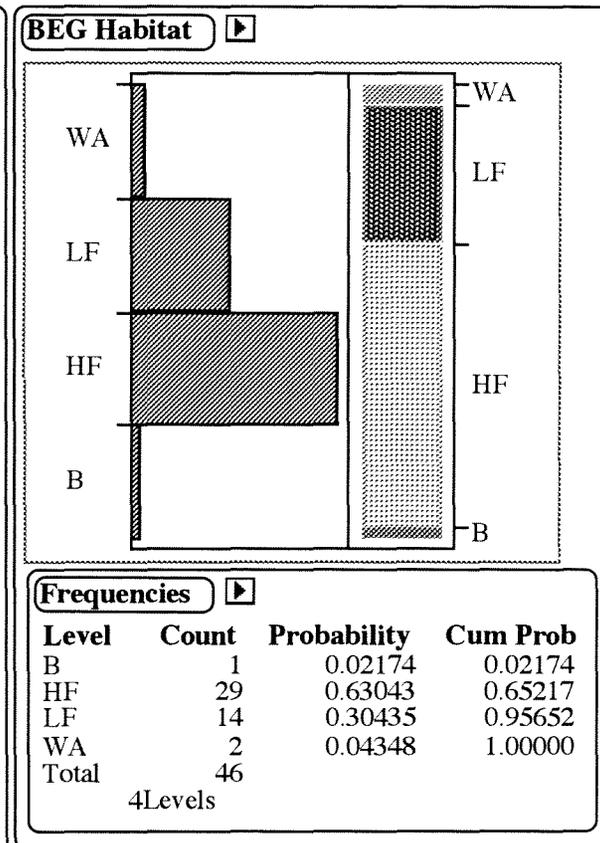
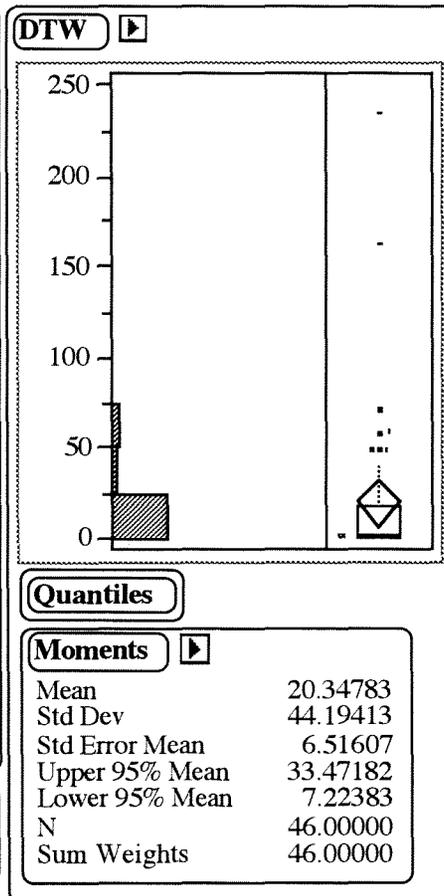
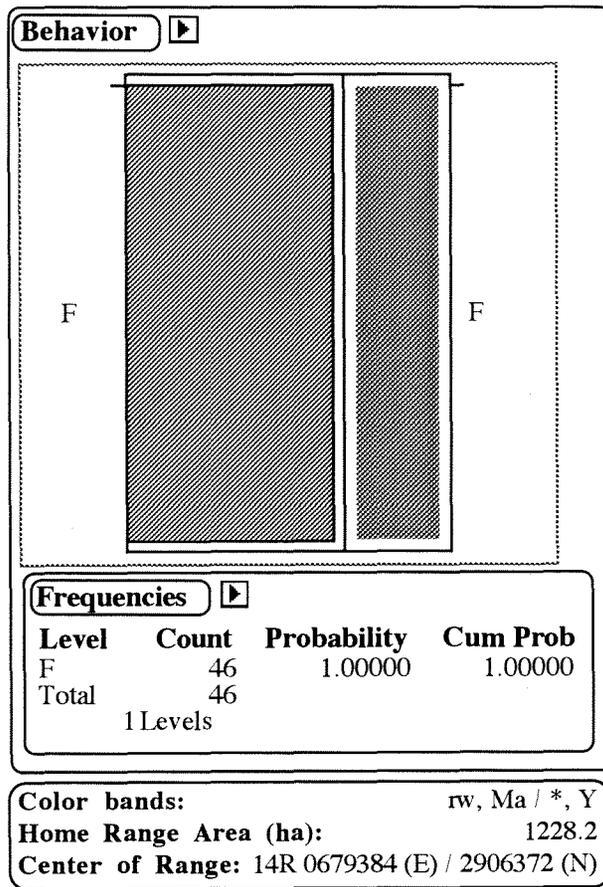
View 1  
Study Area

View 2  
Close-up of relocation  
cluster from View 1

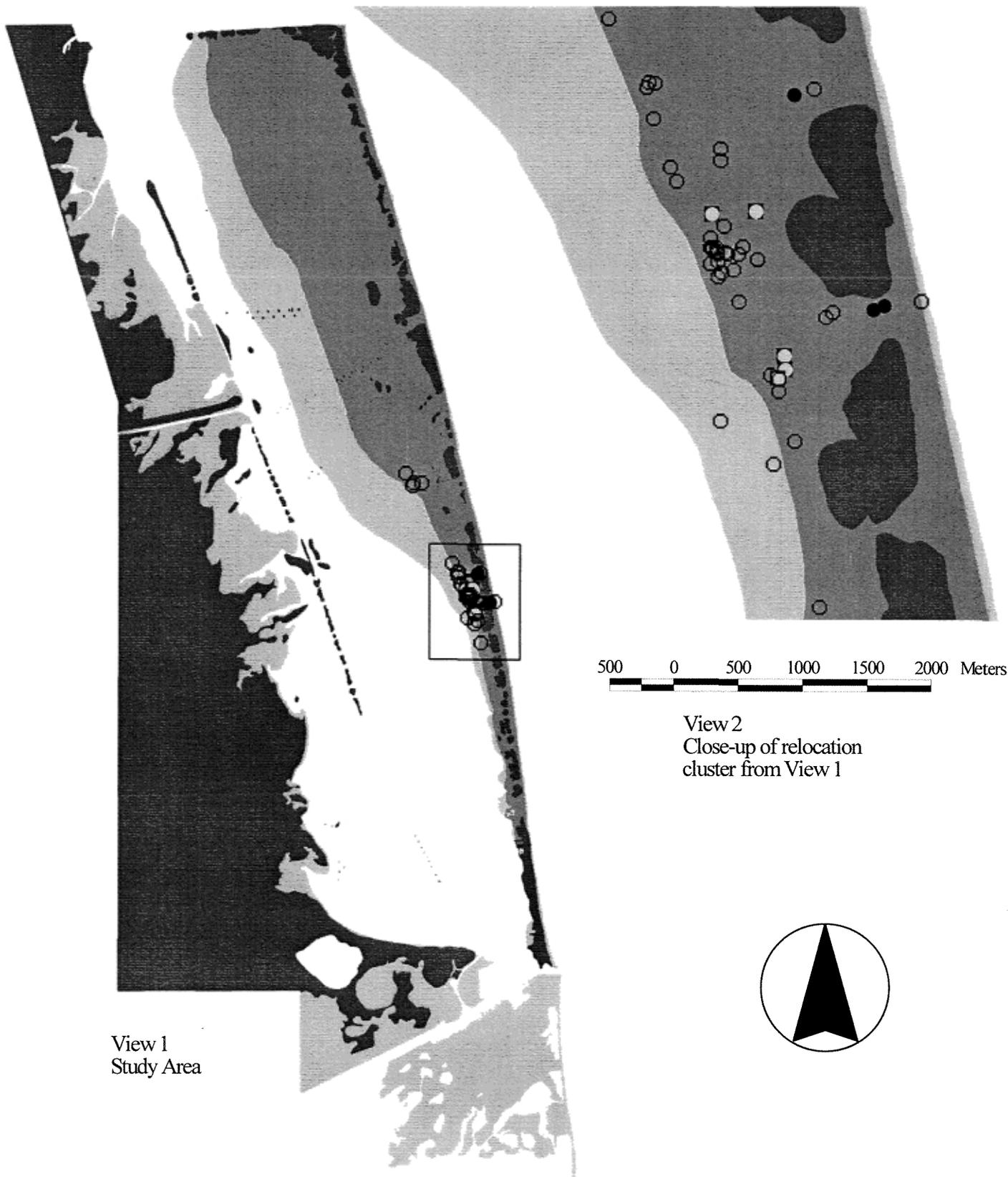
2 0 2 4 6 8 10 Kilometers

5 0 5 10 15 20 Kilometers

**Radiofrequency 384 (PIPL)**

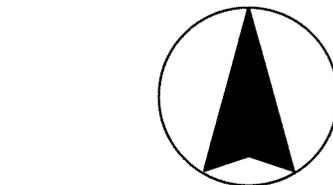


**Radiofrequency 417 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.

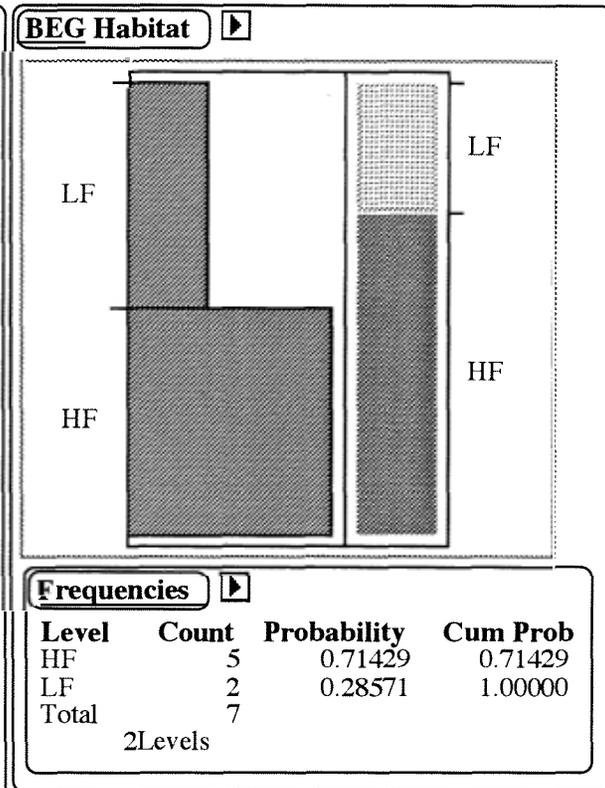
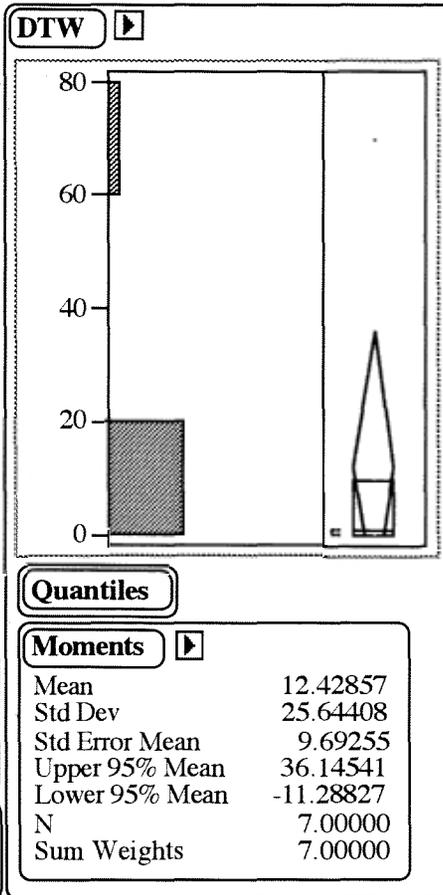
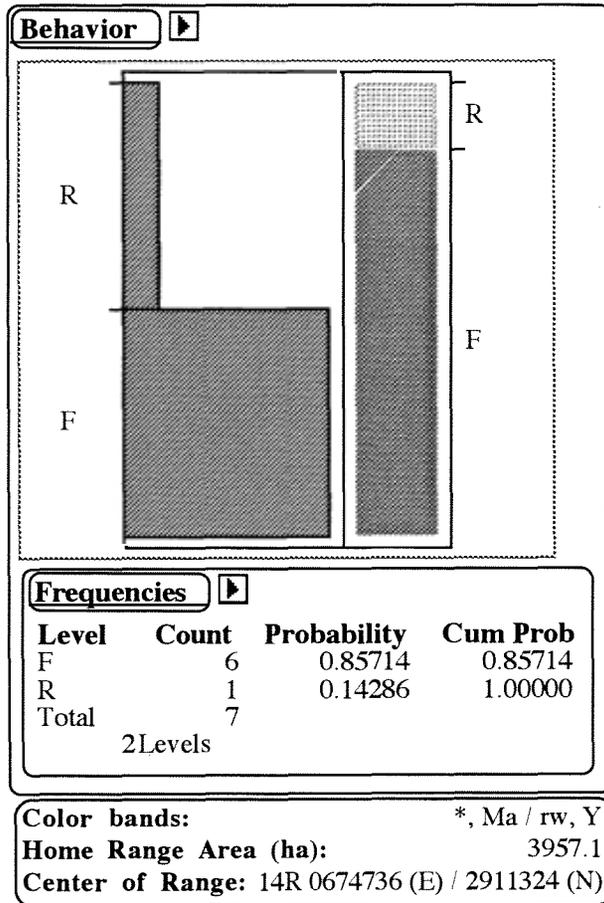


View 1  
Study Area

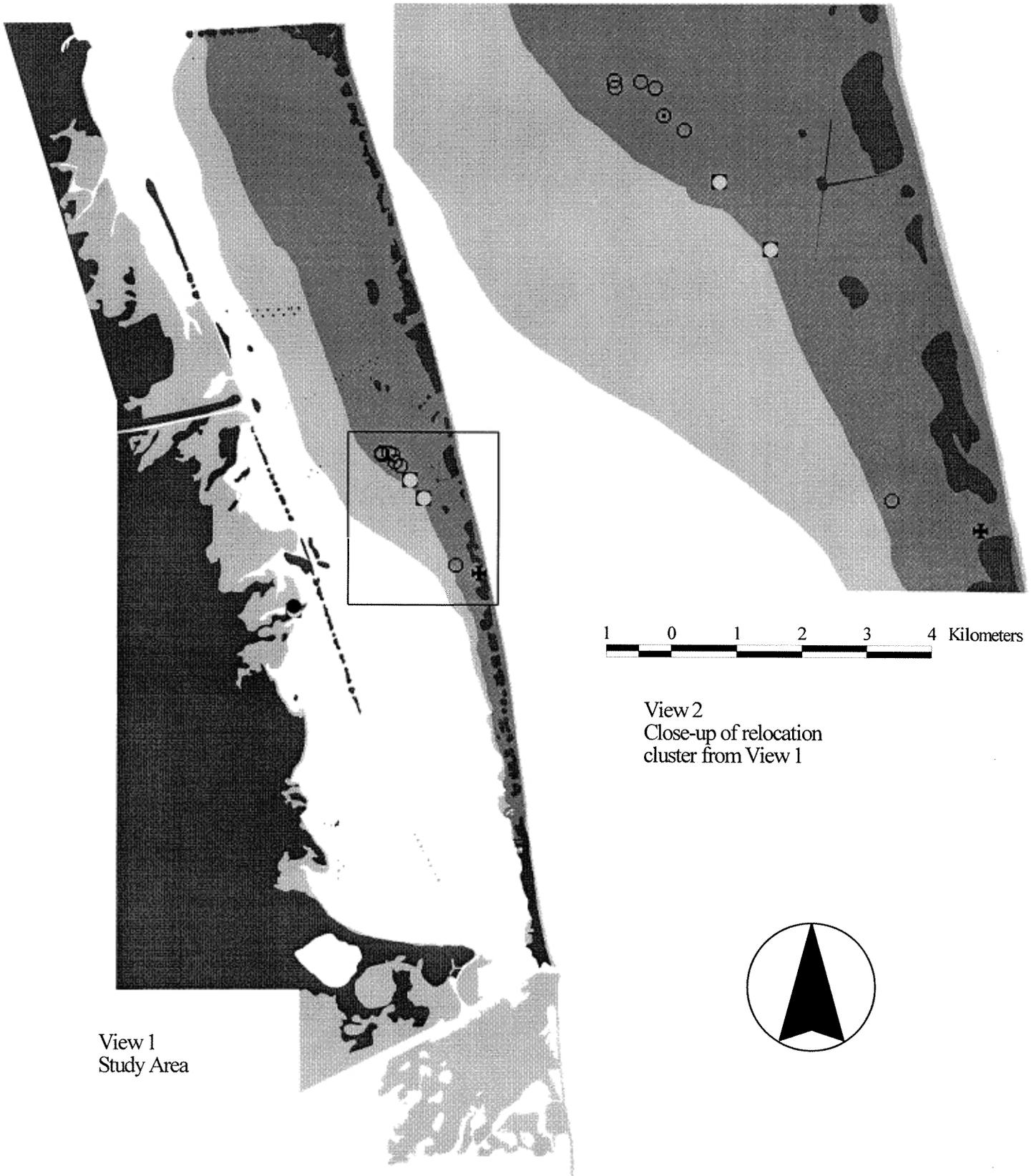
View 2  
Close-up of relocation  
cluster from View 1



## Radiofrequency 417 (PIPL)



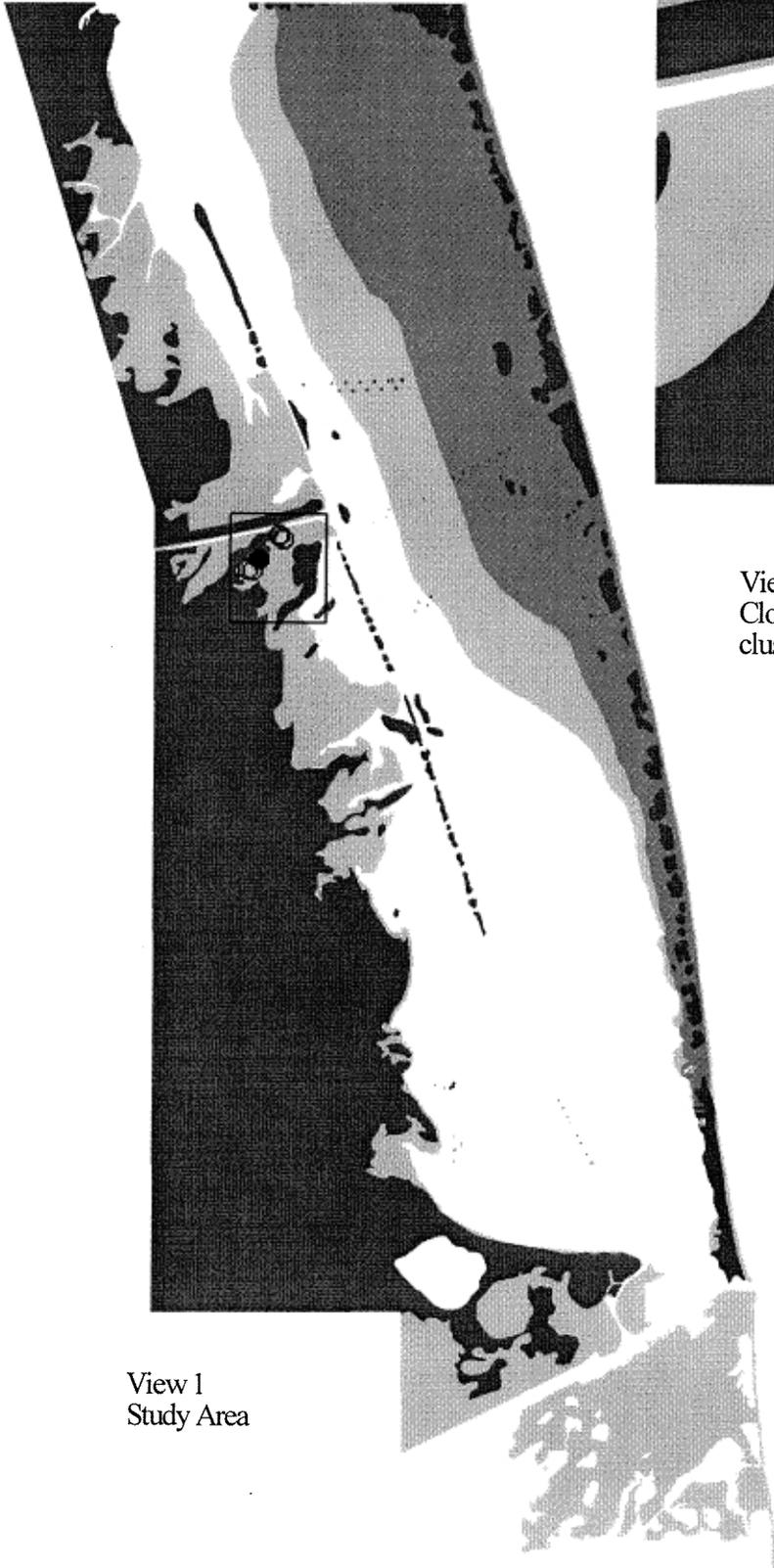
**Radiofrequency 440 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



View 1  
Study Area

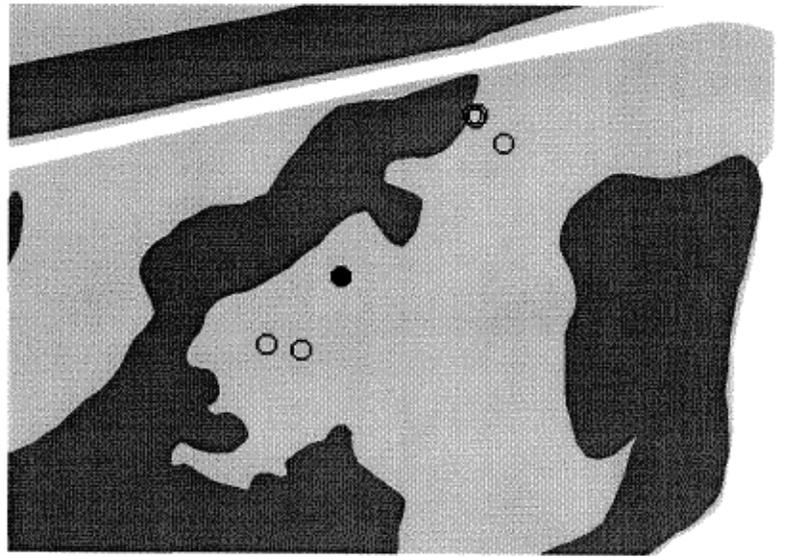
View 2  
Close-up of relocation  
cluster from View 1

**Radiofrequency 440 (PIPL)**



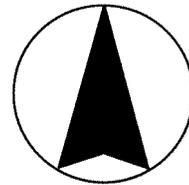
View 1  
Study Area

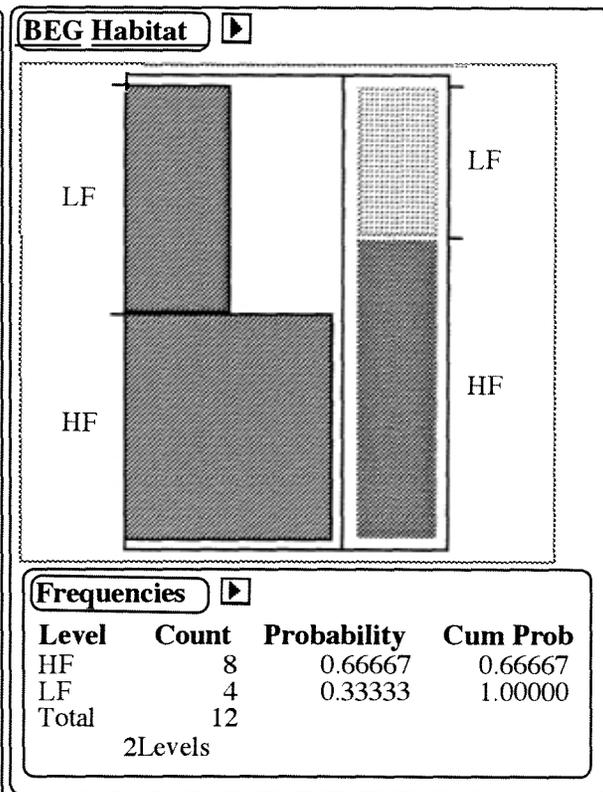
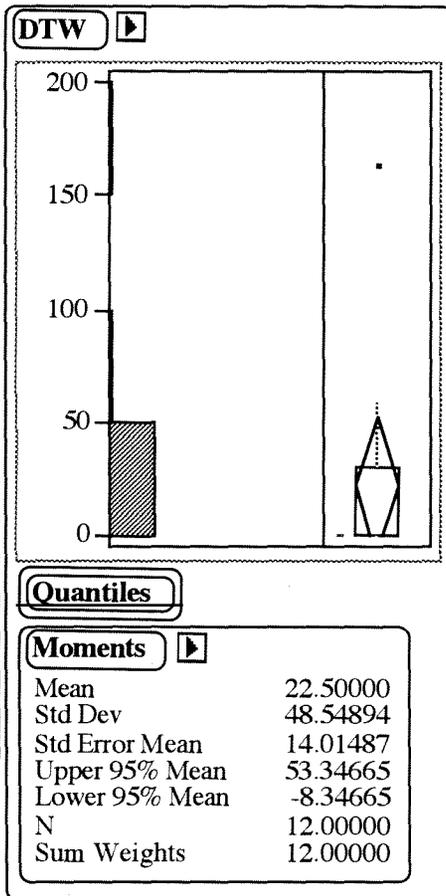
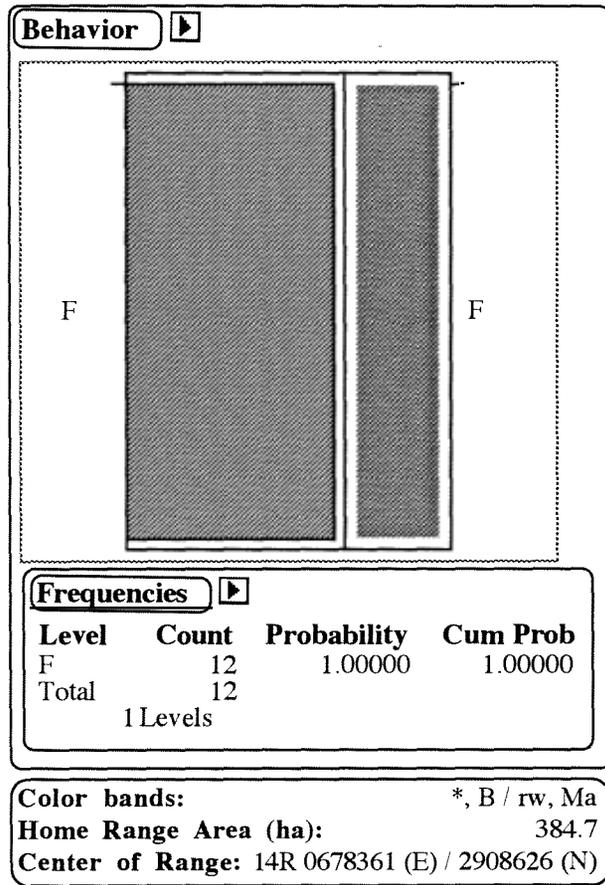
5 0 5 10 15 20 Kilometers



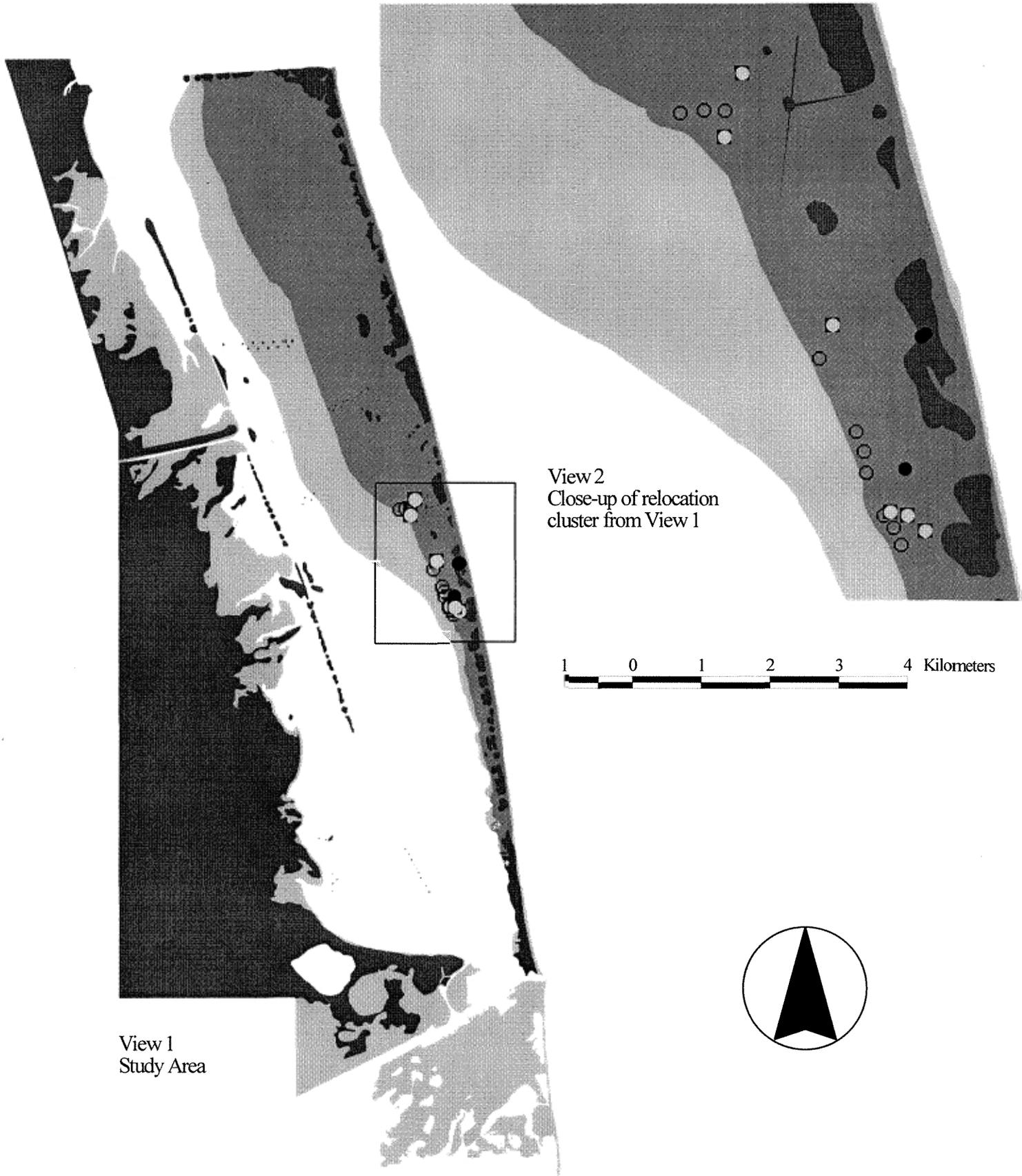
500 0 500 1000 1500 Meters

View 2  
Close-up of relocation  
cluster from View 1





**Radiofrequency 461 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.

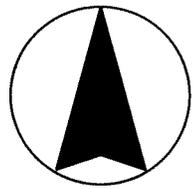


View 1  
Study Area

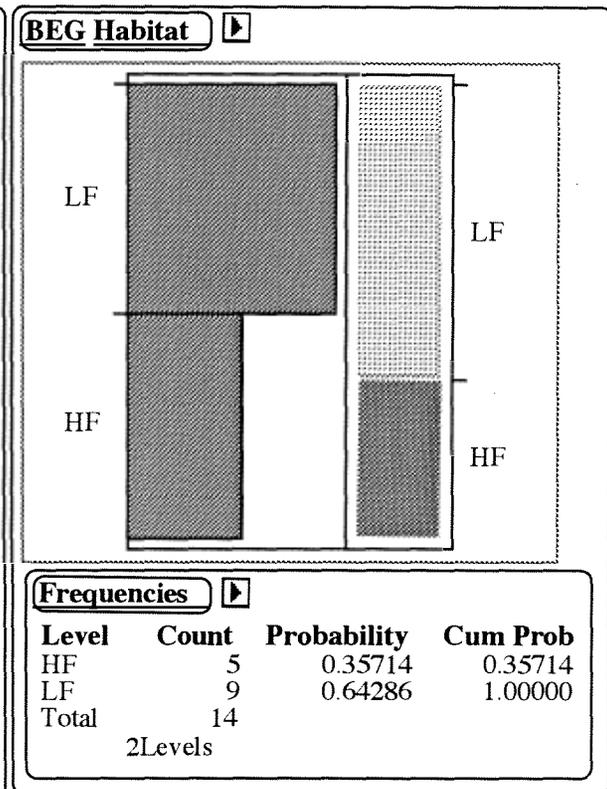
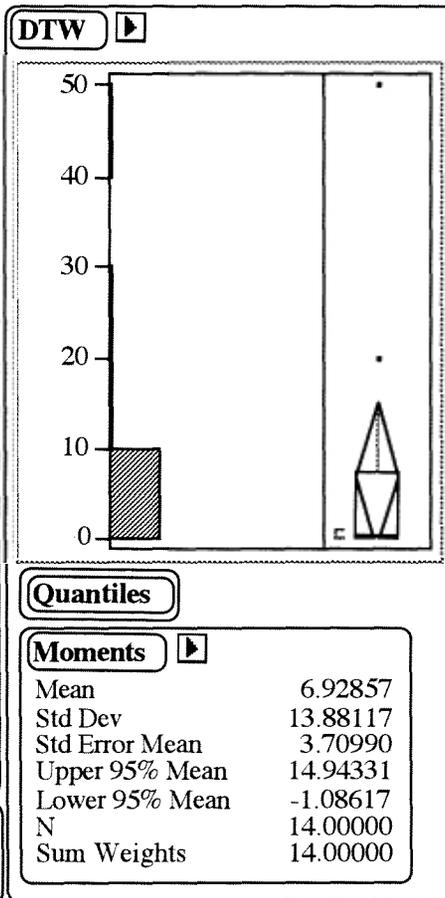
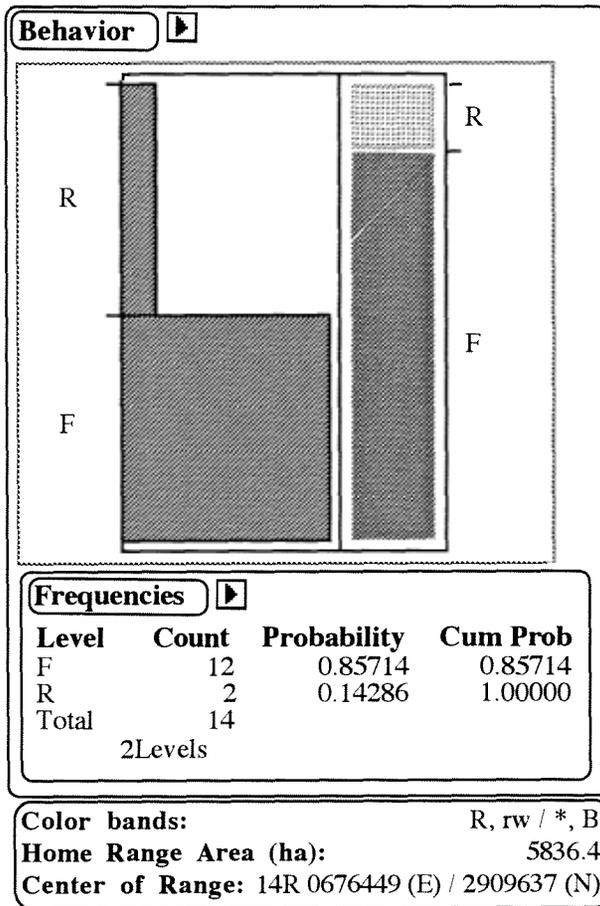
View 2  
Close-up of relocation  
cluster from View 1

1 0 1 2 3 4 Kilometers

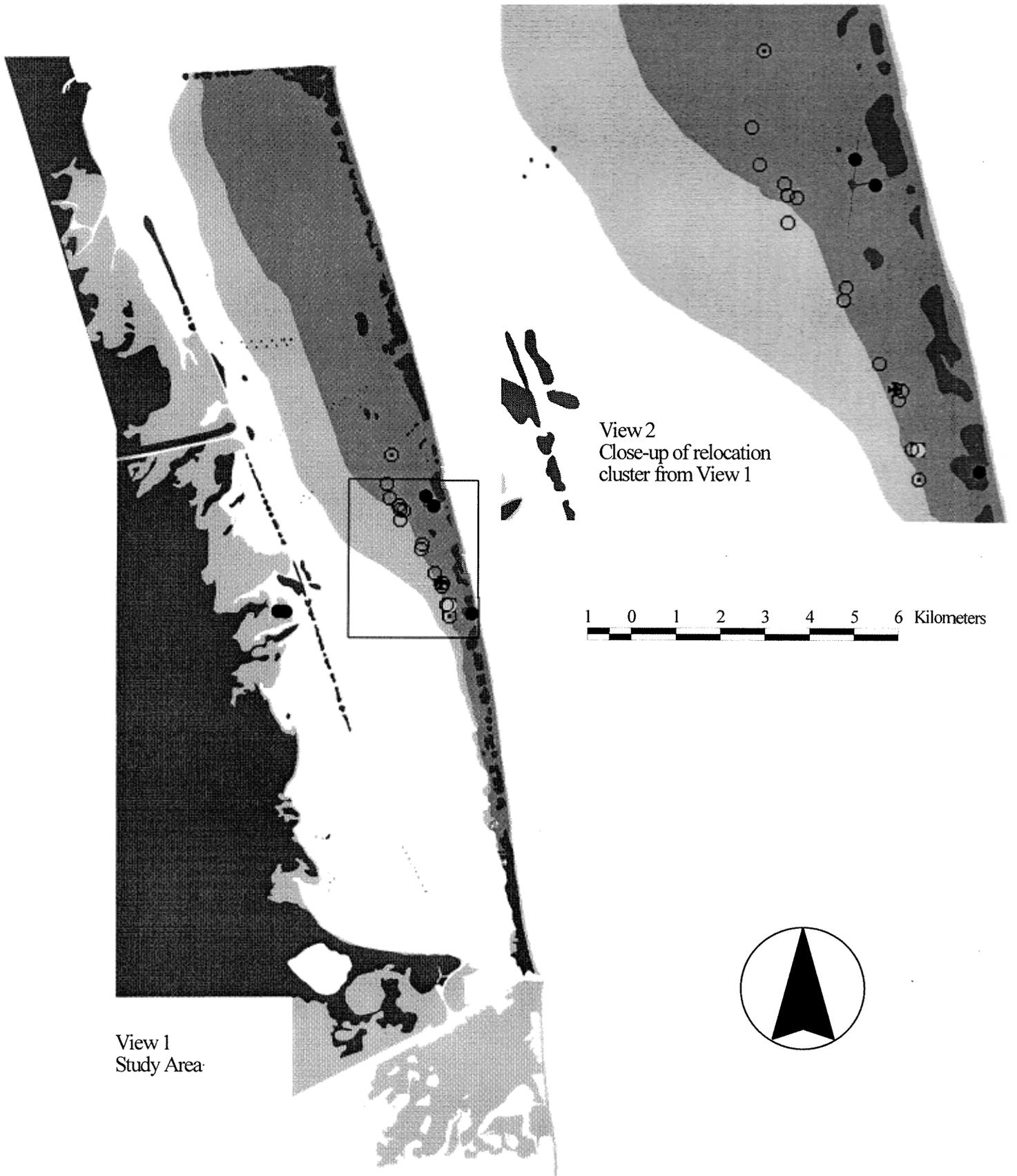
4.8 0 4.8 9.6 14.4 19.2 Kilometers



# Radiofrequency 461 (PIPL)



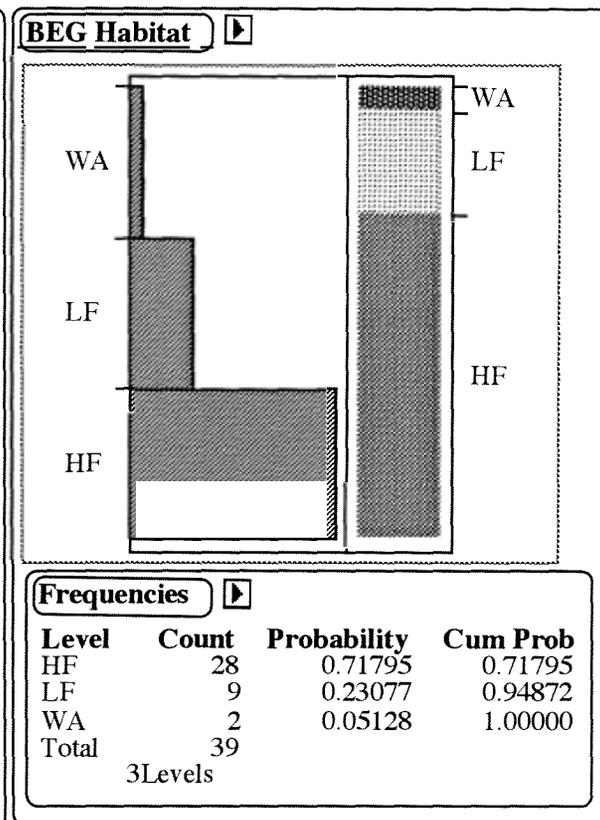
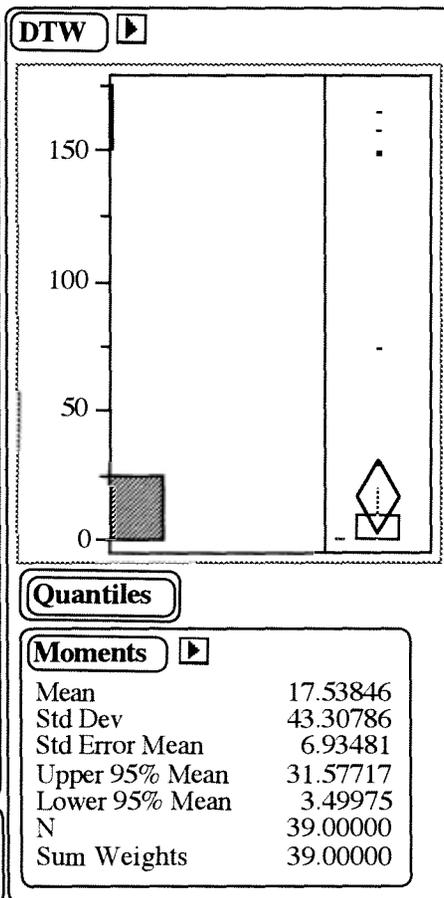
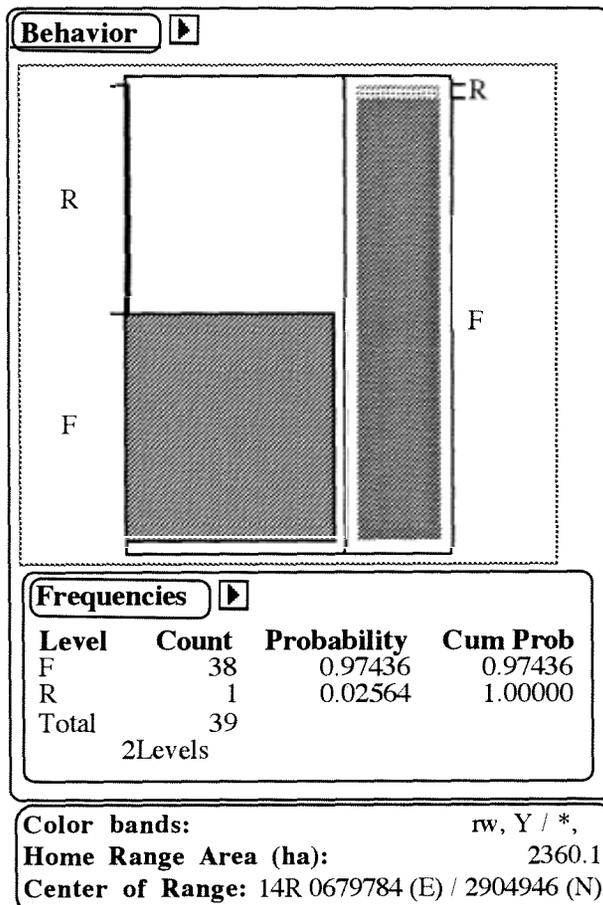
**Radiofrequency 479 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



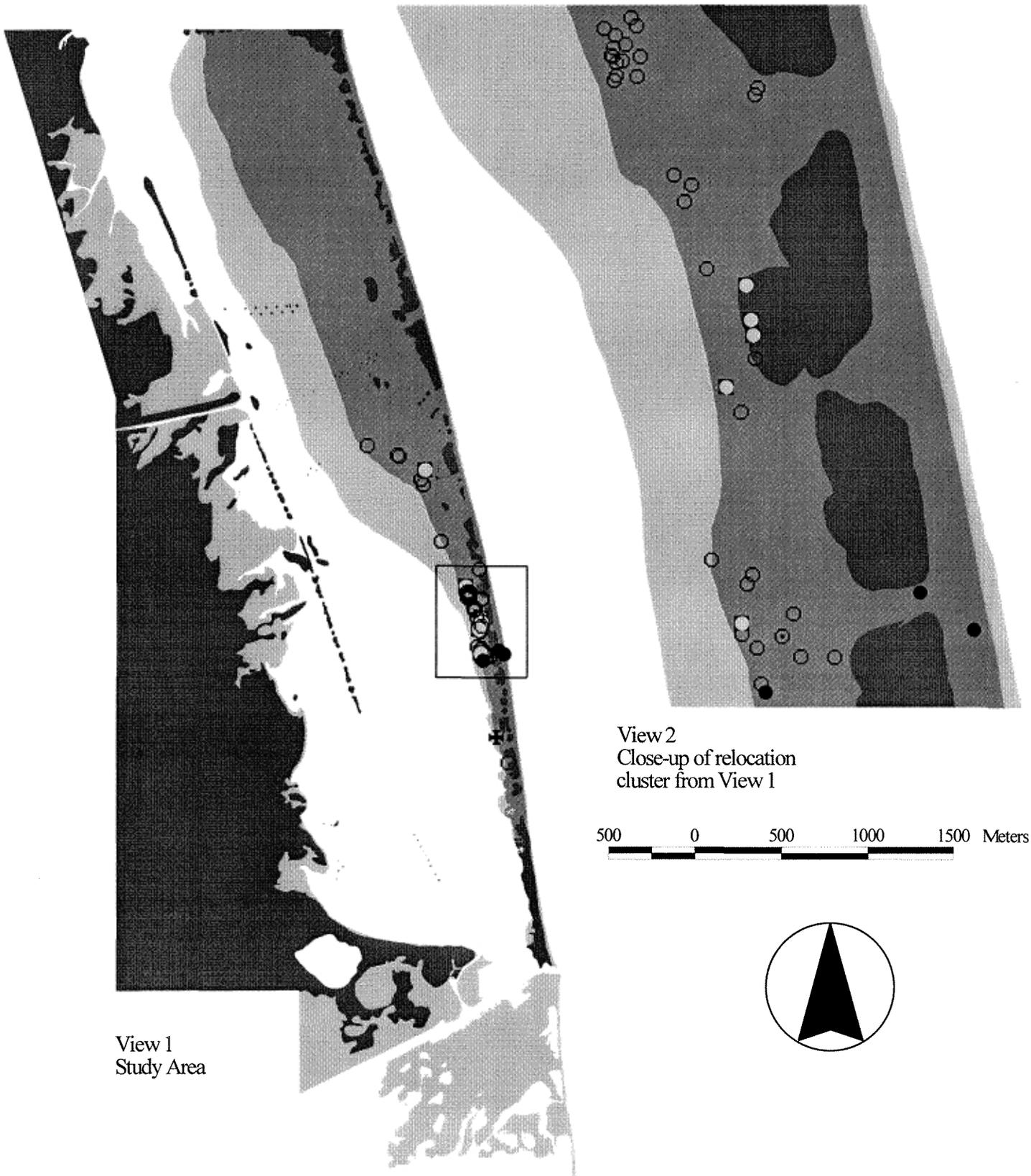
View 1  
Study Area

View 2  
Close-up of relocation  
cluster from View 1

**Radiofrequency 479 (PIPL)**



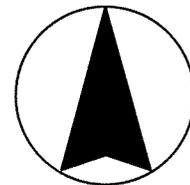
**Radiofrequency 507 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



View 1  
Study Area

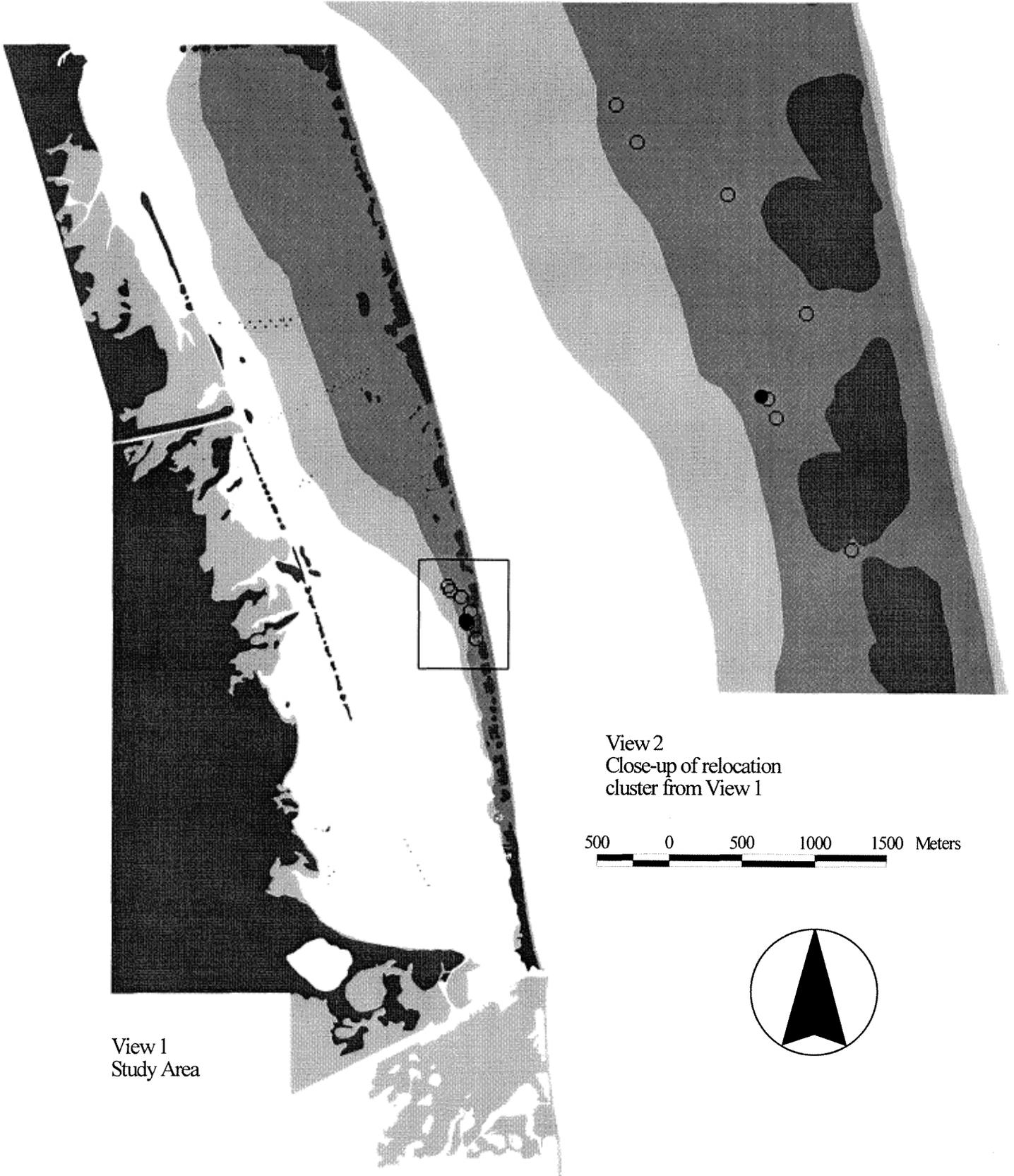
View 2  
Close-up of relocation  
cluster from View 1

500 0 500 1000 1500 Meters



5 0 5 10 15 20 Kilometers

**Radiofrequency 507 (PIPL)**



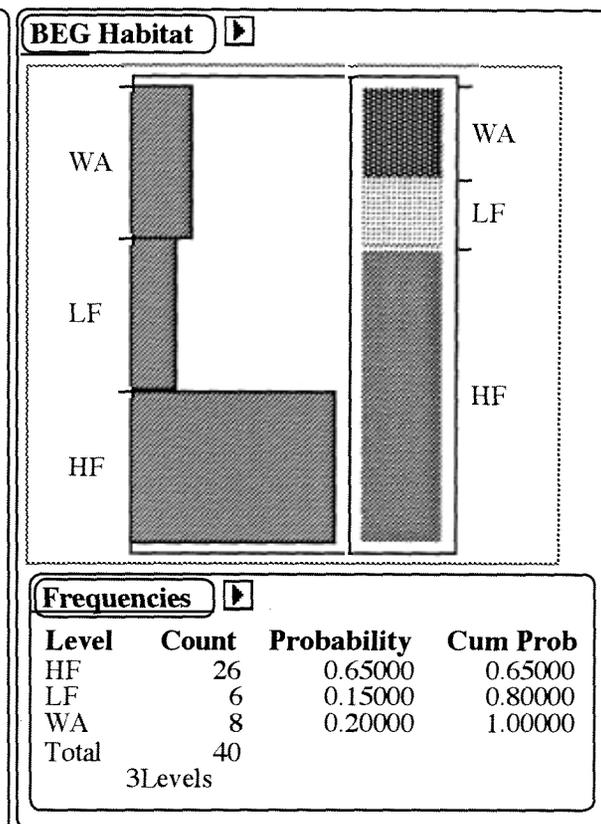
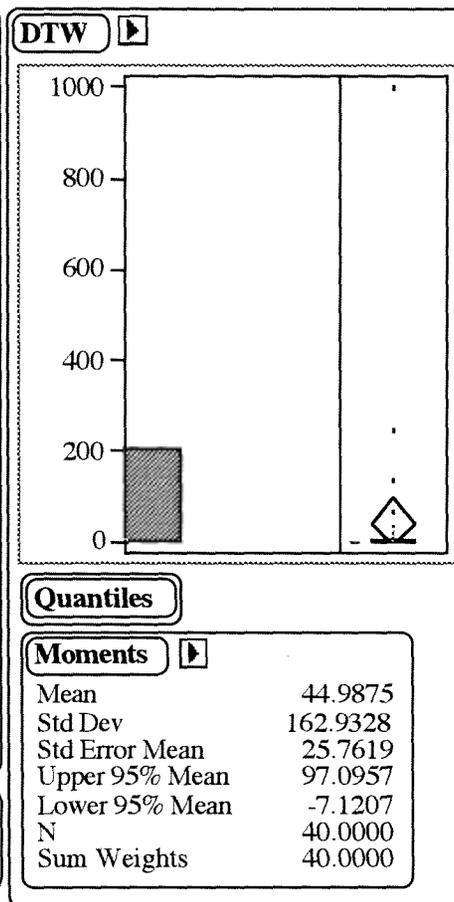
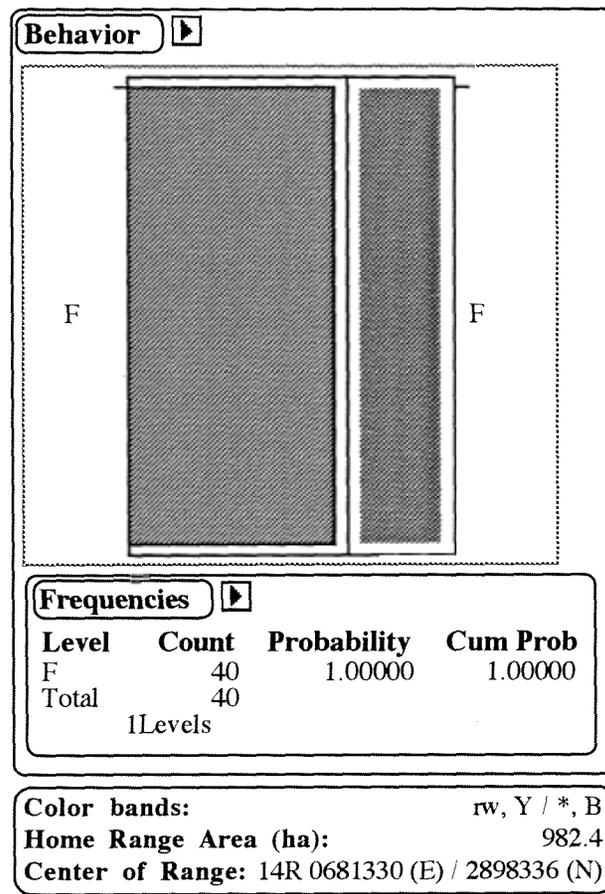
View 1  
Study Area

View 2  
Close-up of relocation  
cluster from View 1

500 0 500 1000 1500 Meters

5 0 5 10 15 20 Kilometers

## Radiofrequency 523 (SNPL)

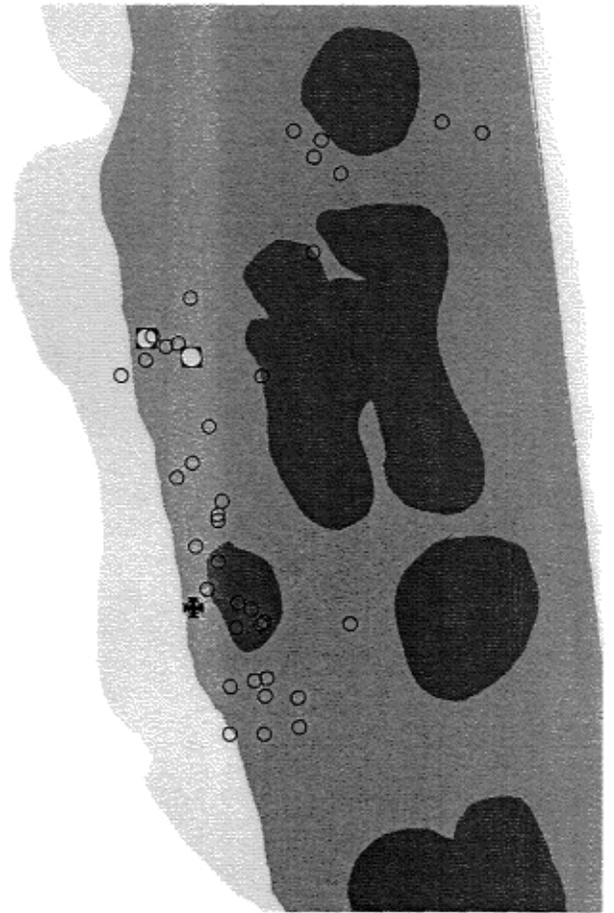


**Radiofrequency 533 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



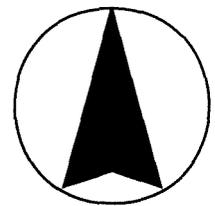
View 1  
Study Area

8 0 8 16 Kilometers

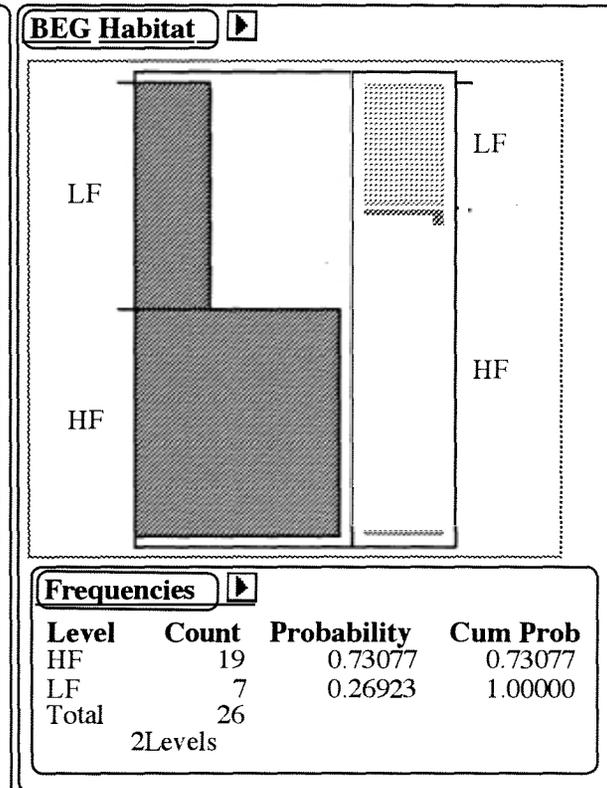
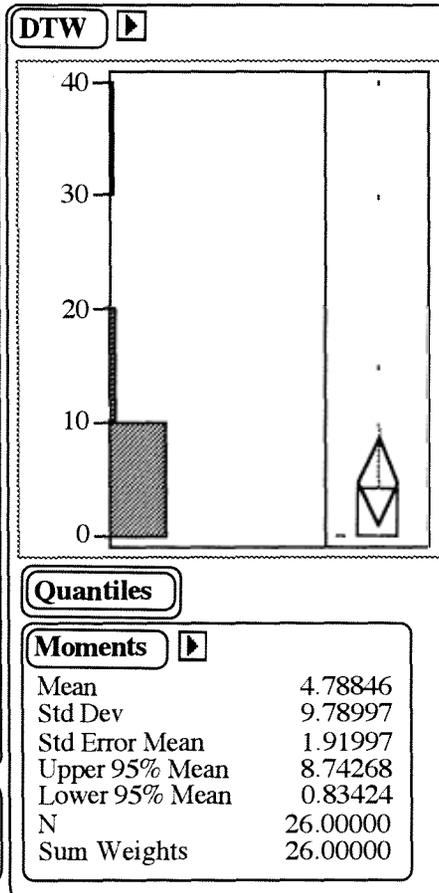
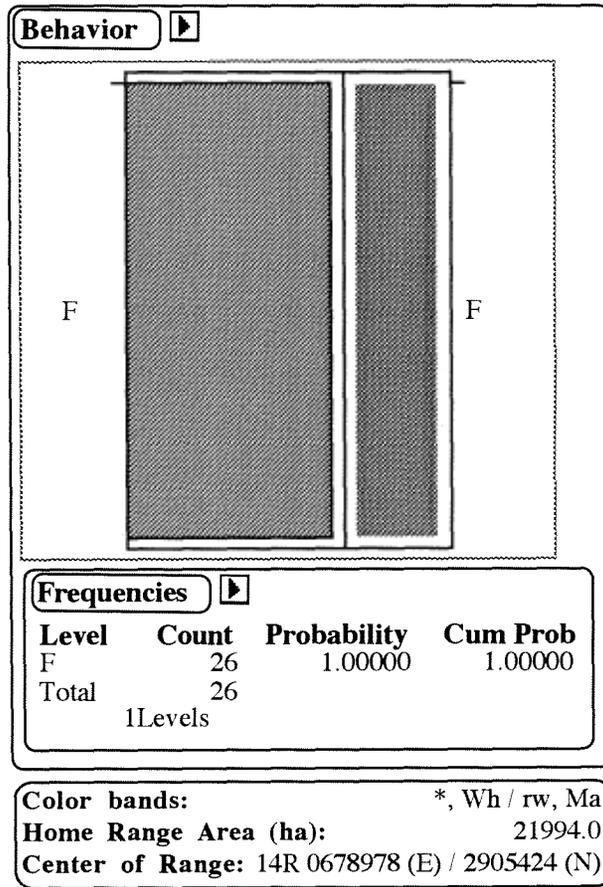


300 0 300 600 Meters

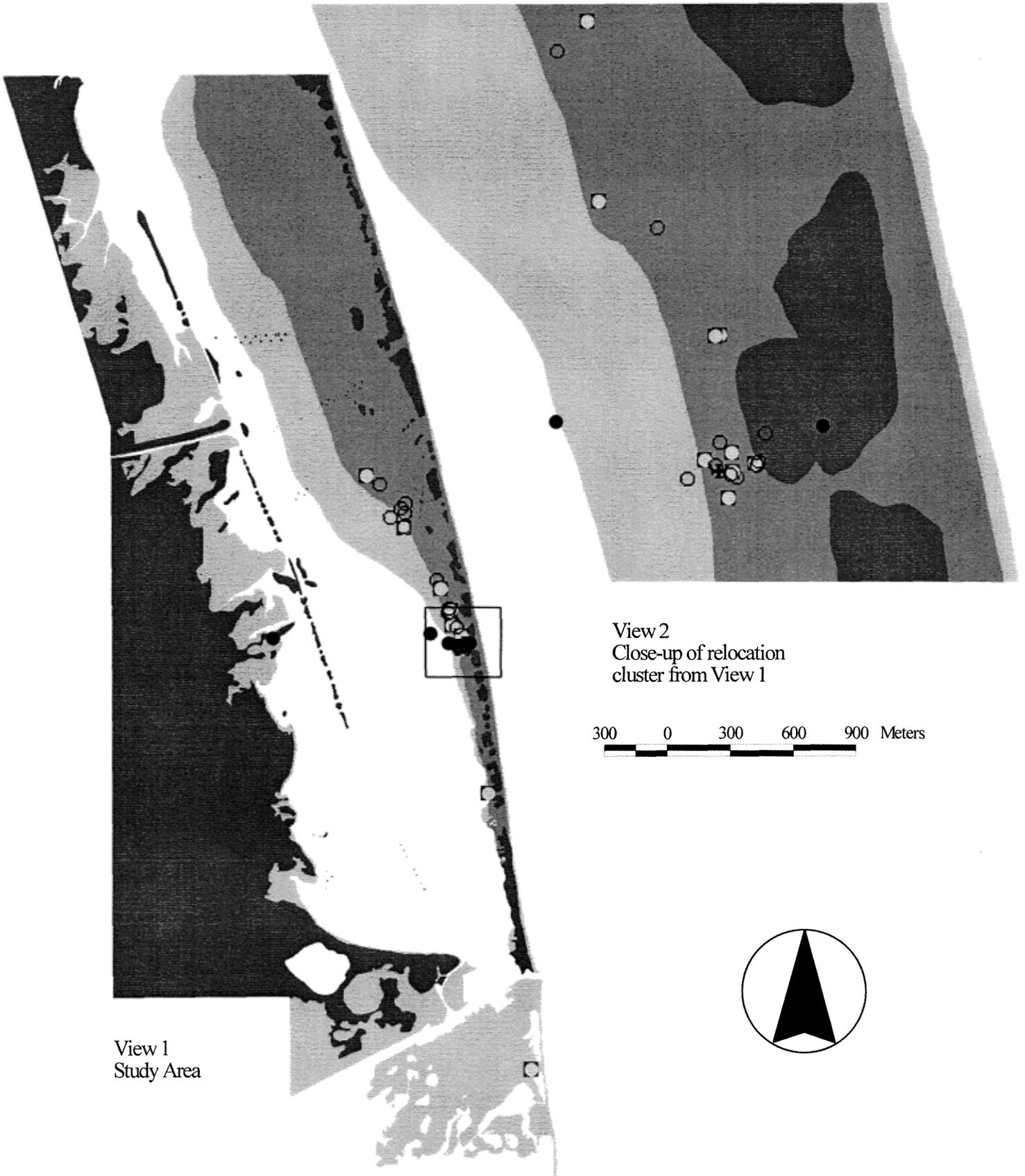
View 2  
Close-up of relocation  
cluster from View 1



## Radiofrequency 533 (PIPL)



**Radiofrequency 557 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



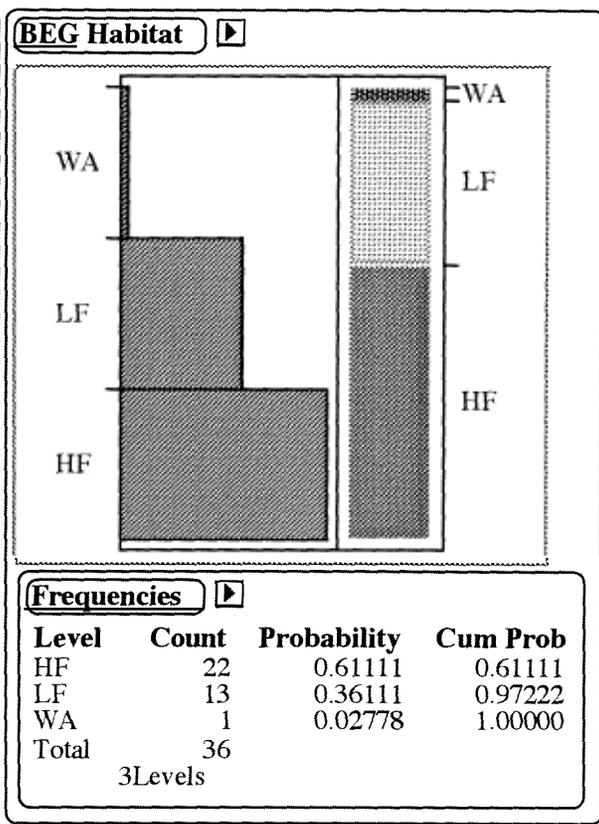
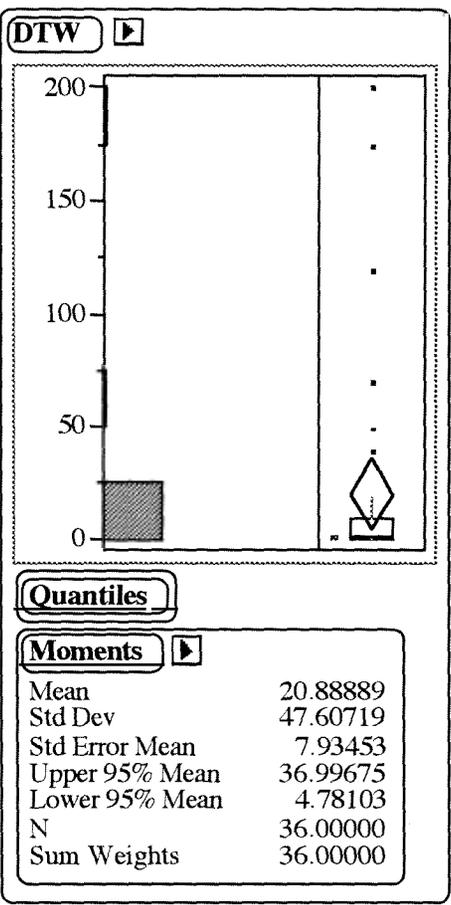
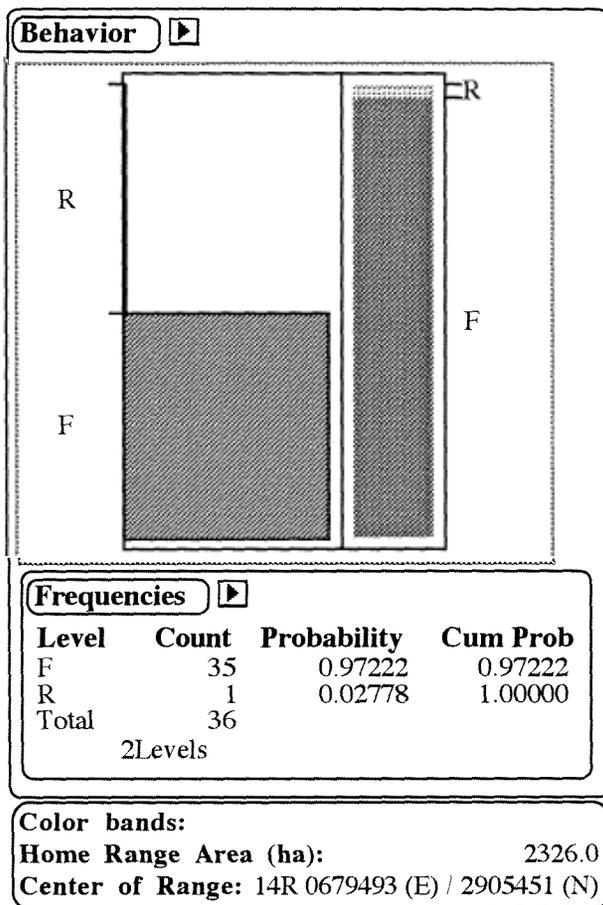
View 1  
Study Area

View 2  
Close-up of relocation  
cluster from View 1

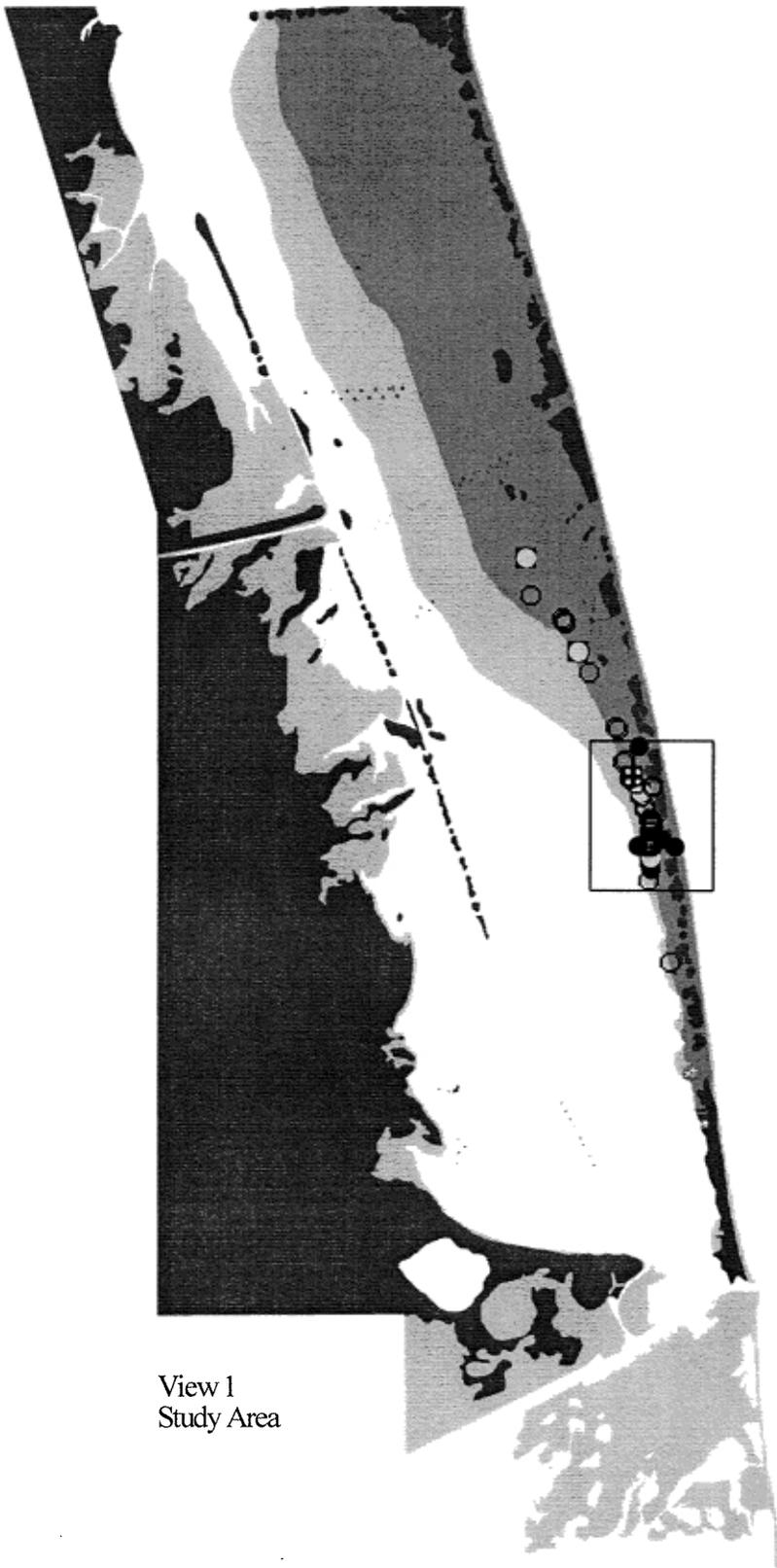
300 0 300 600 900 Meters

5 0 5 10 15 20 Kilometers

**Radiofrequency 557 (PIPL)**

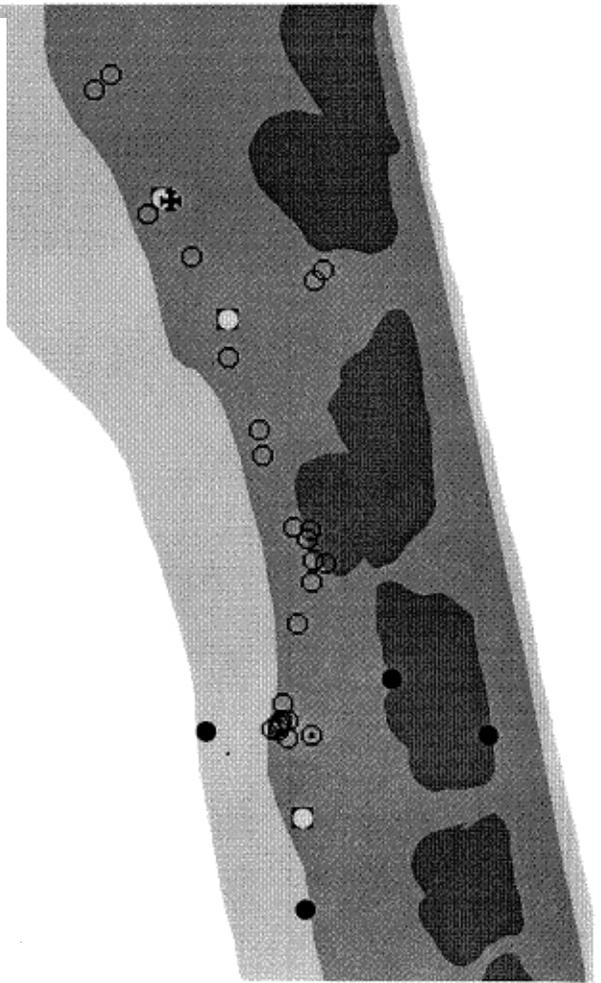


**Radiofrequency 585 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



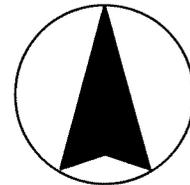
View 1  
Study Area

5 0 5 10 15 20 Kilometers

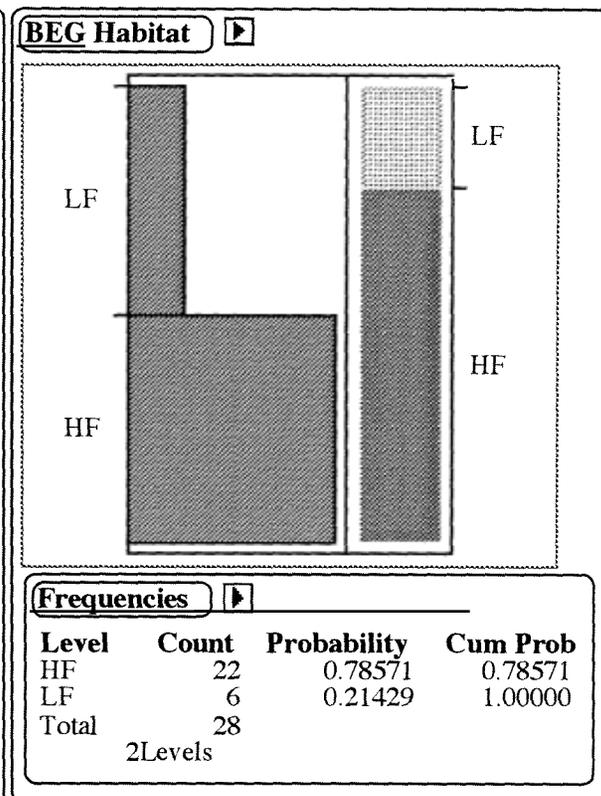
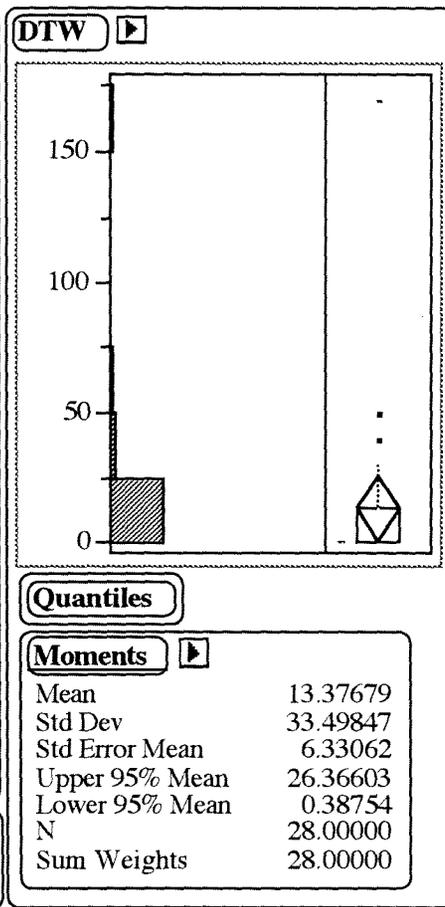
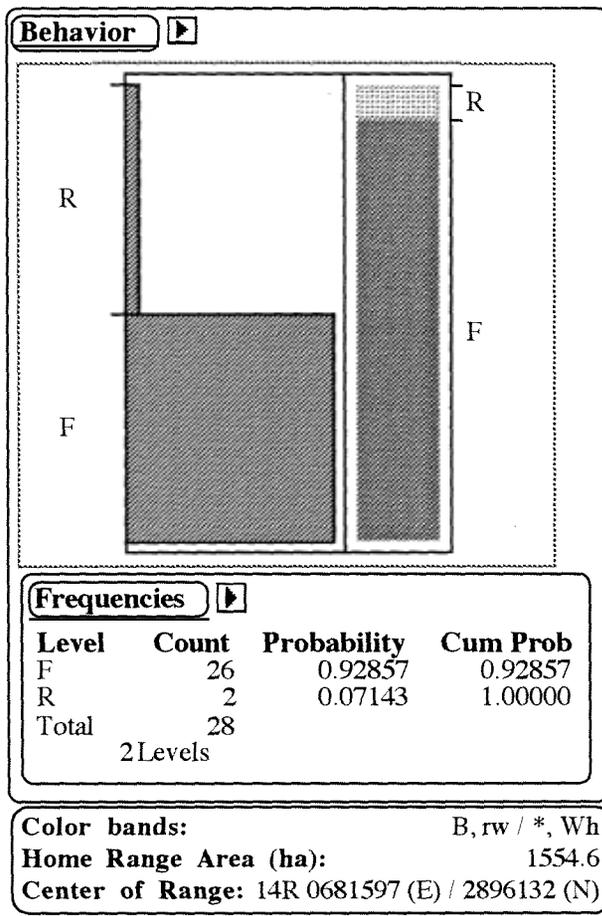


View 2  
Close-up of relocation  
cluster from View 1

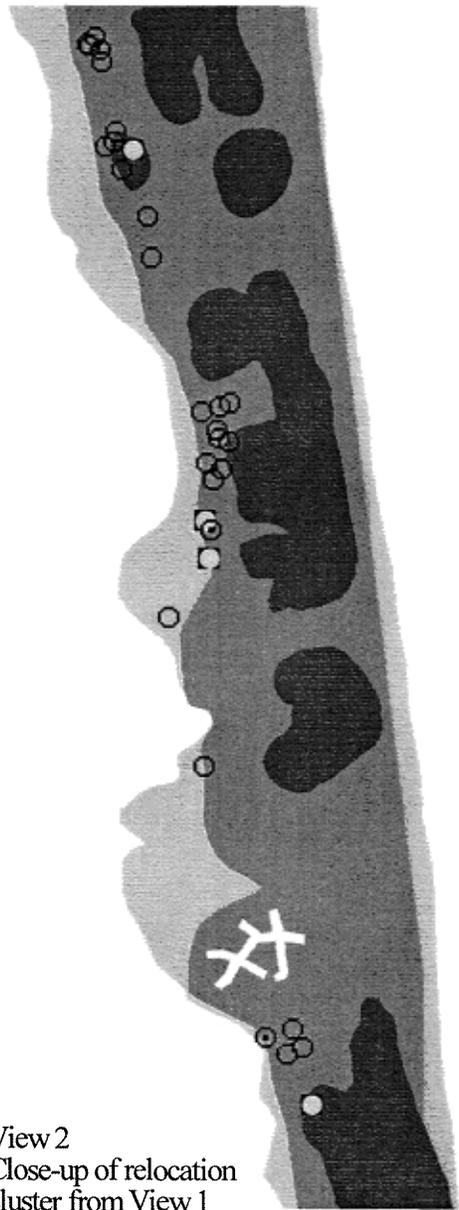
500 0 500 1000 1500 2000 Meters



## Radiofrequency 585 (PIPL)



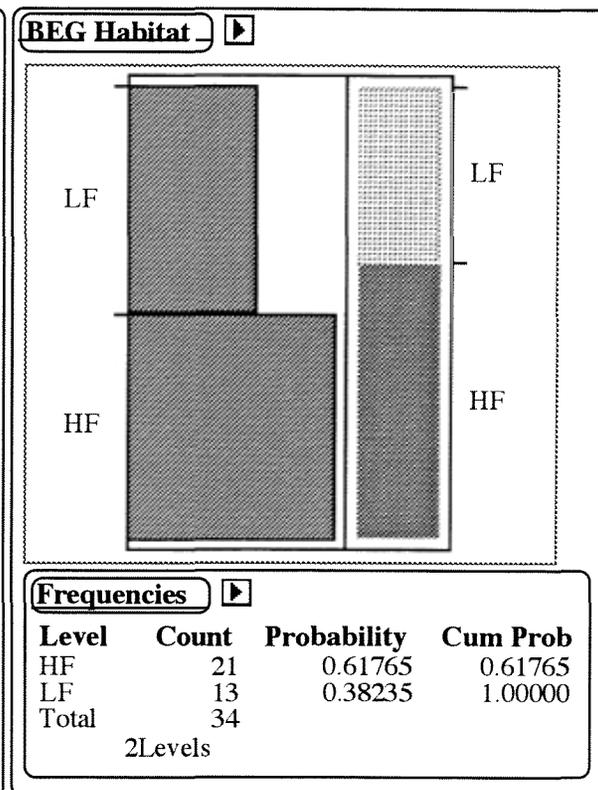
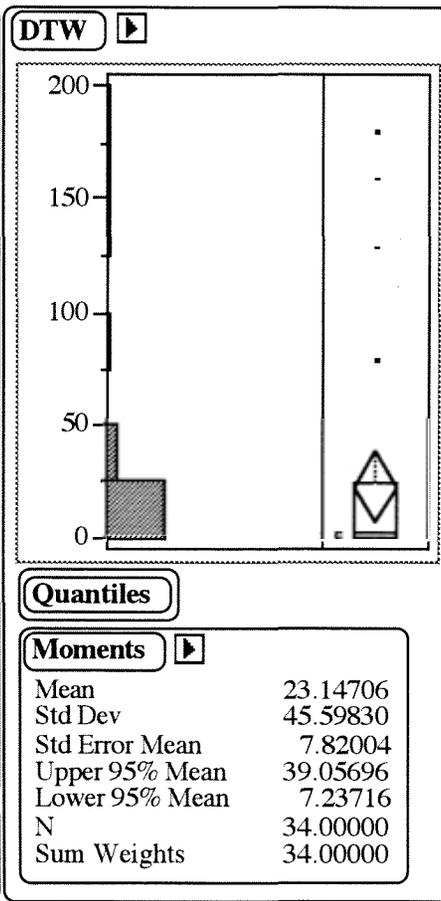
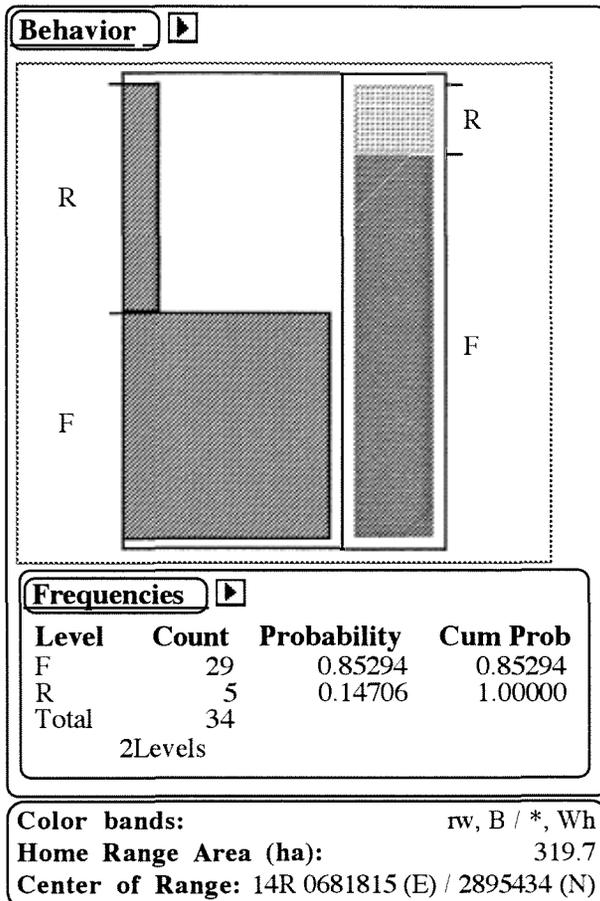
**Radiofrequency 601 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



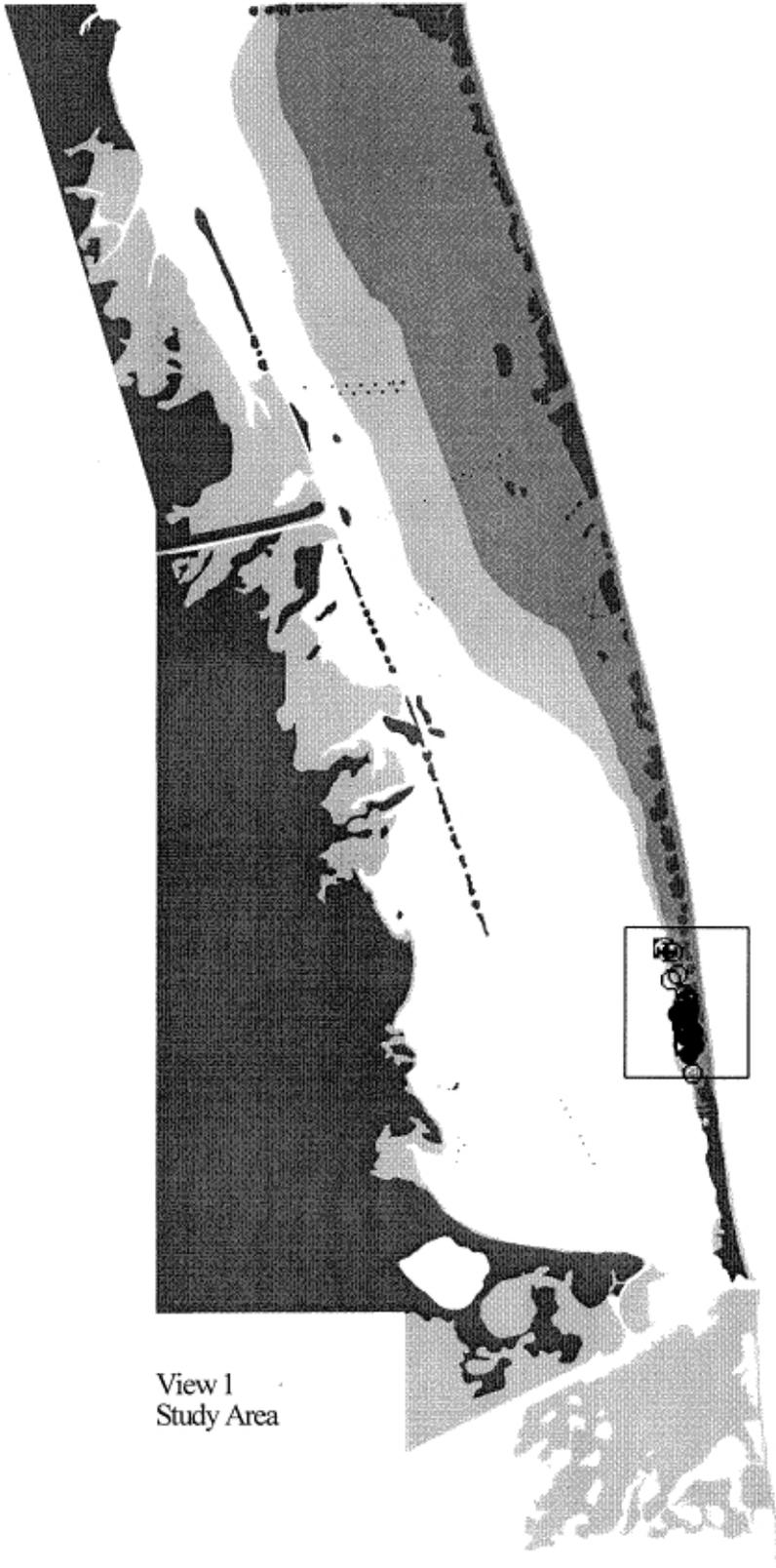
500 0 500 1000 1500 Meters

5 0 5 10 15 20 Kilometers

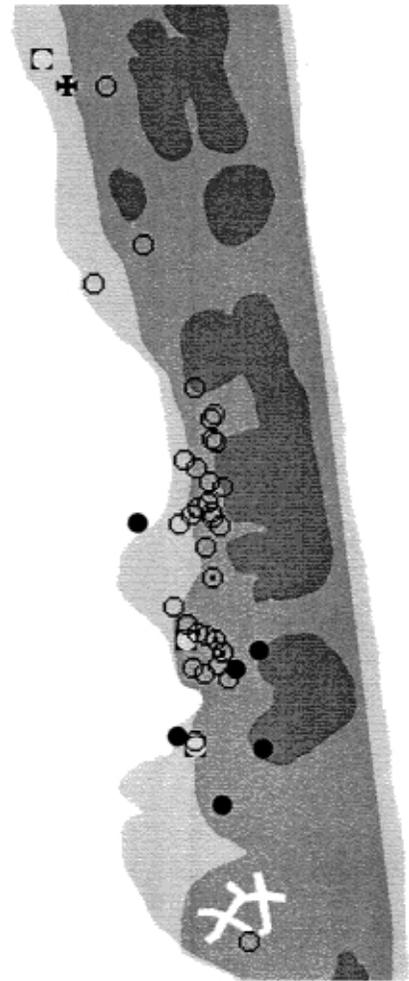
**Radiofrequency 601 (PIPL)**



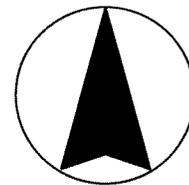
**Radiofrequency 612 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



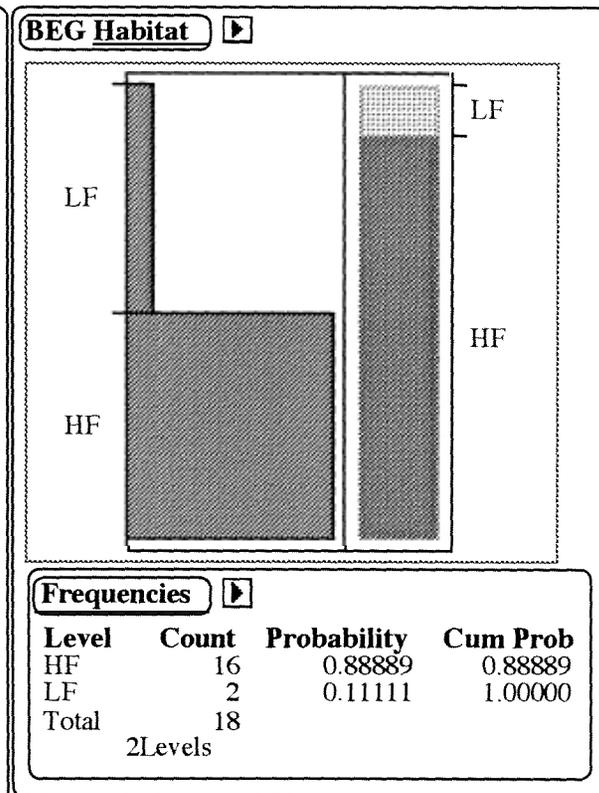
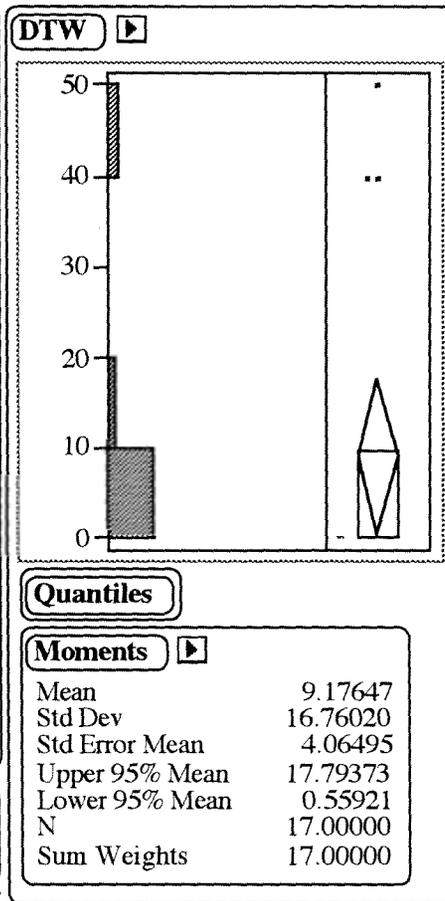
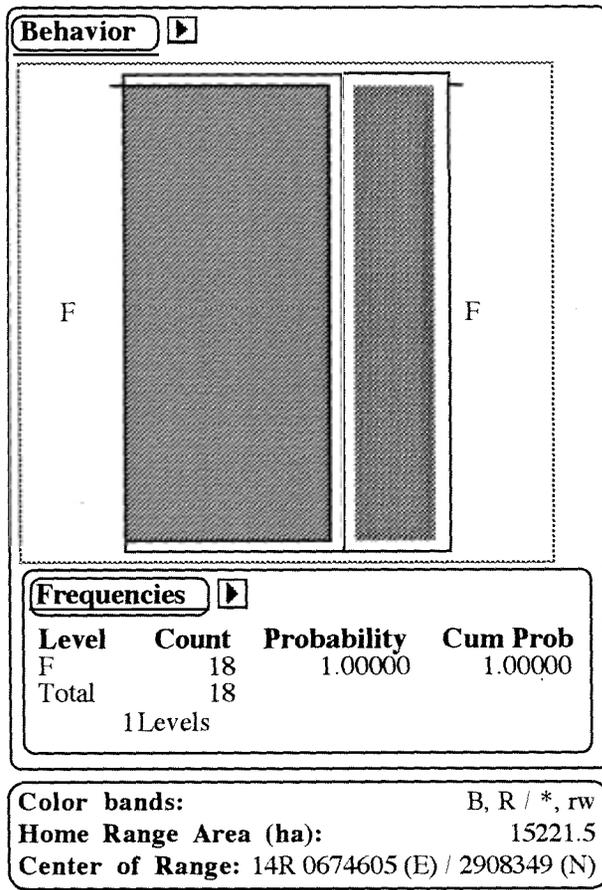
5 0 5 10 15 20 Kilometers



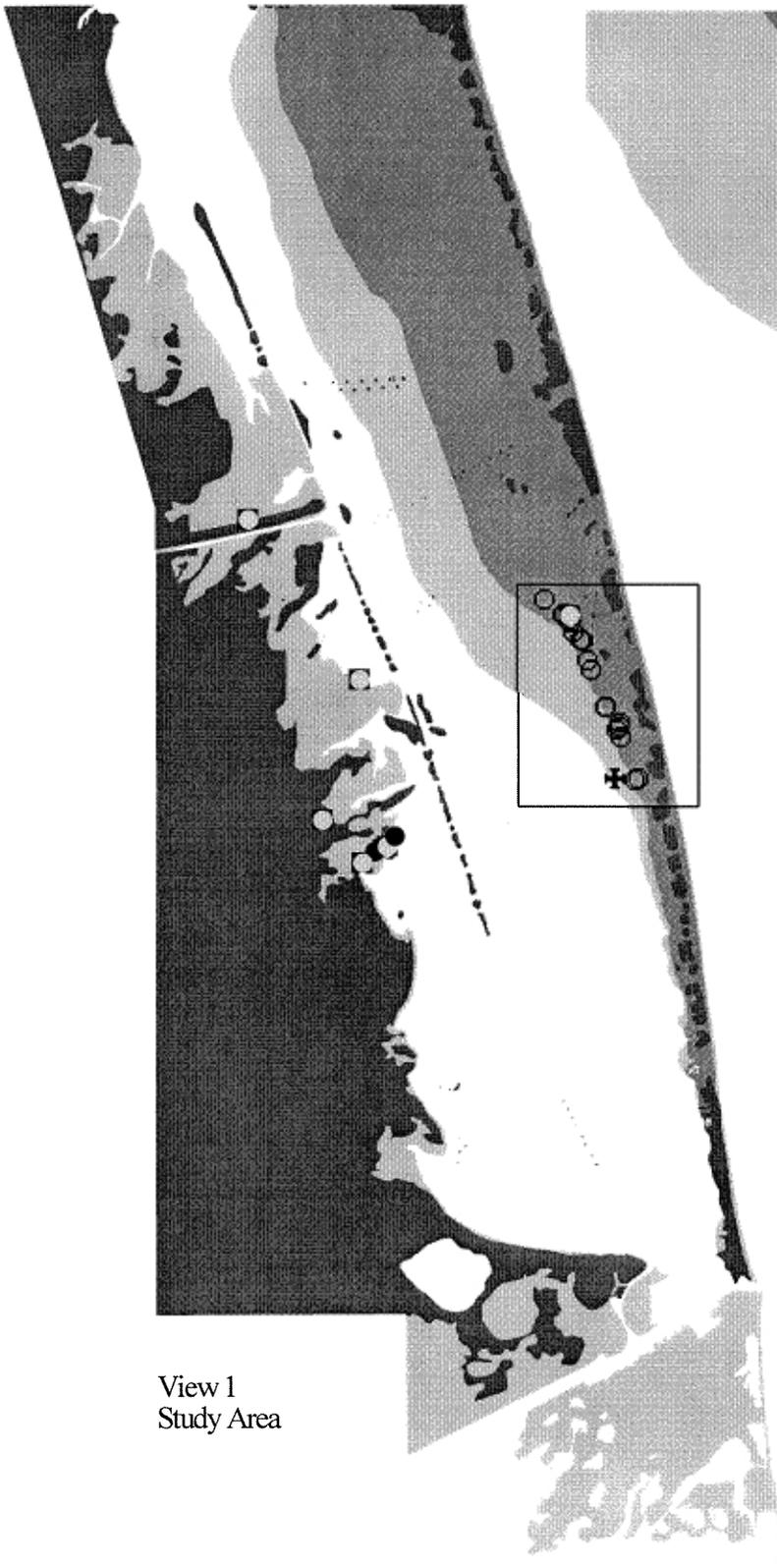
500 0 500 1000 1500 2000 2500 Meters



**Radiofrequency 612 (PIPL)**

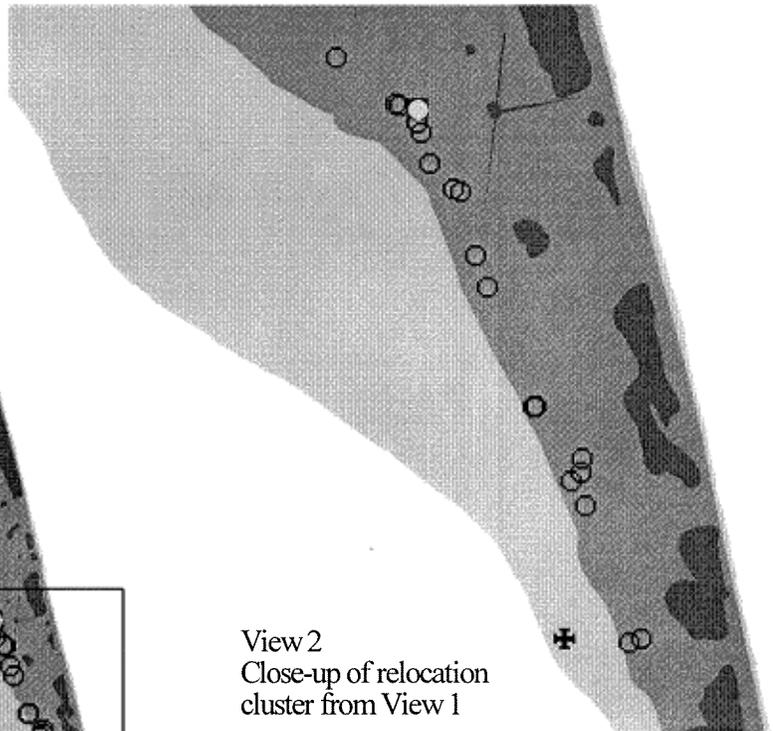


**Radiofrequency 621 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



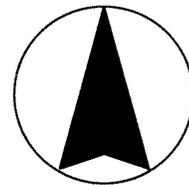
View 1  
Study Area

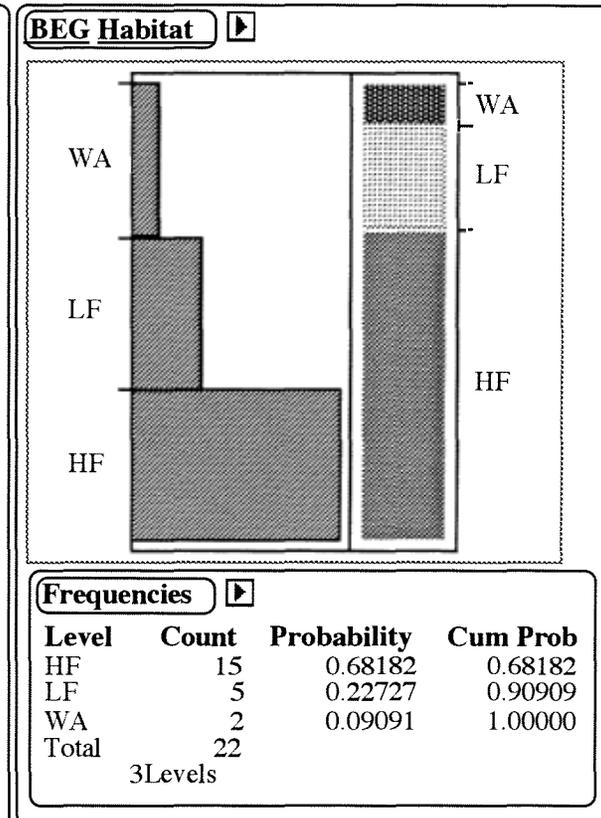
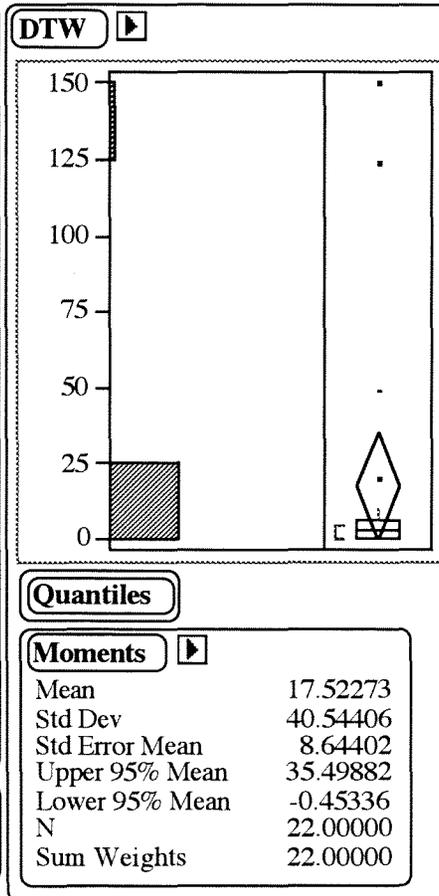
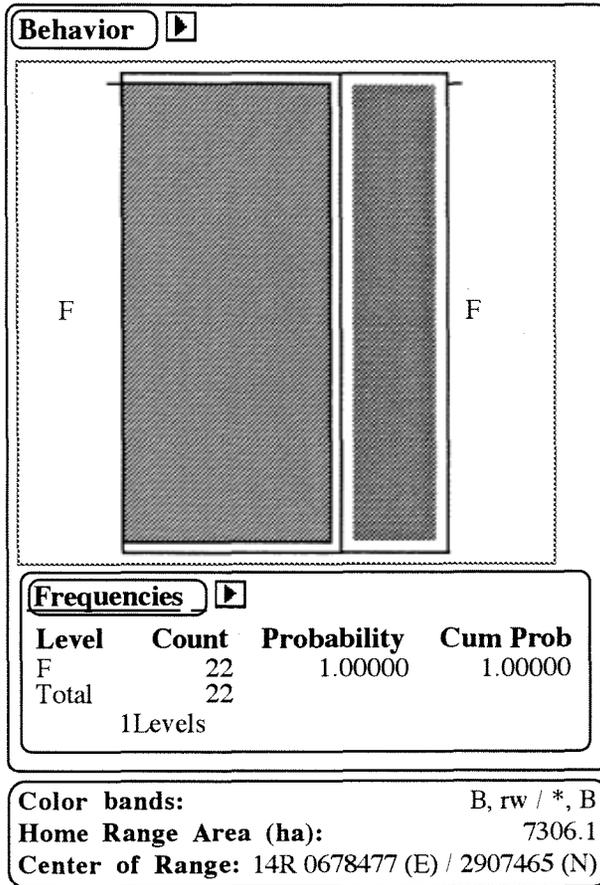
5 0 5 10 15 20 Kilometers



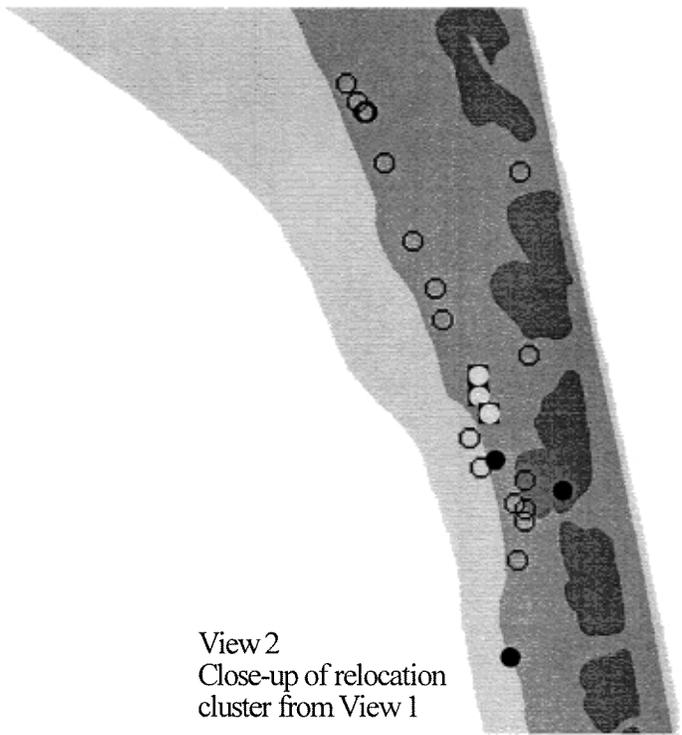
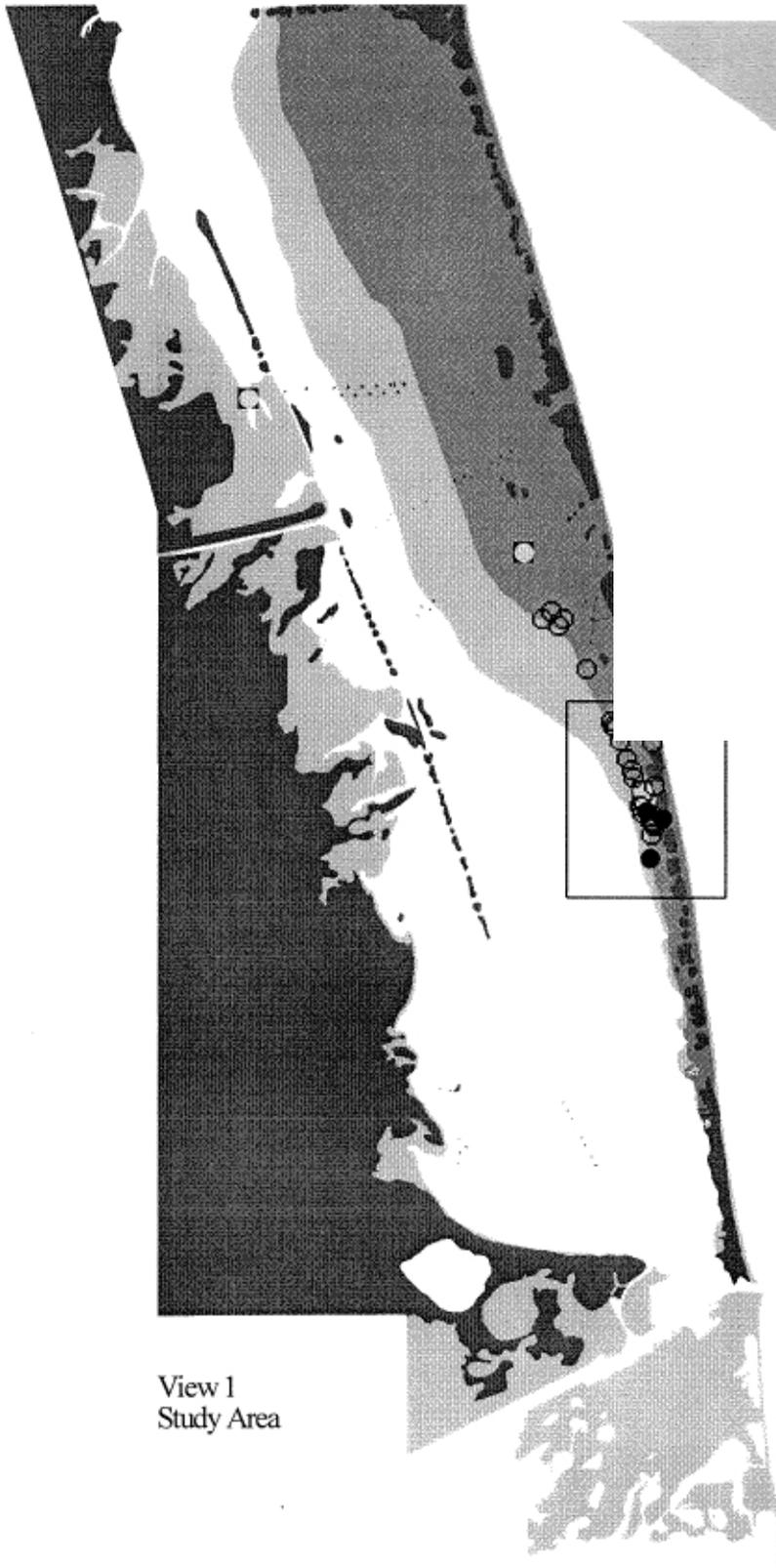
View 2  
Close-up of relocation  
cluster from View 1

1 0 1 2 Kilometers

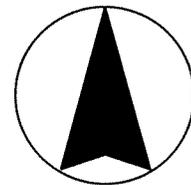




**Radiofrequency 642 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.

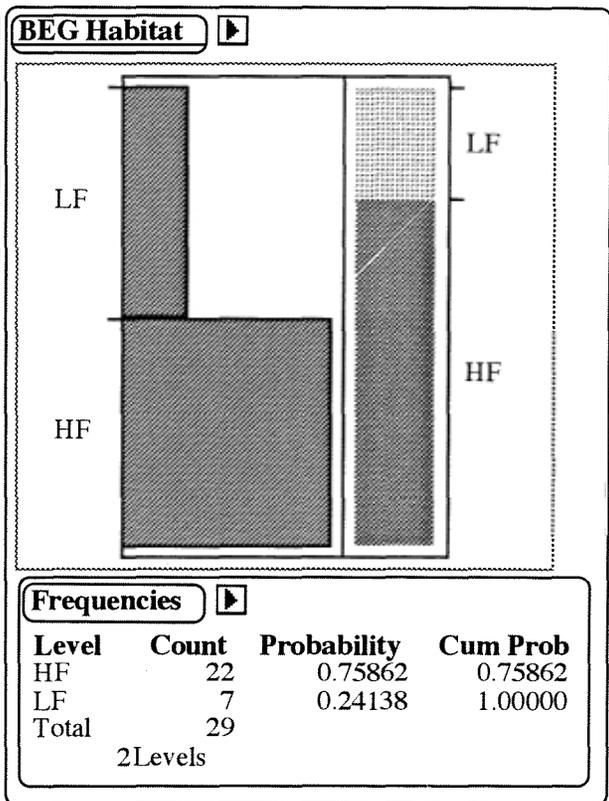
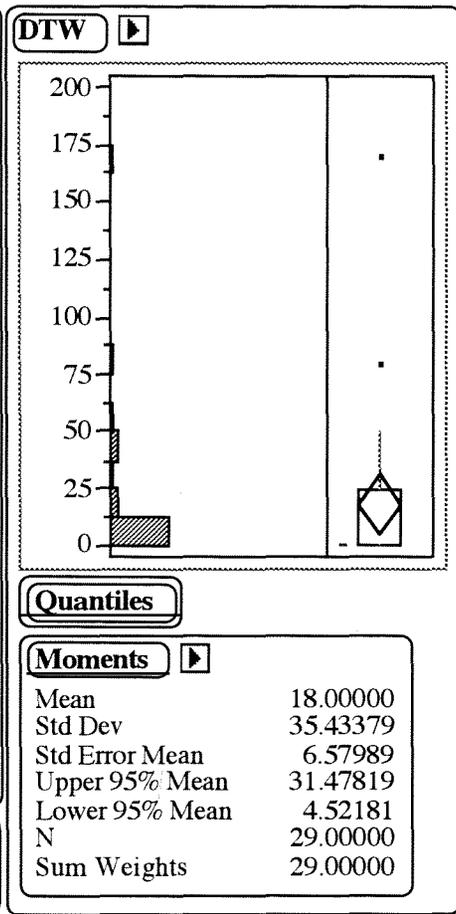
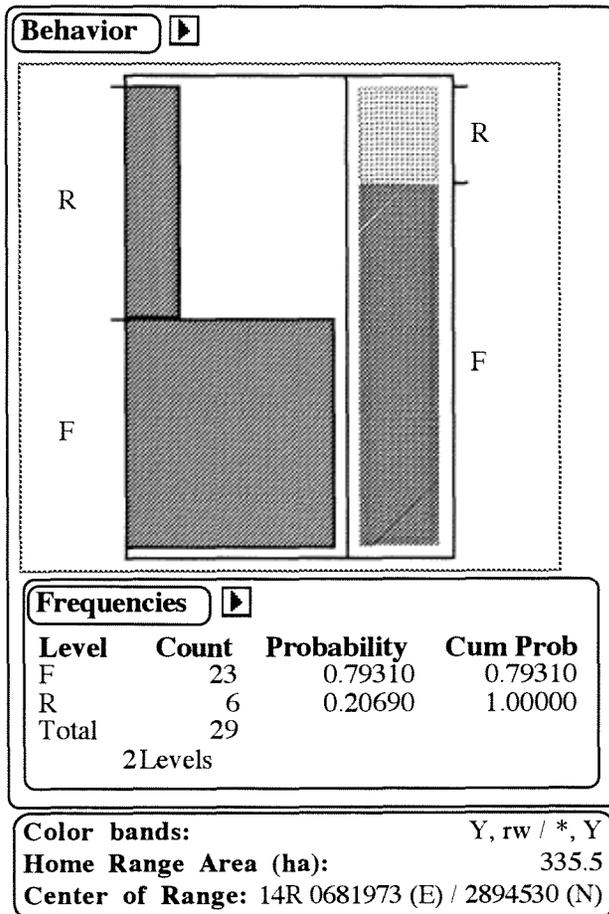


500 0 500 1000 1500 2000 Meters

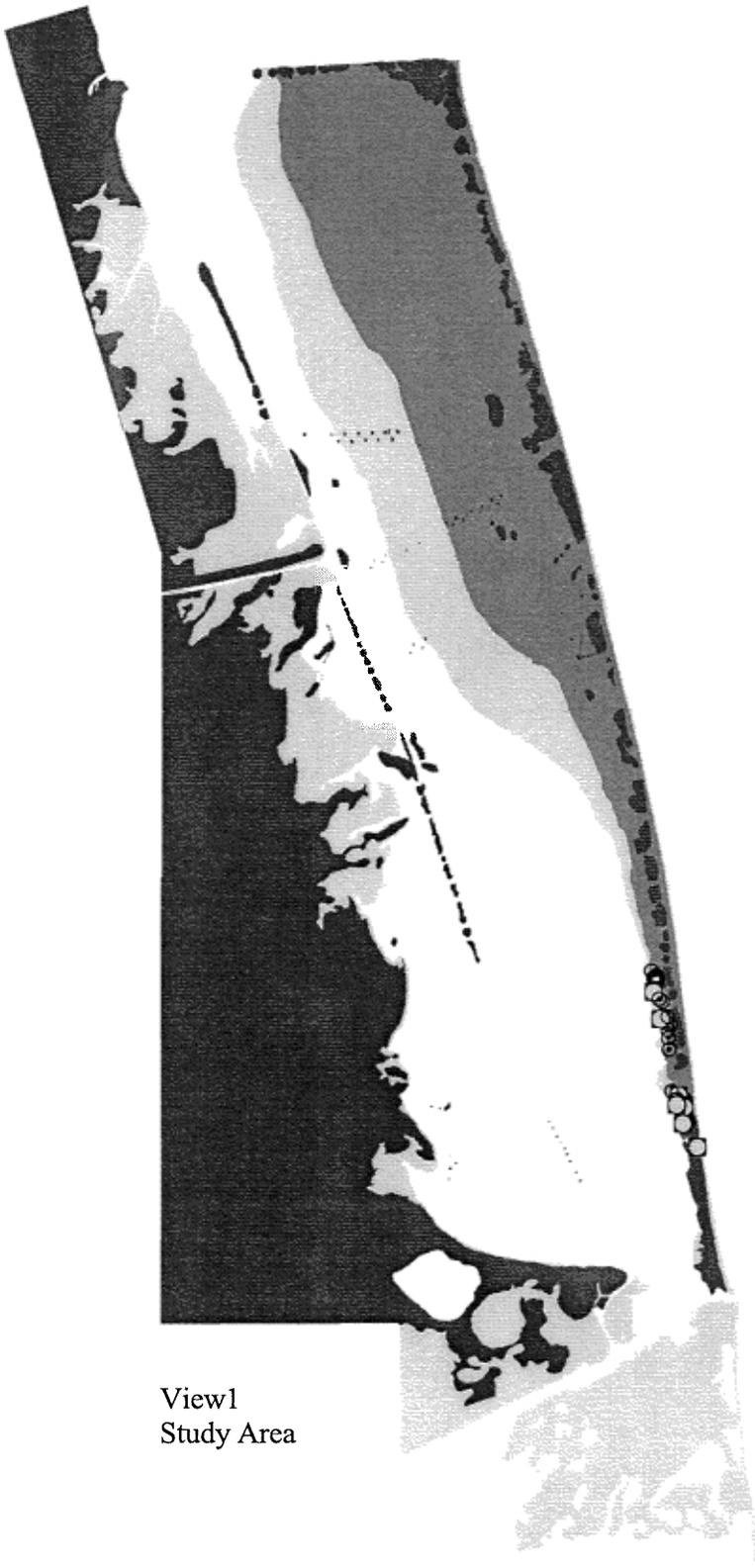


5 0 5 10 15 20 Kilometers

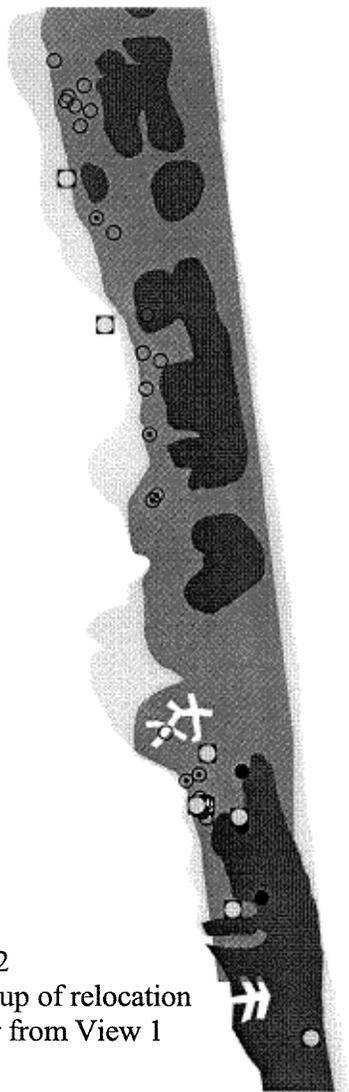
**Radiofrequency 642 (PIPL)**



**Radiofrequency 661a (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



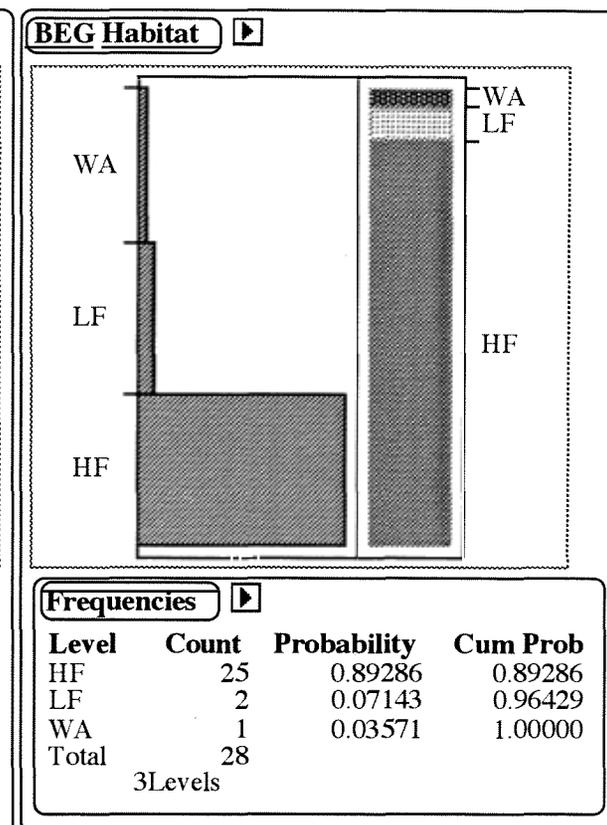
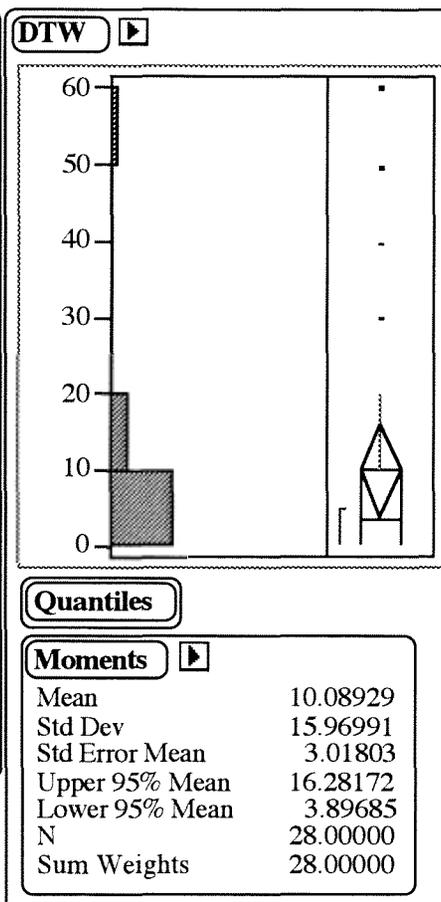
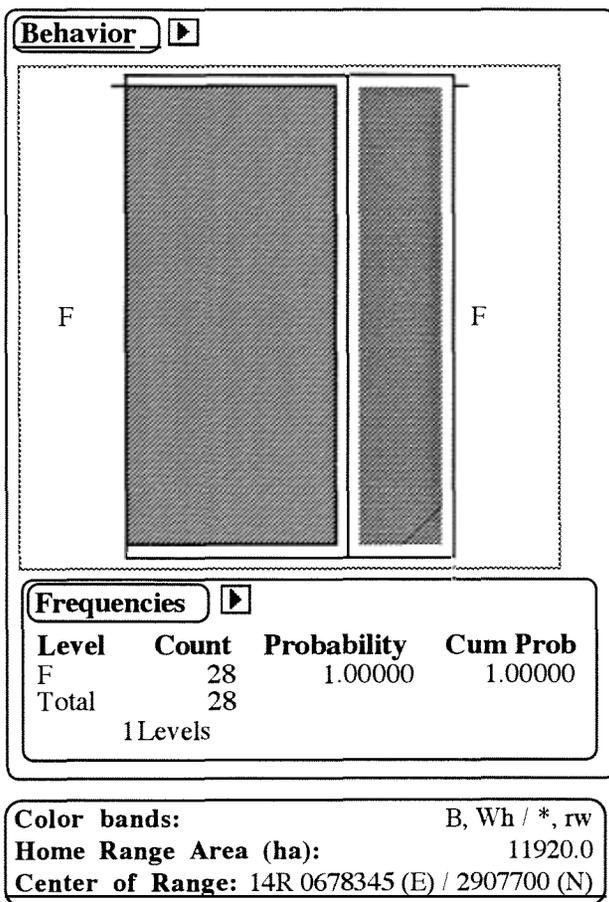
View1  
Study Area



View 2  
Close-up of relocation  
cluster from View 1



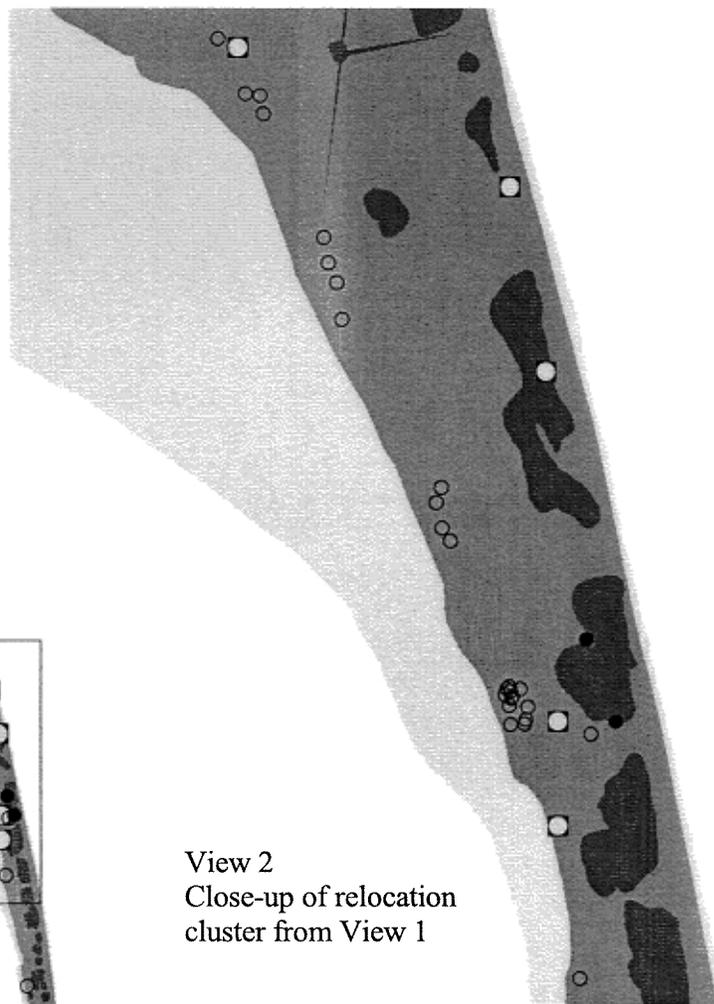
**Radiofrequency 661a (PIPL)**



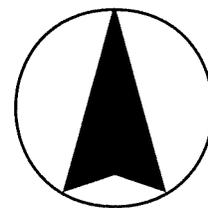
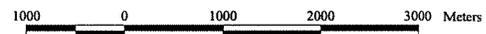
**Radiofrequency 661b (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



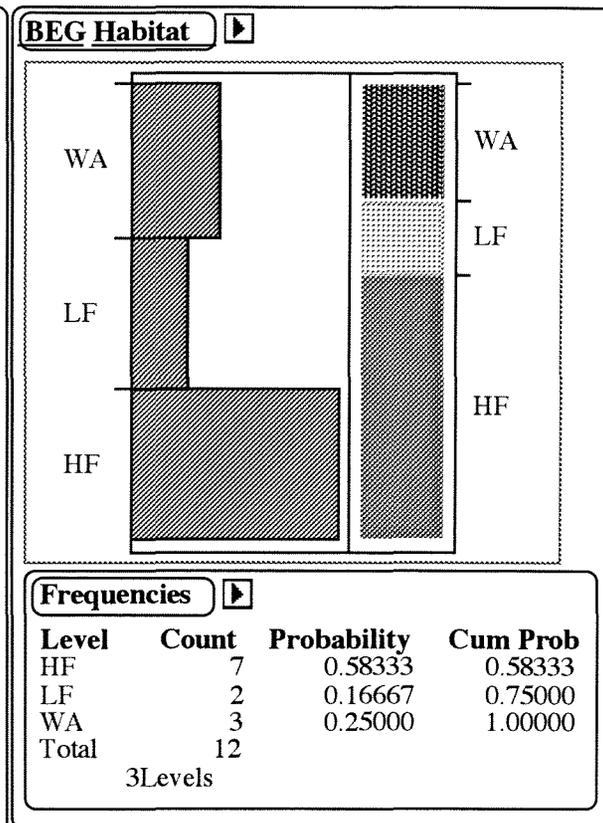
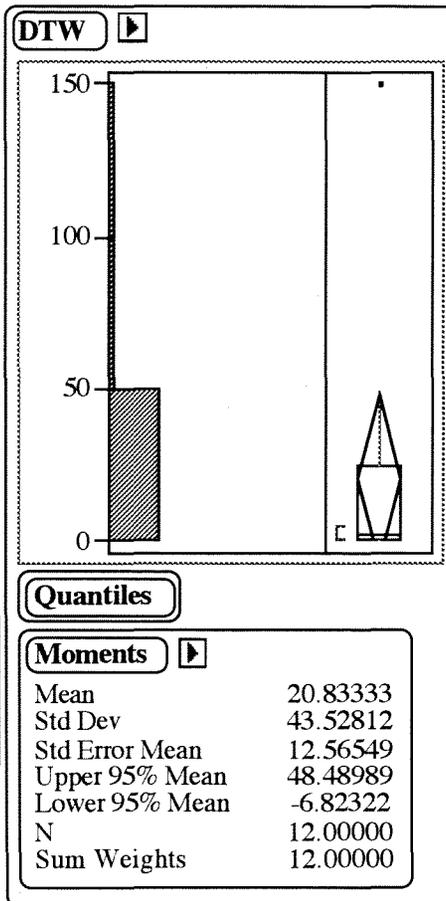
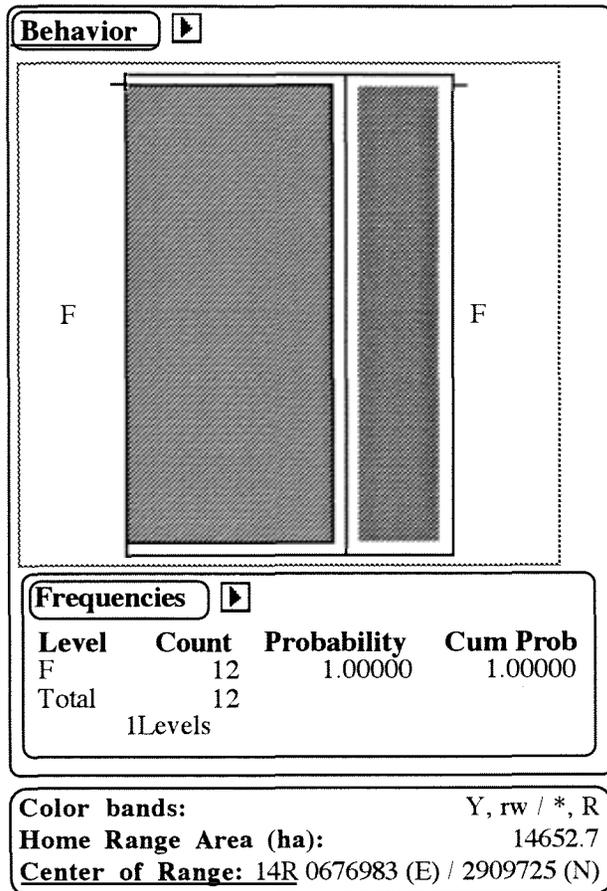
View 1  
Study Area



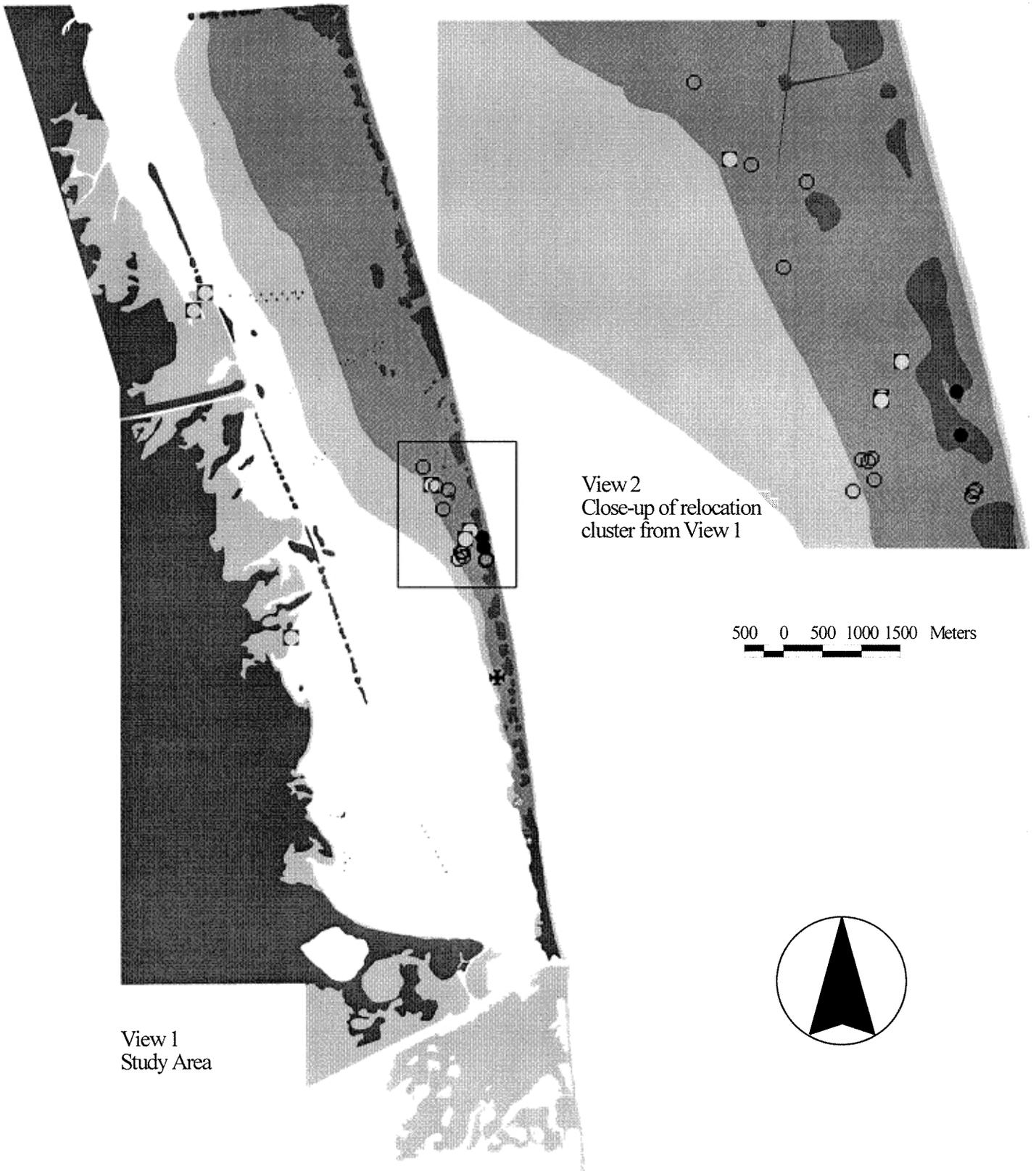
View 2  
Close-up of relocation  
cluster from View 1



**Radiofrequency 661b (PIPL)**



**Radiofrequency 682 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



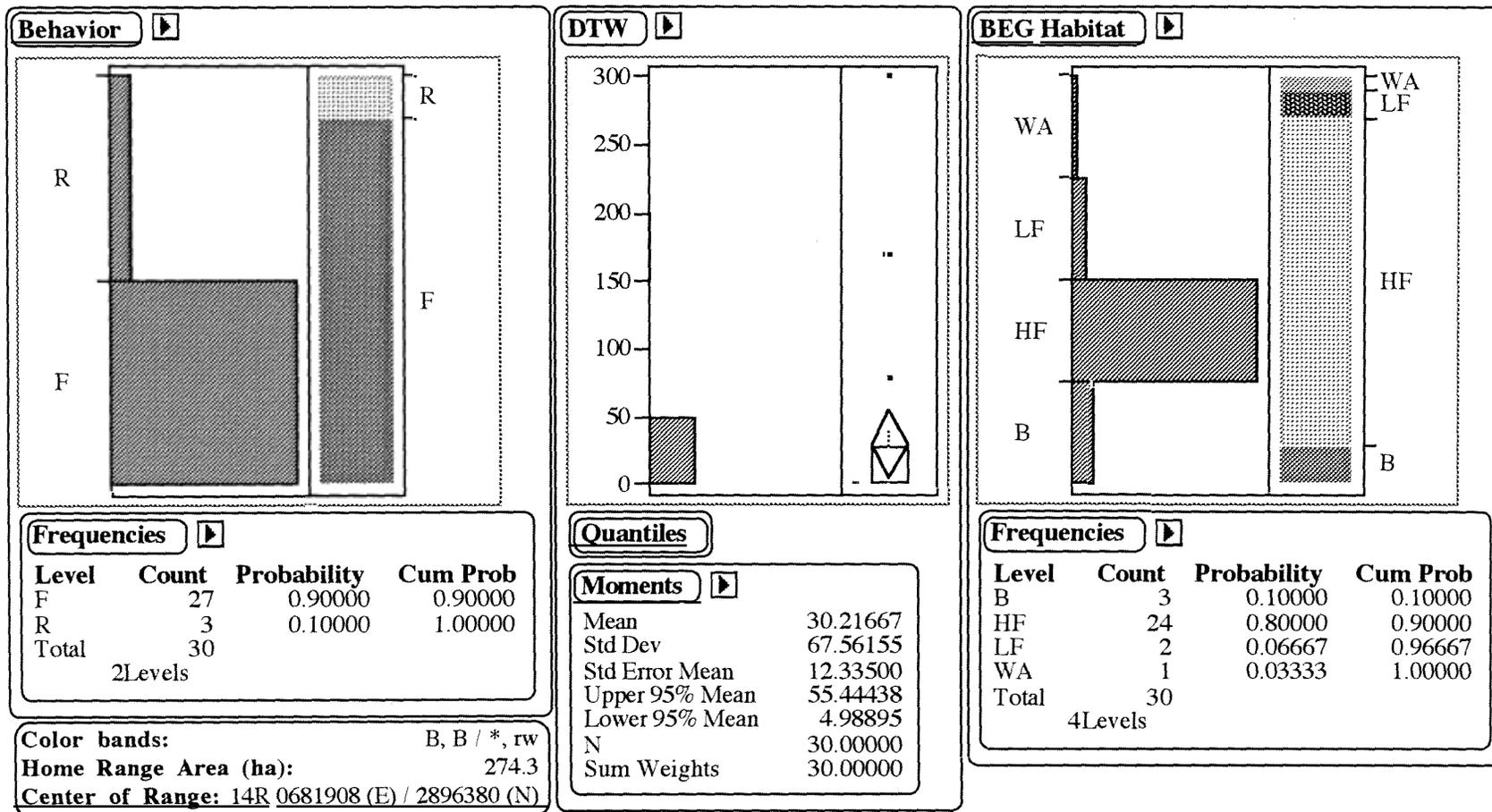
View 1  
Study Area

View 2  
Close-up of relocation  
cluster from View 1

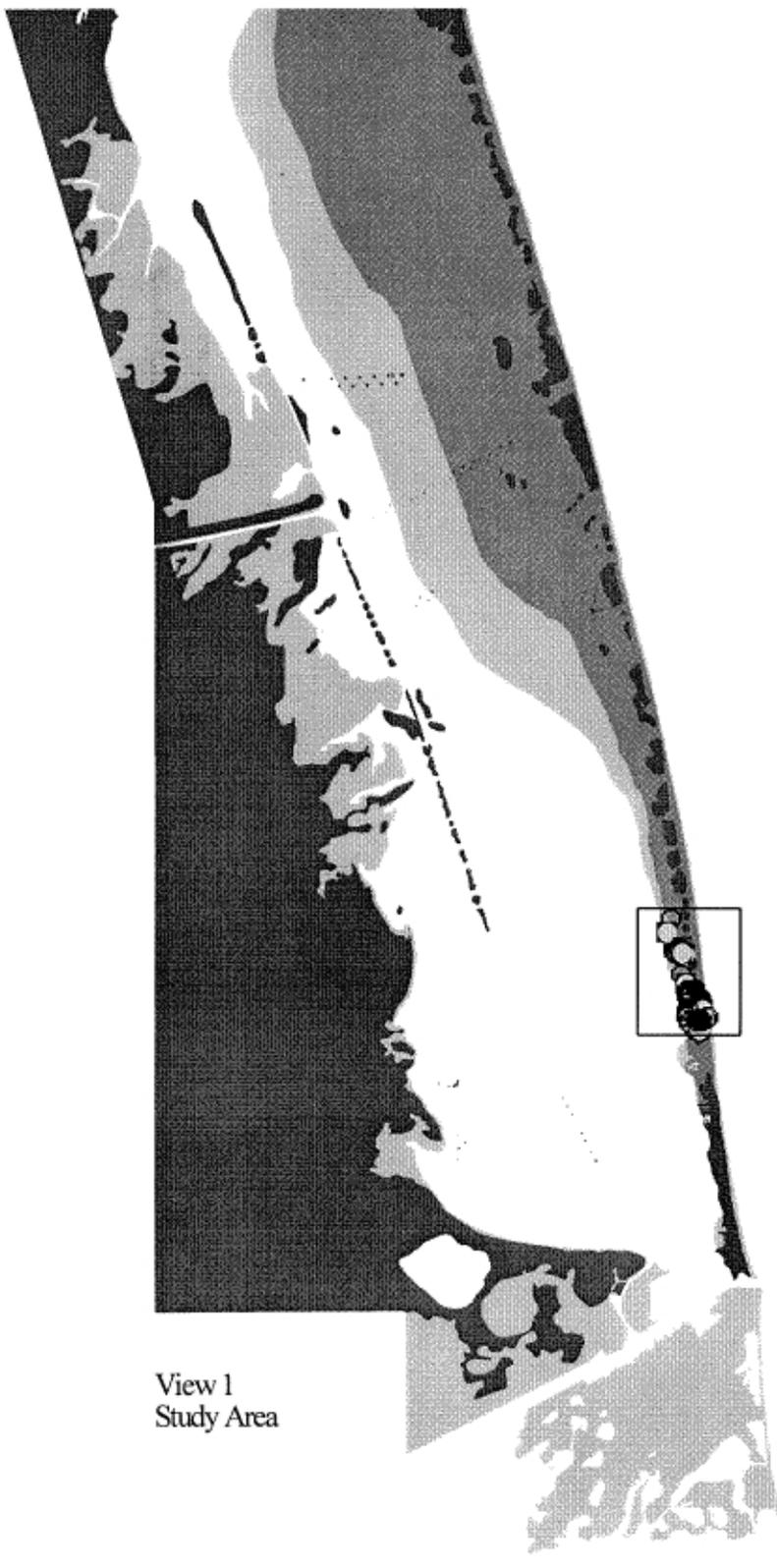
500 0 500 1000 1500 Meters

5 0 5 10 15 20 Kilometers

**Radiofrequency 682 (PIPL)**

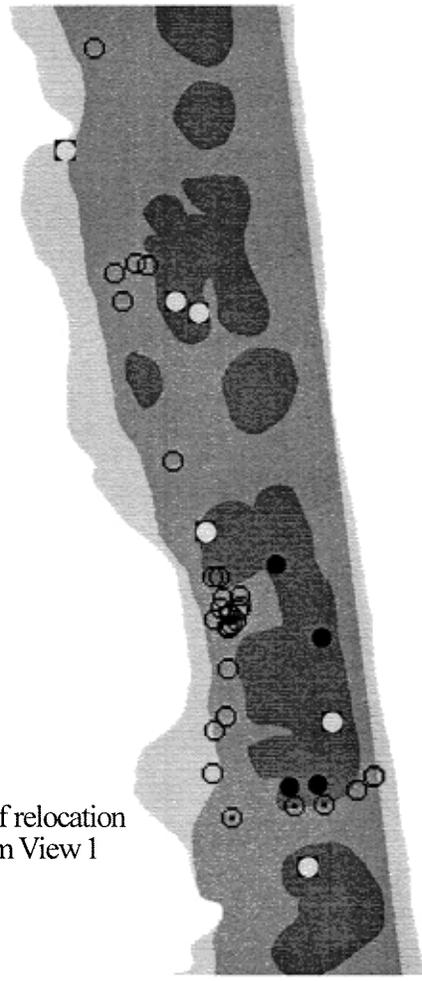


**Radiofrequency 701 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



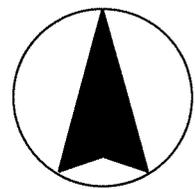
View 1  
Study Area

5 0 5 10 15 20 Kilometers

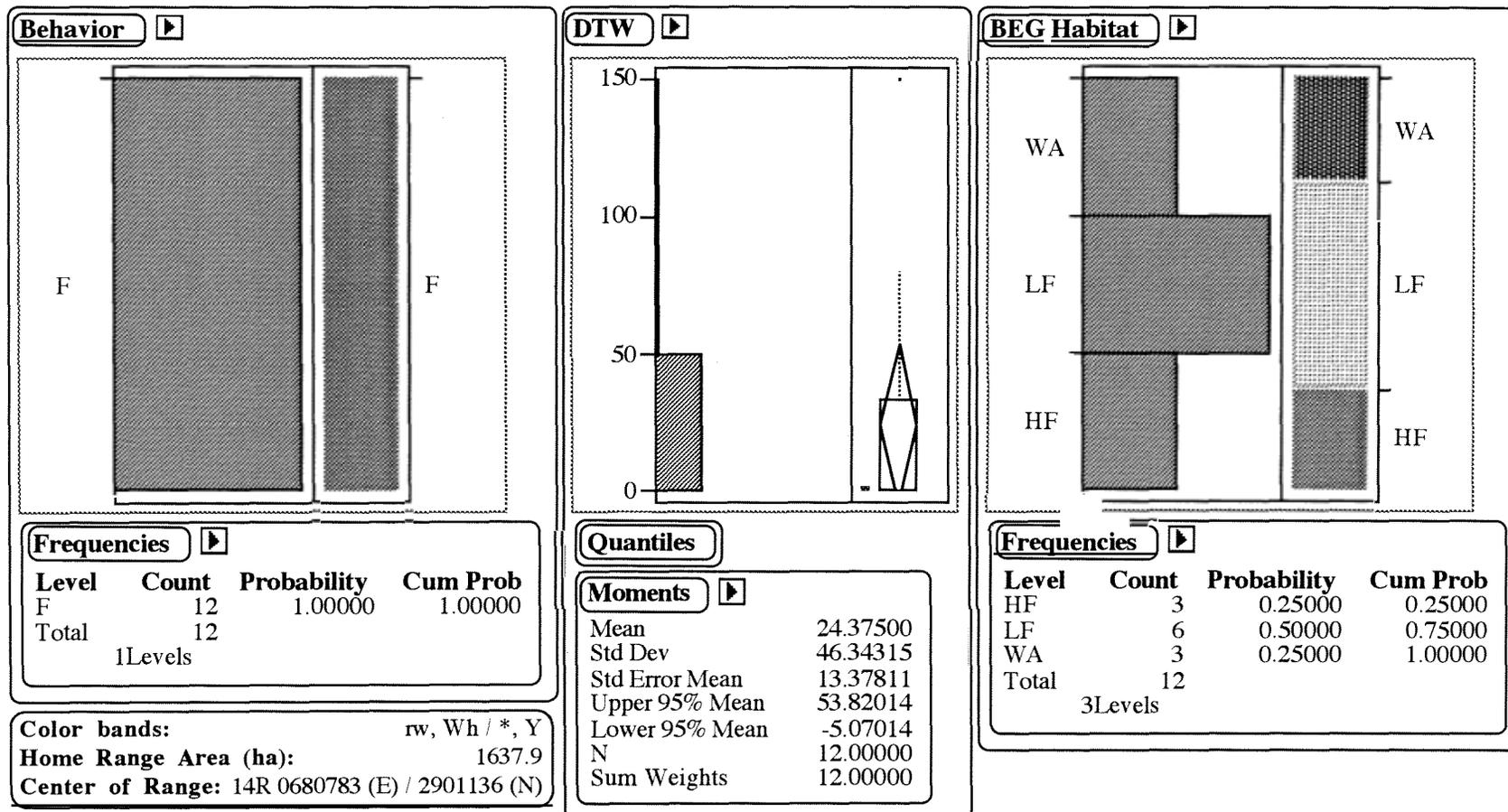


View 2  
Close-up of relocation  
cluster from View 1

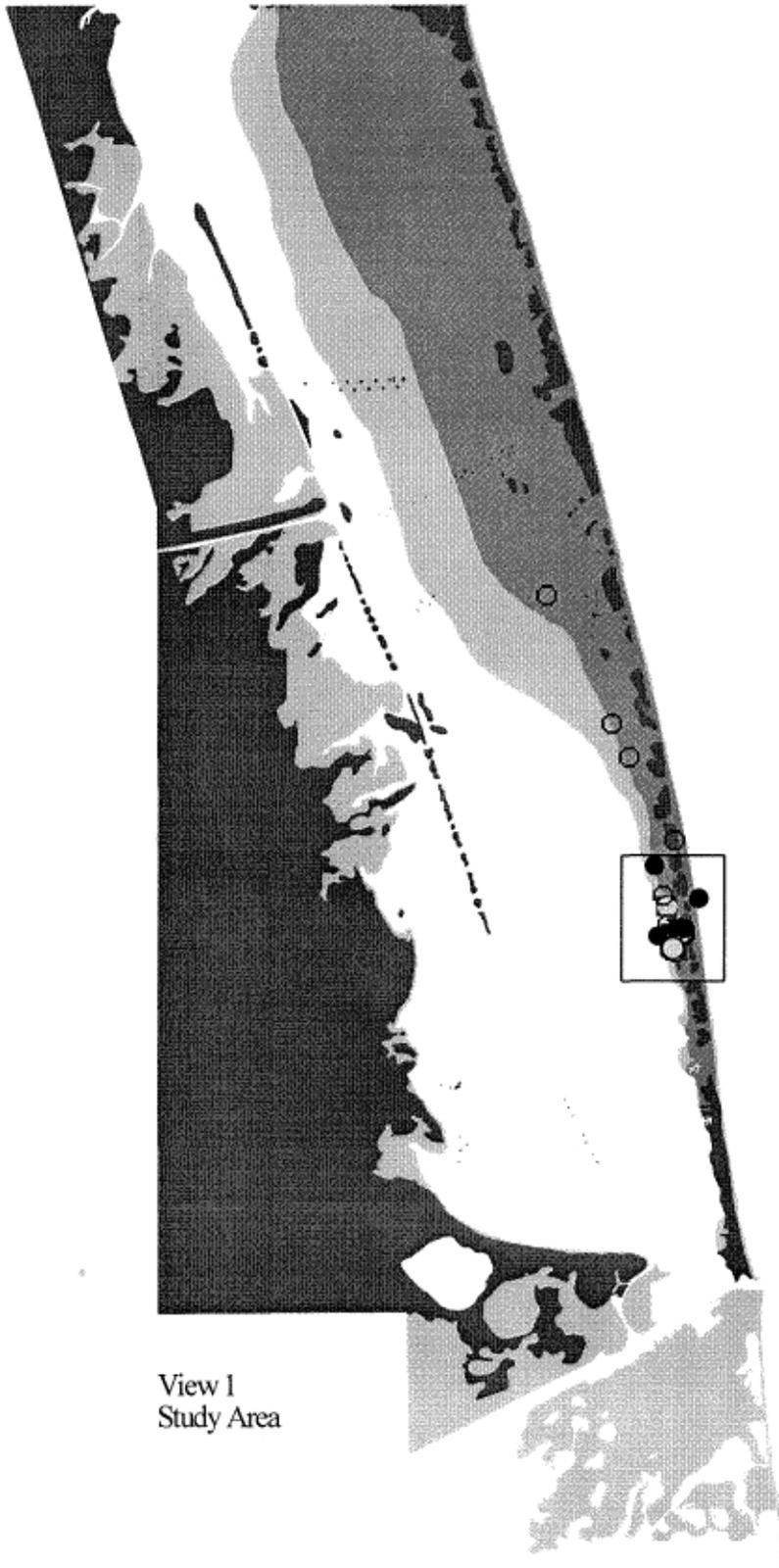
500 0 500 1000 Meters



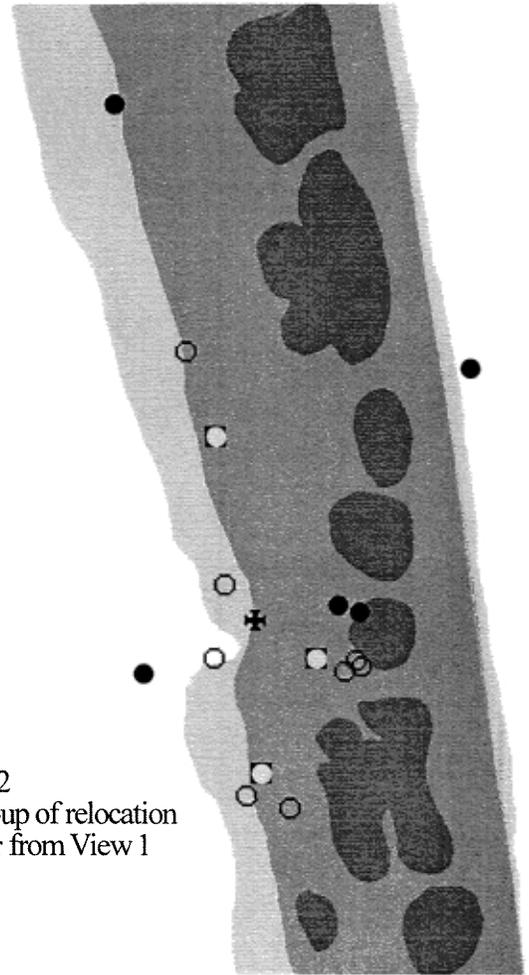
# Radiofrequencies 701



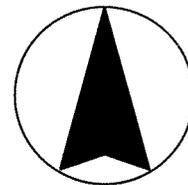
**Radiofrequency 714 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



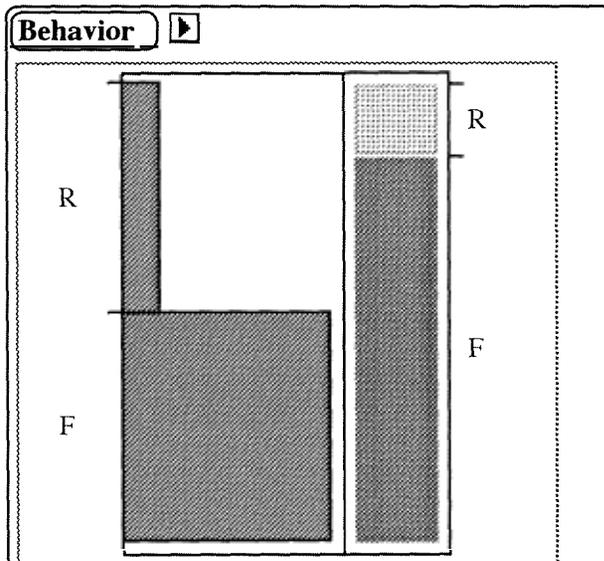
5 0 5 10 15 20 Kilometers



500 0 500 1000 Meters



## Radiofrequencies 714

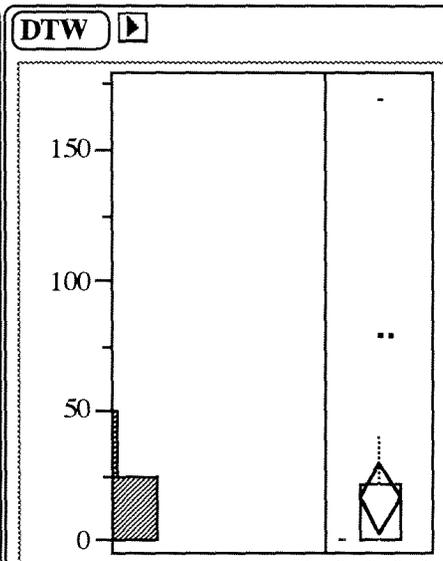


**Frequencies** ▾

Level	Count	Probability	Cum Prob
F	27	0.84375	0.84375
R	5	0.15625	1.00000
Total	32		

2Levels

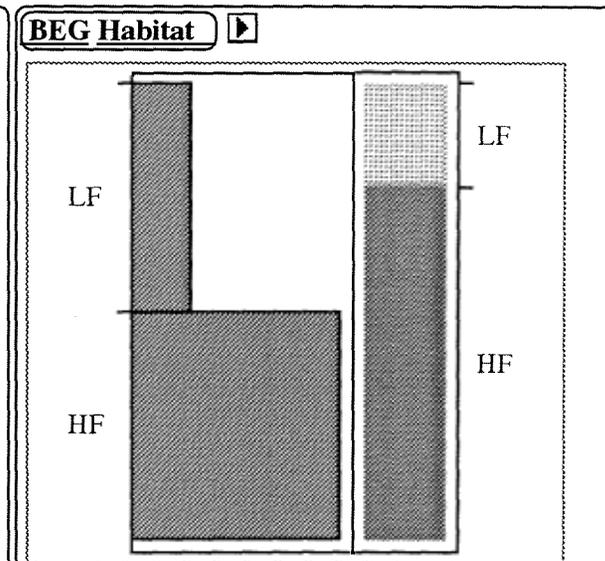
**Color bands:**  
**Home Range Area (ha):** 1461.3  
**Center of Range:** 14R 0681844 (E) / 2895290 (N)



**Quantiles**

**Moments** ▾

Mean	17.11667
Std Dev	36.44355
Std Error Mean	6.65365
Upper 95% Mean	30.72481
Lower 95% Mean	3.50852
N	30.00000
Sum Weights	30.00000

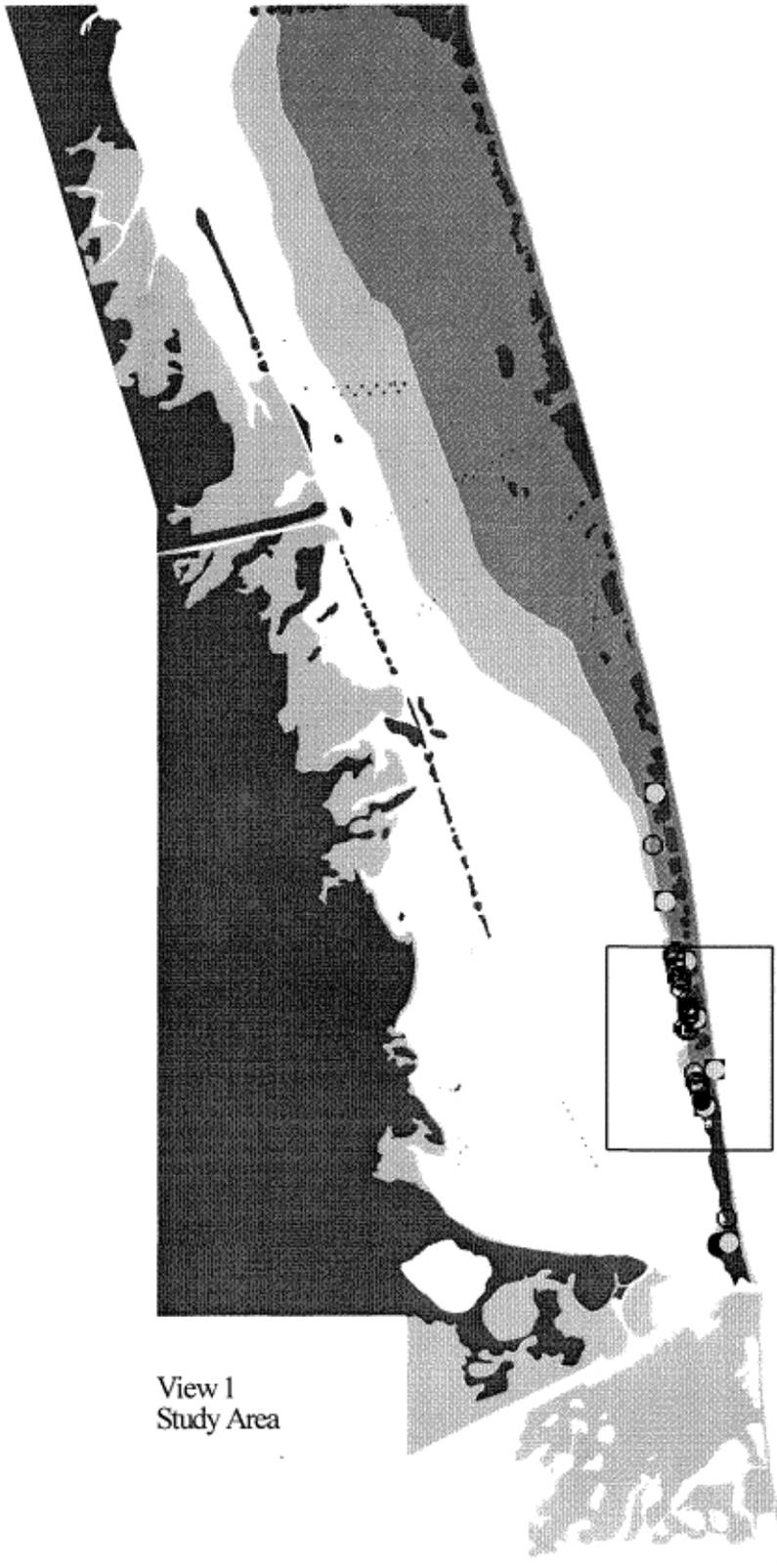


**Frequencies** ▾

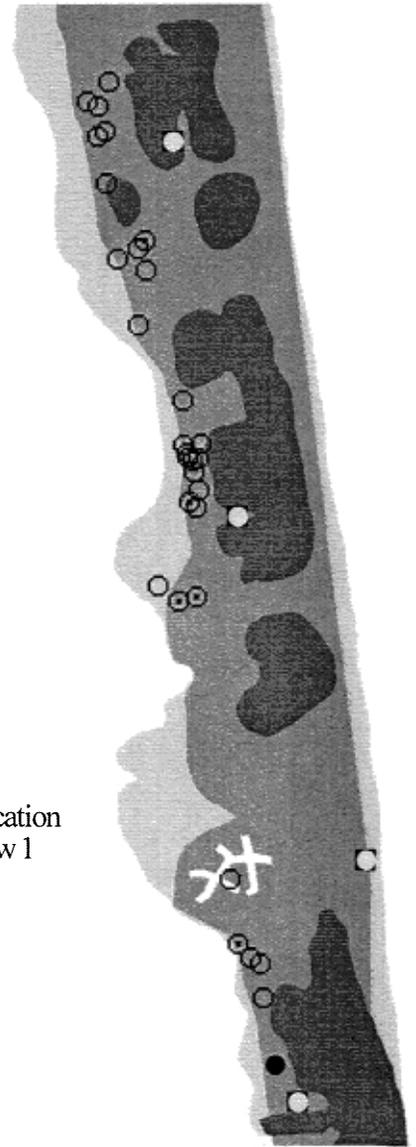
Level	Count	Probability	Cum Prob
HF	25	0.78125	0.78125
LF	7	0.21875	1.00000
Total	32		

2Levels

**Radiofrequency 720 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



View 2  
Close-up of relocation  
cluster from View 1



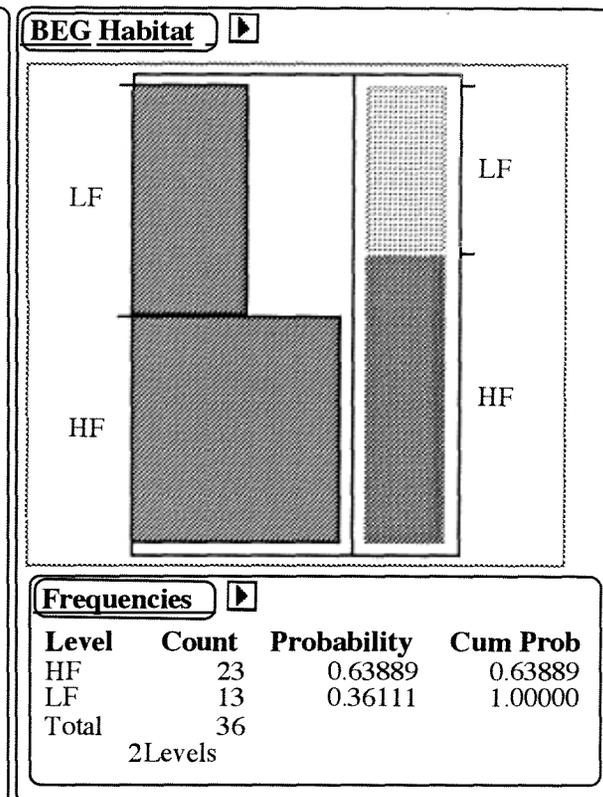
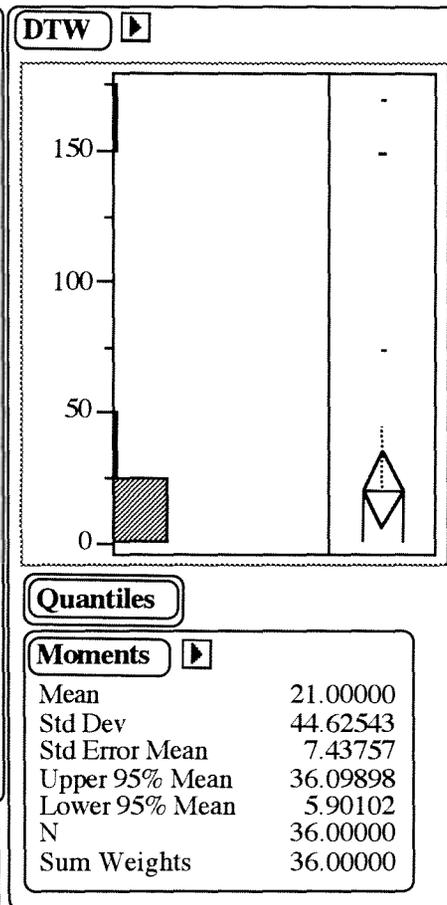
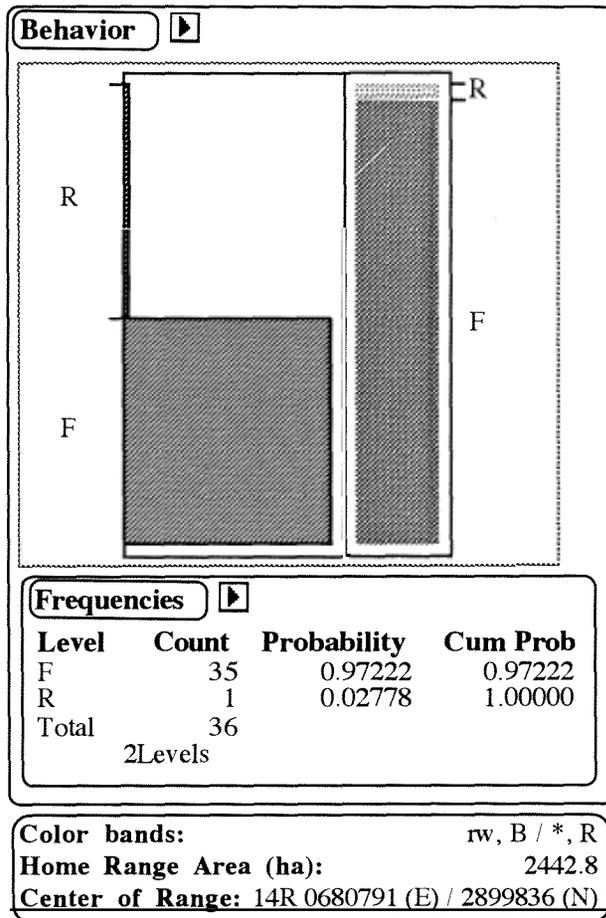
500 0 500 1000 1500 Meters



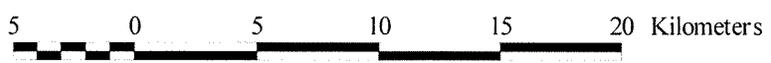
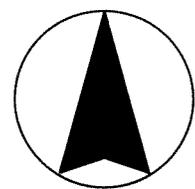
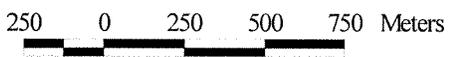
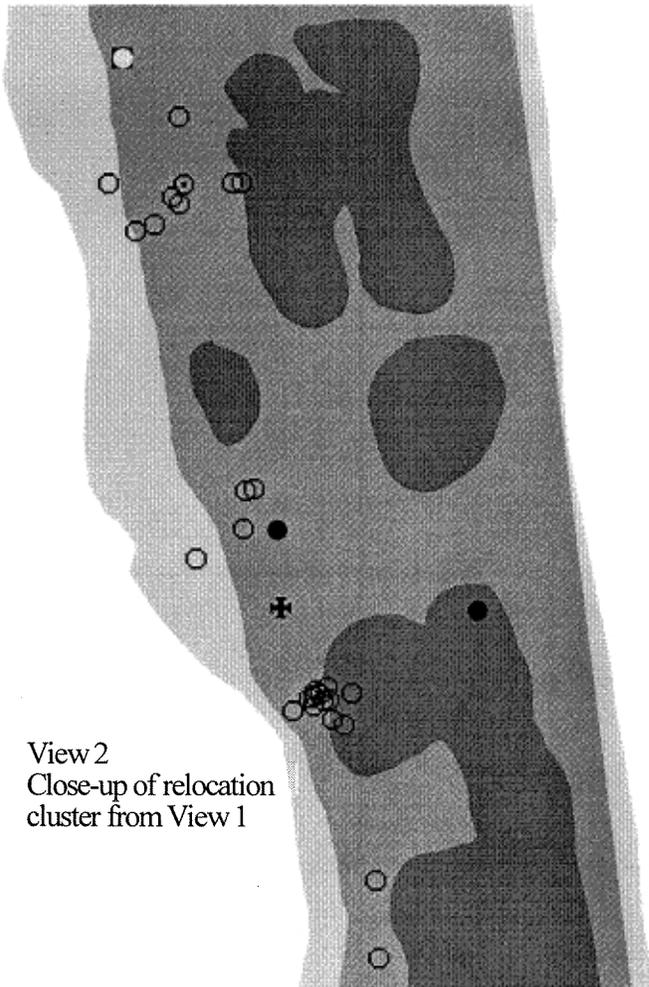
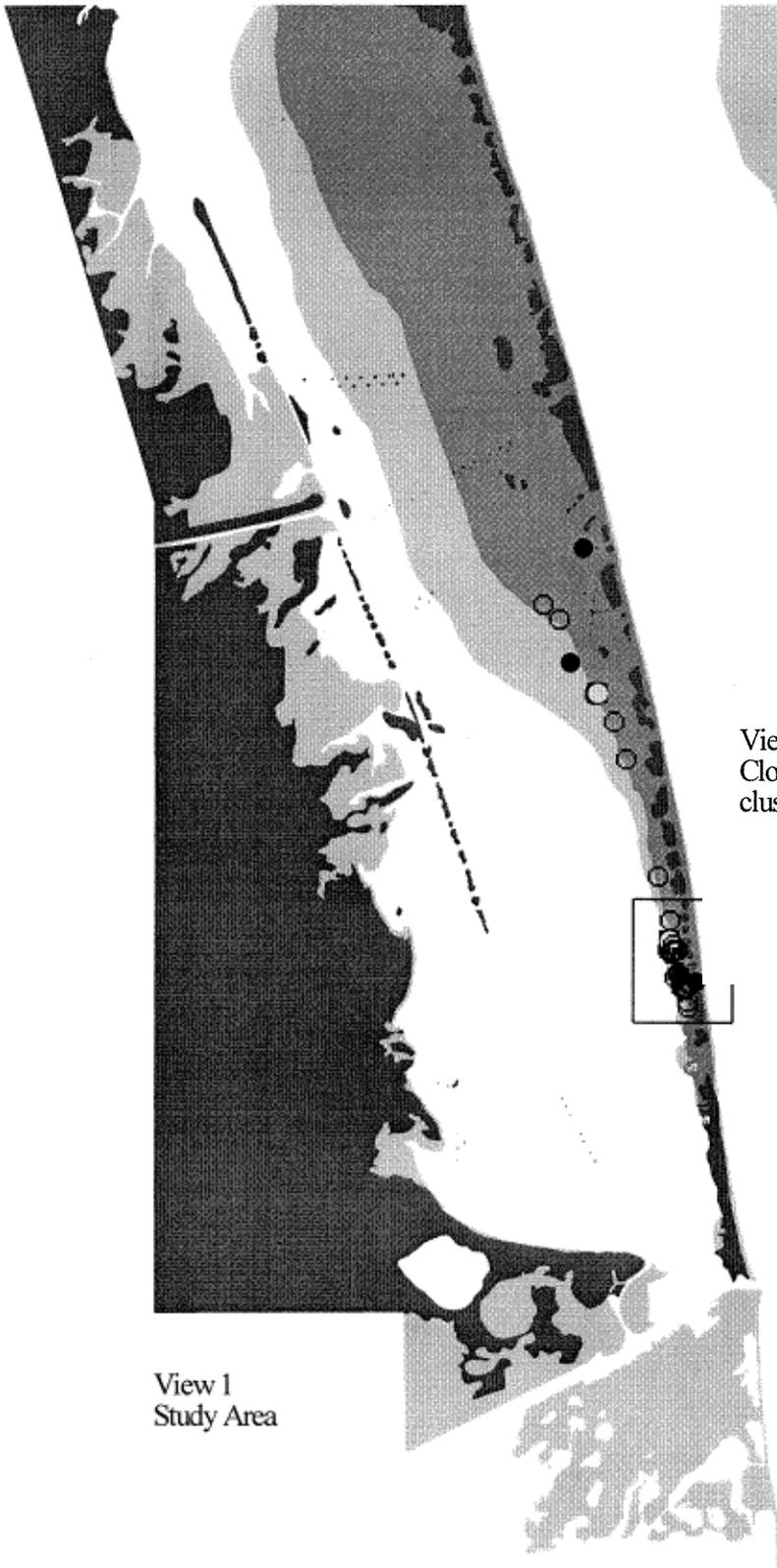
5 0 5 10 15 20 Kilometers



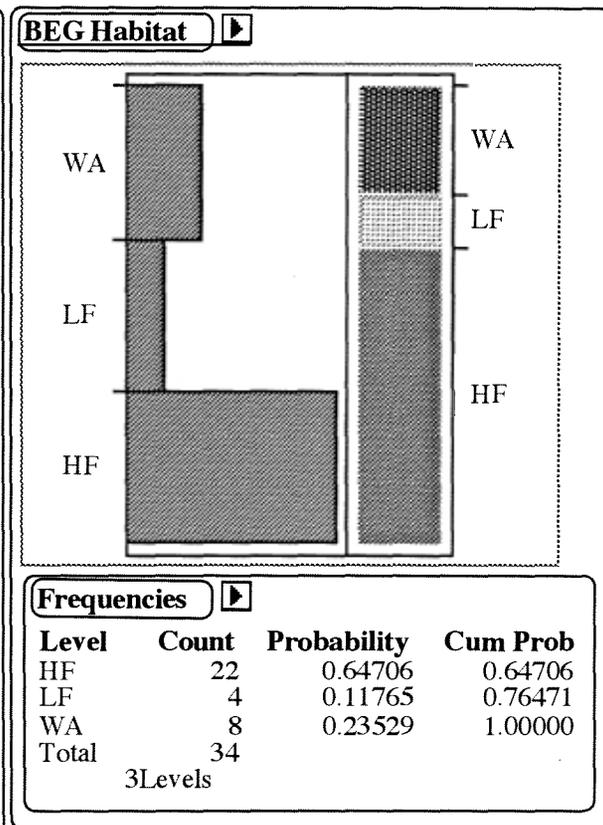
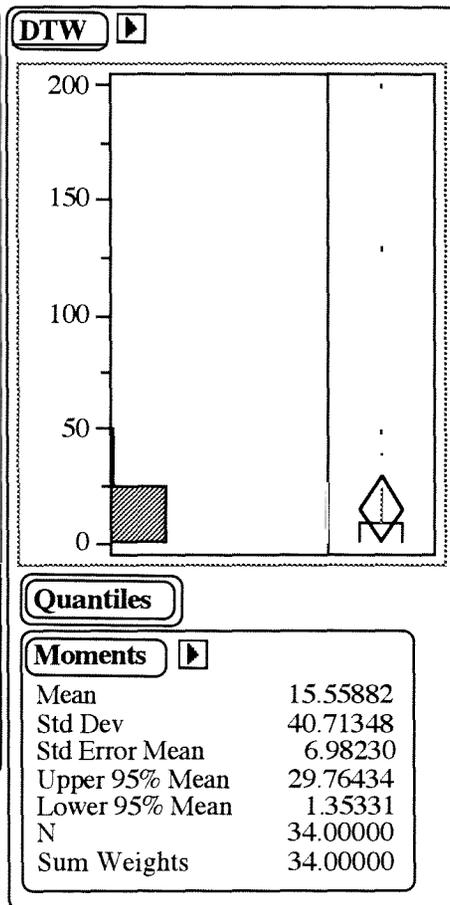
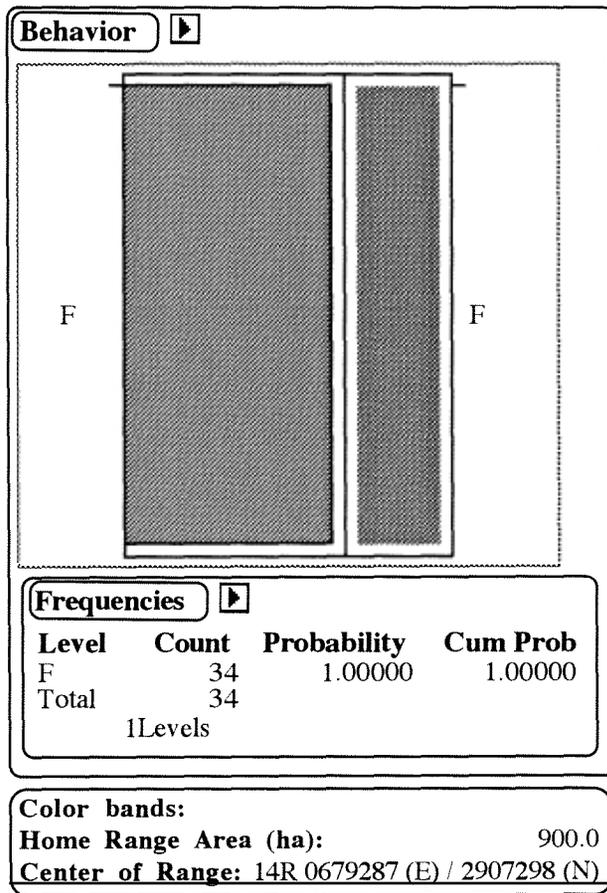
## Radiofrequencies 720



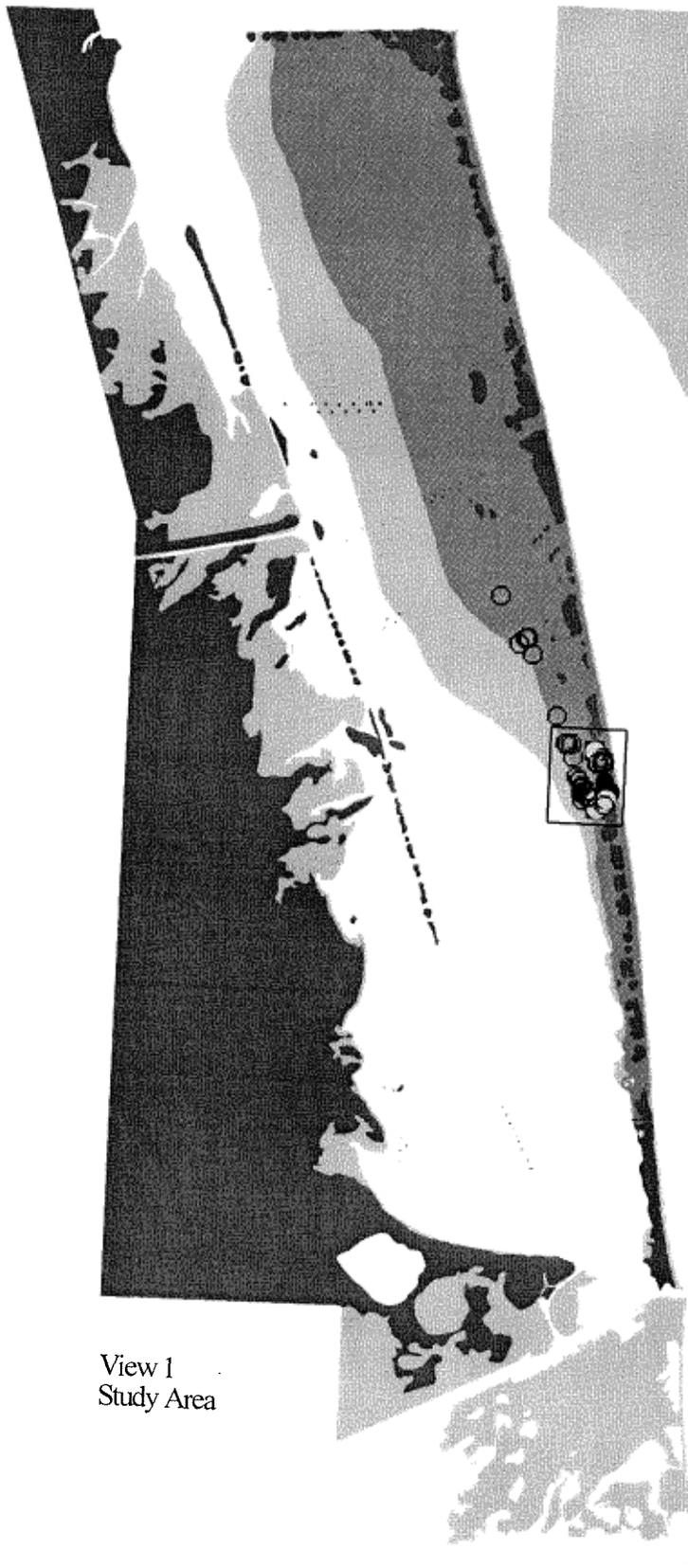
**Radiofrequency 731 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



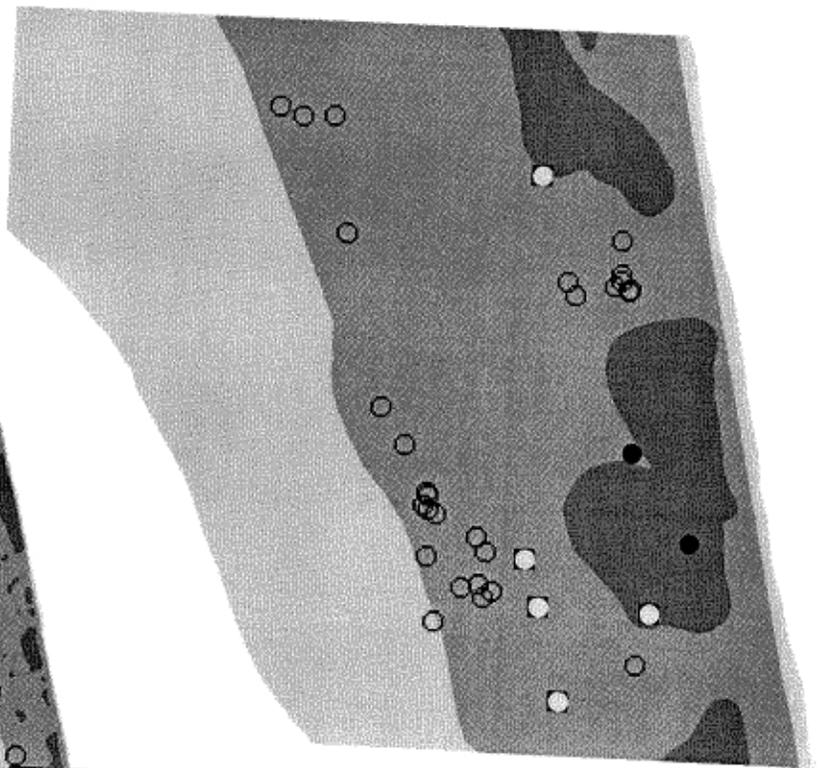
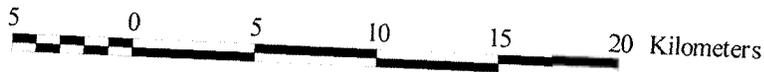
# Radiofrequencies 731



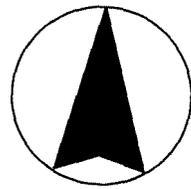
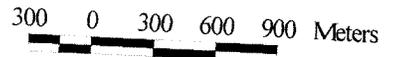
**Radiofrequency 741 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



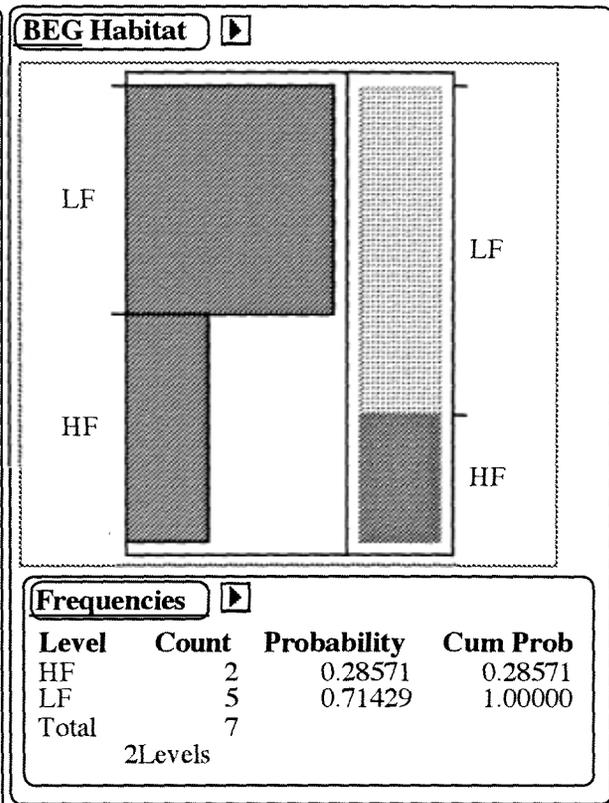
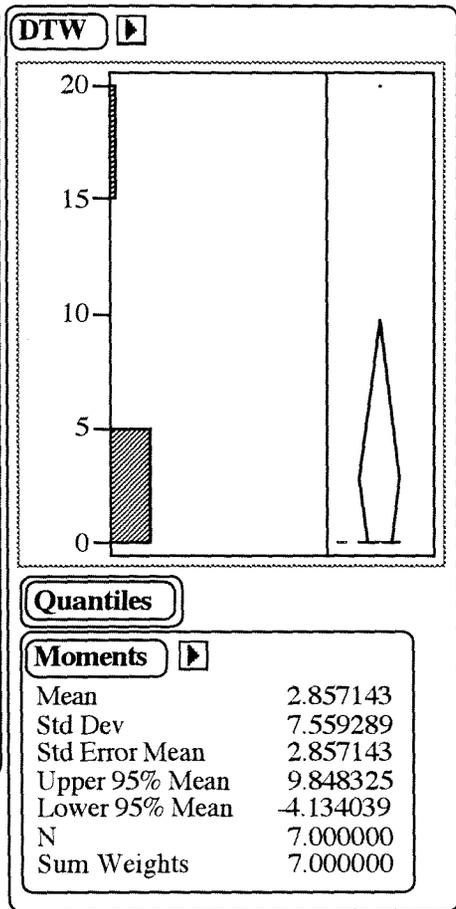
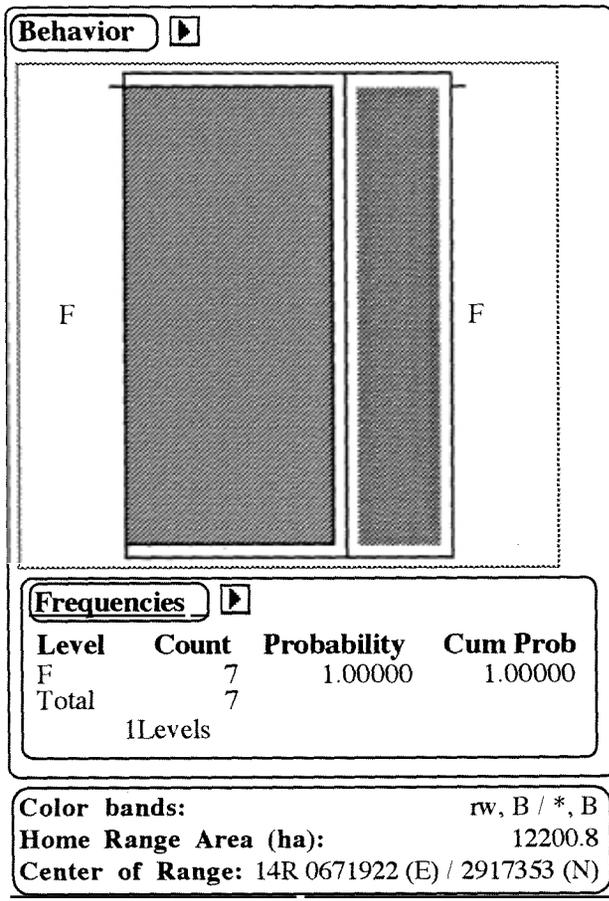
View 1  
Study Area



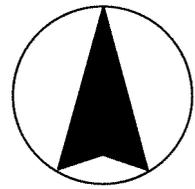
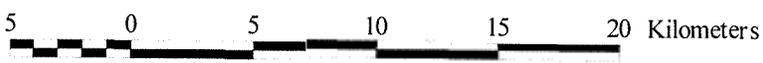
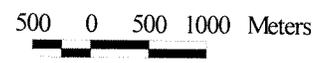
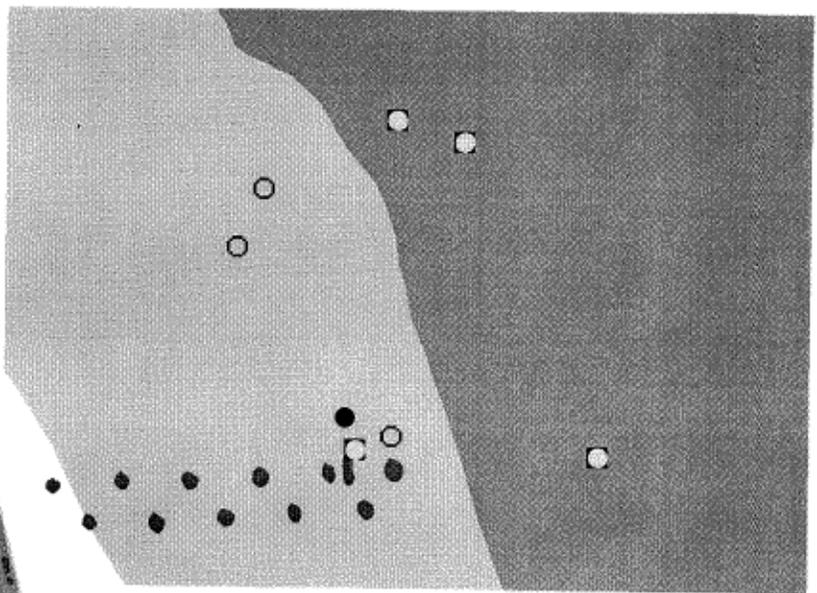
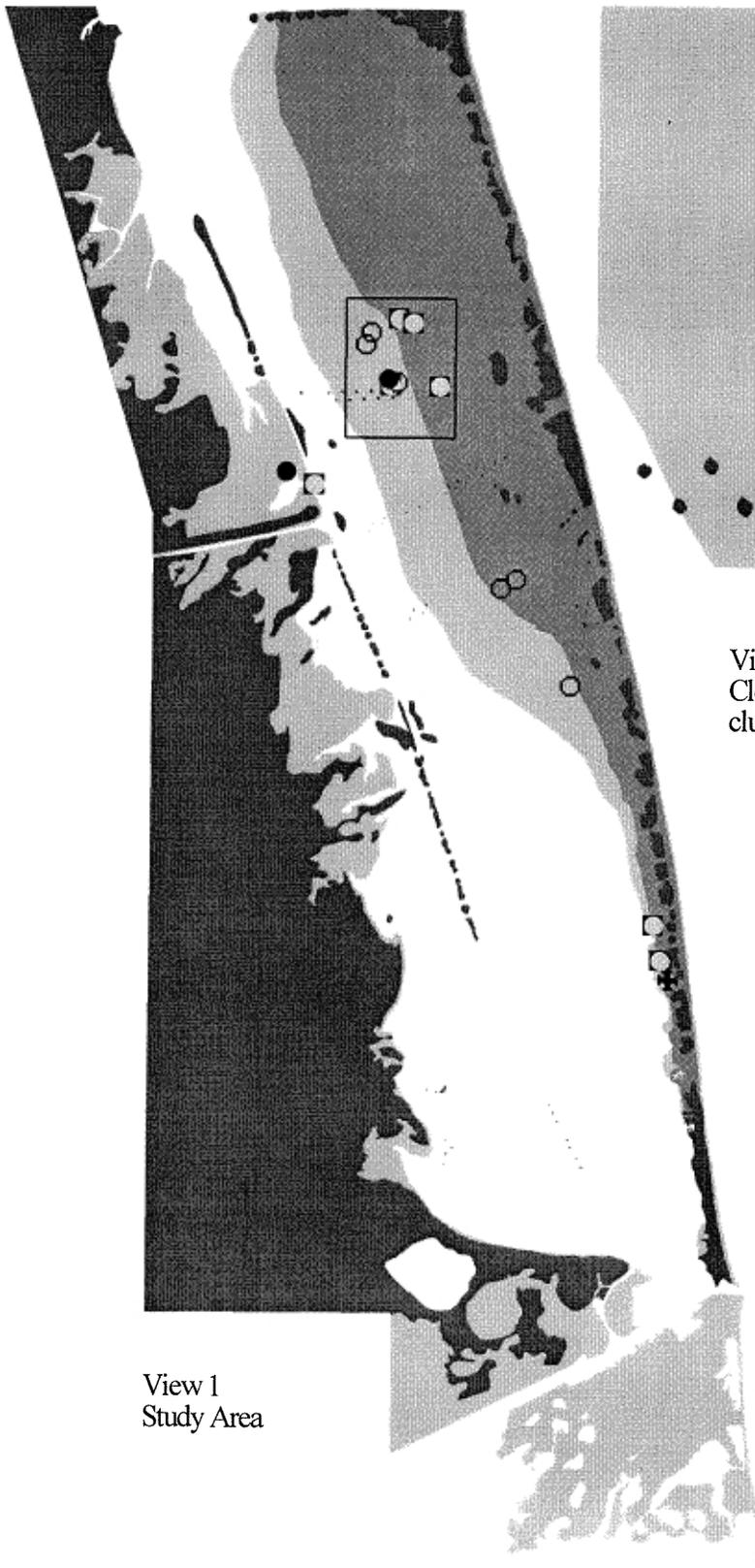
View 2  
Close-up of relocation  
cluster from View 1

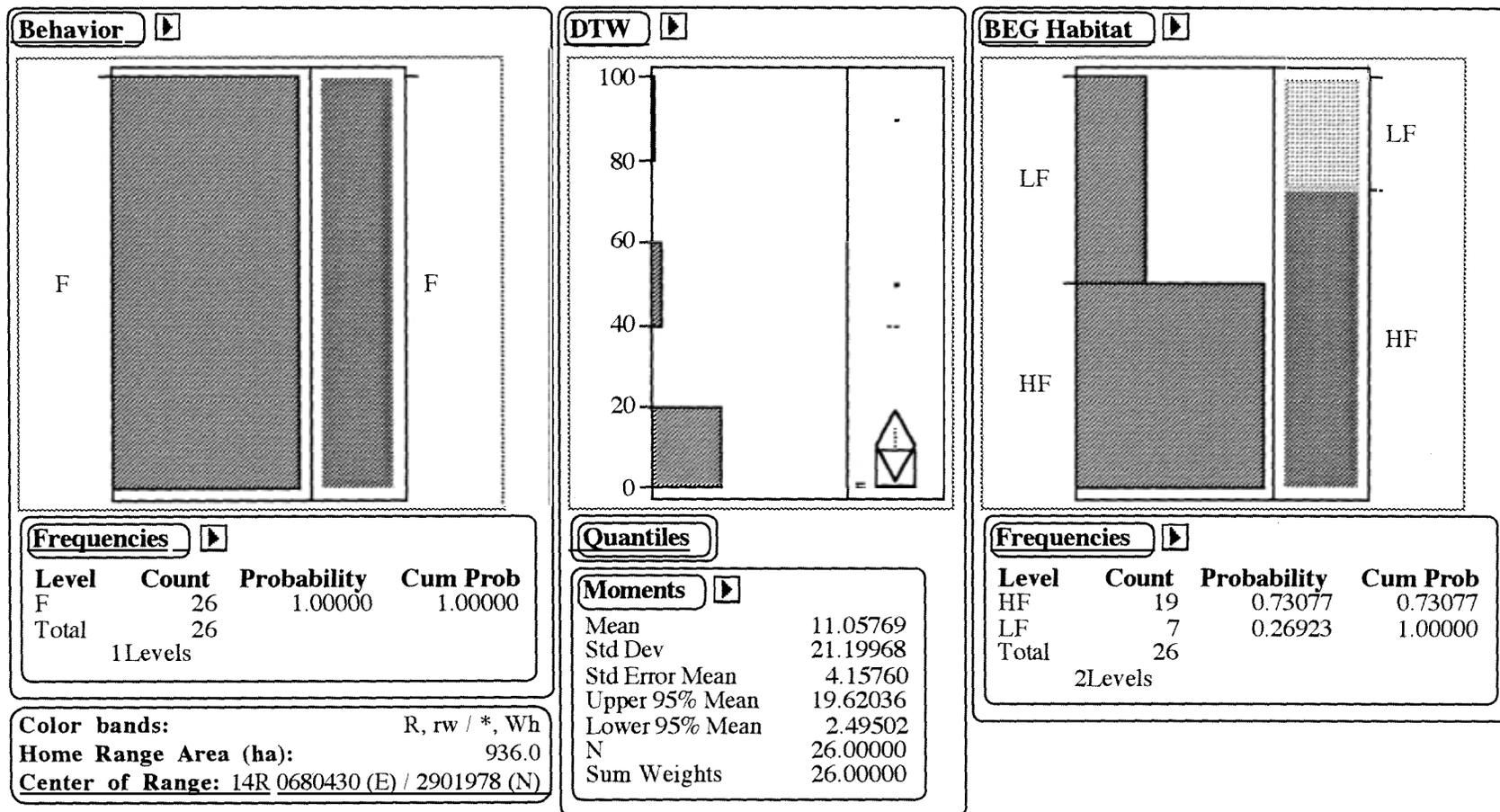


# Radiofrequencies 741

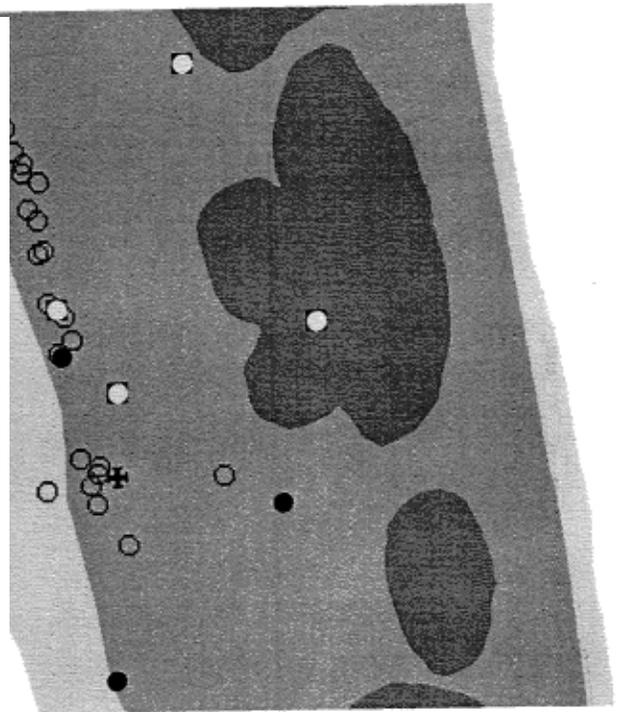
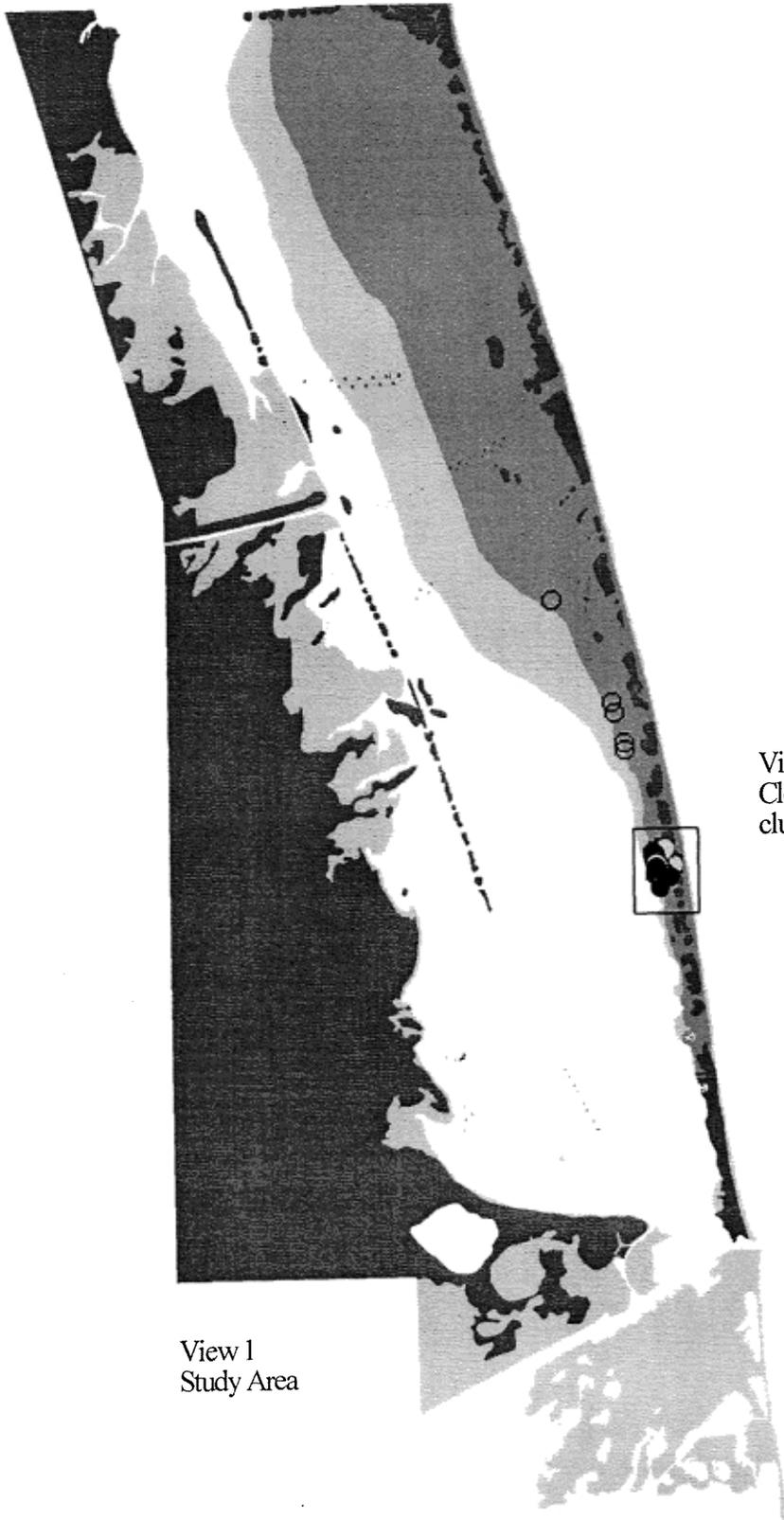


**Radiofrequency 757 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.





**Radiofrequency 760 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



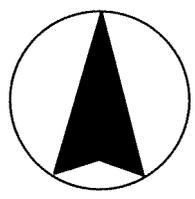
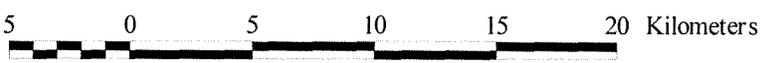
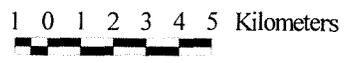
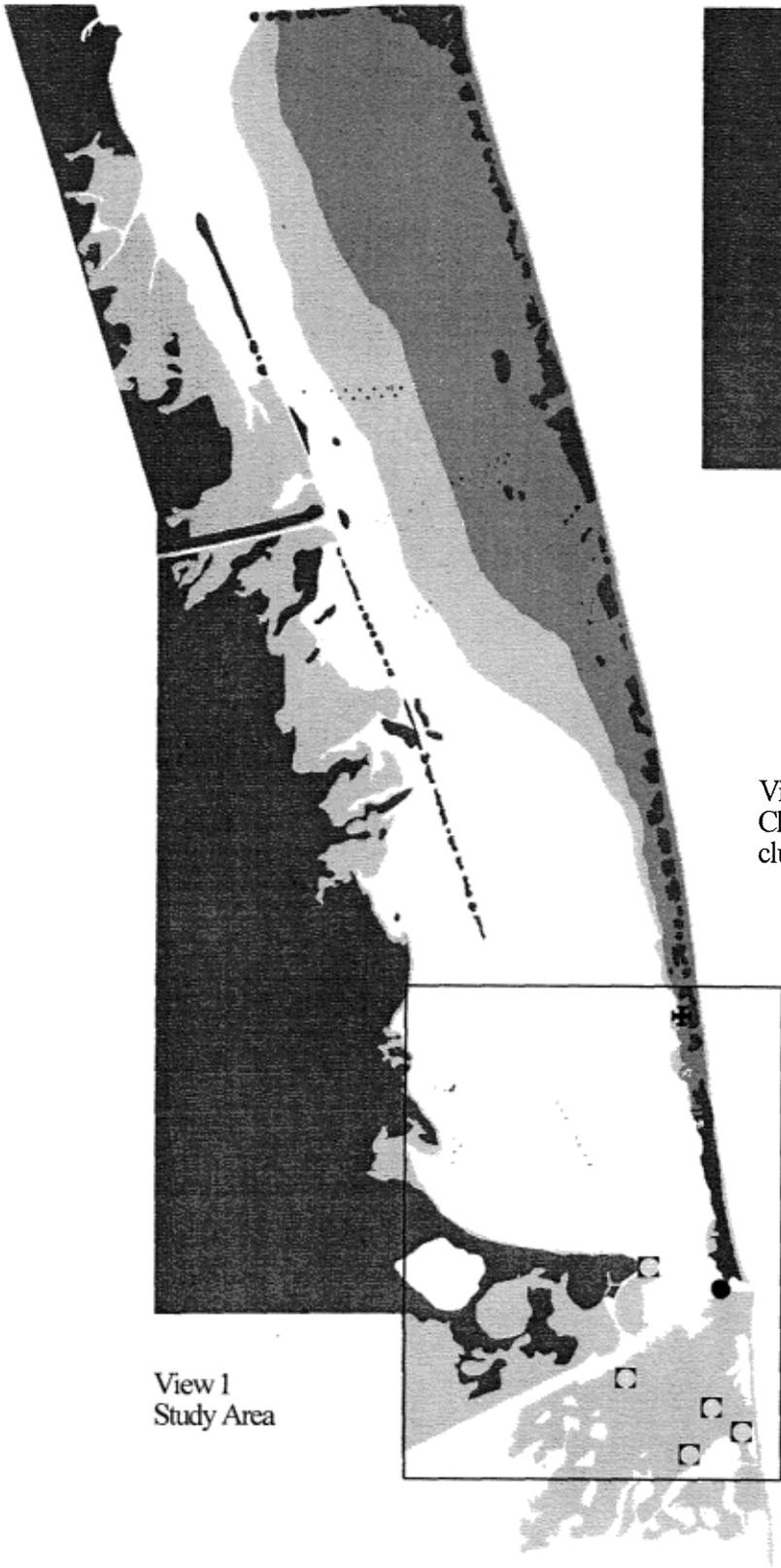
View 2  
Close-up of relocation  
cluster from View 1

200 0 200 400 Meters

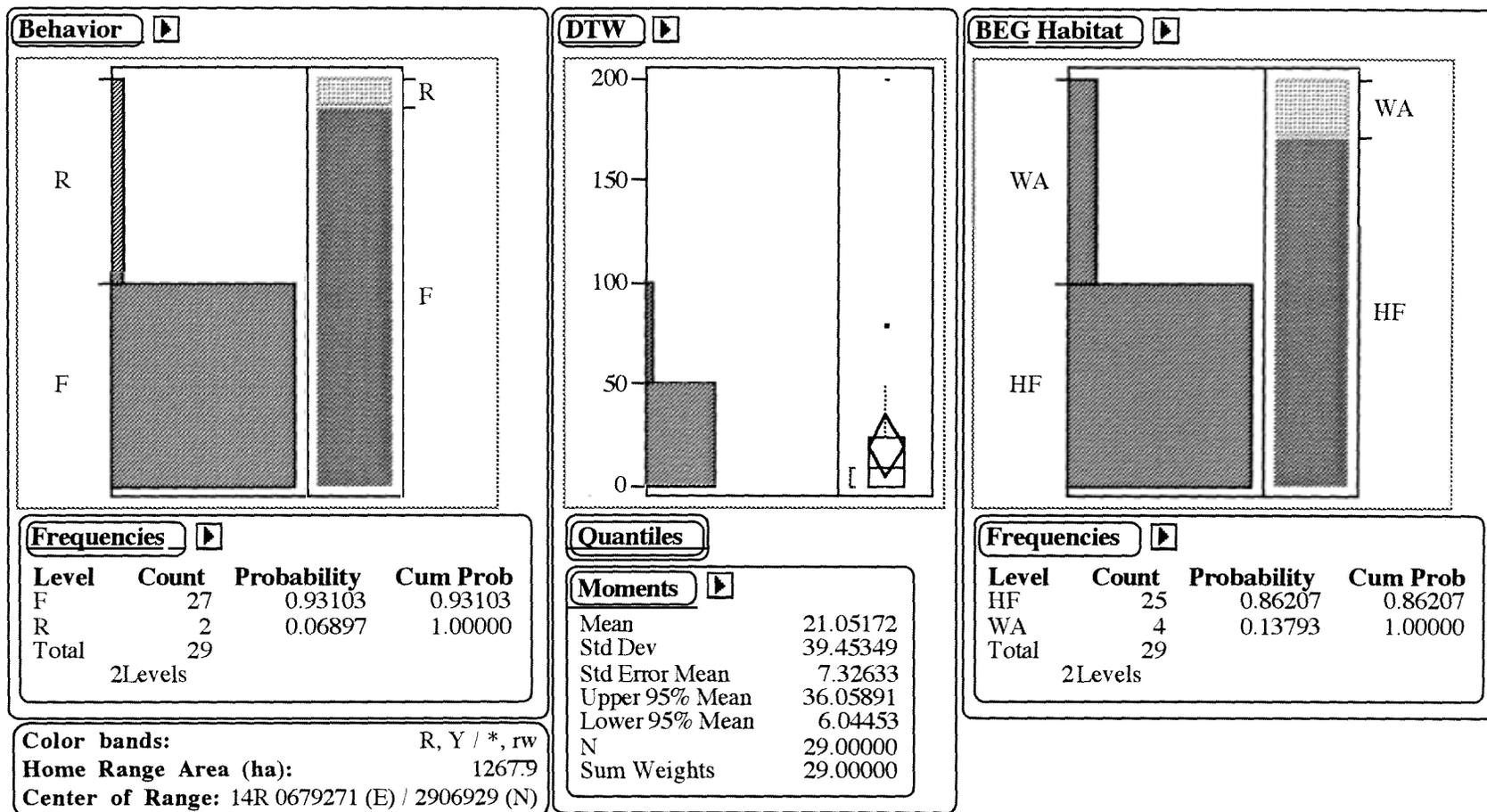


5 0 5 10 15 20 Kilometers

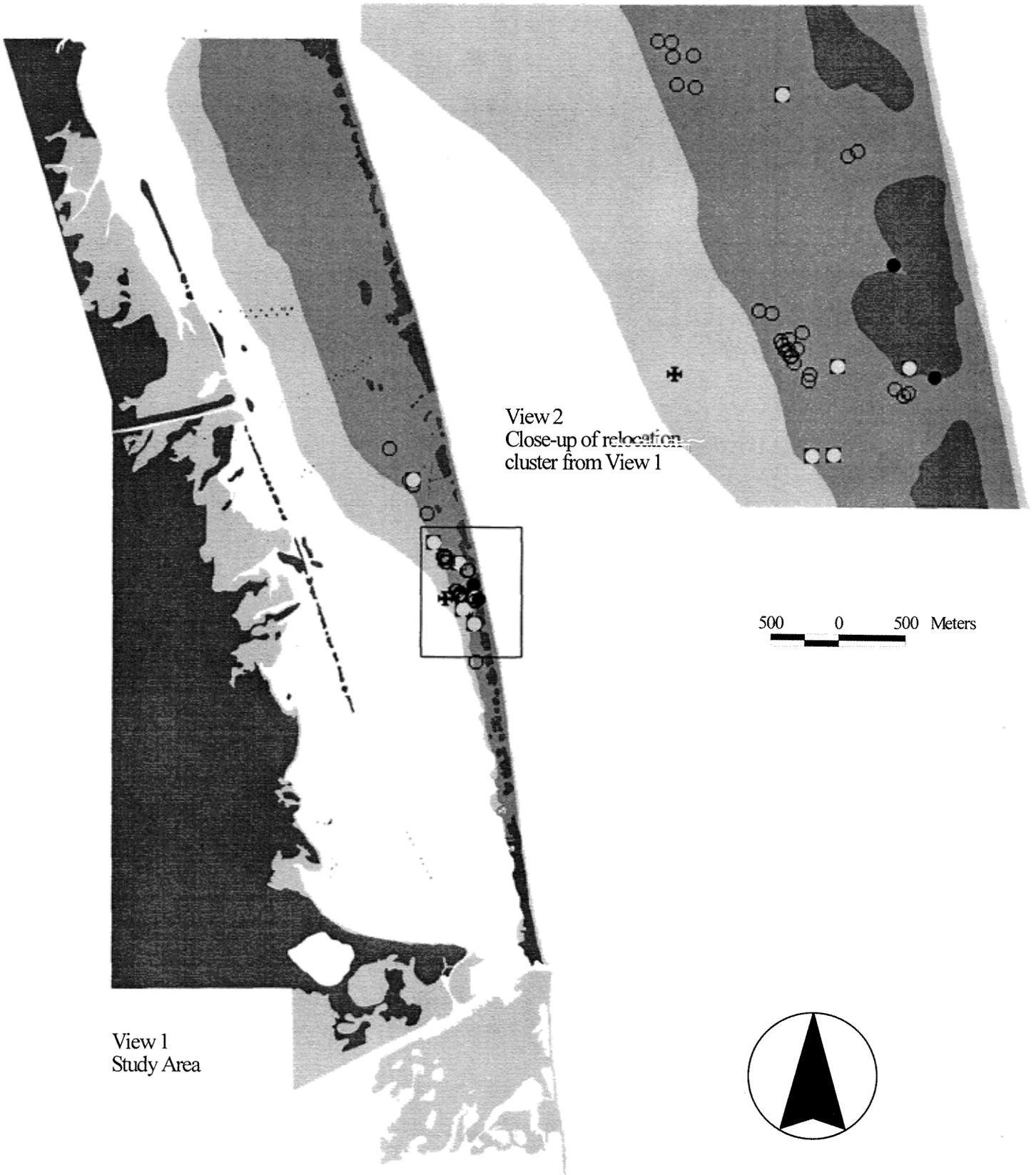
# Radiofrequencies 760



**Radiofrequencies 774**



**Radiofrequency 778 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



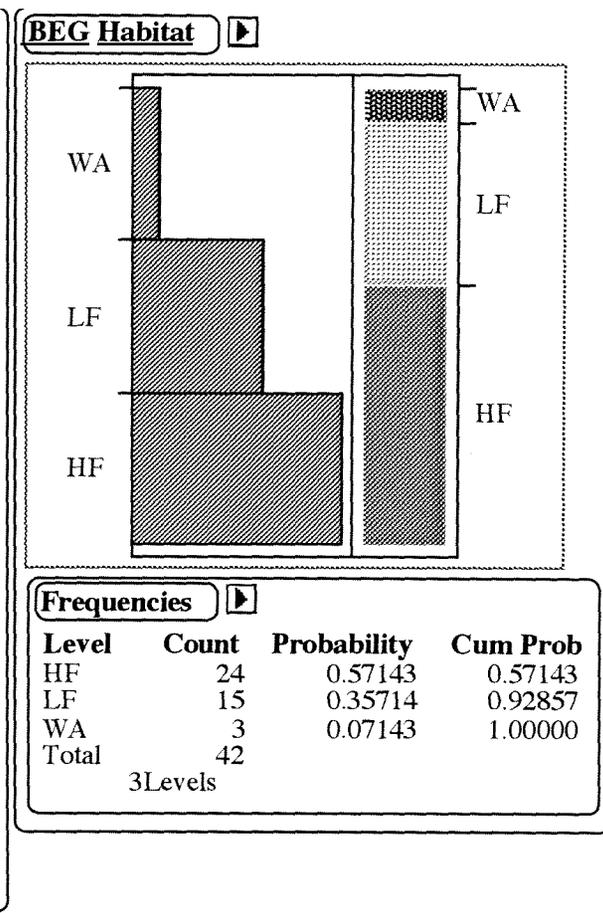
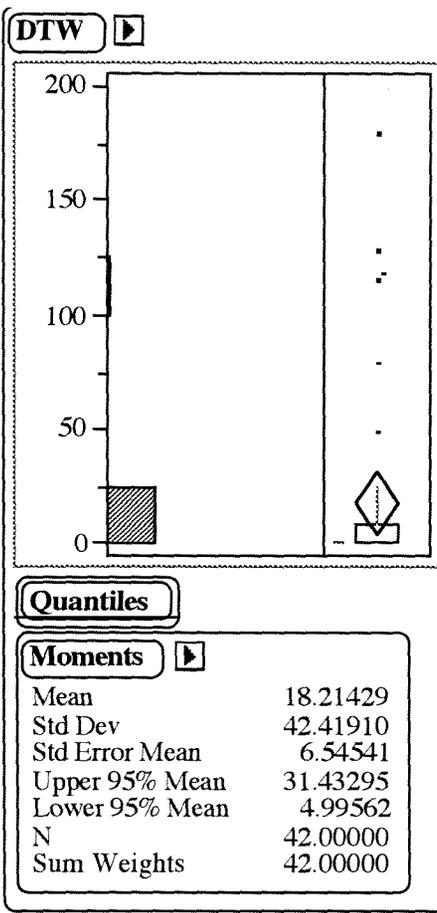
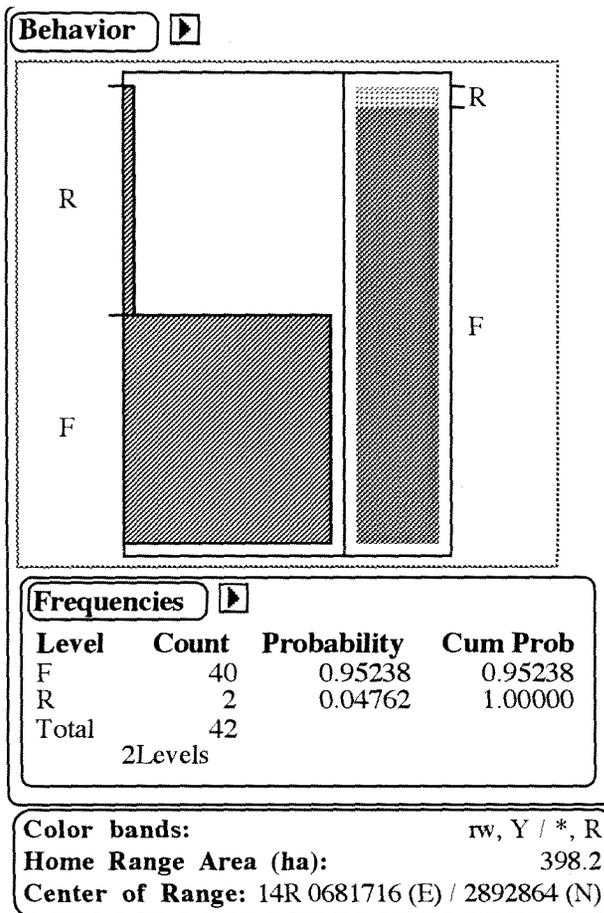
View 1  
Study Area

View 2  
Close-up of relocation  
cluster from View 1

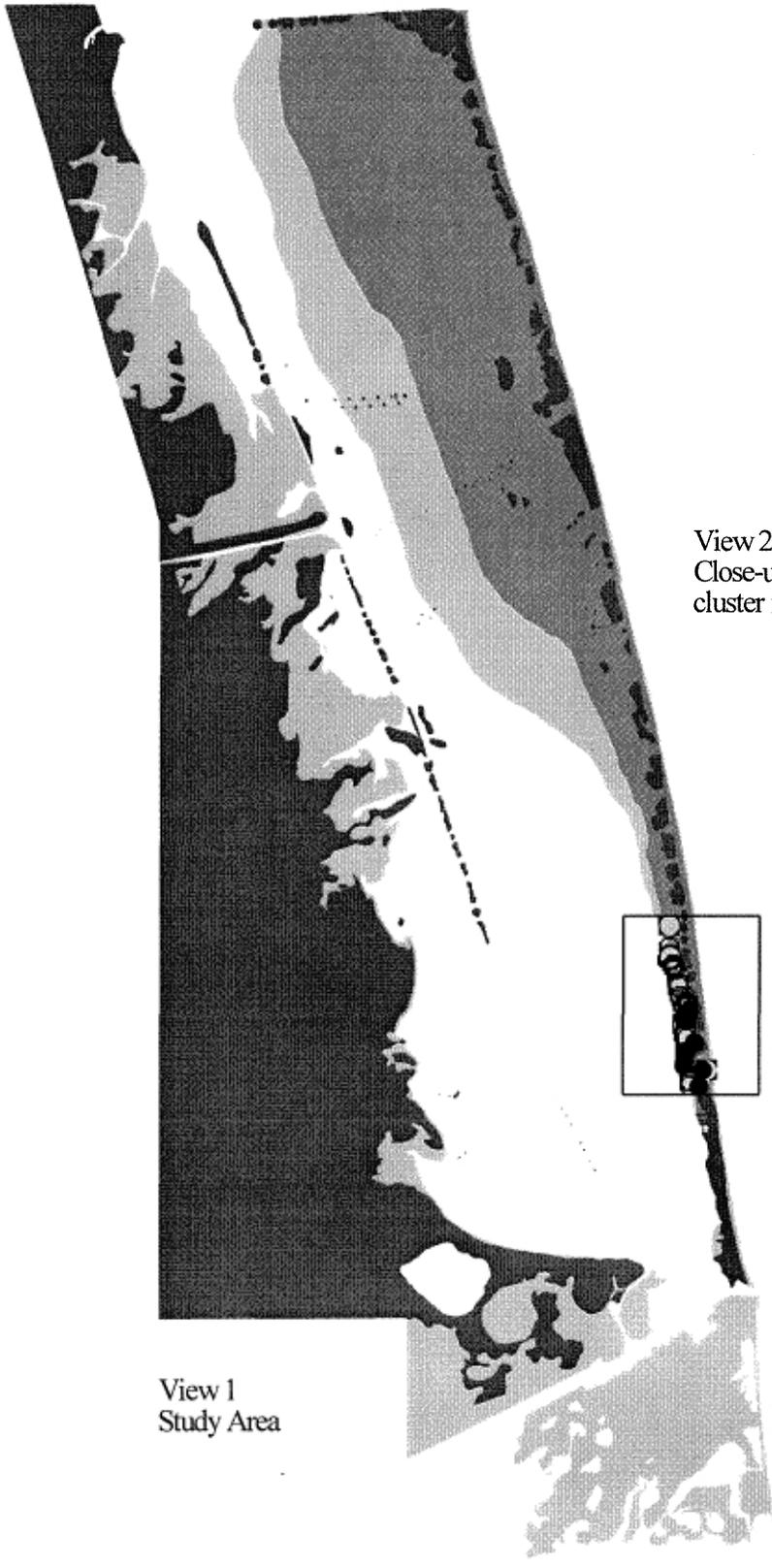
500 0 500 Meters

5 0 5 10 15 20 Kilometers

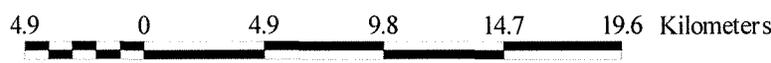
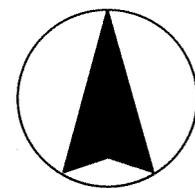
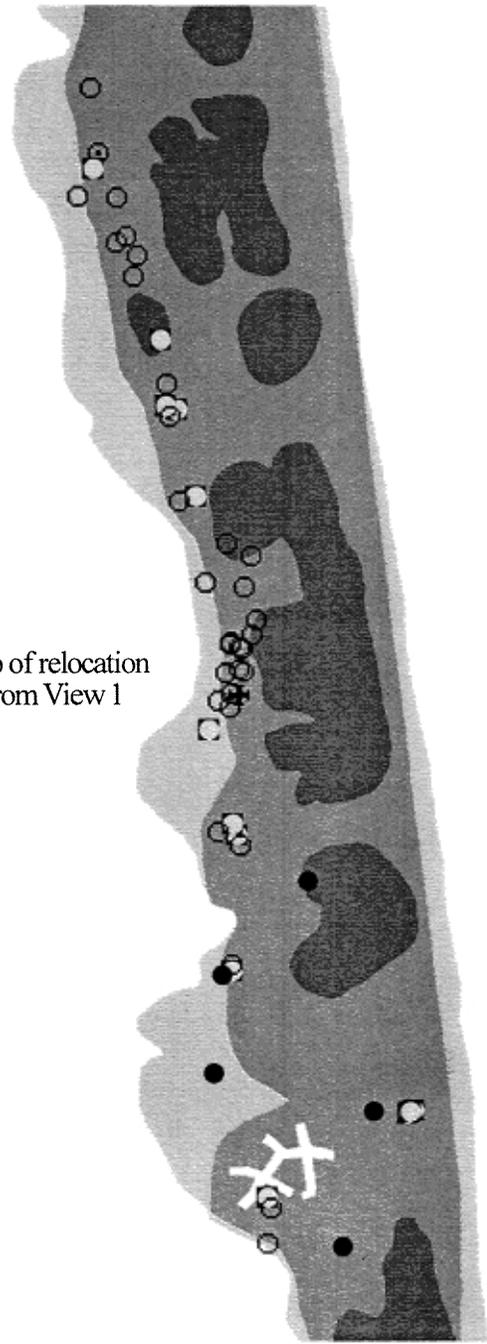
# Radiofrequencies 778



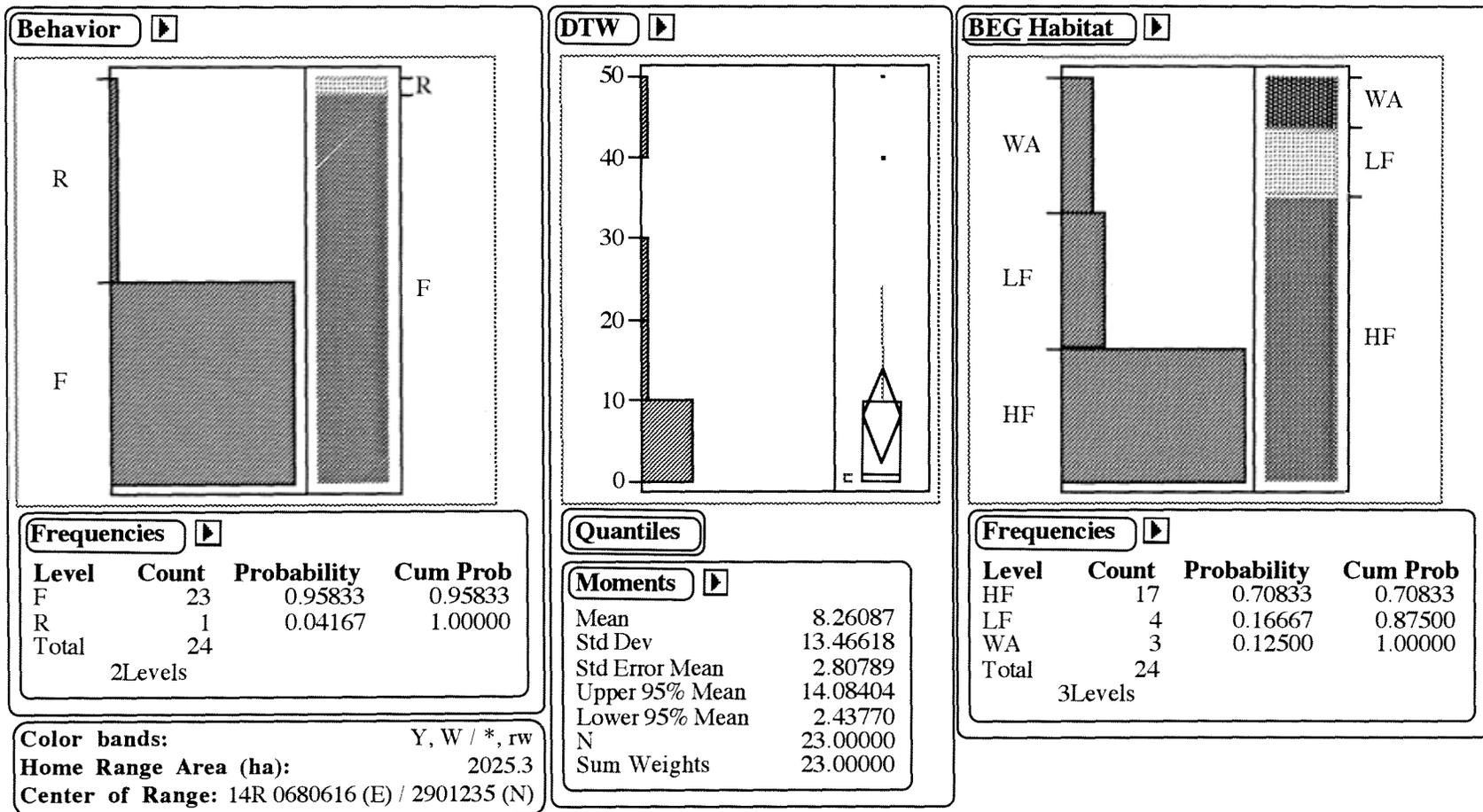
**Radiofrequency 798 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



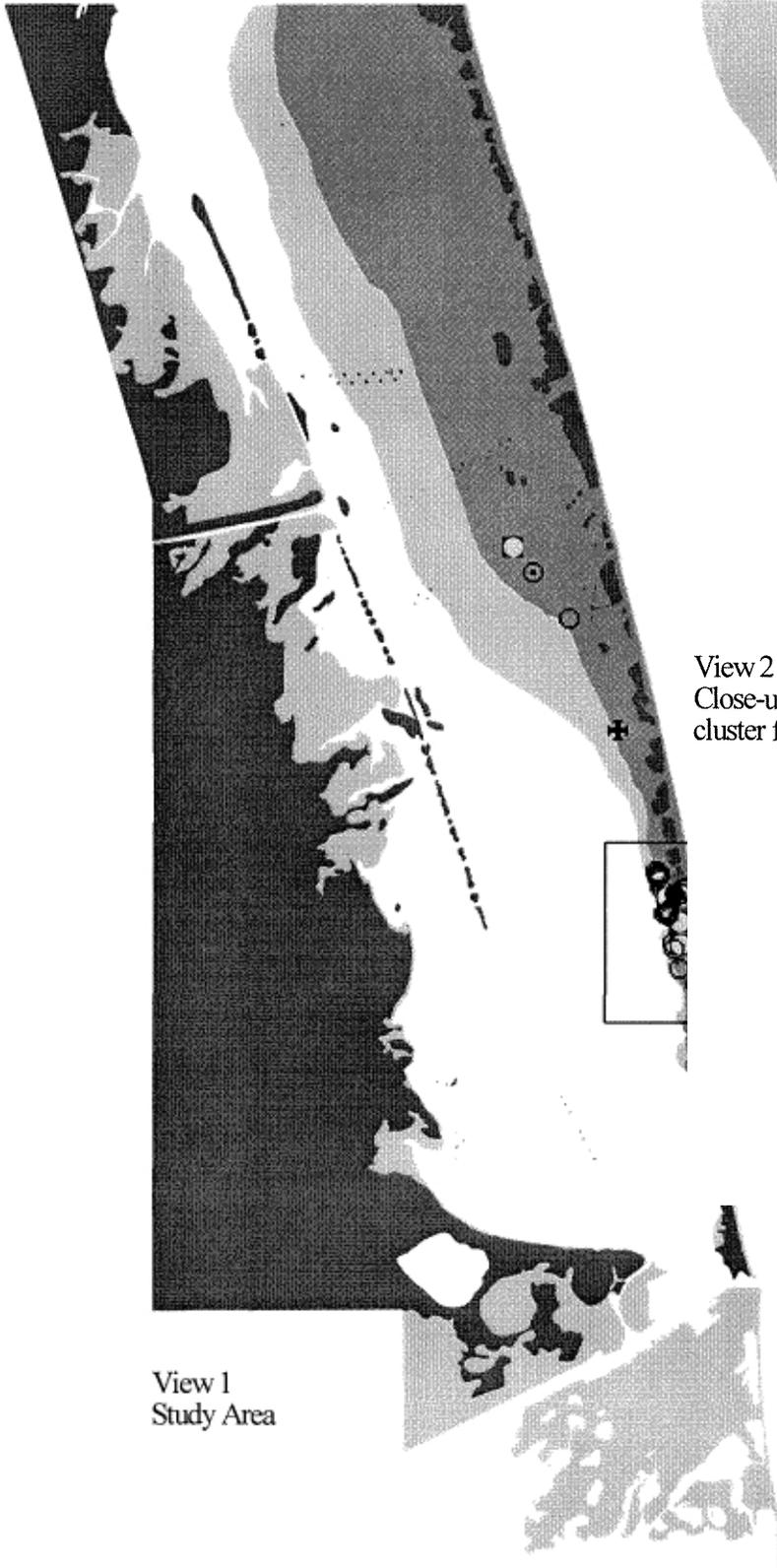
View 2  
Close-up of relocation  
cluster from View 1



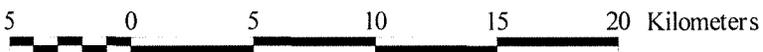
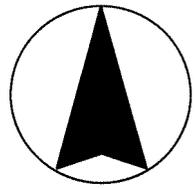
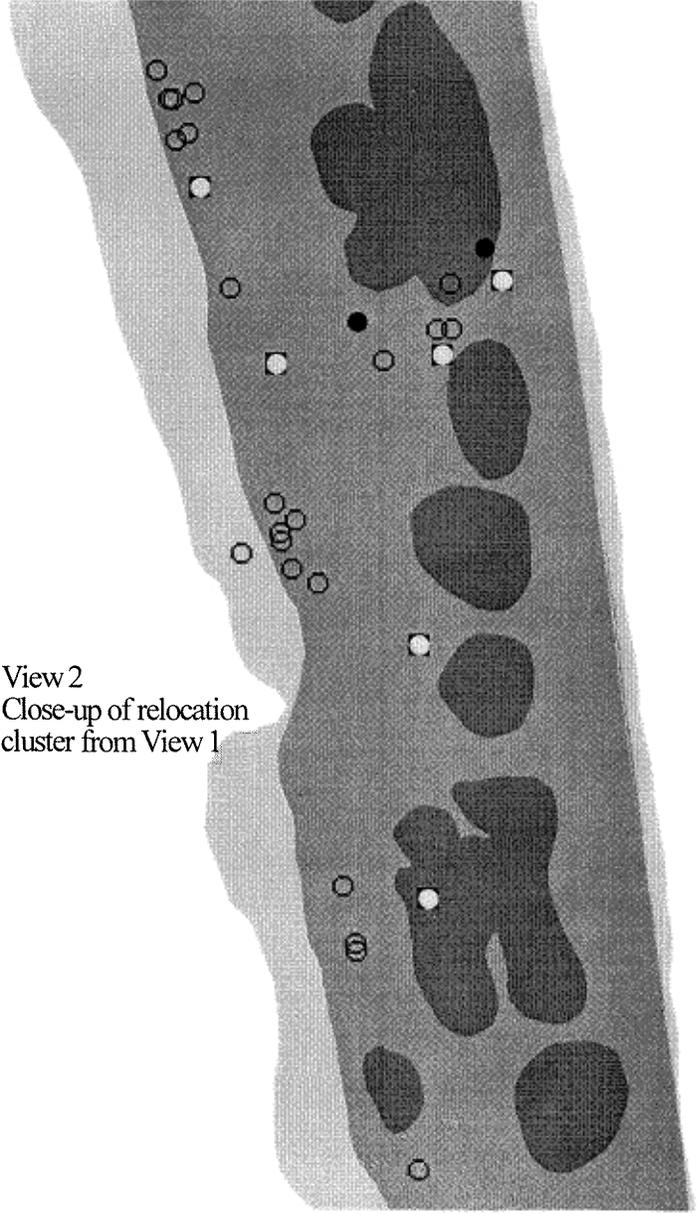
# Radiofrequencies 798



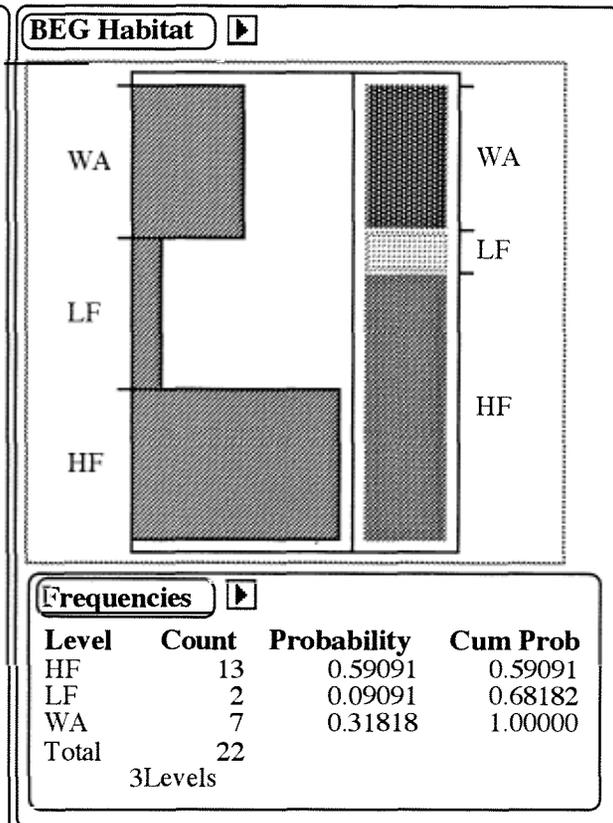
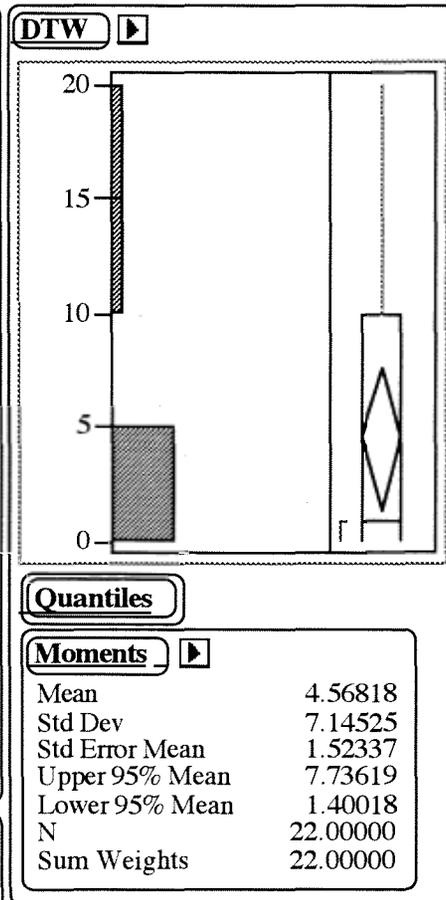
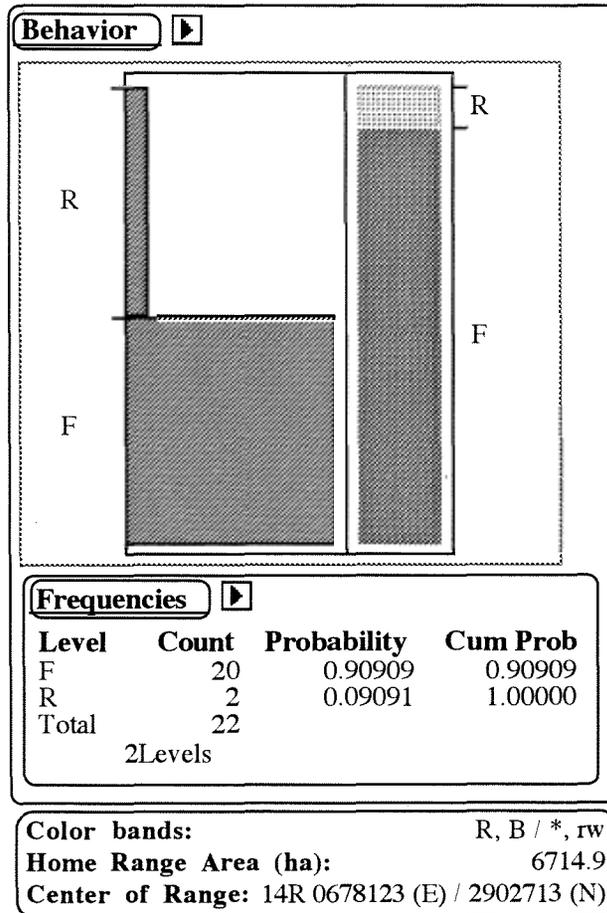
**Radiofrequency 801 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



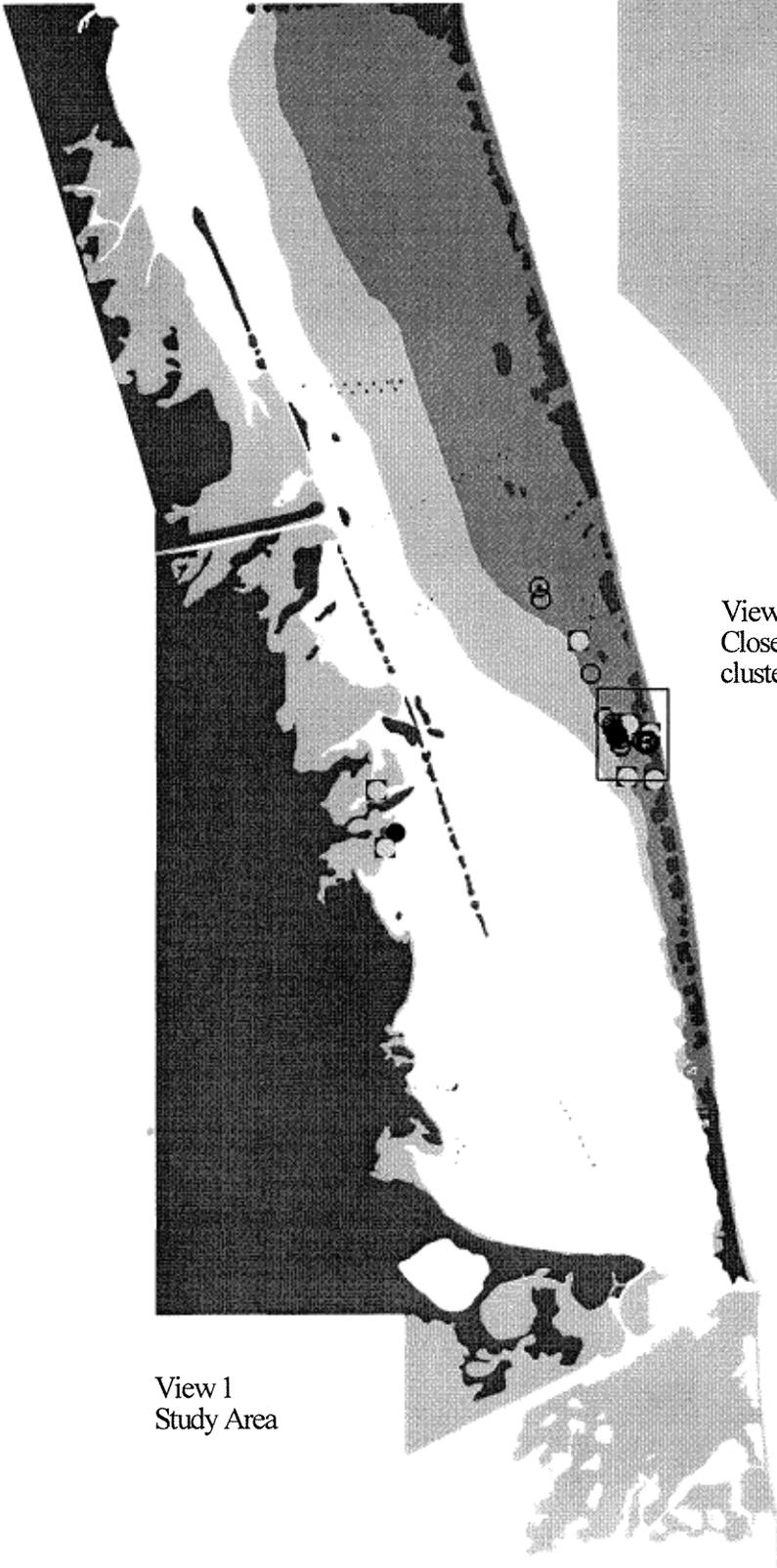
View 2  
Close-up of relocation  
cluster from View 1



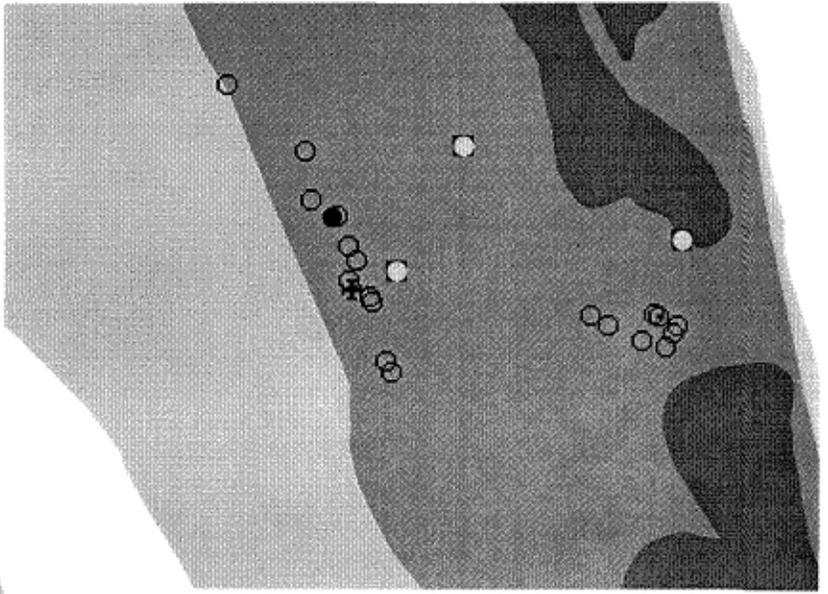
# Radiofrequencies 801



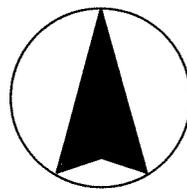
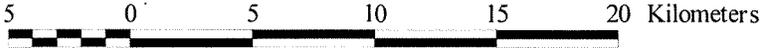
**Radiofrequency 821 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



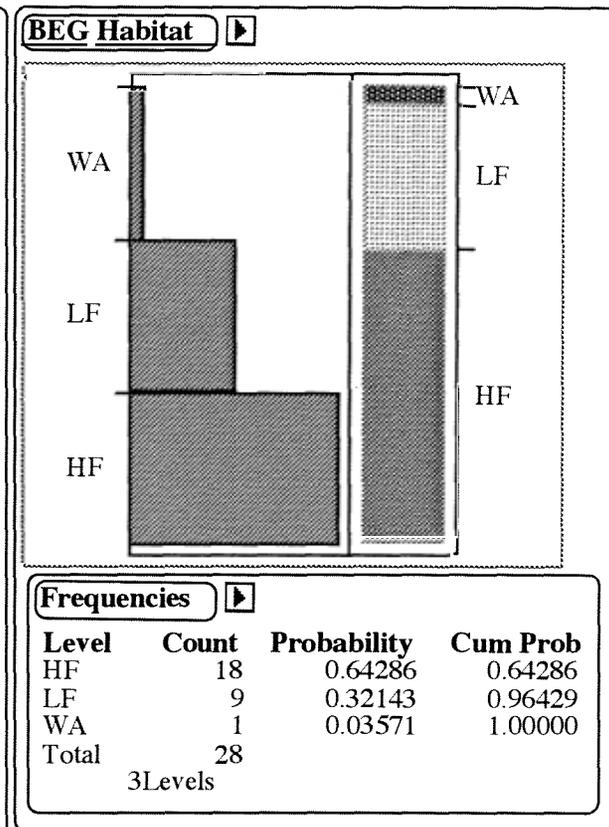
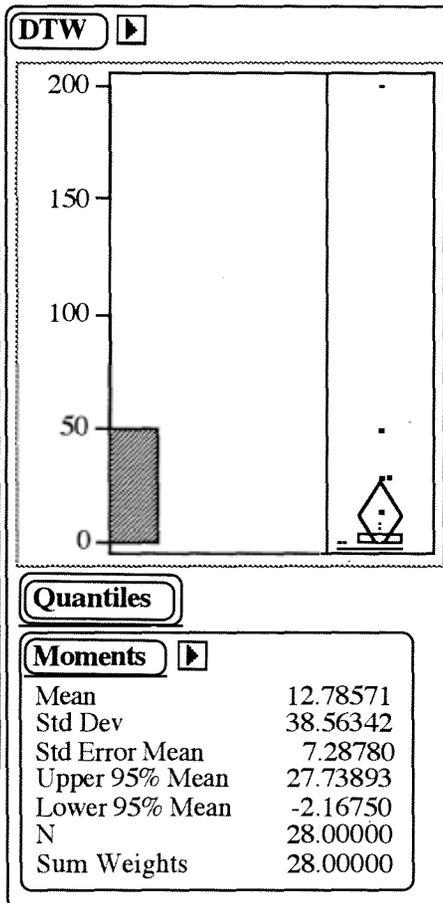
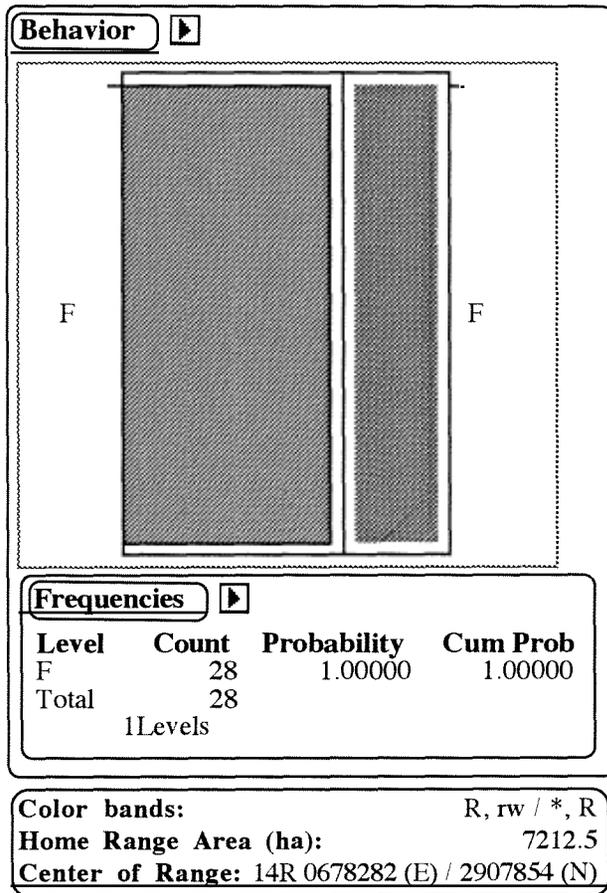
View 1  
Study Area



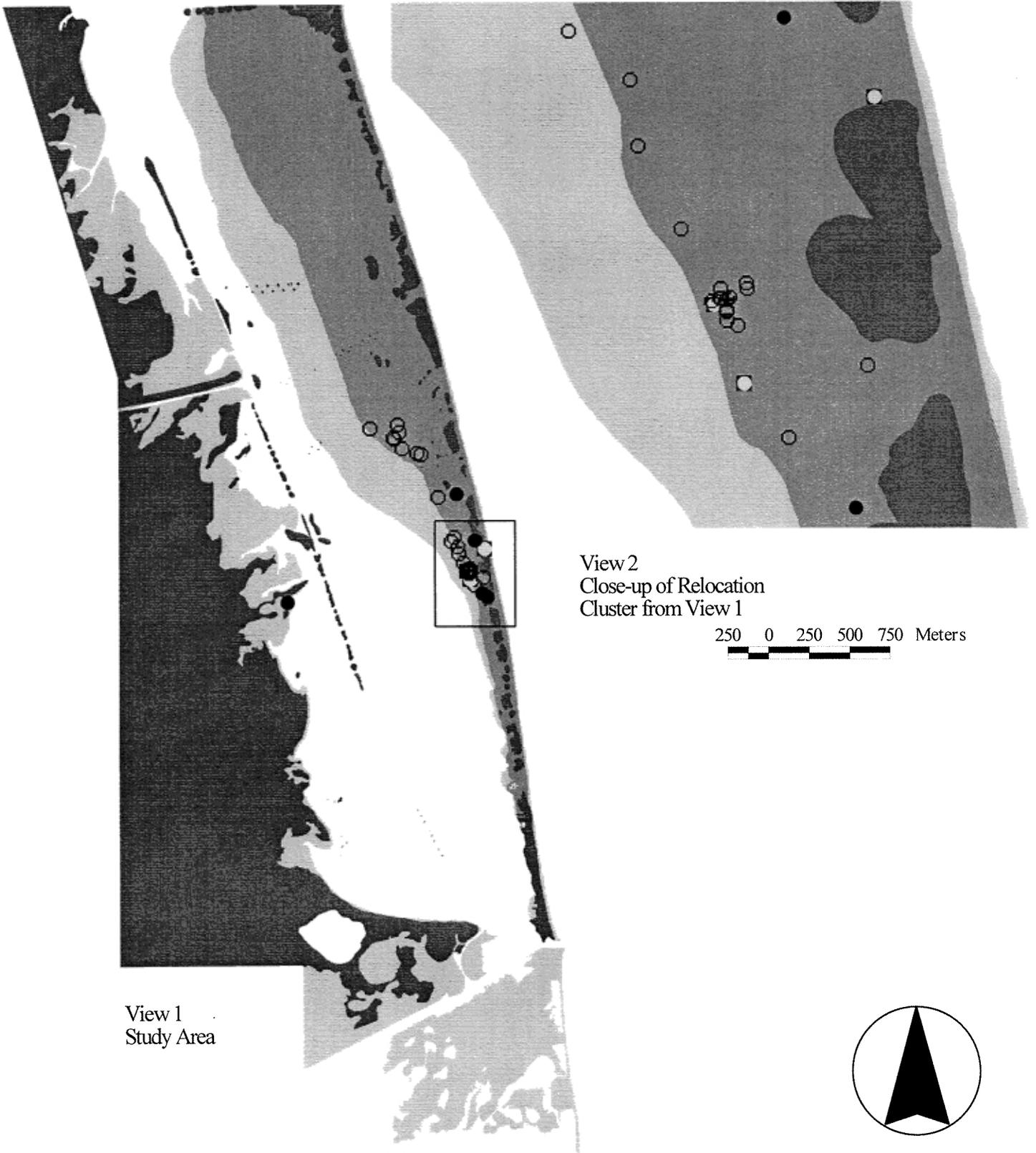
View 2  
Close-up of relocation  
cluster from View 1



# Radiofrequencies 821



**Radiofrequency 836 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.

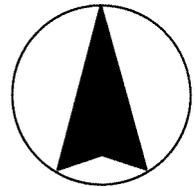


View 2  
Close-up of Relocation  
Cluster from View 1

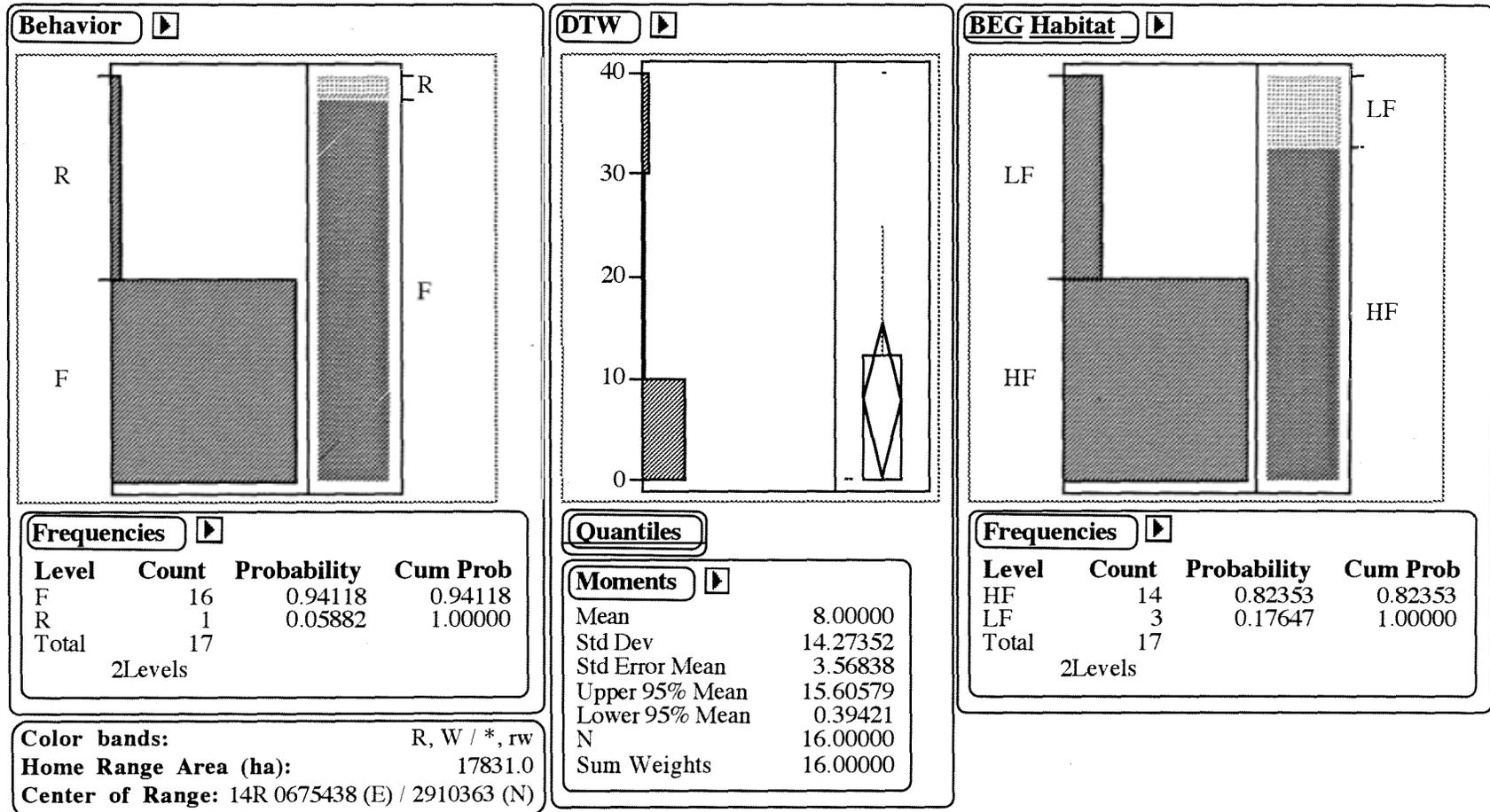
250 0 250 500 750 Meters

View 1  
Study Area

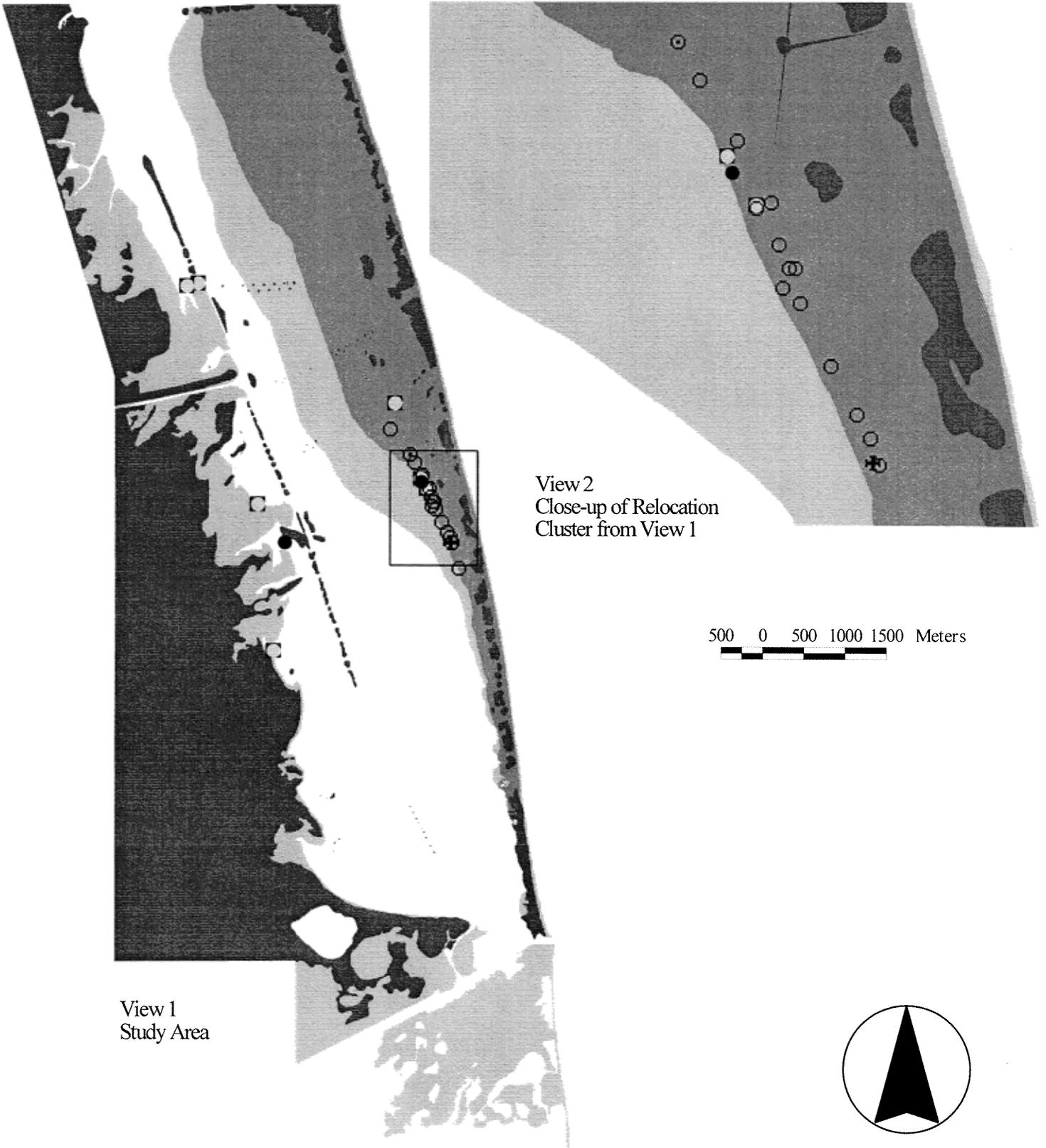
5 0 5 10 Kilometers



## Radiofrequency 836 (PIPL)



**Radiofrequency 842 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.

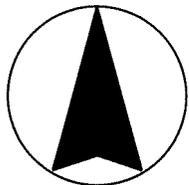


View 1  
Study Area

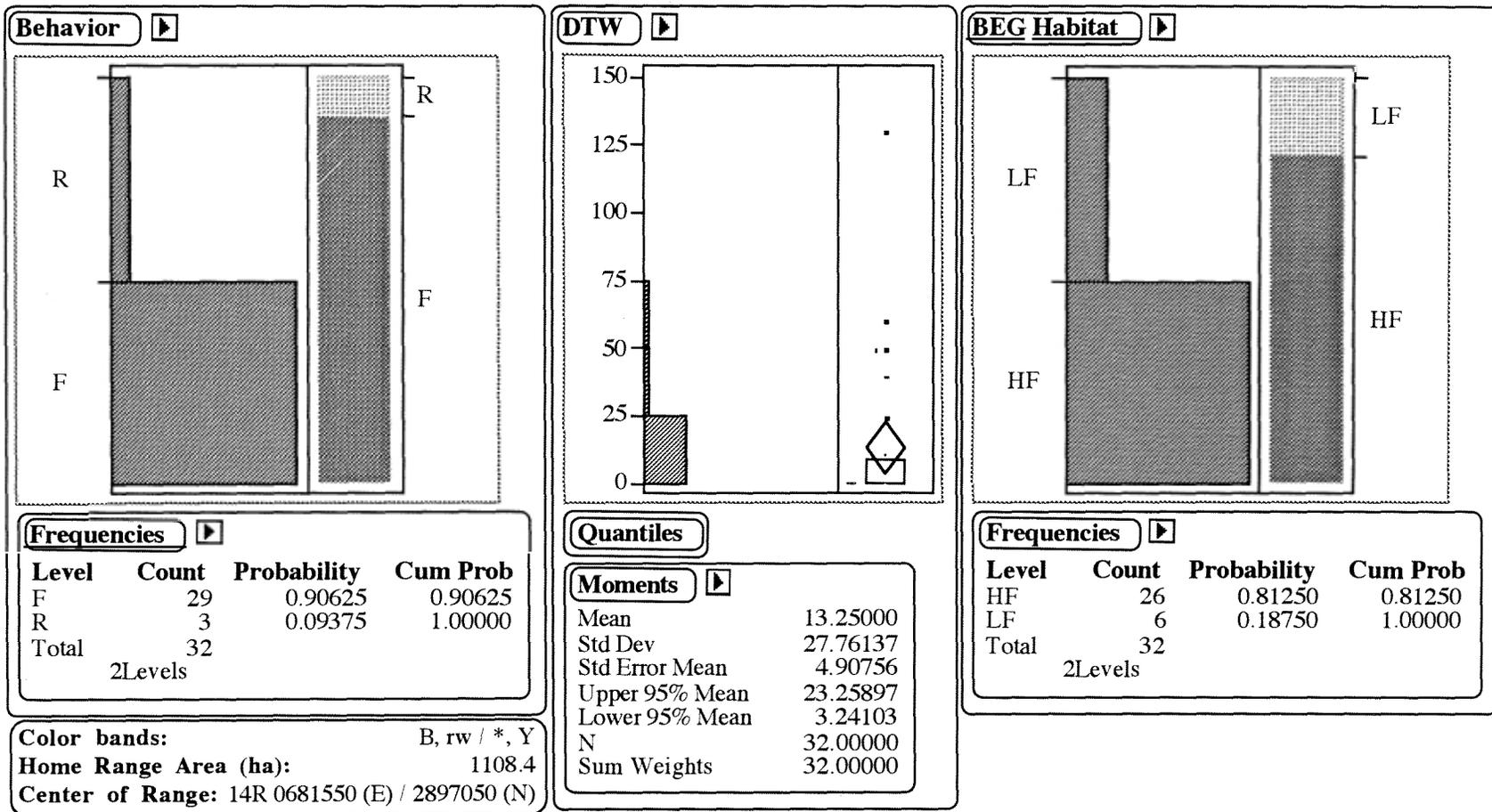
View 2  
Close-up of Relocation  
Cluster from View 1

500 0 500 1000 1500 Meters

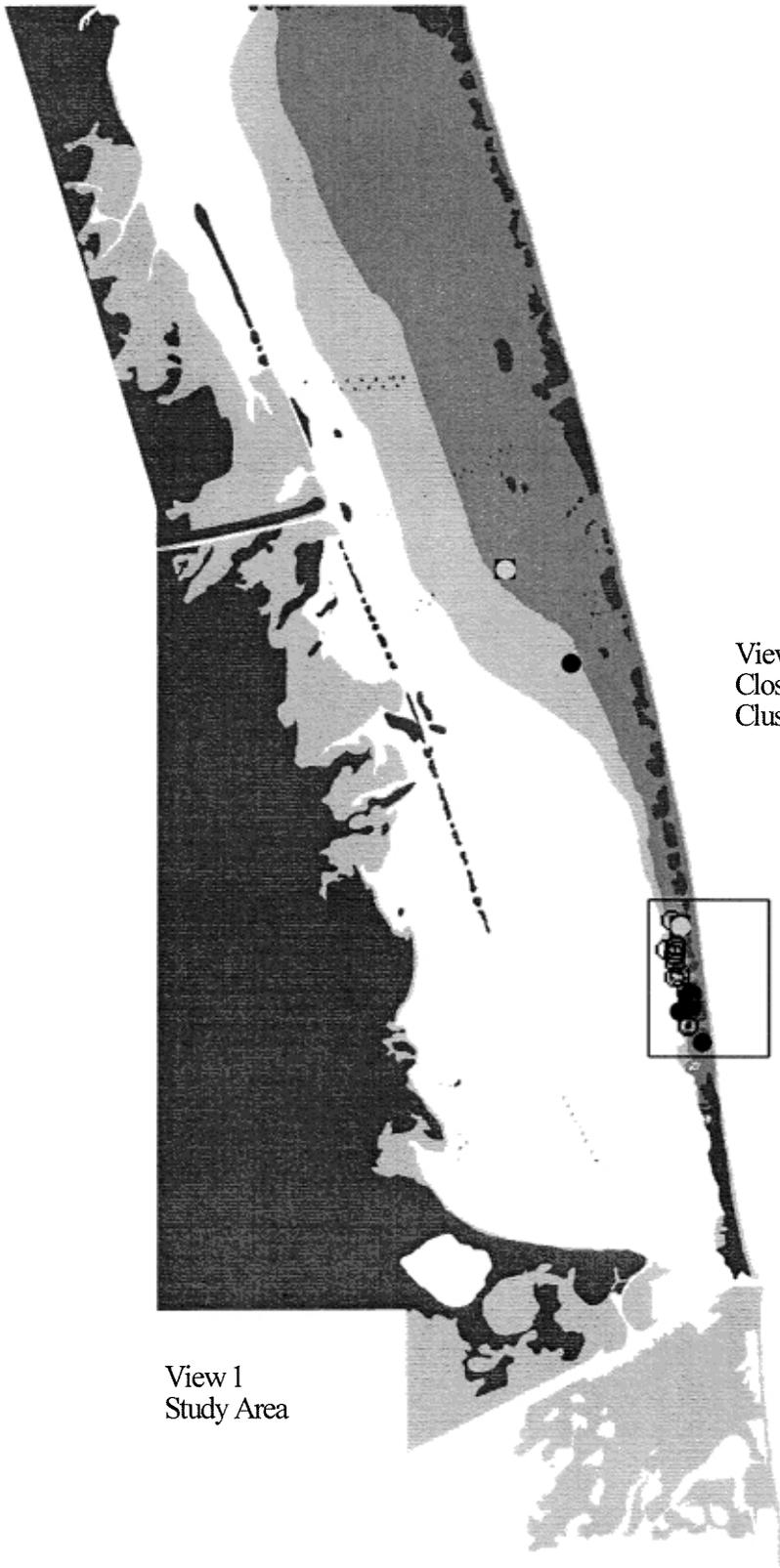
5 0 5 10 Kilometers



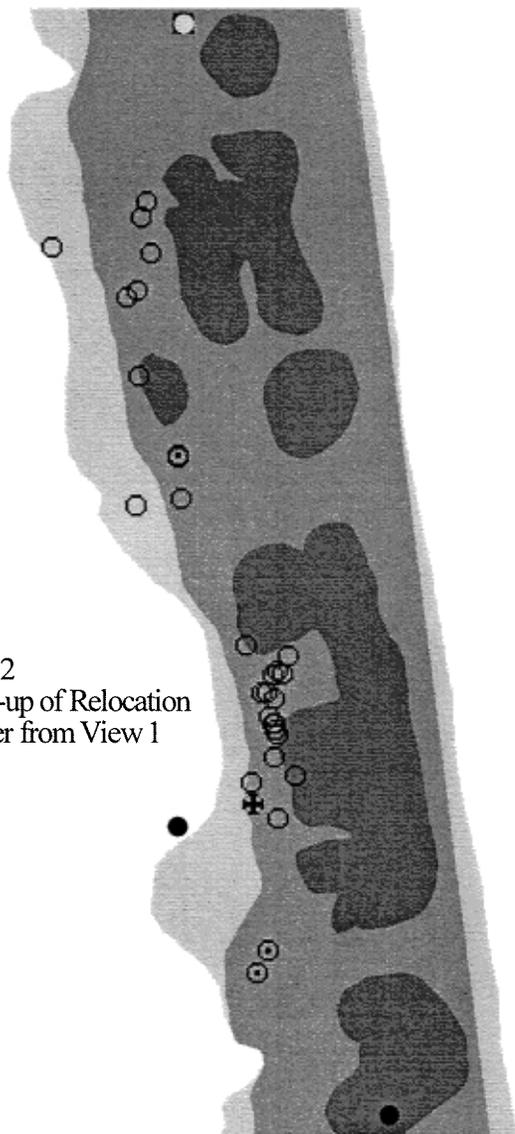
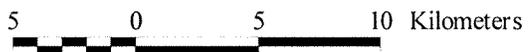
# Radiofrequency 842 (PIPL)



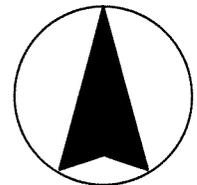
**Radiofrequency 855 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



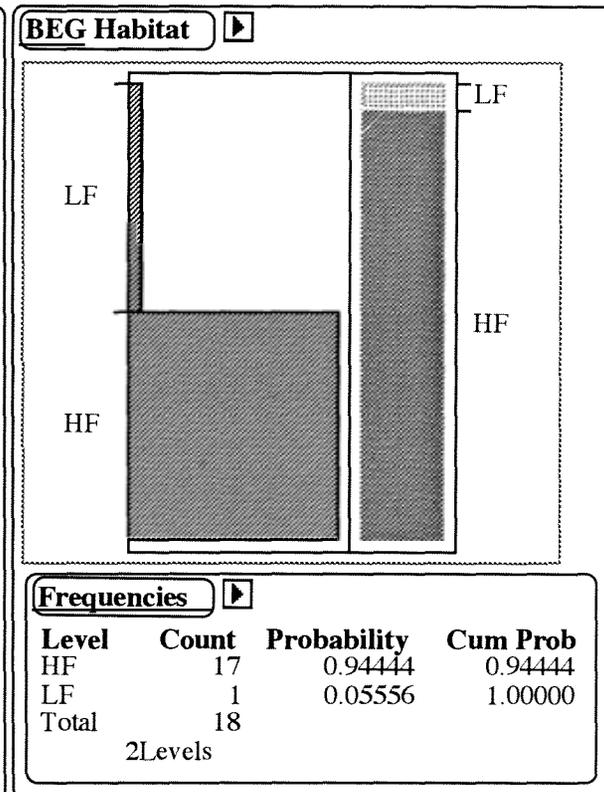
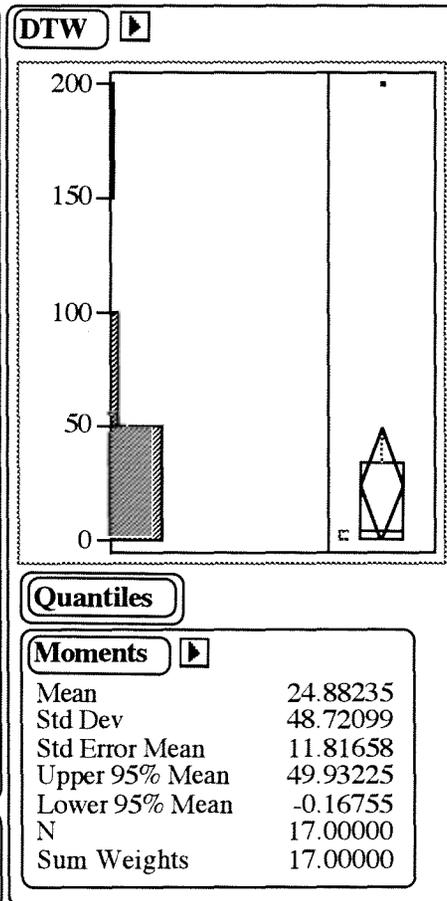
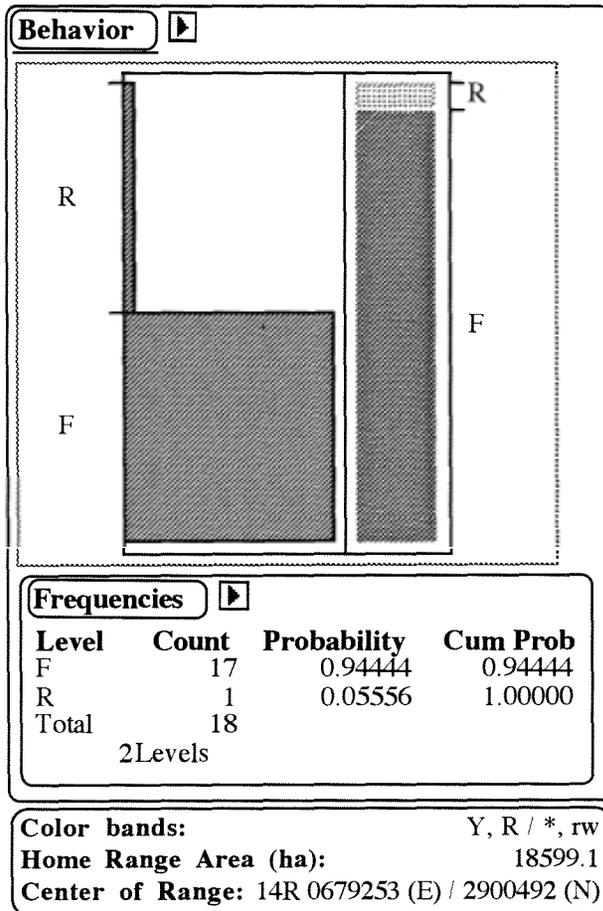
View 1  
Study Area



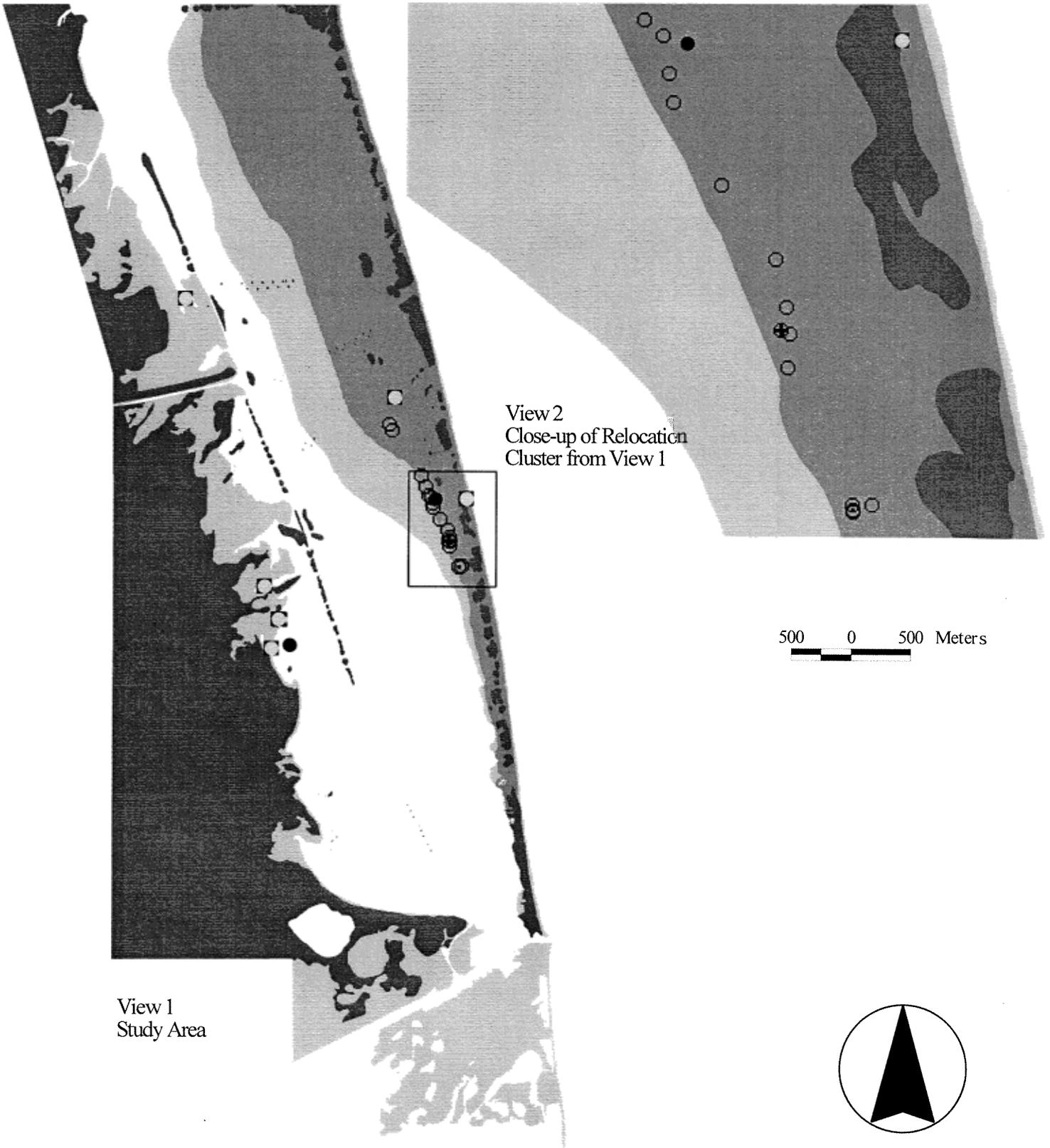
View 2  
Close-up of Relocation  
Cluster from View 1



## Radiofrequency 855 (PIPL)



**Radiofrequency 861 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.

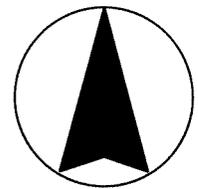


View 1  
Study Area

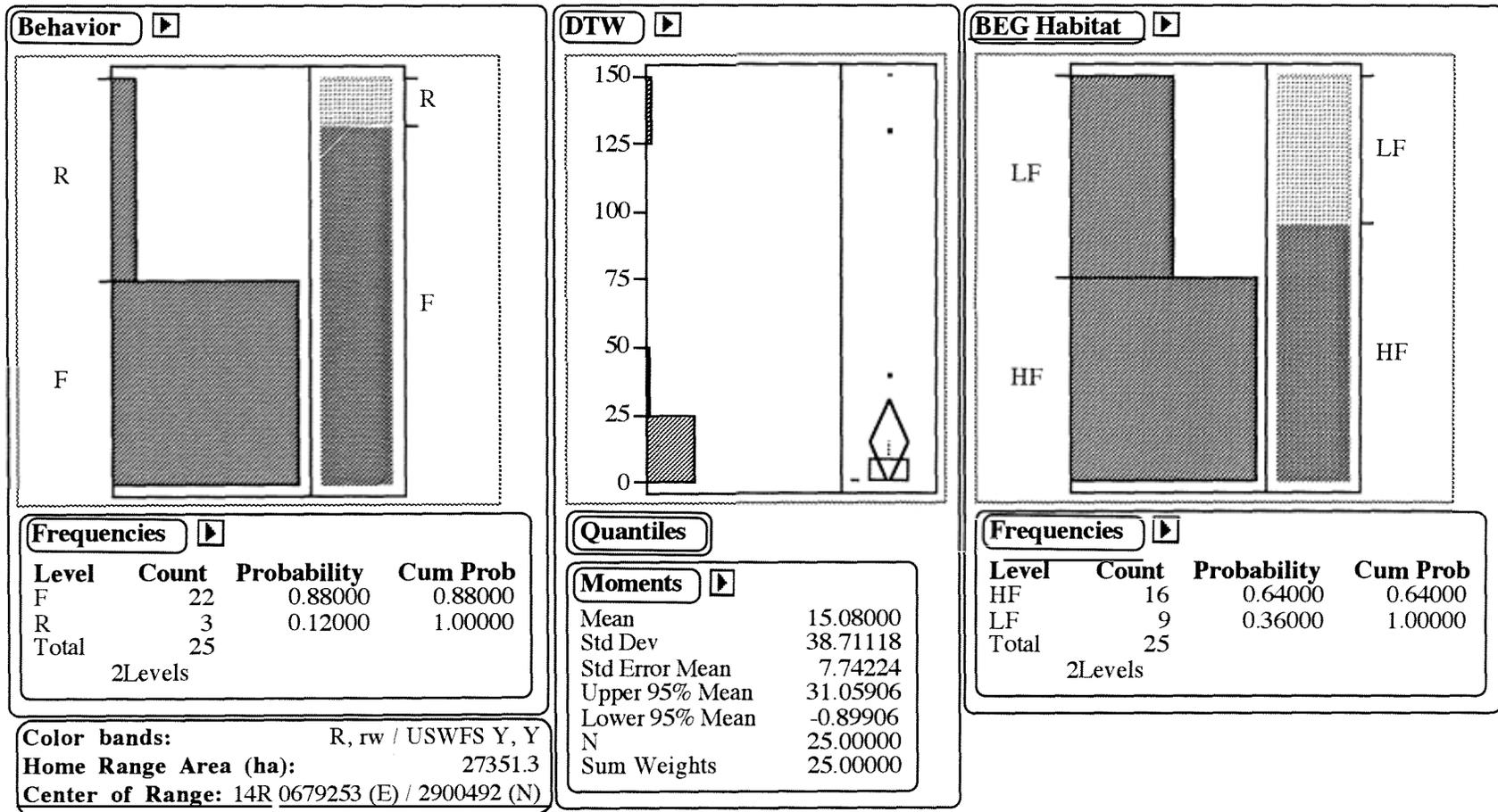
View 2  
Close-up of Relocation  
Cluster from View 1

500 0 500 Meters

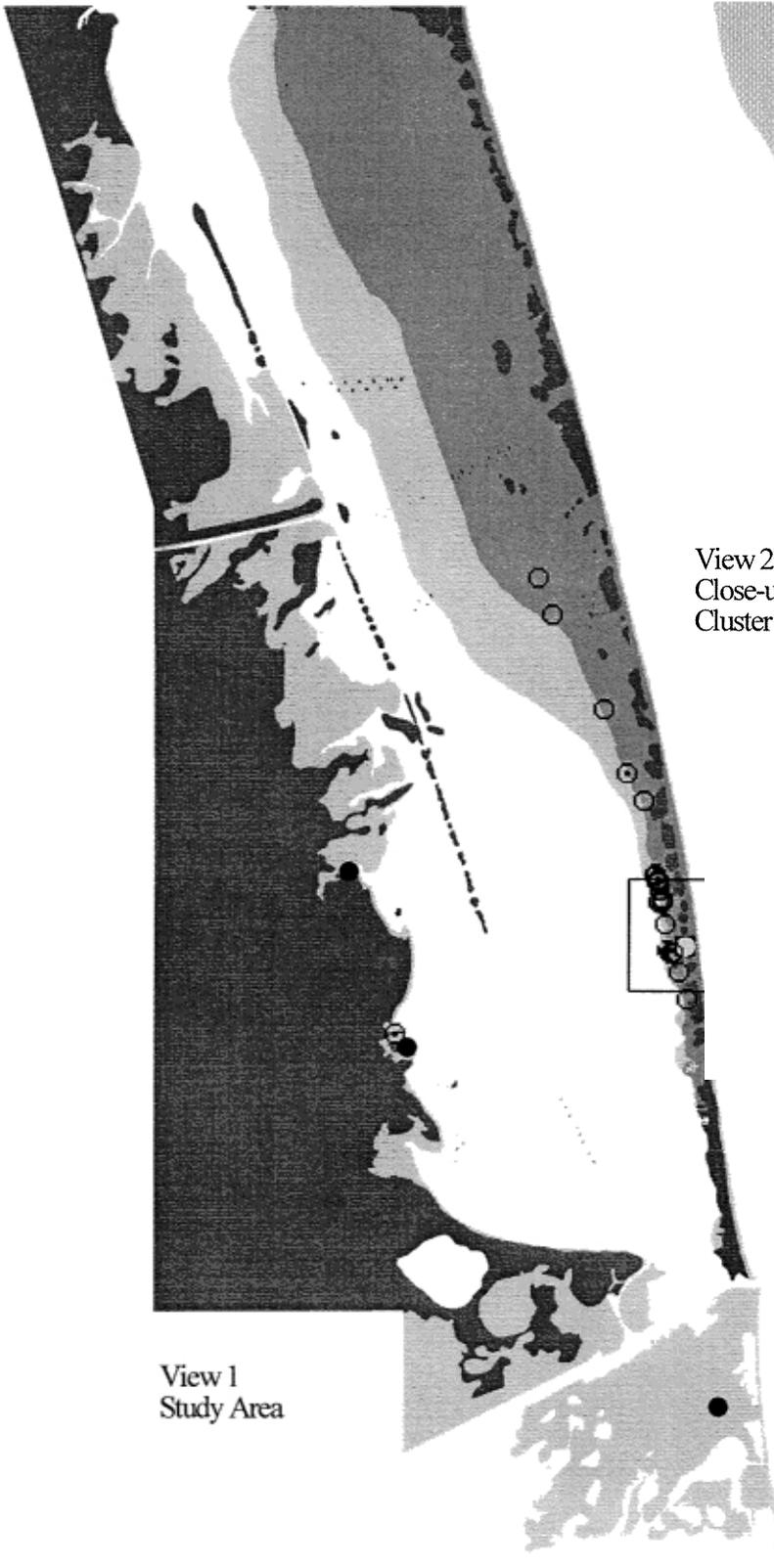
5 0 5 10 Kilometers



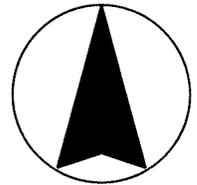
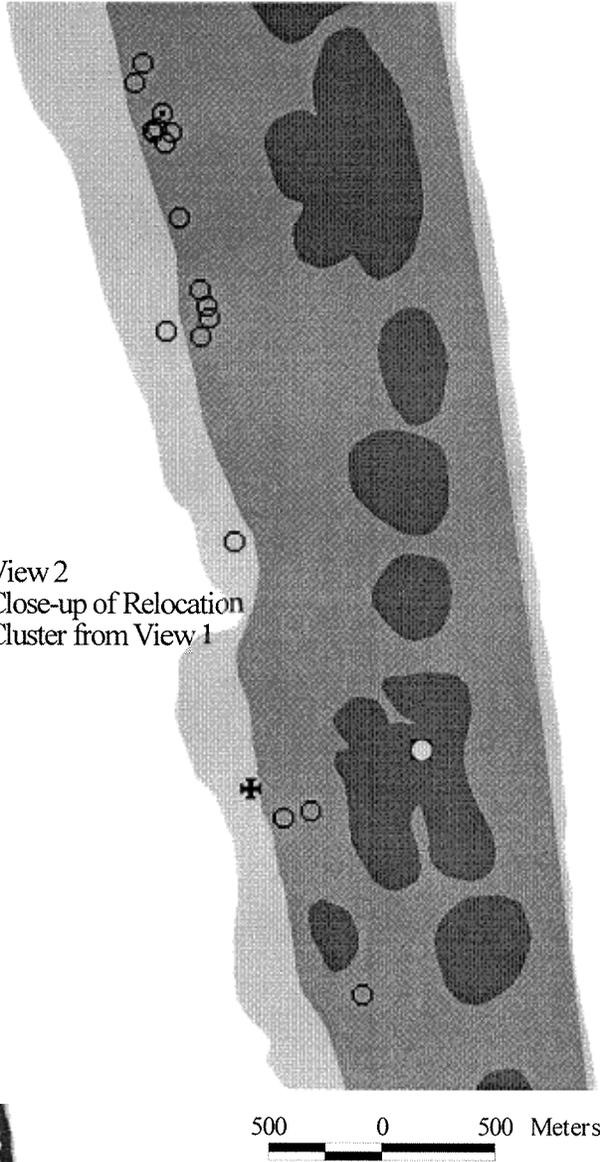
# Radiofrequency 861 (PIPL)



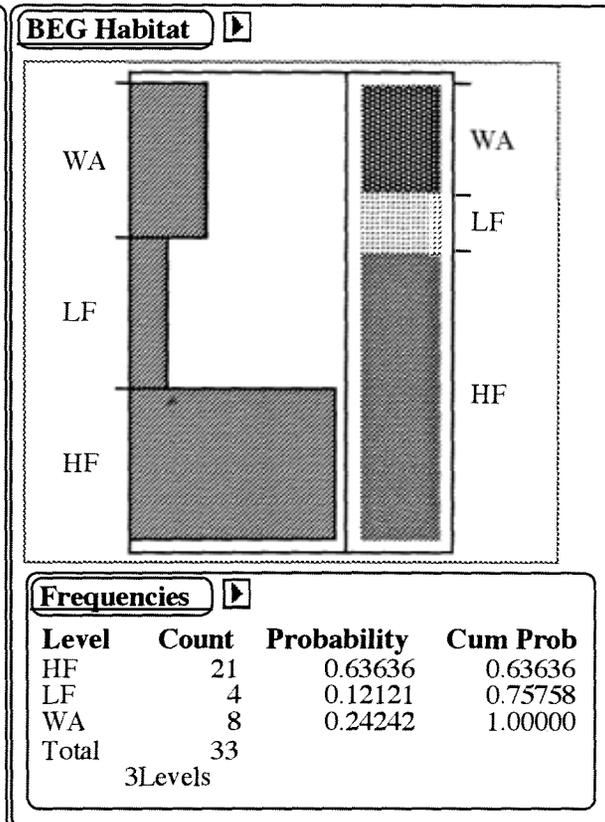
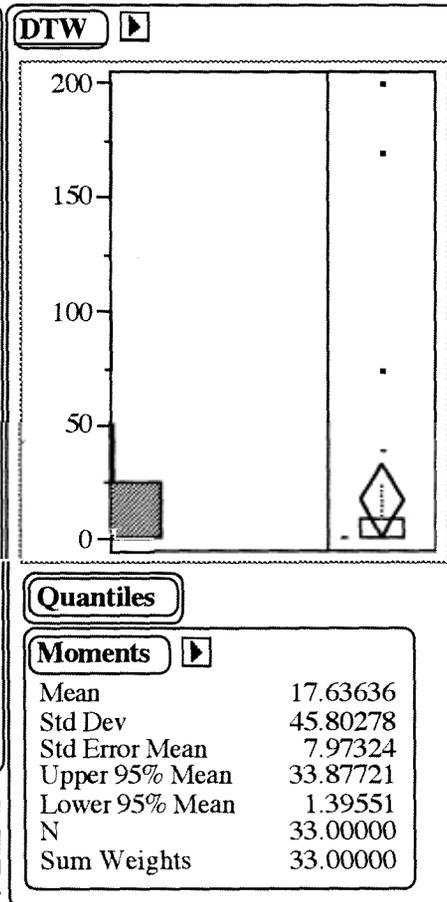
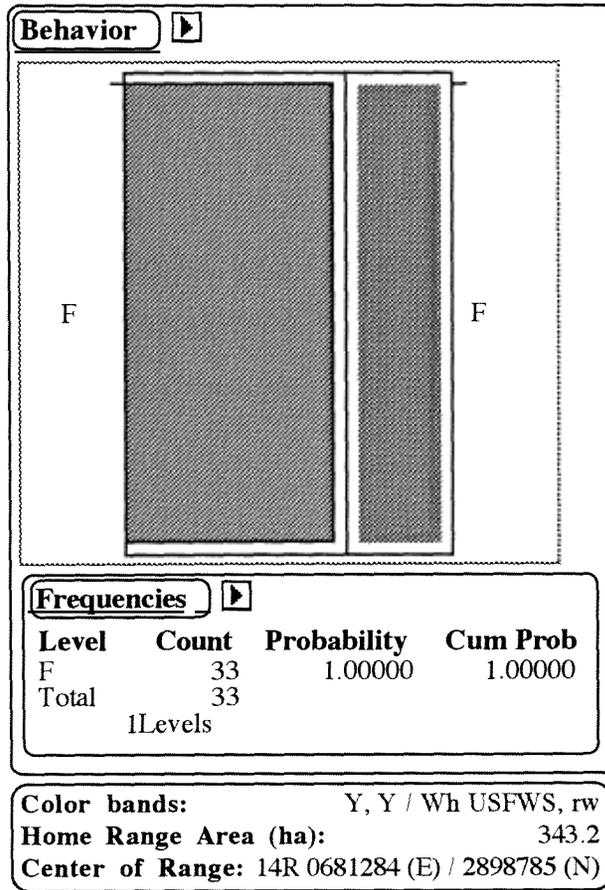
**Radiofrequency 871 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



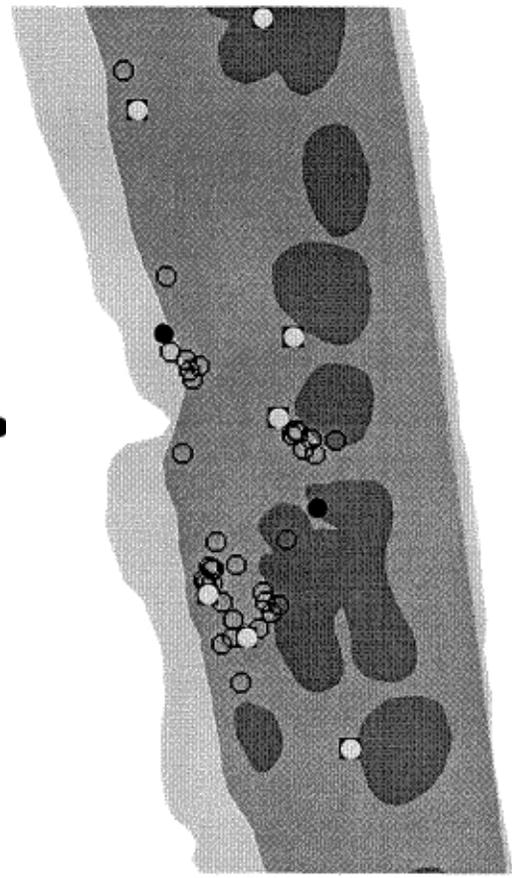
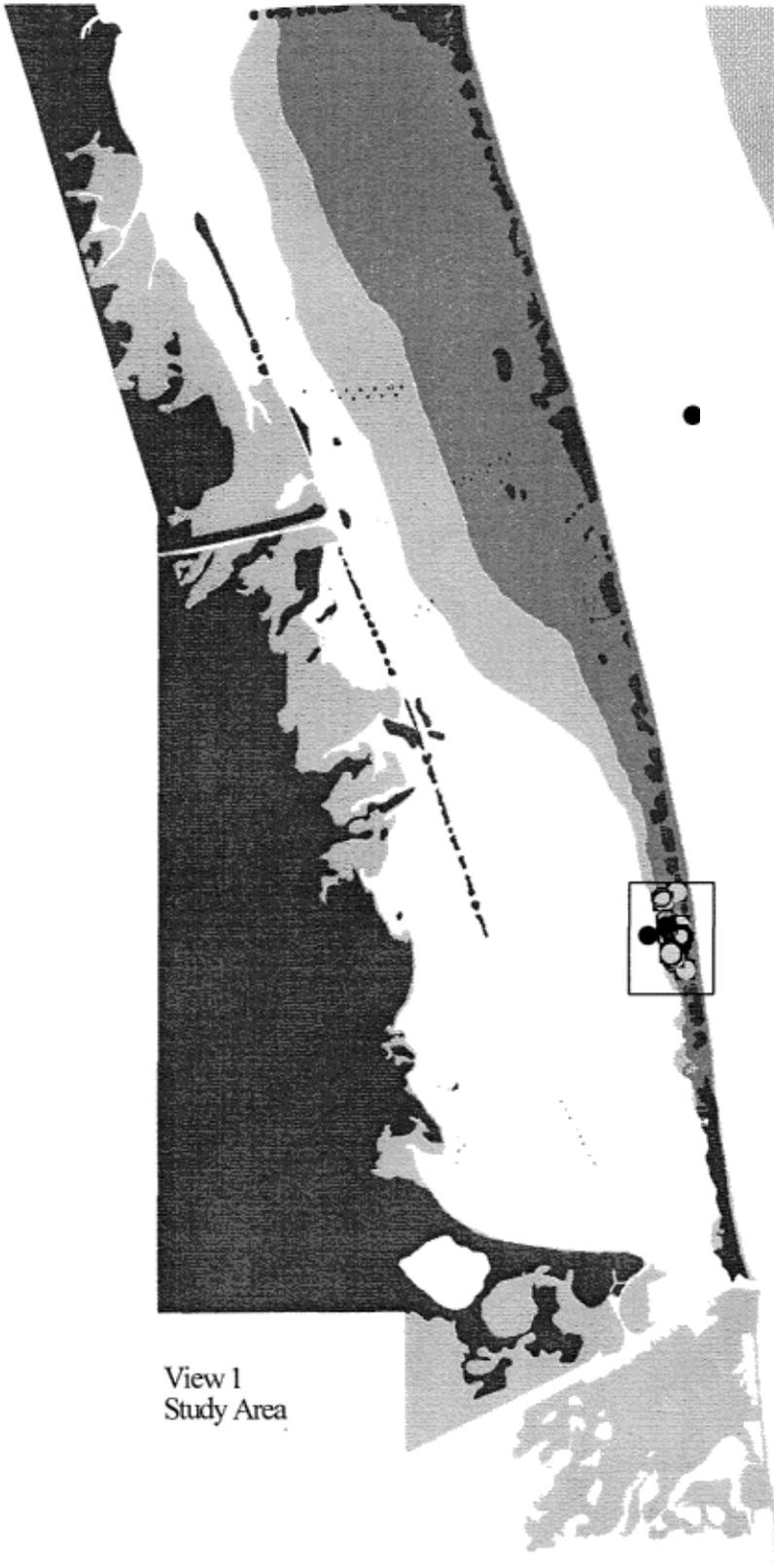
View 2  
Close-up of Relocation  
Cluster from View 1



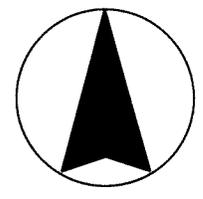
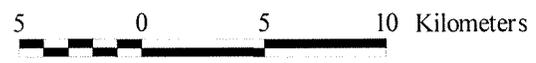
## Radiofrequency 871 (PIPL)



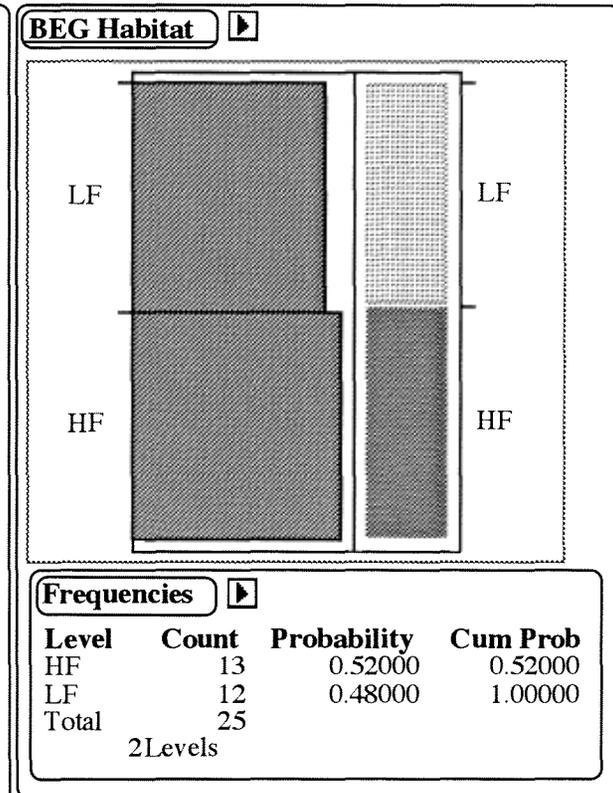
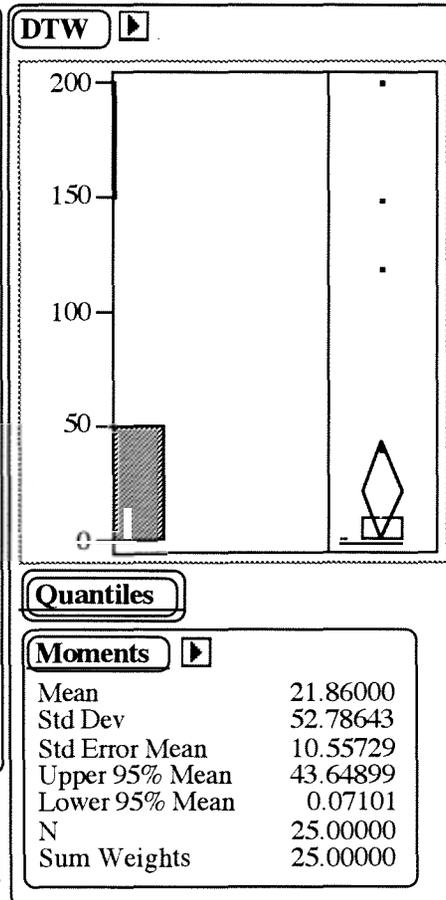
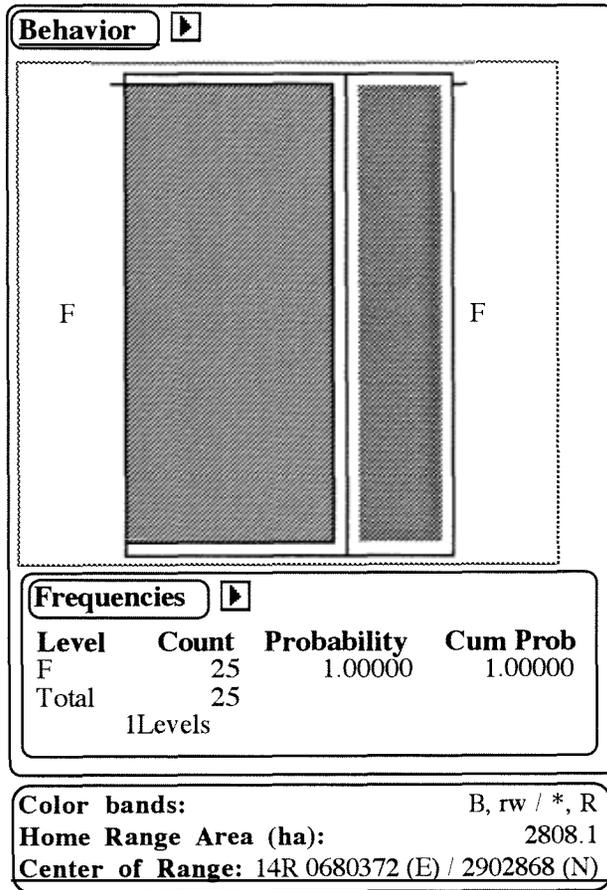
**Radiofrequency 882 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



View 2  
Close-up of Relocation  
Cluster from View 1



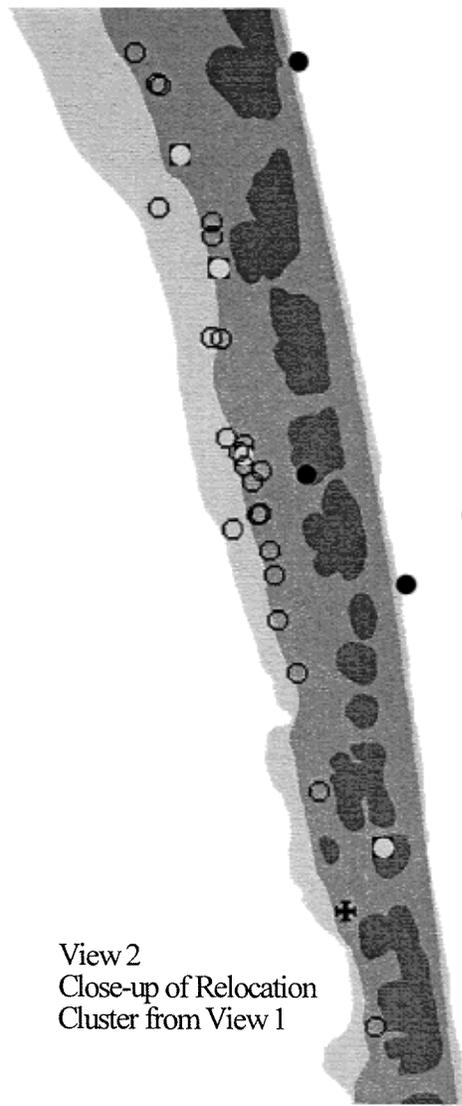
# Radiofrequency 882 (PIPL)



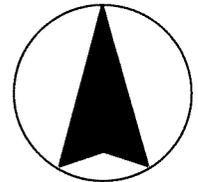
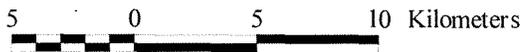
**Radiofrequency 891 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



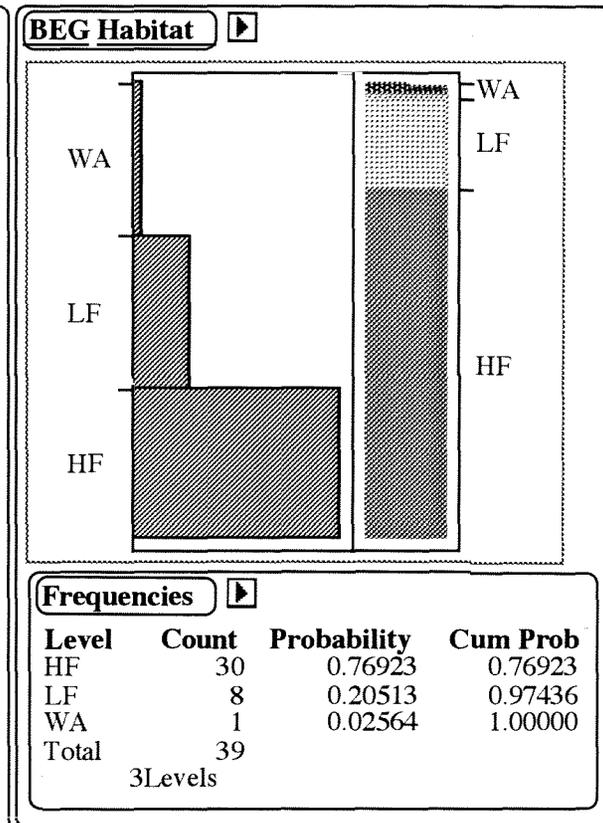
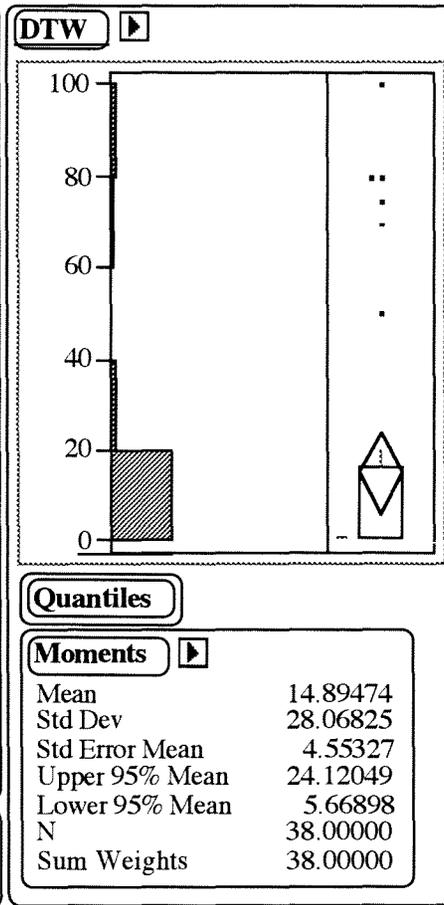
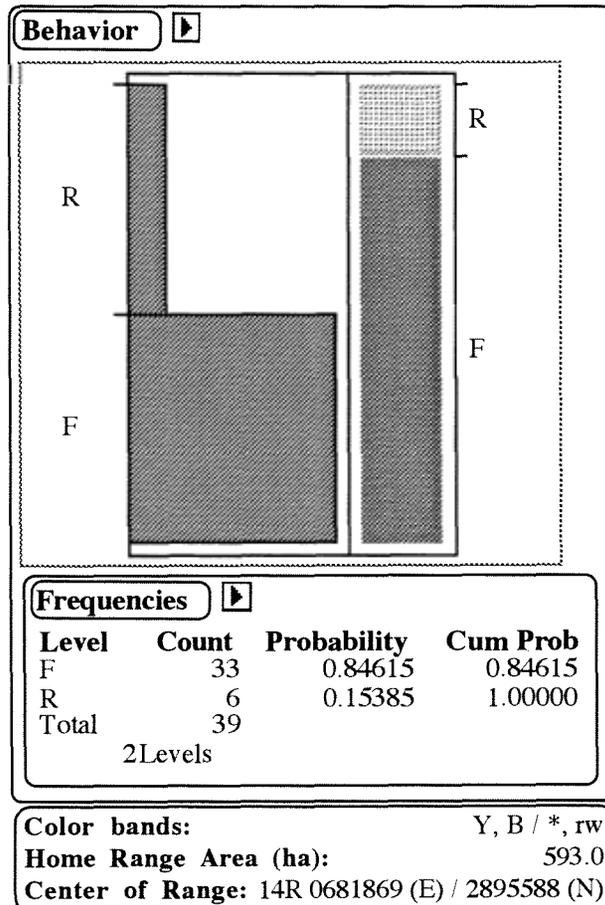
View 1  
Study Area



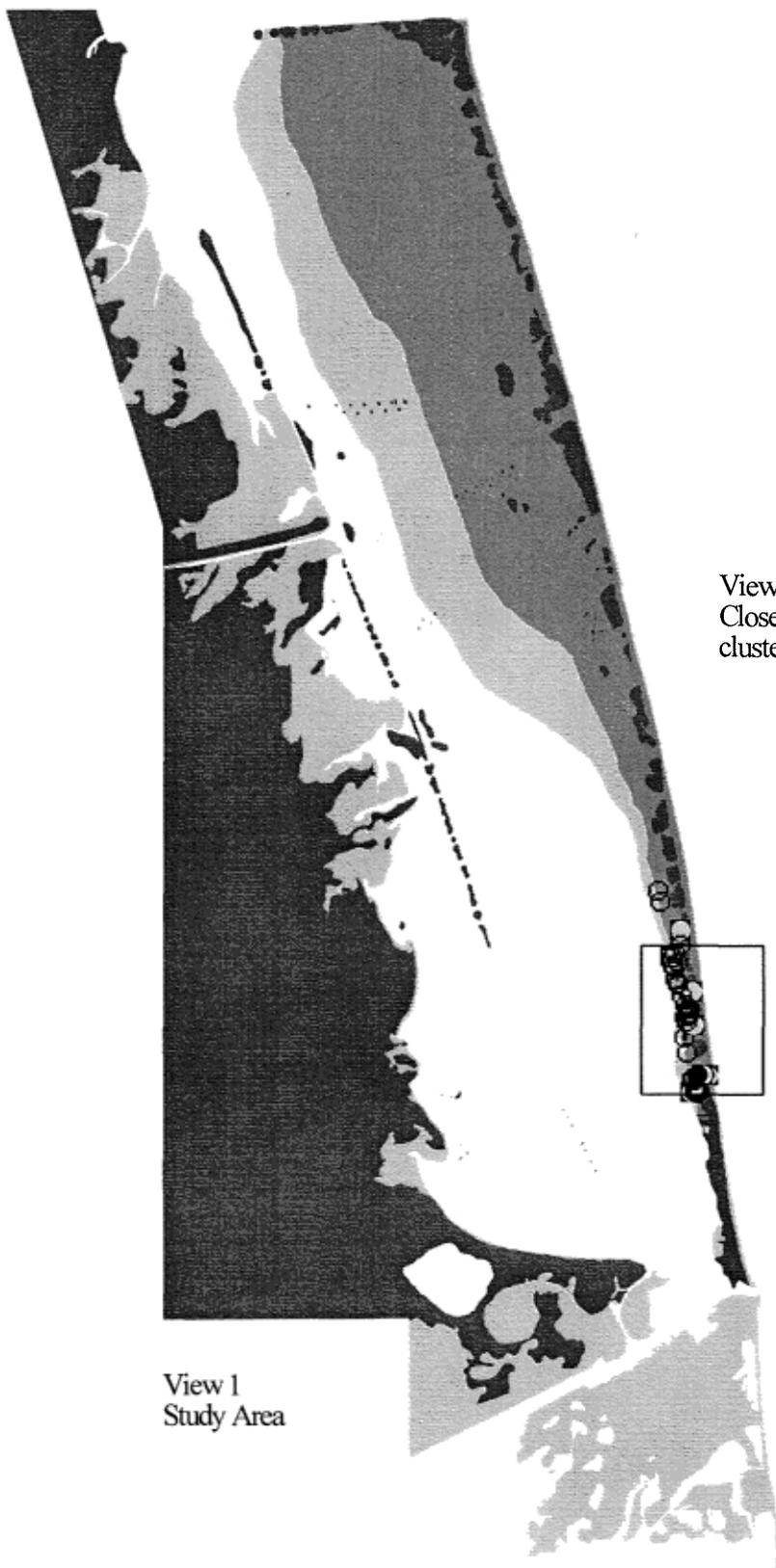
View 2  
Close-up of Relocation  
Cluster from View 1



## Radiofrequency 891 (PIPL)



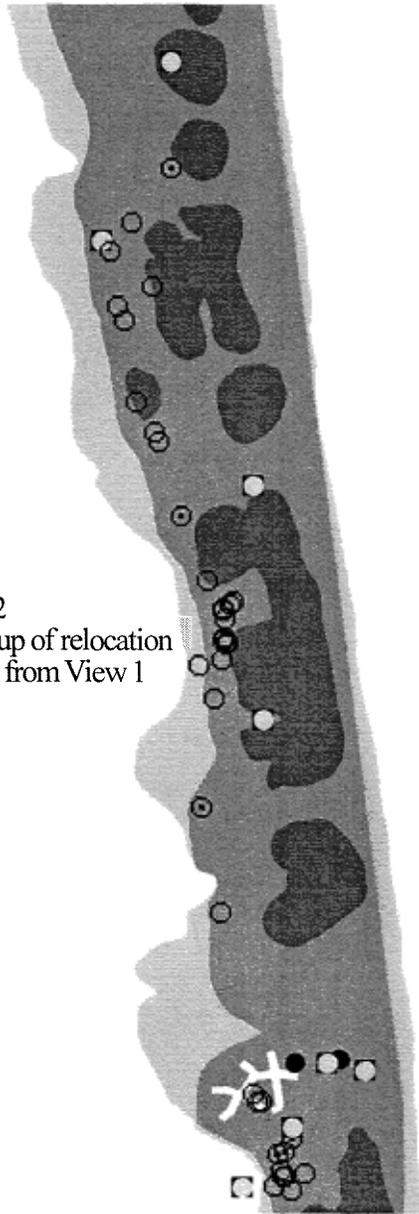
**Radiofrequency 901 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



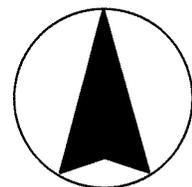
View 1  
Study Area

5 0 5 10 15 20 Kilometers

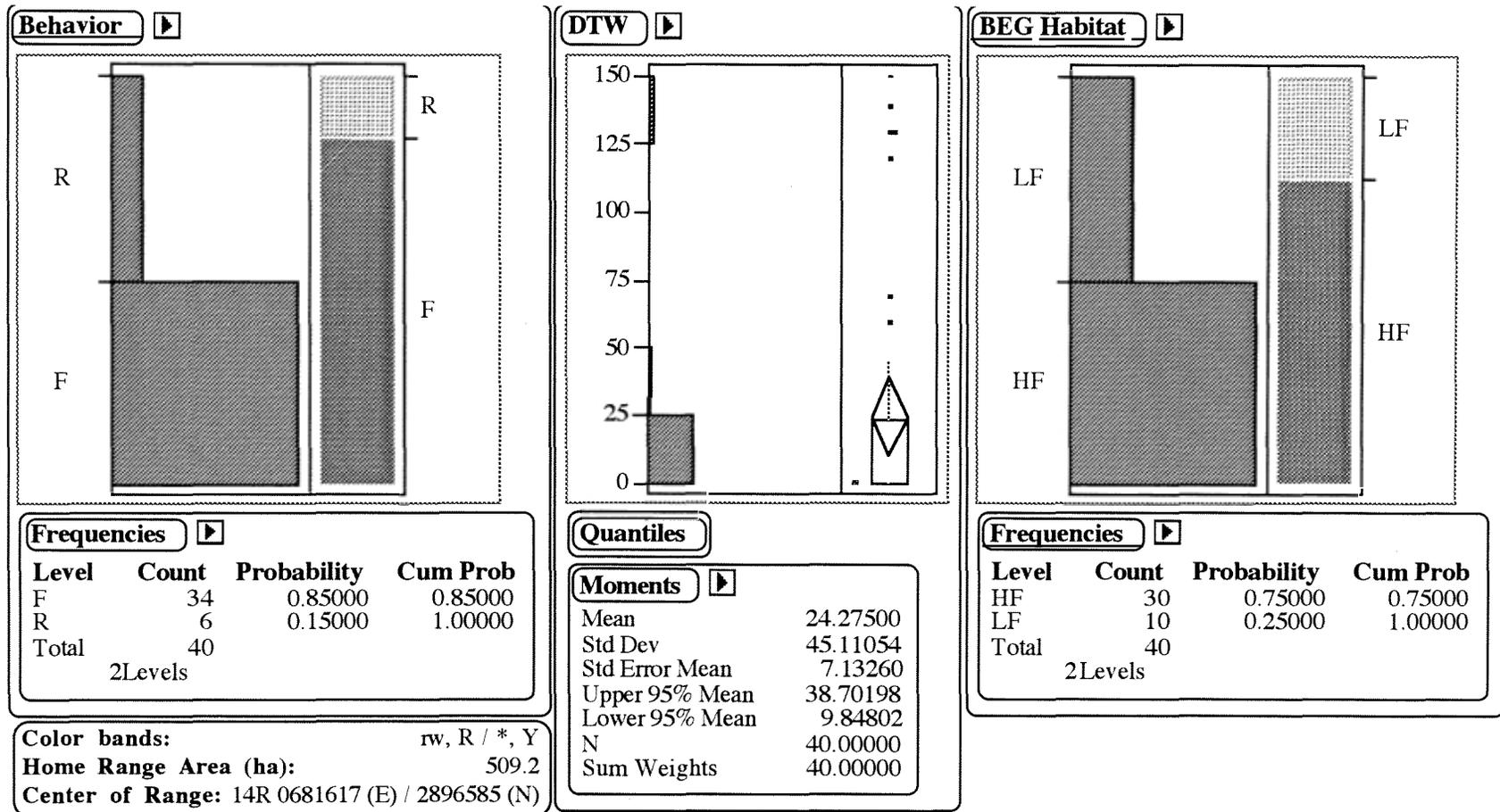
View 2  
Close-up of relocation  
cluster from View 1



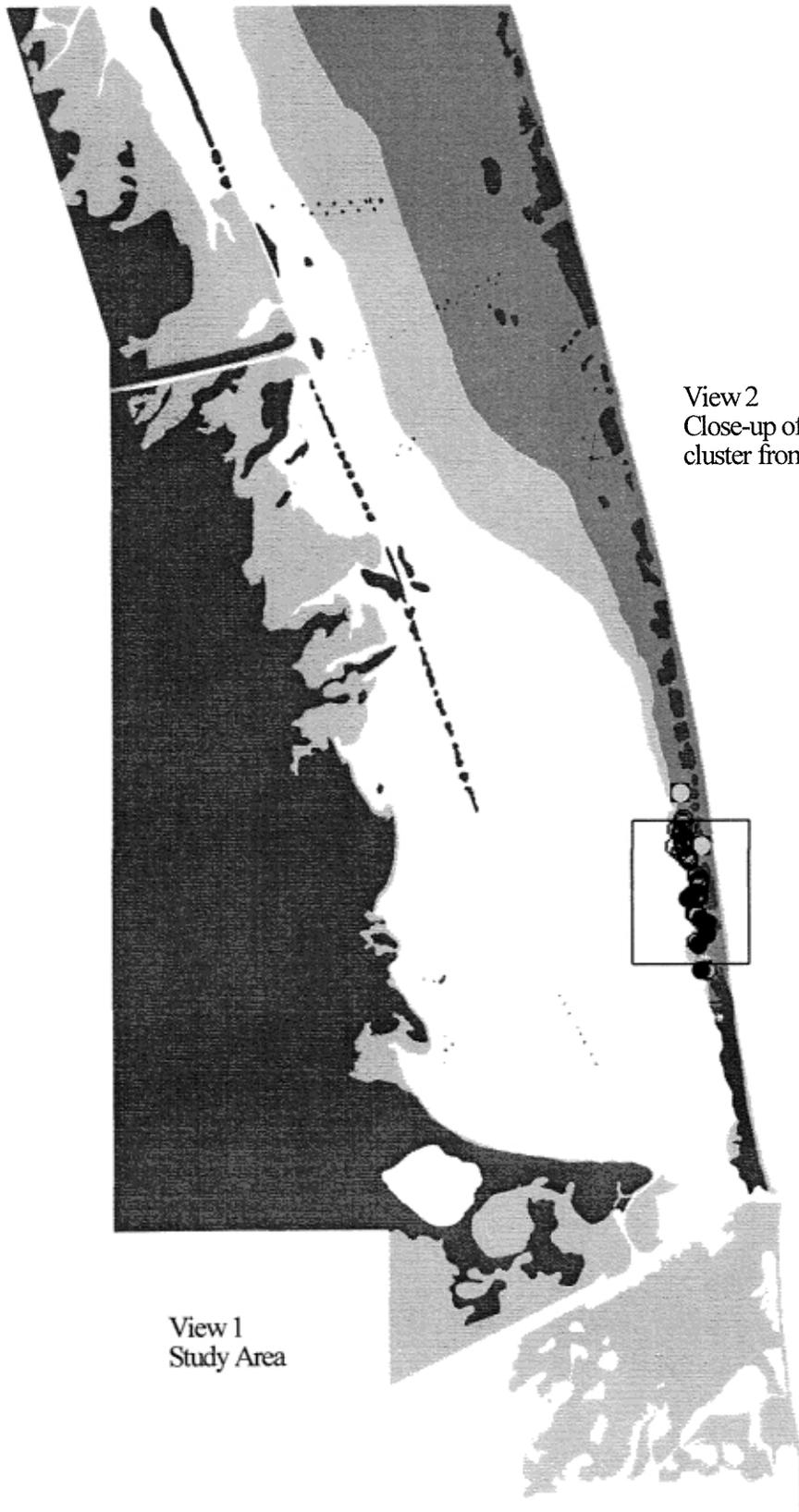
500 0 500 1000 Meters



**Radiofrequency 901 (PIPL)**

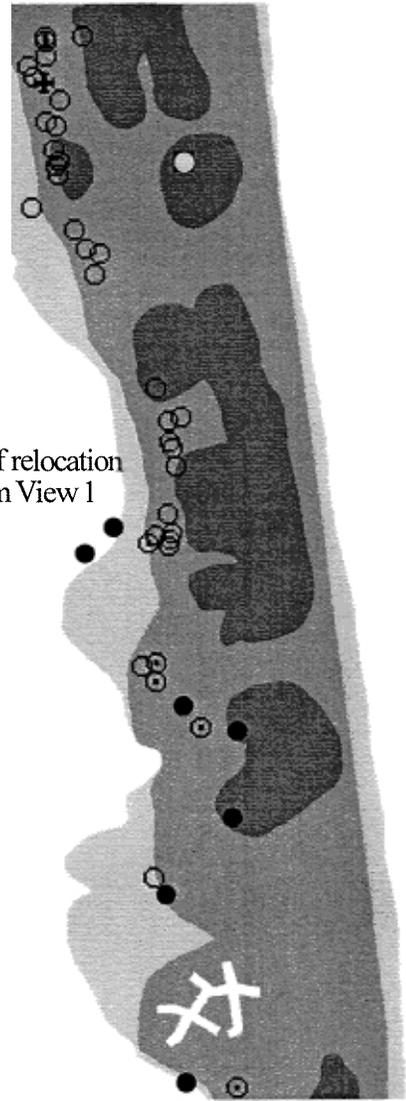


**Radiofrequency 919 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



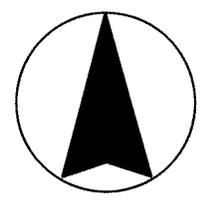
View 1  
Study Area

5 0 5 10 Kilometers

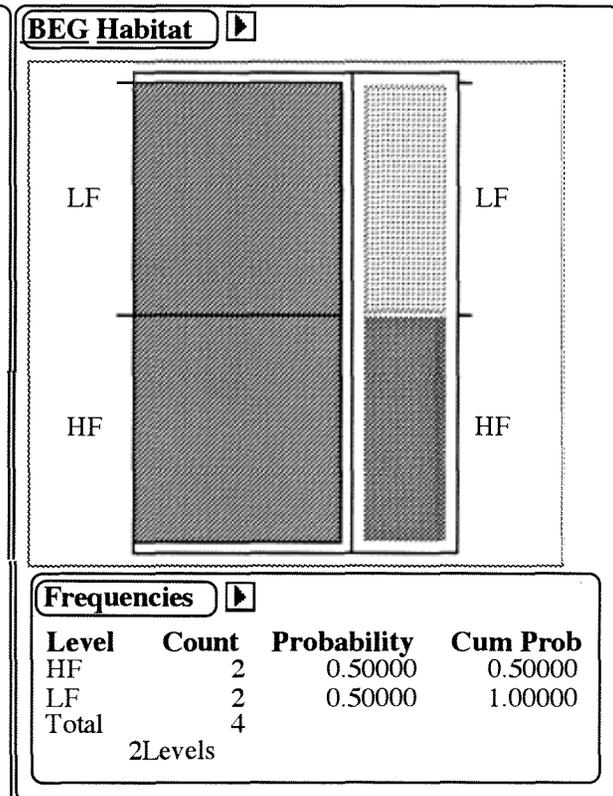
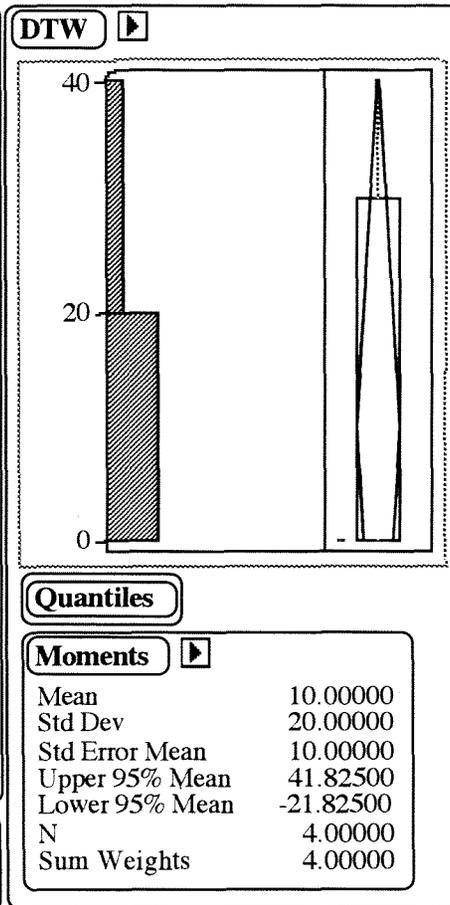
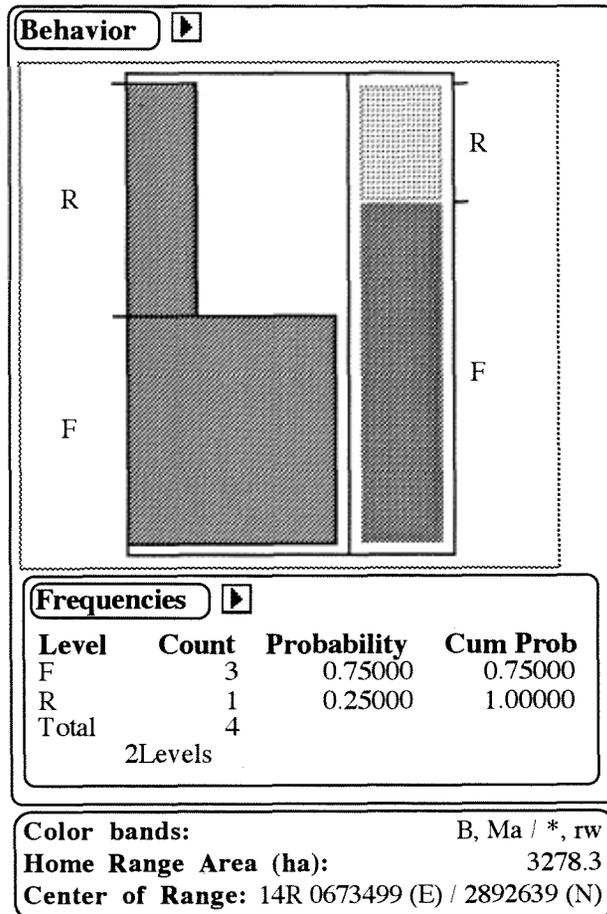


View 2  
Close-up of relocation  
cluster from View 1

500 0 500 Meters



# Radiofrequency 919 (PIPL)



**Radiofrequency 924 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.

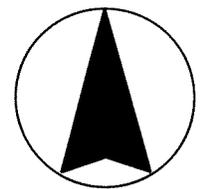


View 1  
Study Area

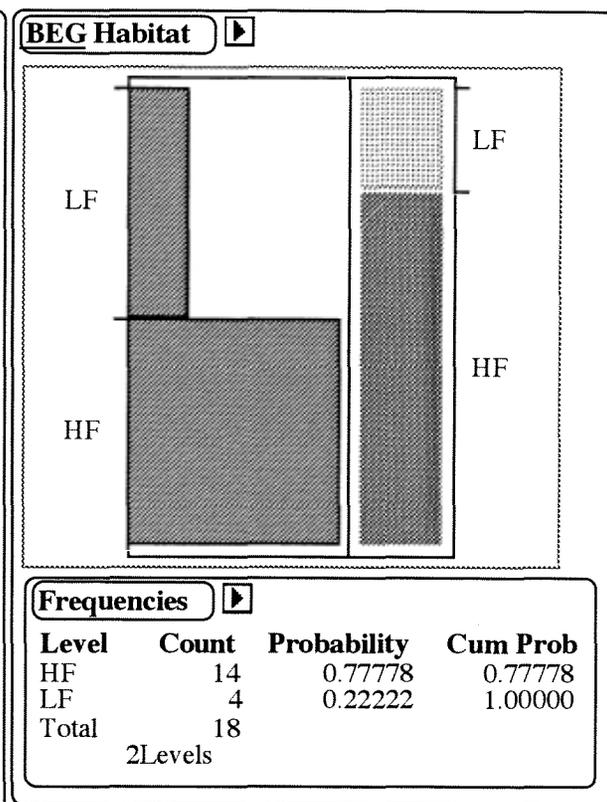
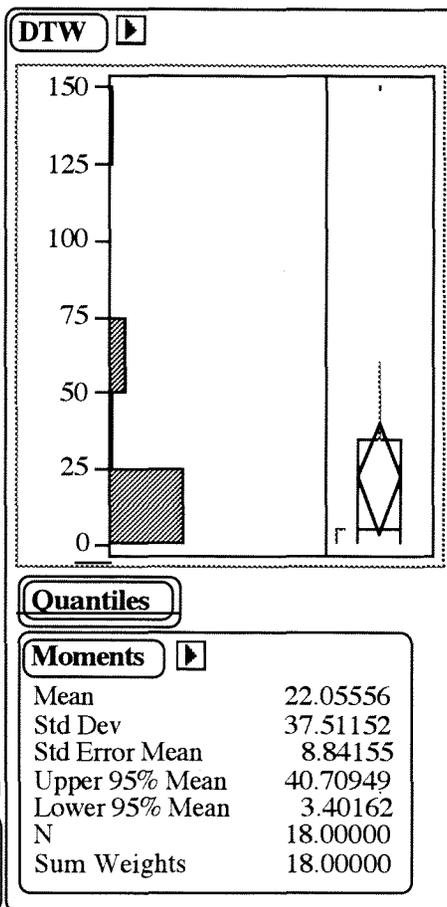
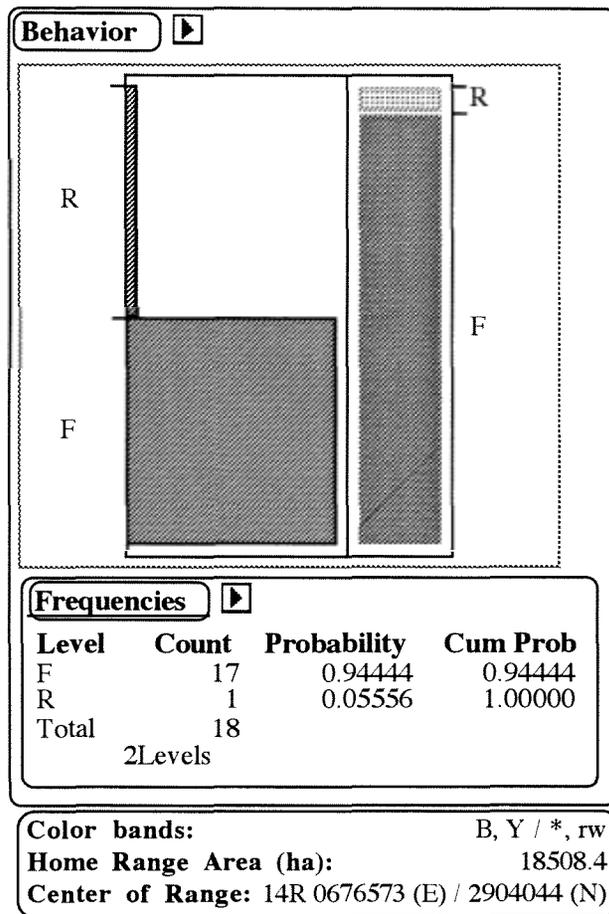
View 2  
Close-up of relocation  
cluster from View 1

1 0 1 2 3 Kilometers

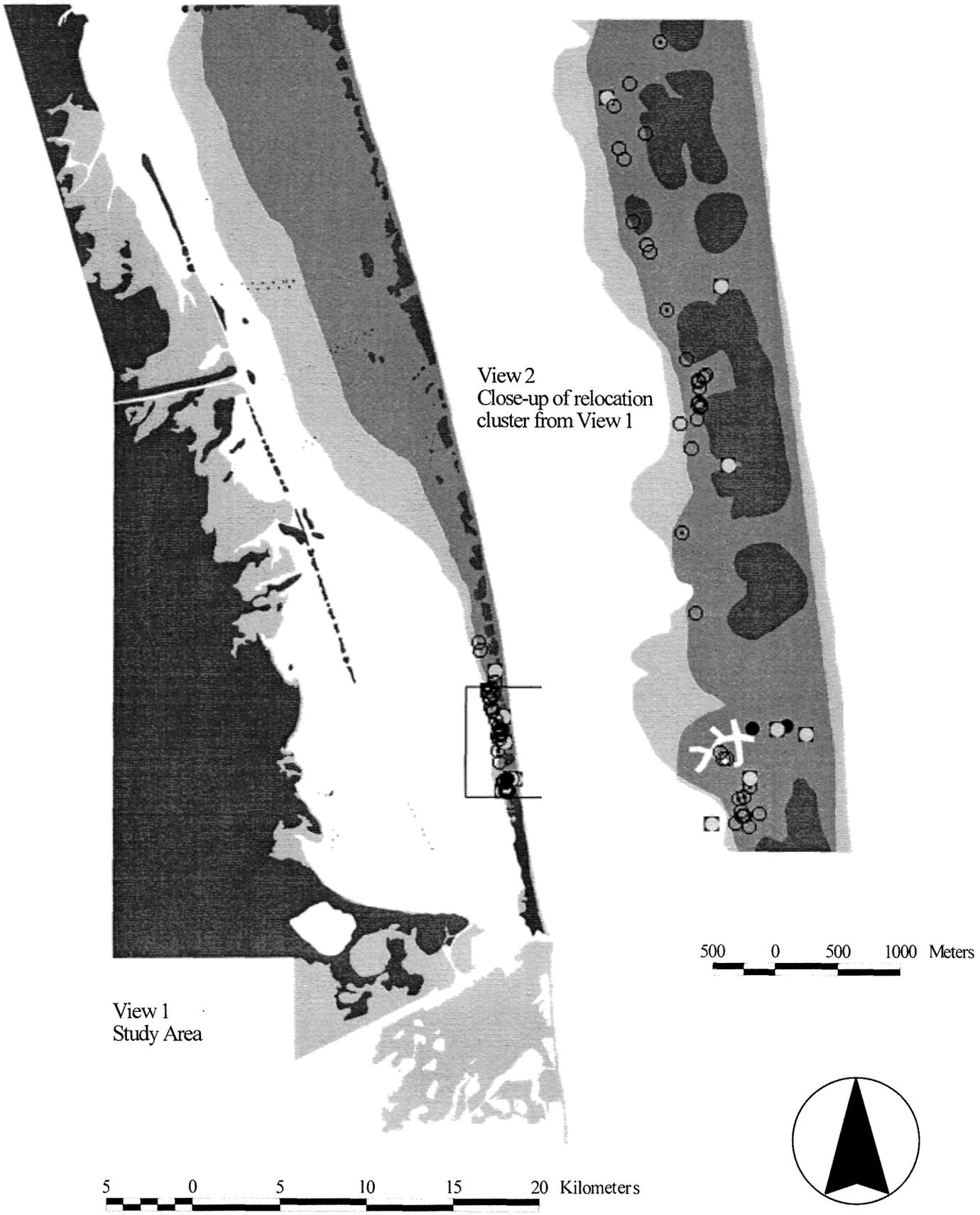
5 0 5 10 15 20 Kilometers



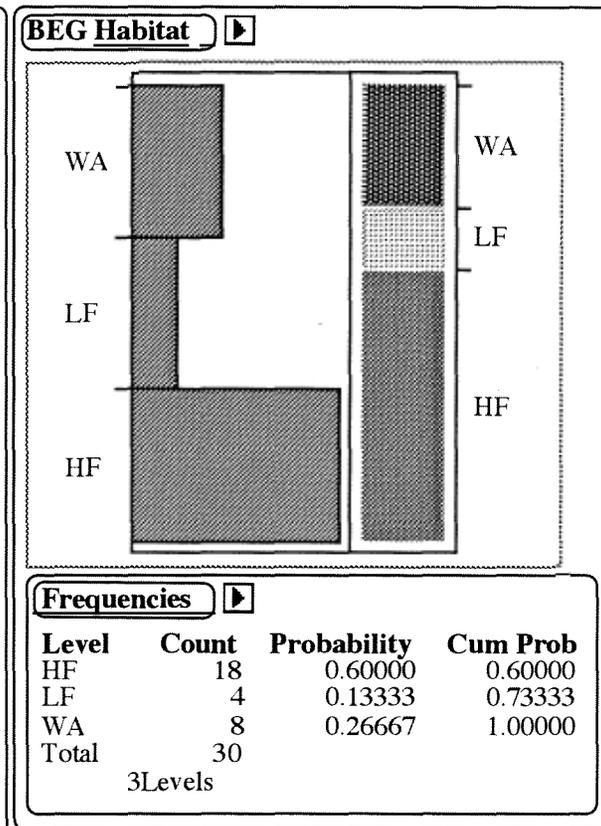
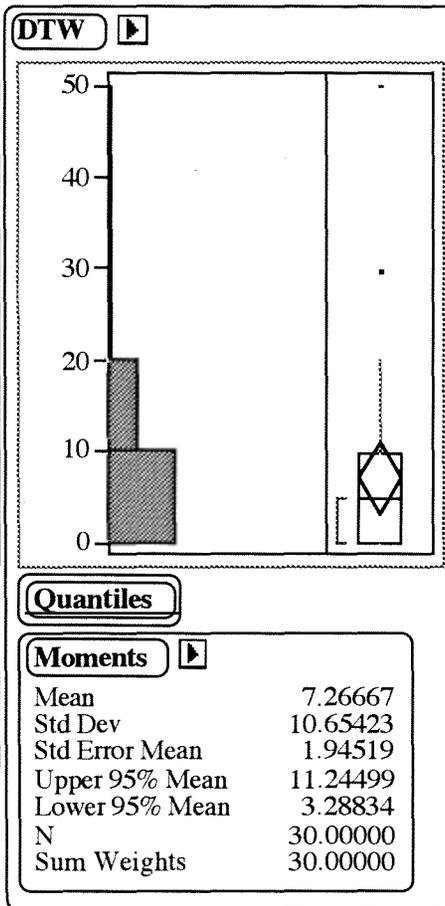
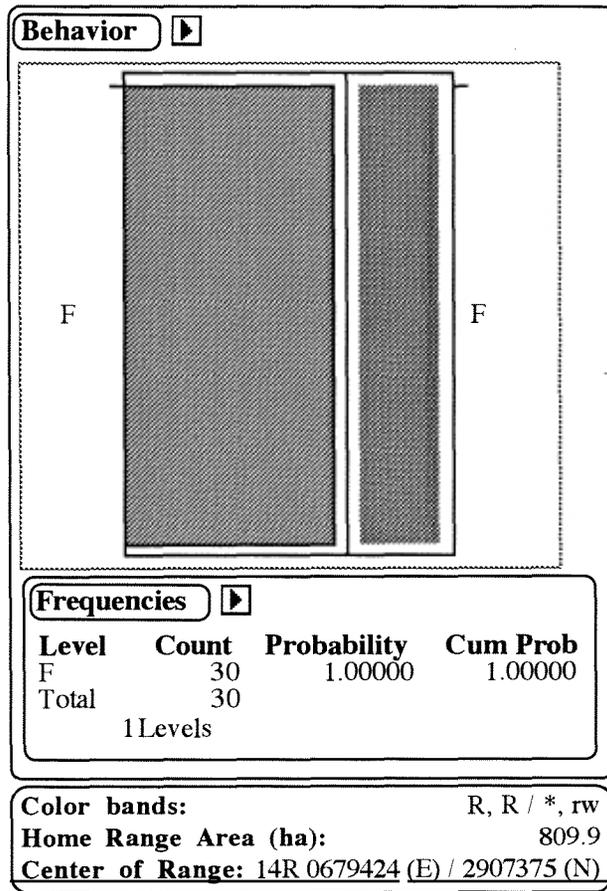
# Radiofrequency 924 (PIPL)



**Radiofrequency 942 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



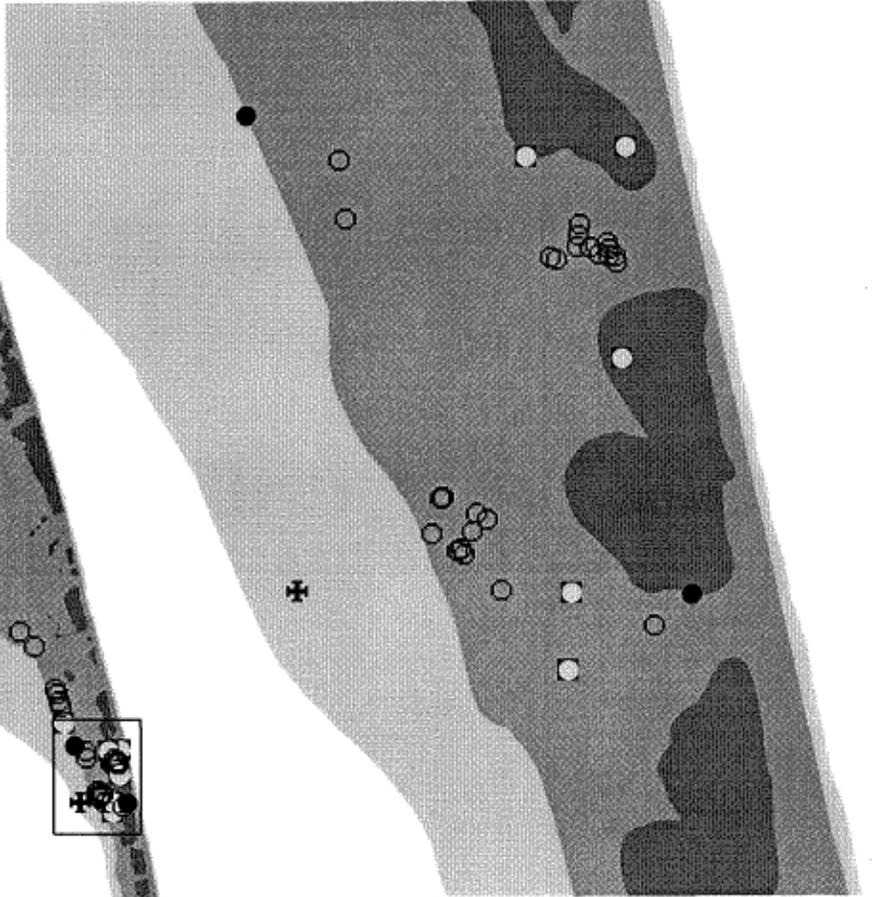
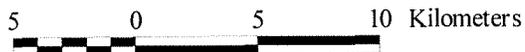
**Radiofrequency 942 (PIPL)**



**Radiofrequency 961 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



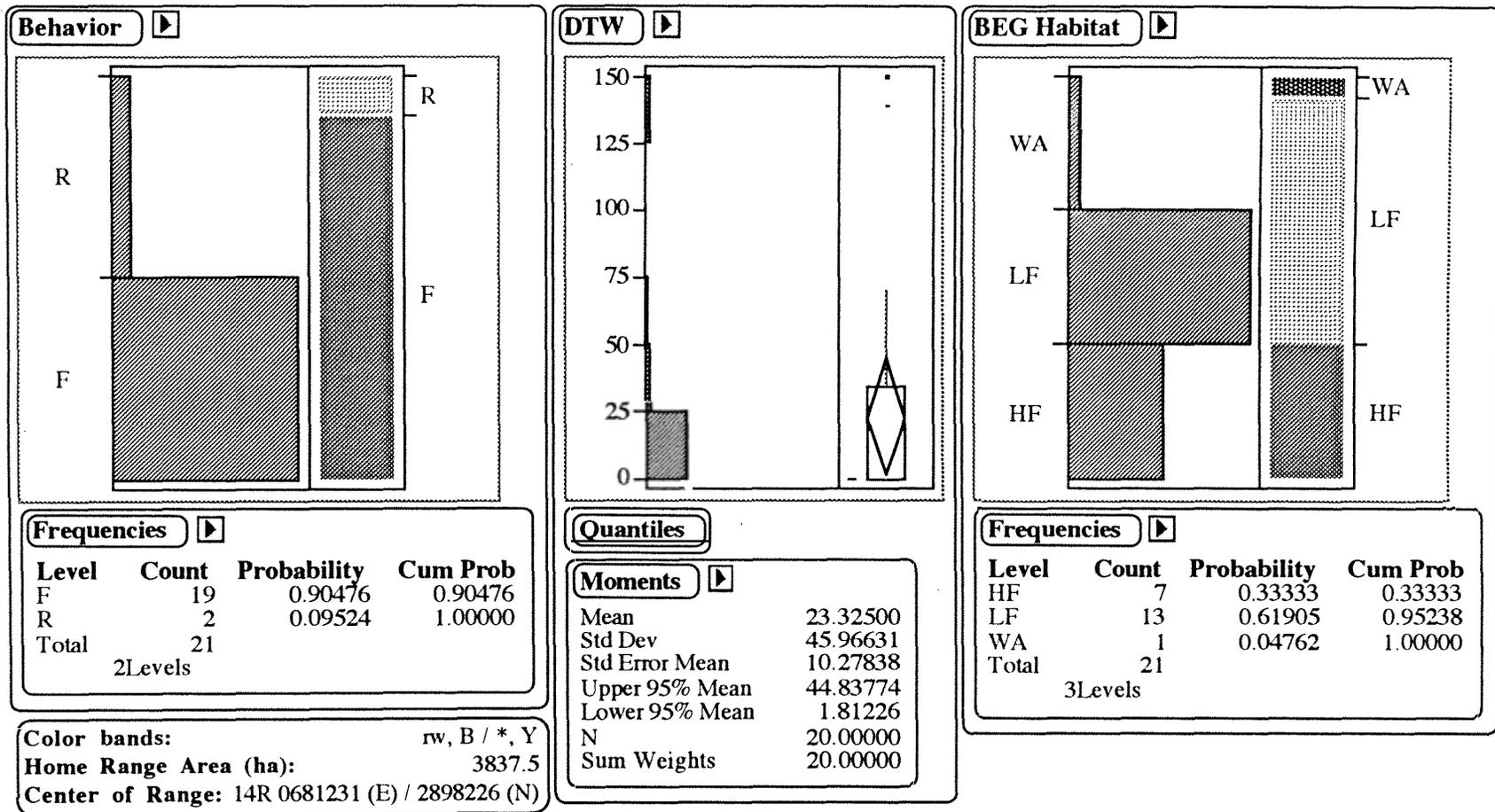
View 1  
Study Area



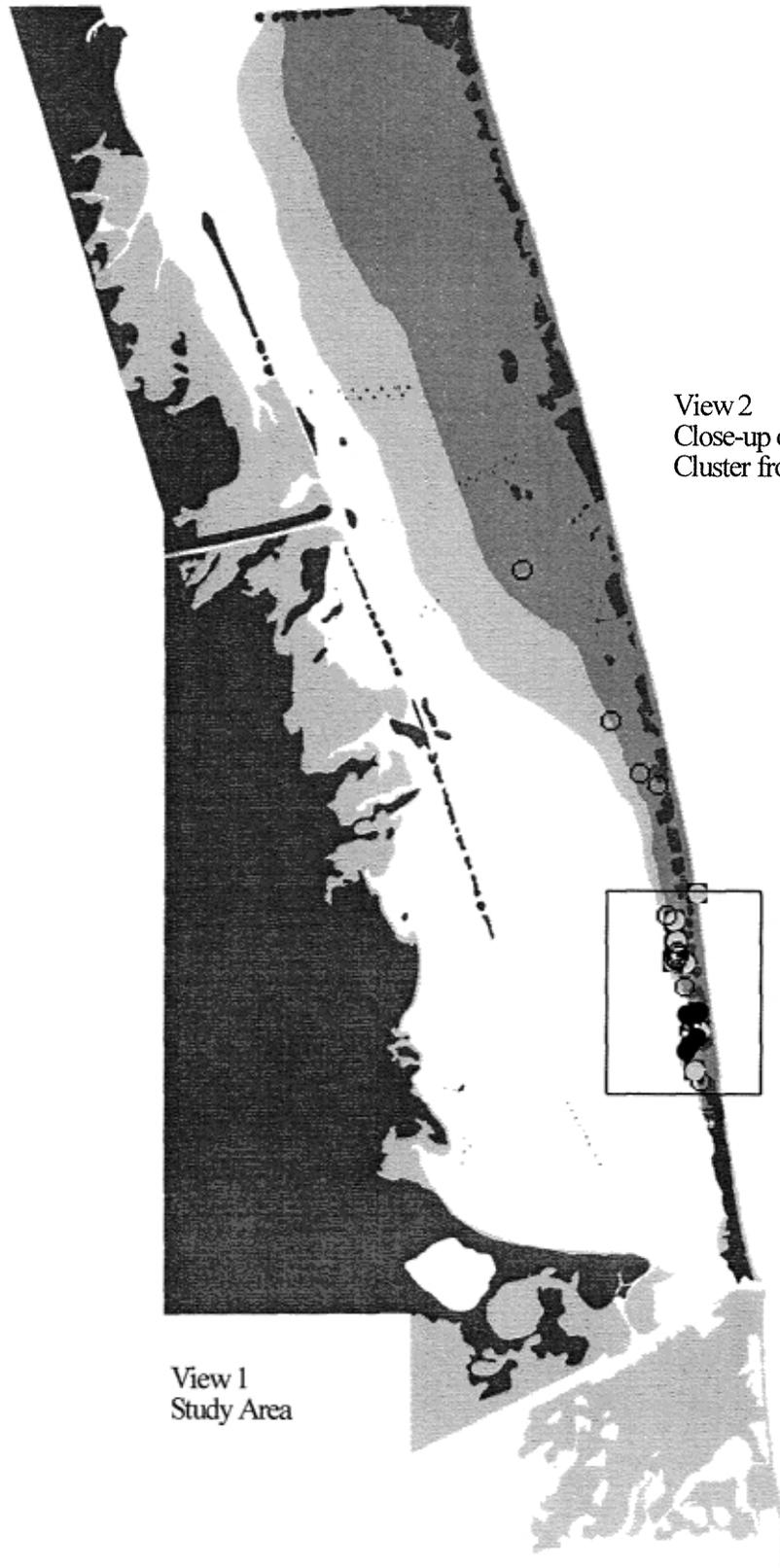
View 2  
Close-up of Relocation  
Cluster from View 1



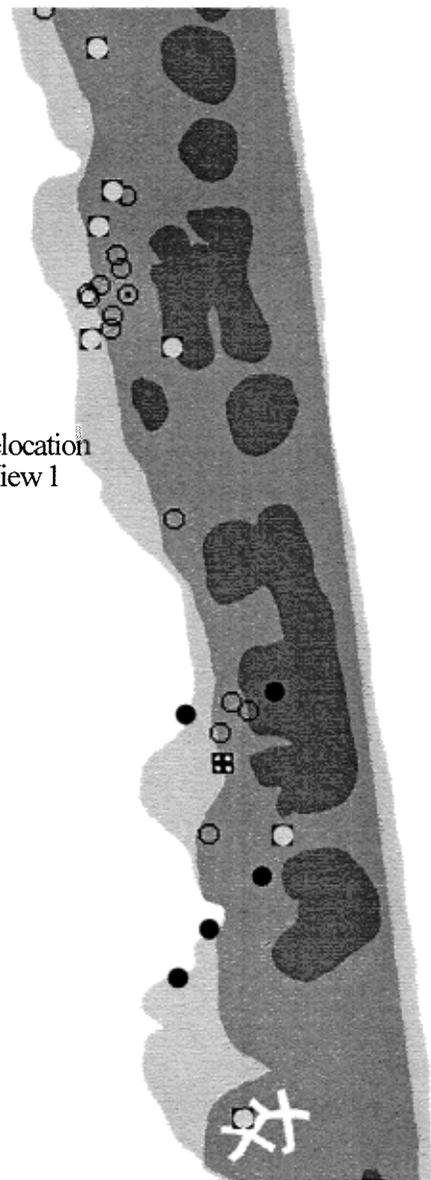
## Radiofrequency 961 (PIPL)



**Radiofrequency 965 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.

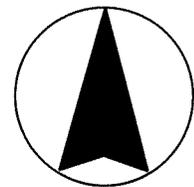


View 2  
Close-up of Relocation  
Cluster from View 1

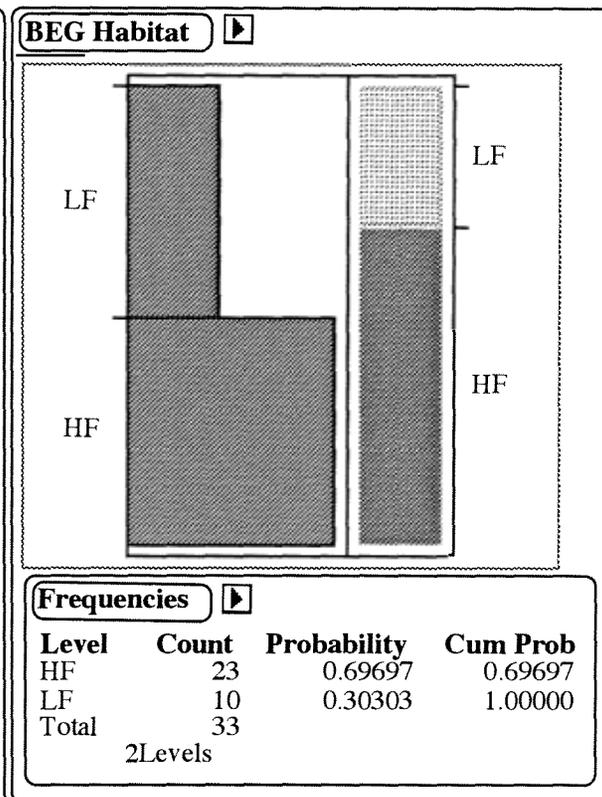
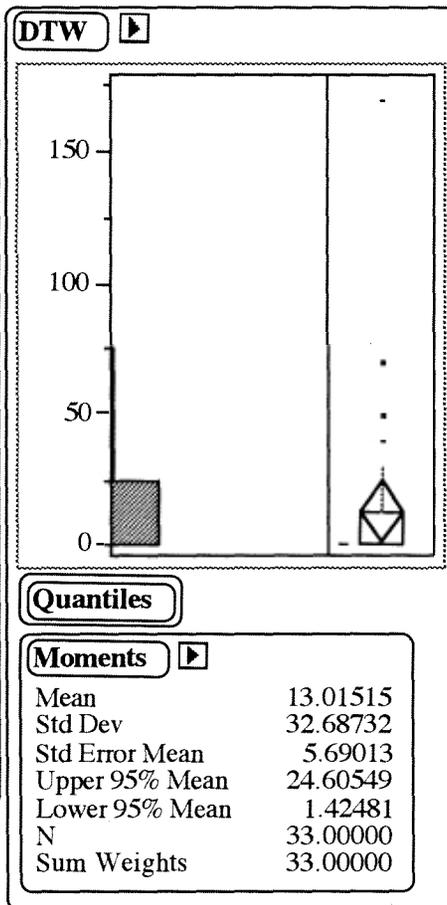
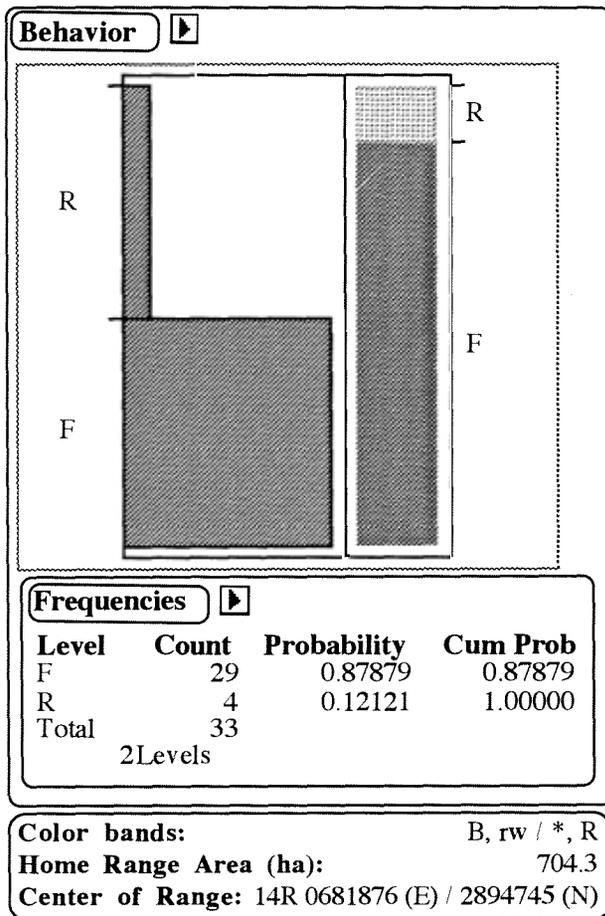


500 0 500 1000 1500 2000 Meters

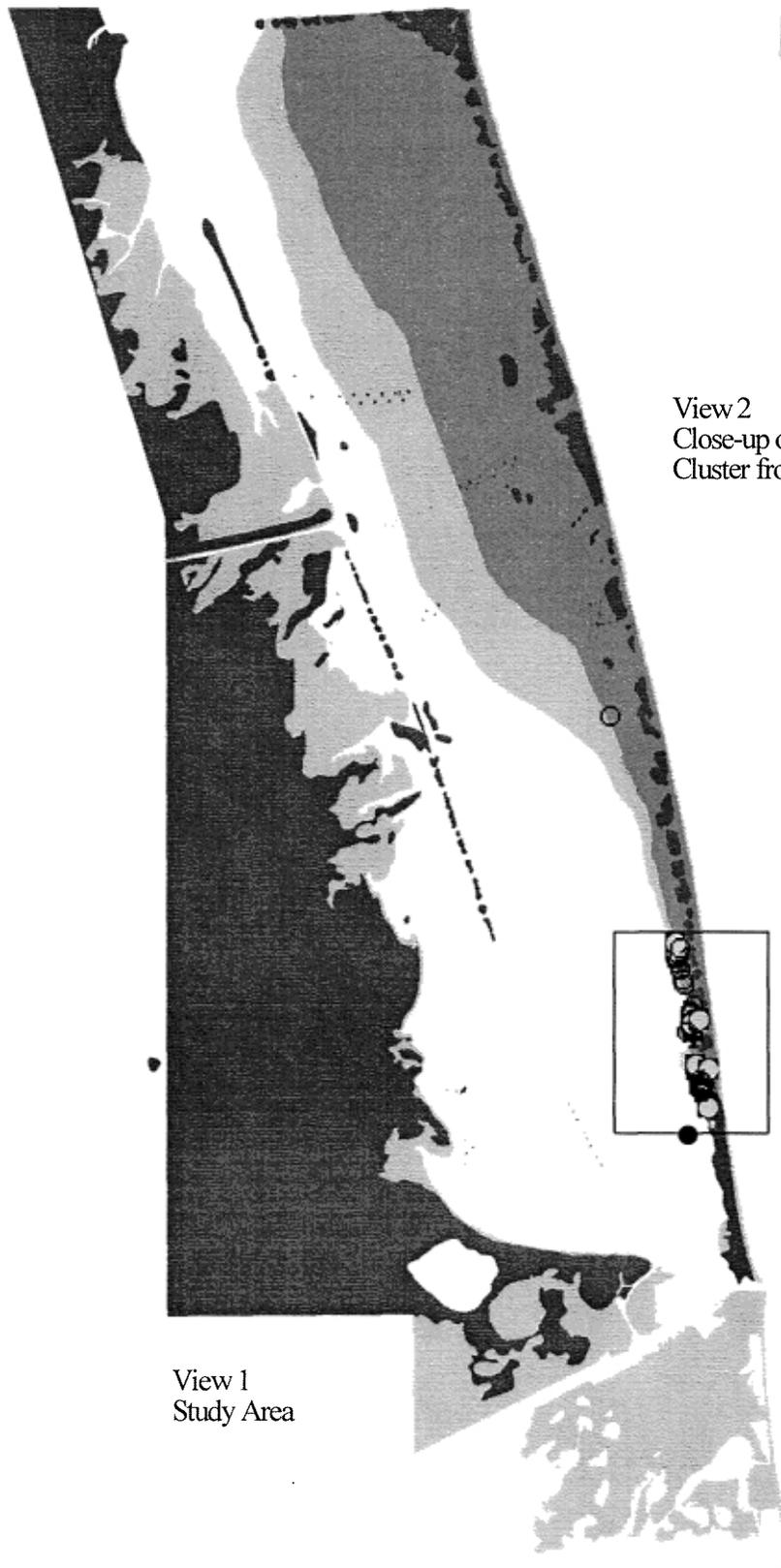
5 0 5 10 Kilometers



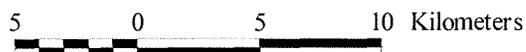
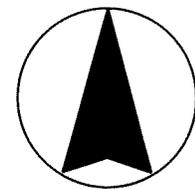
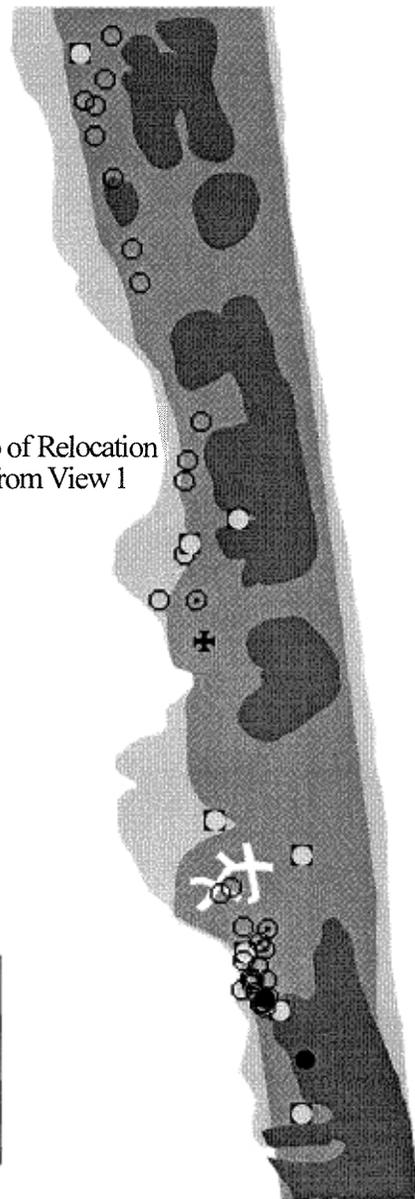
**Radiofrequency 965 (PIPL)**



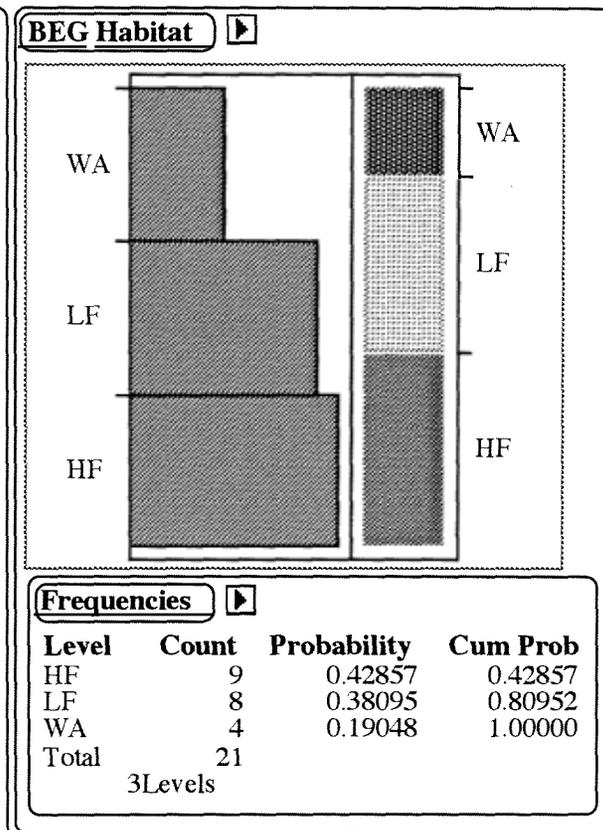
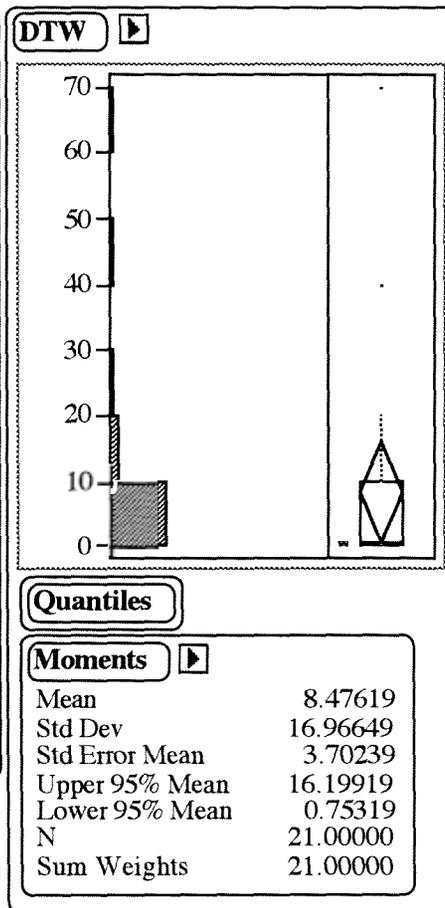
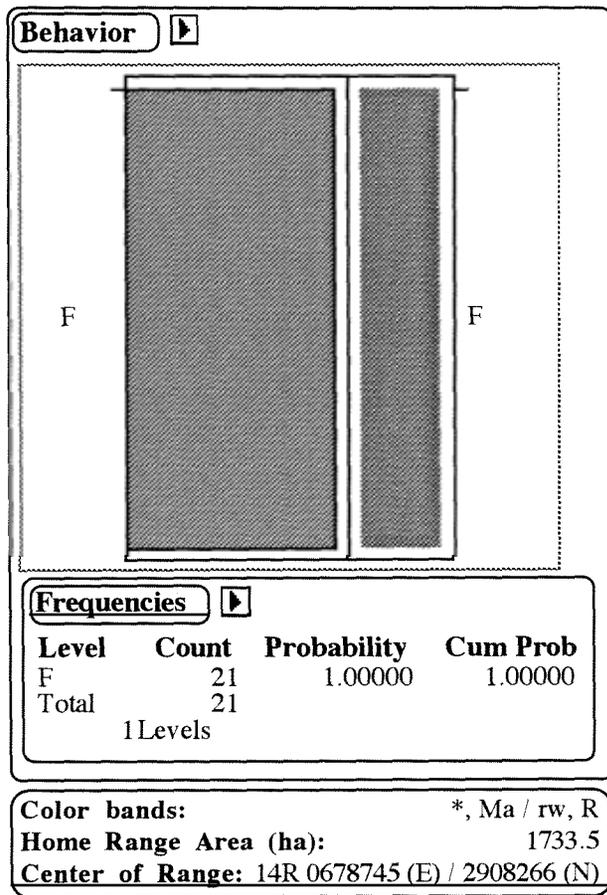
**Radiofrequency 981 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.



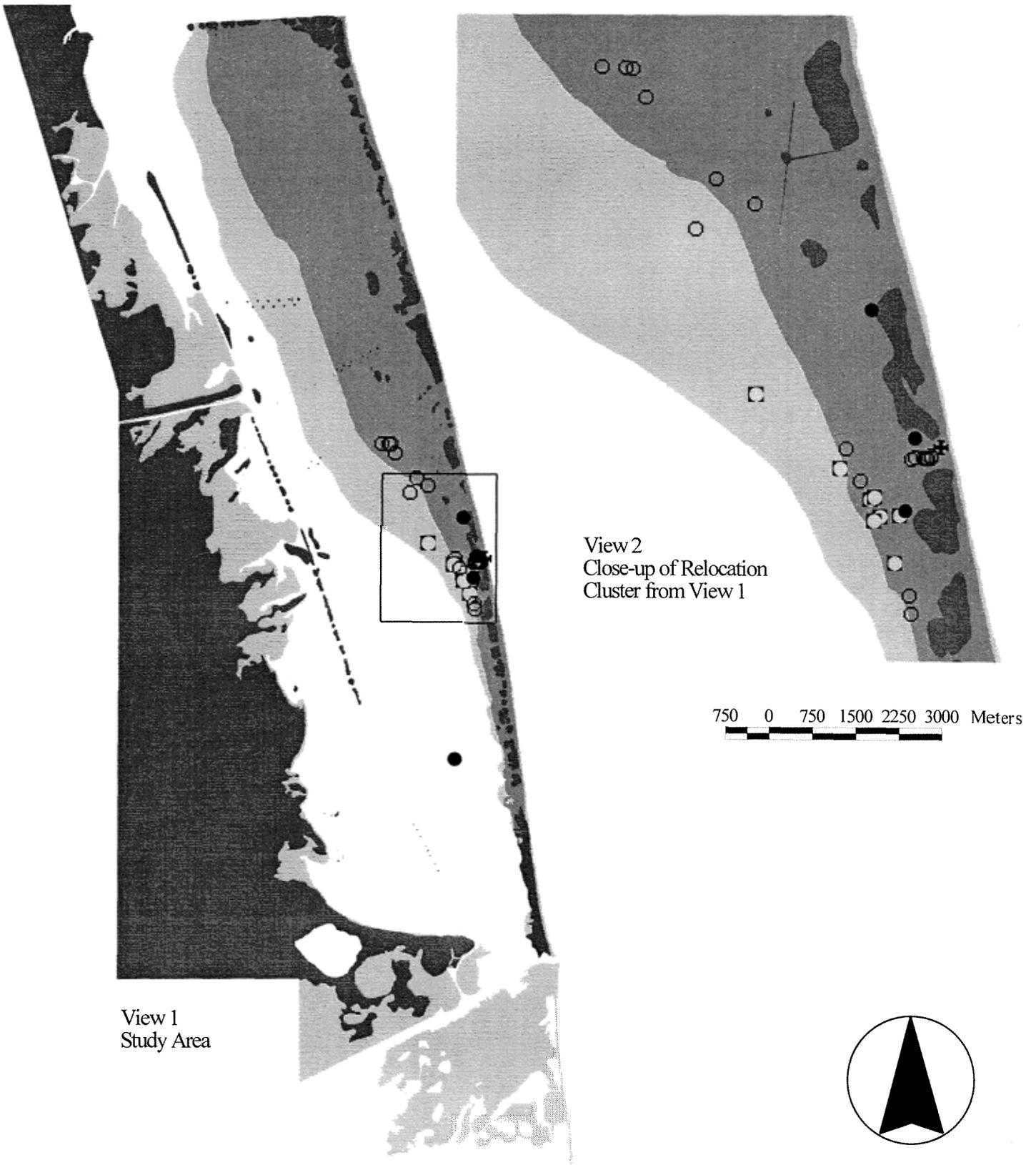
View 2  
Close-up of Relocation  
Cluster from View 1



**Radiofrequency 981 (PIPL)**



**Radiofrequency 984 (Piping Plover).** Relocation data for this plover are summarized above. Behavior (foraging [F] or roosting [R]), distance to water (DTW [meters]), habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]), color band information and winter range estimates are presented.

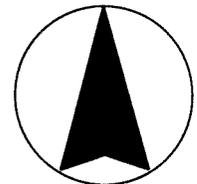


View 1  
Study Area

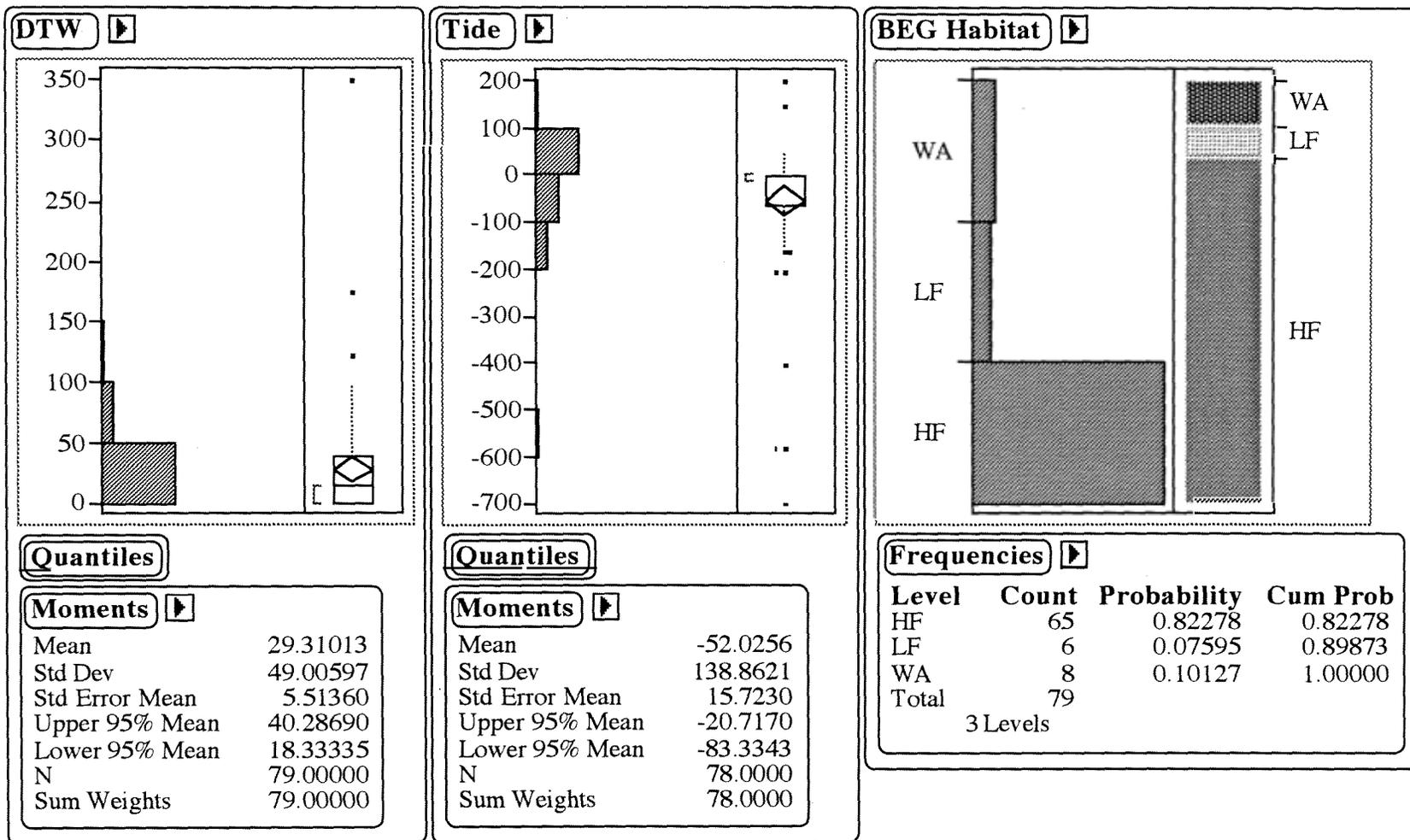
View 2  
Close-up of Relocation  
Cluster from View 1

750 0 750 1500 2250 3000 Meters

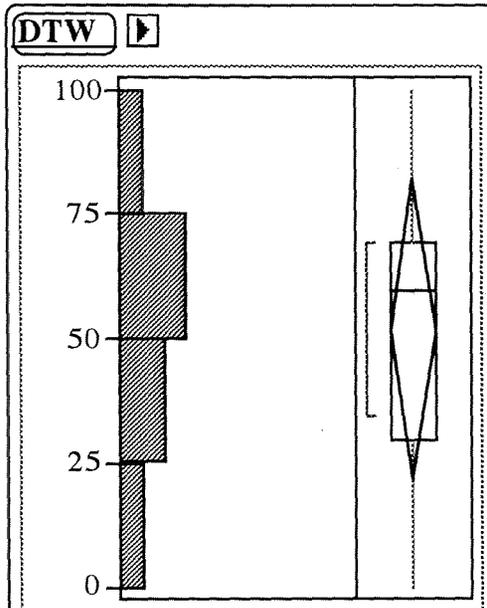
5 0 5 10 Kilometers



**Radiofrequency 984 (PIPL)**



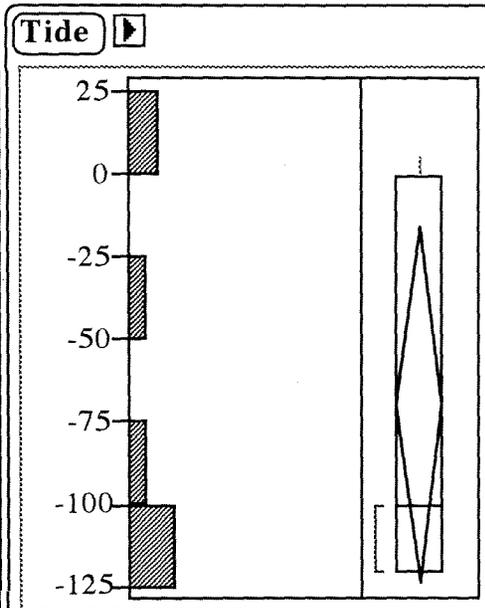
**All Foraging Snowy Plovers.** The distance to water (DTW [meters]), bayshore tidal amplitude (# meters inundated above the mean high tide line) and habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]) history for all marked Snowy Plovers engaged in foraging behavior when relocated.



**Quantiles**

**Moments** ▾

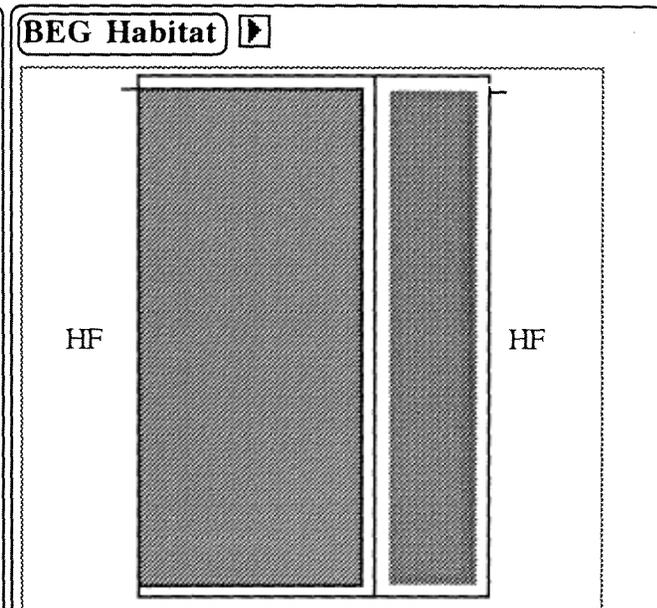
Mean	52.21429
Std Dev	32.76413
Std Error Mean	12.38368
Upper 95% Mean	82.51607
Lower 95% Mean	21.91250
N	7.00000
Sum Weights	7.00000



**Quantiles**

**Moments** ▾

Mean	-69.2857
Std Dev	58.4828
Std Error Mean	22.1044
Upper 95% Mean	-15.1981
Lower 95% Mean	-123.3733
N	7.0000
Sum Weights	7.0000



**Frequencies** ▾

Level	Count	Probability	Cum Prob
HF	7	1.00000	1.00000
Total	7		

1Levels

**All Roosting Snowy Plovers.** The distance to water (DTW [meters]), bayshore tidal amplitude (# meters inundated above the mean high tide line) and habitat use (high flat [HF], low flat [LF], washover pass [WA] and beach [B]) history for all marked Snowy Plovers engaged in roosting behavior when relocated.