

**DISTRIBUTION AND ABUNDANCE OF TWO RARE TIGER
BEETLES, *CICINDELA DORSALIS MEDIA* AND *C.
LEPIDA*, AT ASSATEAGUE ISLAND NATIONAL
SEASHORE IN 2016**

FINAL REPORT



Photos by Chris Wirth

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ABSTRACT

In 2016, surveys continued monitoring the distribution and abundance of *Cicindela dorsalis media* and *C. lepida* at Assateague Island National Seashore. Surveys were conducted on five dates in late July. The survey area for *C. d. media* included the whole length of shoreline from the north inlet to the Virginia line. This included the ocean shoreline of the North End, the State Park, the NPS Developed Zone and the extensive OSV zone including plover closure areas. Surveys for *C. lepida* were conducted along the whole length of the OSV zone and concentrated in and behind the primary dune line where this species is known to occur.

The results of the 2016 survey for *C. dorsalis media* produced a total count of 1498 adults (26 in the north end), the highest count we have ever recorded for this species at Assateague. The previous high counts were 902 in 2015 and 598 in 2001; other high recent counts were 391 in 2013 and 245 in 2010. The distribution of adults has varied significantly over the years, and in all but two years from 1985 to 2007 most adults were along the north end shoreline, and until the past few years nearly all of the others were in the south most few kms of the OSV zone. In summary, these surveys indicate two distinct trends, one a decline in adults along the north end shoreline after 2005 until the present; only two counts during this period had more than 57 adults and one of these was in 2015. The other trend is the distinct increase in adult numbers in the OSV zone, especially since 2009 when annual counts were over 100 adults in all years and over 200 in all but one year from 2010 to 2016. The presence of adults in the OSV zone over the years was assumed to be primarily due to dispersal from the large populations along the Virginia shoreline to OSV shoreline closed off for plover protection. Presence and abundance of these adults was clearly associated with the amount and period of protection. The exceptionally high numbers in 2015 and 2016 suggest that although dispersal is likely the main cause, successful recruitment and development of larvae to the adult stage may be involved. With the extended protection some sections of the OSV zone could provide suitable habitat even despite the long period the whole OSV is open to vehicle use. The southern end of the zone is the most likely to support recruitment and development since vehicle use and impacts are lower there.

Results of the *C. lepida* survey in 2016 produced a count of only 2 adults. This matches the lowest ever count of 2 in 2013 and compares with 84 in 2014 and 69 in 2015. These recent counts indicate a significant decline from high counts of 976 in 2010 and 465 in 2008, and is substantial evidence that the *C. lepida* population is experiencing a progressive and significant pattern of decline from these earlier high numbers. Moreover, despite the extensive area of former and potential habitat at ASIS, these recent declines could signal the loss of the population of this species at Assateague. Tiger beetle populations commonly exhibit dramatic increases and declines, most often tied to habitat factors. We believe this decline of the *C. lepida* population is a result of the progressive natural stabilization and increased vegetation growth in former areas of primary dune habitat. This reduces the open areas and perhaps fresh substrates the adults and larvae need. The large numbers of adults from 2003 to 2010 were believed to be a result of a series of storms in the mid- and late 1990's that caused significant breaks in the primary dunes, creating washovers and extensive deposition of patches of new sand behind the foredunes. These patches were colonized by *C. lepida*, but have been undergoing succession with increasing vegetation. Another factor, such as disease perhaps associated with dune stabilization may be involved, but diseases in tiger beetles have not been documented.

Management and survey recommendations suggested previously are still appropriate. Continued high numbers in the closed areas of the south OSV zone indicate this area might be suitable permanent habitat if vehicle use and their disturbance impacts are eliminated or

reduced. Permanent protection of some of area might improve the overall viability of *C. dorsalis* at ASIS, especially since the North end population is marginal at best and may be at risk for being lost. The most important factor for improving the status of *C. lepida* is reducing vegetation and possibly creating fresh substrates, neither of which seems a feasible management option.

OBJECTIVES

The 2016 survey objectives were the same as those in previous years. These objectives were to: 1. determine the distribution and abundance of adults of *C. d. media* and *C. lepida* at ASIS, 2. evaluate population trends and distribution patterns of these species compared to previous years, and 3. determine changes along the ASIS shoreline that might explain the trends in distribution and abundance.

BACKGROUND

This study is a continuation of surveys for these two tiger beetles initiated in 1985 and continued each year from 2001 to the present. Numbers of both species have fluctuated significantly over the years, presumably due primarily to shoreline/habitat changes and climatic, especially rainfall). While we have not monitored these factors, observations and limited additional information on these changes have been included in the annual reports. For example, the long term restoration project by the U. S. Army Corps of Engineers has stabilized the Island's sediment budget and slowed the migration of the North End. Additional efforts to reduce potential vehicle impacts to tiger beetles along the North End shoreline have been implemented. These include reduced patrols by law enforcement and adjusting plover monitoring activities by using a single lane of travel just above the high tide line. Expanded closures for plovers in recent years have also been associated with increased numbers of *C. d. media* in the OSV zone while increasing stabilization by vegetation in this zone may be the cause of declines in *C. lepida* populations.

C. d. media. This tiger beetle is restricted to extensive, dynamic sandy coastal beaches without significant human disturbance (e.g. shoreline erosion control structures, resort development, OSV's, high pedestrian use) (Boyd 1978, Glaser 1984, Knisley and Schultz 1997). It occurs in the beach zone at the water edge, not inland interiors, because adults and larvae are dependent on regular tidal wave action to create suitable microhabitat conditions. Like the Federally-listed nominate subspecies (*C. d. dorsalis*), its presence is generally considered an indicator of pristine or "natural" beach habitat (Knisley 1986).

Historically, *C. d. media* occurred at scattered localities along the Atlantic coast, from southern New Jersey to south Florida (Knisley and Schultz 1997, Pearson et al. 1997). Most records are from barrier islands but it also has been found along mainland coastal beaches directly exposed to ocean waves. It has been extirpated from many of these areas, probably as a result of intense human recreational use, beach erosion control and shoreline development. Today, it is considered rare to uncommon in some of its remaining range. The only extant populations north of Maryland are located at Cape Henlopen, DE and on a small island north of Atlantic City, NJ. To the south, it occurs in

a few areas on the Virginia portion of Assateague Island and is locally common at several other Virginia barrier islands (Knisley and Hill 1992). Scattered, highly localized populations are also present in the Carolinas, Georgia, and Florida (Yarborough and Knisley 1994, Ciegler 1997, Knisley and Schultz 1997). In Maryland, *C. d. media* probably occurred historically along most of the ocean shoreline of Fenwick and Assateague Islands (Glaser 1984; Knisley and Hill 1990). It was last collected from Fenwick Island during 1926 and has since been extirpated from there (Knisley and Hill 1990). On Assateague Island, surveys since 1985 indicated that initially this species was largely confined to the northern 6 km of the island and absent from the other shoreline of the island. However, high intensity beach use by pedestrians and OSV's had apparently eliminated it from all areas between the State Park and Maryland-Virginia state line. Surveys since 2001 found adults have continued to be present in variable numbers along the north end shoreline but also within the OSV zone, it has been typically most abundant at the far south end near the Virginia state line and further northern where closures for piping plover have been in place during the summer. Overall, total adult numbers have fluctuated dramatically over the years from a low of 14 in 1998 to a high of 1402 in 2016.

Cicindela dorsalis media, like the closely-related Federally Threatened taxon, *C. d. dorsalis*, is known to be impacted by a variety of natural and human-induced factors. The cause of the apparent severe decline at Assateague in the late 1990's is uncertain. However, several major coastal storms struck this region in the mid-late 1990's resulting in severe shoreline erosion at Assateague Island and dramatic changes in the shoreline configuration, elevation and overall habitat conditions on much of the island, especially on the North End. A 1998 storm event was particularly severe. The long-term sand starvation effects resulting from stabilization of the Ocean City Inlet on natural barrier island beach processes also may have contributed to the apparent decline. Use of OSV's on the North End during routine patrols and piping plover research activities also may have contributed to the decline. Distribution and abundance of adults in the OSV zone has over the years been closely correlated with closure of shoreline sections in this zone to protect piping plovers.

***C. lepida*.** This species is typically found in sparsely vegetated dunes or extensive sand blows with dry, loose sand (Laroche 1974; Boyd 1978; Knisley 1979; Glaser 1984; Knisley and Schultz 1997; Leonard and Bell 1999). It occurs in widespread, scattered localities throughout central and eastern North America (Knisley and Schultz 1997; Pearson et al. 1997; Leonard and Bell 1999). In most parts of the eastern U.S. it is uncommon to rare especially along the Atlantic coast where it is nearly restricted to coastal dunes (Boyd 1978; Knisley and Schultz 1997). North of Maryland, the closest extant population is located at Cape Henlopen, Delaware. A few populations still occur in New Jersey, but the species apparently has been extirpated from much of the remaining northeastern U. S., including Massachusetts, Long Island and Pennsylvania. South of Maryland, the species is known from only two areas, the Virginia portion of Assateague Island and Nags Head, North Carolina. In Maryland, it has been extirpated from Fenwick Island (Glaser 1984), and the state's only remaining population has been found to be restricted to the southern part of ASIS. Beach stabilization, coastal

development, OSV's and other sources of dune disturbance (e.g. high levels of pedestrian use) have probably contributed to the decline and extirpation of this species from many coastal areas in the eastern U.S. (Knisley and Schultz 1997; Leonard and Bell 1999).

C. lepida was first reported in Maryland by Glaser (1984) and Knisley (1986). Before our recent studies (2001-present) the only attempts to systematically survey for *C. lepida* at ASIS occurred in 1990 (Knisley and Hill 1990) and 1998 (Hill and McCann, unpublished data). In 1990, a total of 127 adults were found at 5 sites on the southern end of the Maryland portion of the island. Approximately half of the individuals occurred at a single site. In 1998, a similar number (84 adults) was detected in three areas although there were some changes in distribution. Storm-related changes in habitat availability apparently resulted in lower numbers of beetles in some interdunal areas that were occupied in 1990. However, more beetles were found in newly formed habitat in nearby, primary dune blowouts. Adult counts have varied significantly over the years, ranging from a high count of 892 in 2003 to 14 in 2012 and 2 in 2013. A very large number of larvae were counted in 2013. The recent progressive decline is believed to be due to a decline in habitat quality caused by increased stabilization from vegetation encroachment in the cut-throughs and washovers in the primary dunes. This has been the preferred habitat where adults were most abundant in past years of peak numbers.

METHODS

Surveys for adults of both species were conducted on July 19 and 25-28, 2016. Four individuals participated in the surveys on various dates. Areas targeted were known from many previous surveys to support *C. d. media* and *C. lepida*. Essentially the same methods have been used since 2001 and the same areas at ASIS surveyed. The method used was a direct visual index count that involved recording the numbers of all adults seen while observers walked slowly through potential habitat. We used hand-held GPS units to record adult beetle locations and sometimes to record reference waypoints to indicate the area covered in surveys. When included we used the GIS program ArcMap to overlay point locations onto aerial photos and/or U.S.G.S. 7.5' topographic maps to depict distribution of both tiger beetle species throughout the island.

Surveys for *C. d. media* were conducted by walking along the wet intertidal zone of the beach during mid-day (1100h to 1700h) when adult beetles are concentrated in this microhabitat. Shoreline areas covered by walking surveys included the ocean sides of the whole North End, the State Park and Developed Zone, and the southern OSV zone including shoreline sections that were closed for piping plovers. Since 2008 we surveyed the long OSV section by walking along the shoreline; in some earlier years we surveyed by making counts from a slow moving vehicle. The reason for the change in recent years was to avoid driving in the expanded closure area and because more beetles were found in this area, unlike earlier years.

Surveys for *C. lepidus* were less frequent in earlier years than for *C. d. media*. However, in most years since 2002, we completed comprehensive, standardized surveys along the entire length of the OSV zone, from km 16 to the Virginia state line. These surveys involved thorough searches of primary dune and interdunal habitats, including the back beach, the front of the fore dune, open areas behind the foredune, and associated washovers and cut throughs. These areas were most often searched by two observers positioned about 10 m apart walking slowly in a zig-zag pattern through potential habitat. In some sections one surveyor covered the potential habitat using the same zig-zag search method. We also spot checked potential areas further inland (e.g., Fox Hills area, along the old OSV road). Areas with clearly unsuitable habitat (e.g., wet swales, vegetated patches and dense scrub) were bypassed. Since *C. lepidus* adults typically dig burrows during the hottest time of the day (1300 – 1600 h) we conducted surveys from 900 to 1300 h and 1630 to 1830h.

RESULTS AND DISCUSSION

C. d. media. The results of the 2016 surveys for this species produced a **total count of 1498, the highest we have ever recorded for this species at Assateague**. This compares with other recent and previous high counts of 902 in 2015 and 598 in 2001. Other high counts were 391 in 2013 and 245 in 2010 (Table 1). The distribution of these adults has varied significantly over the years, and in all but two years from 1985 to 2007 most adults were along the north end shoreline and until the past few years nearly all of the others were in the southern most few kms of the OSV zone (within the plover protection section). These surveys over the years indicate two distinct trends, one a decline in adults along the north end shoreline after 2005 until the present. Only two counts during this period had more than 57 adults and one of these was in 2015. From 1985 to 2005 there were nine counts with over 100 adults and five years with more than 200. Numbers were so low from 2011 through 2014 (range of 0 to 14) that this north end segment of the population seemed likely to be lost. However, the increase to 109 adults in 2015 reverses this trend and increases the prospect of adults continuing to exist in the portion of the shoreline. The low 2016 count and the limited distribution of adults in the north end in recent years indicate the north end remains as very marginal habitat. The other trend is the distinct increase in adult numbers in the OSV zone, especially in the past three years, and especially the major increases in 2015 and 2016. As indicated below, the source of this major increase could be from dispersal into the area and/or development within this part of sometimes protected shoreline.

Causes of the observed trends. In general, the primary factor explaining adult numbers in a particular year are habitat factors which increase the recruitment and survival of new larvae in the previous two years. These factors include climate, especially rainfall, temperature and storms, which can increase the prey base which in turn reduces mortality and increases oviposition. Observations of *C. d. dorsalis* over the years have found extremely high growth rates with adult numbers capable of increasing 2-4 fold from one year to the next, apparently due to these favorable habitat factors. Also of

significance is shoreline change which can have dramatic positive or negative impacts on habitat. Since the adults and larvae of *C. d. media* occupy the dynamic intertidal zone, shoreline change can reduce or eliminate habitat and beetles in that habitat. However, these impacts have been found to ultimately benefit this species by creating new substrates and eliminating vegetation, both which can provide suitable conditions for colonization and recruitment of larvae. Studies with *C. dorsalis*, especially *C. d. dorsalis* over many years have found new sandy substrates either from natural accretion or dredge deposition were readily colonized by adults which recruited larvae (Fenster et al. 2006).

Another factor important in explaining population trends in *C. dorsalis* and probably a factor explaining the large numbers in the OSV zone at Assateague in 2015, 2016 and other recent years is dispersal. The survival of species like *C. dorsalis* which occur in ephemeral, dynamic habitats depends on dispersal and colonization of suitable patches of new habitat. Coastal and bay shorelines are highly dynamic and can be lost from erosion, so recolonization of new areas is necessary for survival. Earlier studies with *C. dorsalis* found adults can move as far as 10 or more miles, and dispersal is greatest during periods of high adult density (late June to mid-July) (Knisley and Hill 1990). It is uncertain but probably unlikely that dispersal from the large numbers of adults from the OSV zone have ever contributed to the north end shoreline numbers; rather those numbers were due to increased population growth or decline of resident beetles.

The large increase in adult numbers in the past three years and especially the last two within the OSV zone was more than twice the previous high in 2013 (Table 1). These high numbers and the distribution over most of the OSV is clearly related to the prolonged and extended closure for plover protection. The closure in 2016 was from km 19 and later from km 22 south to the Virginia line. Much of this area proved suitable habitat for adults as they moved into or remained active within this area when OSV activity was eliminated. Surveys in all recent years within the OSV zone have found few or no adults within km sections of OSV use. In the past few years (since 2011) and especially in the past two years, the extended areas of closure has resulted in large numbers of adults while sections remaining open had few or no adults. Prior to this, nearly all of the adults were restricted to the shorter closure section at the far south end of the OSV (km 34-35 to south end). High levels of pedestrian foot traffic as seen in the public beach areas in the middle of the island are a likely cause of adults being absent for this area.

However, there remains the question of if and to what extent the high numbers of adults have developed within the OSV zone. It is possible from what we know about *C. dorsalis* dispersal that they could all be dispersers, assuming a very large population along the Virginia shoreline. Alternatively, given such large numbers it seems likely that adults in recent years have successfully recruited larvae and these developed to the adult stage within some sections of the OSV zone. This possibility is increased as the shoreline length and period of the plover protection area has increased. Determining if numbers at ASIS are due to dispersal and not resident populations would require extensive fall larval surveys within the OSV zone. However, as we found years ago,

these surveys may not provide confirmation since the large area involved is so large and larvae are likely at low densities and patchy in distribution. Surveys along the Virginia shoreline would also be necessary to determine the status of the adult population there.

Table 1. Numbers of adult C. dorsalis media counted within specific sections at ASIS, 1985-2016.

North End	1985	1986	1987	1988	1990	1991	1992	1996	1998	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
(kms from N end Jetty	10	19	11		23	52	7	6	0	0	11	0	0	0	0	0	1	0	1	0	0	0	0	20	14	
0.5	20	8	28		64	140	57	2	0	0	3	0	0	1	0	0	2	1	6	1	0	0	2		6	
1	41	5	36		108	109	10	7	0	1	0	0	0	5	0	2	0	1	6	0	0	0	0	40	0	
1.5	25	12	3		26	40	4	5	0	5	3	0	1	3	4	2	0	1	3	0	0	0	0		0	
2	1	38	0		14	23	2	3	5	6	0	4	0	21	1	11	0	2	1	0	0	0	0	10	3	
2.5	4	49	0		0	4	0	3	5	2	2	0	0	8	0	11	0	0	13	0	0	0	0		0	
3	27	59	0		17	3	1	2	4	2	4	1	0	5	10	9	0	4	30	0	0	0	2	8	0	
3.5	42	42	11		67	12	5	18	0	66	15	8	3	37	3	6	1	0	28	0	0	0	0		0	
4	7	12	24		27	0	1	13	0	112	18	14	1	25	2	0	1	0	9	0	0	3	0	3	0	
4.5	8	9	4		2	0	0	10	0	106	0	18	0	75	4	4	0	6	0	0	0	0	0		0	
5	2	3	5		0	0	1	2	0	34	1	11	1	34	1	9	0	0	0	0	0	0	0	1	0	
5.5	2	1	0		0	0	0	0	0	10	2	13	0	5	0	0	0	0	0	1	0	0	0		0	
6	1	0	0		0	0	0	3	0	54	11	10	0	12	0	0	0	0	0	0	0	0	0	3	1	
6.5	2	0	0		0	0	0	0	0	62	3	38	0	4	0	1	0	0	0	0	0	0	0		2	
7	3	2	0		0	0	0	0	0	83	2	14	0	11	0	2	0	0	0	0	0	0	3	12	0	
7.5	0	0	0		0	0	0	0	0	17	0	9	0	12	0	0	0	1	0	2	0	0	0		0	
8	0	0	0		0	0	0	0	0	22	0	0	0	15	0	0	0	1	0	4	0	0	0	5	0	
8.5	0	0	0		0	0	0	0	0	27	0	3	0	7	0	0	0	3	0	2	0	0	0		0	
9	0	0	0		0	0	0	0	0	1	0	3	0	7	0	0	0	1	0	4	0	0	0	7	0	
9.5	0	0	0		0	0	0	0	0	1	0	2	0	1	0	0	0	0	0	0	0	0	0		0	
Total N end Shoreline	195	259	122	200	346	383	88	74	14	611	75	148	6	265	25	57	5	21	96	14	0	3	7	109	26	
North end Bayside										15	15		8		0	0	8	0	0	0	0	0	0	0	0	
St. Pk and Dev. Zone	0	0	0	0	0	0	0	0	0	0	0	21	8	12		0	0	0	0	0	0	0	0	12	0	
OHV, N of closure										0	18	12	18	7	11	5	57*	31	31**	32	0	0	0	below	below	
OHV Zone km 16																							0	6	0	
17																							0	21	9	
18																							0	136	7	
19																							4	106	32	
20																							12	10	53	
21																							0	1	108	
22																							0	9	95	
23																							7	54	33	
24																							7	64	51	
25																							24	63	88	
26																							20	175	88	
27																							18	4	41	
28																							28	0	89	
29																							7	6	116	
30																							0	8	208	
31																							0	12	250	
32																							6	3	126	
33																							7	9	14	
34																							35	33	23	
35																							28	61	41	
Total in OSV zone																								775	1472	
Total in plover closure					13					72	97	9	20	145	21	16	99	32	118	189#	123#	388&	203	781>	1456	
Grand AINS total	195	259	122	220	359	383	88	74	14	698	220	190	60	429	57	88	169	84	245	235	123	391	210	902	1498	
*Most in new plover closure: km24, 26 individuals; km26, 4; km28, 1; km30, 3; 31, 2; 32, 1 = 57																										
**4 in km 29, 6 in km 30, 5 in km 32, 6 in km 33																										
# In 2011 and 2012 the shoreline section closed for plover nesting extended from north of km 24 to the Va line																										
& Closure zone in 2013 was km 19 south to VA state line; 25 adults in km 26, 235 in km 34 and 70 in km 35																										
> In 2015 closure zone was in place from 18.3 or km 24 south to the state line for varying periods (see text)																										
In 2016 plover closure was at km 19																										
*Most in new plover closure: km24, 26 individuals; km26, 4; km28, 1; km30, 3; 31, 2; 32, 1 = 57																										
**4 in km 29, 6 in km 30, 5 in km 32, 6 in km 33																										
# In 2011 and 2012 the shoreline section closed for plover nesting extended from north of km 24 to the Va line																										

C. lepida. Results of the *C. lepida* survey in 2016 produced a count **2 adults**. This equals the lowest ever count of 2013 and compares with 41 in 2012, 84 in 2014 and 69 in 2015. These recent counts suggest a very significant drop and progressive decline from the counts of over 100 in previous years when numbers peaked at 976 adults in 2010. These recent surveys are clear evidence that the *C. lepida* population is experiencing a pattern of very rapid and significant decline and is in danger of being extirpated from Assateague. This is surprising given the extensive area of former and potential habitat throughout much of the OSV zone. Other studies with several tiger beetle species indicate such declines and extirpations are not unusual, and most often a result of habitat changes which reduce carrying capacity. The factor apparently involved in this case with *C. lepida* is the progressive natural stabilization and increased vegetation growth in former areas of primary dune habitat. The lack of significant storm events in recent years allowed for the growth of beach grass in the formerly open bowls, swales, cut throughs and overwash patches, and the coincidental decline of the beetle population. Encroaching vegetation has been found to be one of the most important causes of decline and localized extirpation of tiger beetle populations (Knisley 2011). Open patches of habitat are essential for adult foraging, oviposition and successful development of the larval stages. Extirpation often occurs rapidly when numbers are low due to the Allee effect when surviving adults cannot find mates and are subject to loss from stochastic factors.

The significance of habitat suitability and population dynamics is also suggested by large increase in adults from 2003 to 2010 after a series of storms in the mid- and late 1990's caused significant breaks in the primary dunes and created washovers with the deposition of many patches of new sand behind the foredunes. These dynamic events have also resulted in progressive wind-driven sand movement since that time, creating new habitat for *C. lepida* in the cuts, breaks, and overwashes in the primary dune. Our observations of many adults and large numbers of larvae in these overwash pans indicated ideal habitat for adult foraging and oviposition and larval development. *Cicindela lepida*, like many tiger beetles, is a colonizer of newly opened bare ground, and unable to persist in habitats that are more stabilized or with reduced sand movement. These areas have been progressively lost by increasing vegetation cover in recent years.

Table 2. Numbers of adult *C. lepidus* counted along whole length of Assateague Island National Seashore, 1990-2016, and numbers of larvae in 2006, 2008 and 2013.

Location (km)	1990*	1998*	2002	2003	2004	2005	2006	2008	Larvae 2006	Larvae 2008	2010	2011	2012	2013	Larvae 2013	2014	2015	2016
0-10			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-16			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-17			0	24	9	0	2	0	0	0	0	0	0	0	9	3	2	0
17-18			2	40	1	1	13	6	93	27	59	0	0	0	84**	9	0	0
18-19			0	65	5	1	18	27	109	124	53	3	0	0	0	0	30	0
19-20			0	67	13	12	6	75	212	48	208	19	6	0	0	9	5	0
20-21			3	46	8	22	3	18	100	0	69	1	0	0	0	10	2	0
21-22			3	11	4	15	0	0	330	0	18	9	0	0	0	6	0	0
22-23			8	12	6	6	0	2	11	8	3	0	5	0	0	0	0	0
23-24			19	73	2	4	0	4	0	5	1	0	0	0	0	3	0	0
24-25			22	34	34	15	5	7	56	38	7	0	0	0	0	2	4	0
25-26			22	66	93	10	18	27	131	35	14	13	0	0	838**	7	5	0
26-27			9	68	52	17	72	66	720	106	35	29	0	0	390**	7	8	0
27-28			27	76	64	30	42	53	1535	77	170	21	15	0	11	9	1	0
28-29			19	52	42	31	33	38	837	5	128	0	17	0	139**	6	7	0
29-30			19	82	79	100	16	31	1282	0	56	3	4	1	1	0	2	0
30-31			25	75	72	71	67	29	2826	95	26	4	0	0	0	4	0	0
31-32			15	22	27	89	36	11	1653	35	22	11	0	0	0	9	3	2
32-33			8	51	20	60	36	19	715	18	43	7	4	1	4	0	0	0
33-34			7	20	35	0	12	47	212	50	35	6	1	0	4	0	0	0
34-35			5	6	14	27	5	5	156	15	28	2	0	0	0	0	0	0
35-VA line			1	2	2	3	2	0	55	0	1	0	0	0	0	0	0	0
Totals	127	84	214	892	582	514	386	465	11033	686	976	128	41	2	1471	84	69	2
* No data collected for individual segments in 1990 and 1998																		
** These were kilometer sections where we surveyed specifically for larvae																		

MANAGEMENT RECOMMENDATIONS AND RESEARCH NEEDS

Long-term monitoring data for *C. d. media* and *C. lepidus* are an essential tool for evaluating potential impacts and providing adequate protection of these species and their requisite habitats. Monitoring also provides both intended and unexpected insights into their biology and ecological requirements. Continued monitoring will provide additional assessment of the effects of plover closures as a cause of the northern extension of beetles and if the North end population can recover and become re-established. Maintaining this species at Assateague will be more likely if there are at least two sections of protected or partially protected habitat areas to sustain populations.

Remarkably, some basic features of the two species' biology remain poorly known. Of particular importance, is whether *C. d. media* has a one or two-year life cycle. As mentioned earlier, this information is essential for understanding the species' population dynamics. Dispersal ability and the seasonal timing of dispersal are not fully understood. Such information will play an obvious role in determining the degree to which there is exchange between different population segments on the island or even,

in the case of *media*, if the North End and state line beetles represent discrete populations or a single metapopulation. Finally, it would be very helpful if future inventory and monitoring efforts for these species occurred throughout the island (i.e., Chincoteague NWR) and that these activities be coordinated between refuge and park staff.

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APPENDIX

Aerial Photographs of the AINS Shoreline showing Distribution and Abundance of *C. d. media* and *C. lepida* (Figs 1-5)

Figure 1a. AINS Tiger Beetle Survey 2016

Green numbers indicate tally of *C. dorsalis media* adults

Red numbers indicate tally of *C. lepida* adults

Yellow circles indicate survey location

↑ Kilometer post

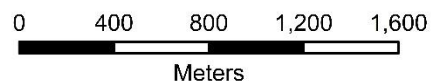


Figure 1b. AINS Tiger Beetle Survey 2016

Green numbers indicate tally of *C. dorsalis media* adults

Red numbers indicate tally of *C. lepida* adults

Yellow circles indicate survey location

↑ Kilometer post



Figure 2a. AINS Tiger Beetle Survey 2016

Green numbers indicate tally of *C. dorsalis media* adults

Red numbers indicate tally of *C. lepida* adults

Yellow circles indicate survey location

↑ Kilometer post

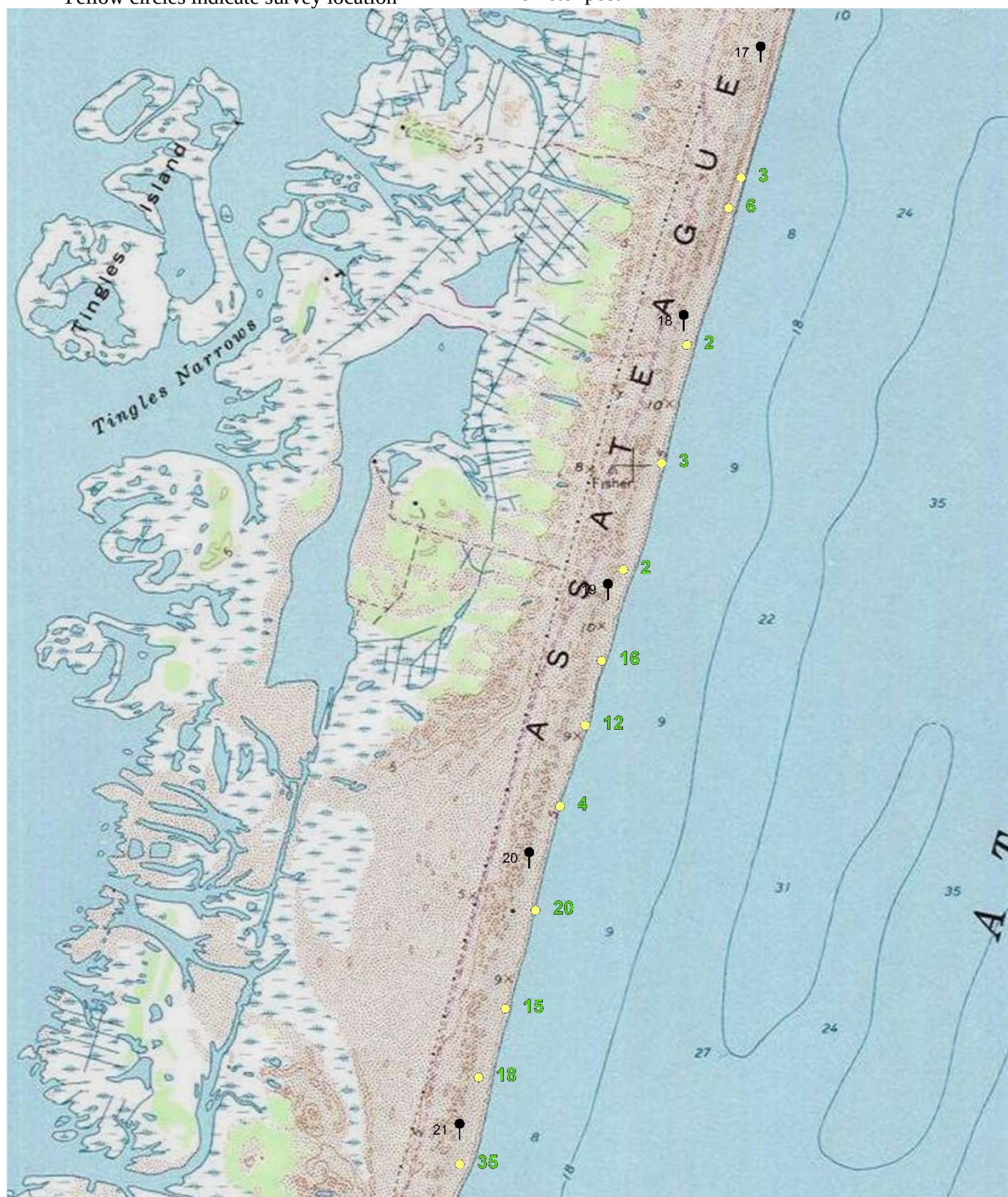
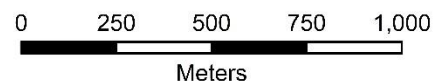


Figure 2b. AINS Tiger Beetle Survey 2016

Green numbers indicate tally of *C. dorsalis* media adults

Red numbers indicate tally of *C. lepida* adults

Yellow circles indicate survey location

↑ Kilometer post

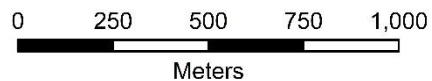


Figure 3a. AINS Tiger Beetle Survey 2016

Green numbers indicate tally of *C. dorsalis media* adults

Red numbers indicate tally of *C. lepida* adults

Yellow circles indicate survey location

↑ Kilometer post

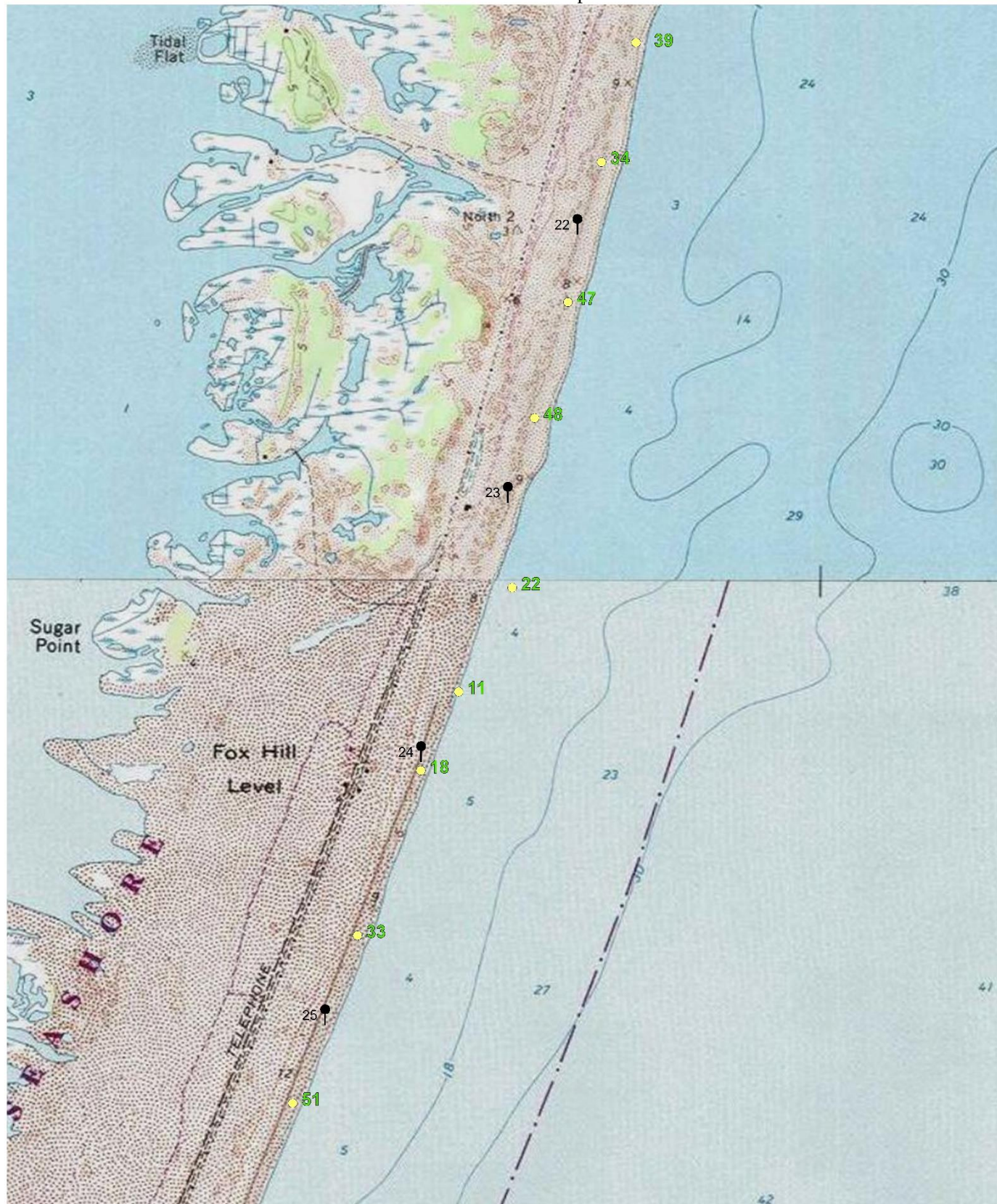
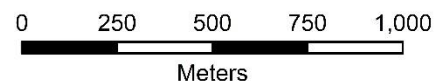


Figure 3b. AINS Tiger Beetle Survey 2016

Green numbers indicate tally of *C. dorsalis media* adults

Red numbers indicate tally of *C. lepida* adults

Yellow circles indicate survey location

↑ Kilometer post

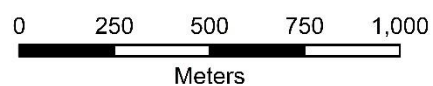


Figure 4a. AINS Tiger Beetle Survey 2016

Green numbers indicate tally of *C. dorsalis media* adults

Red numbers indicate tally of *C. lepida* adults

Yellow circles indicate survey location

↑ Kilometer post

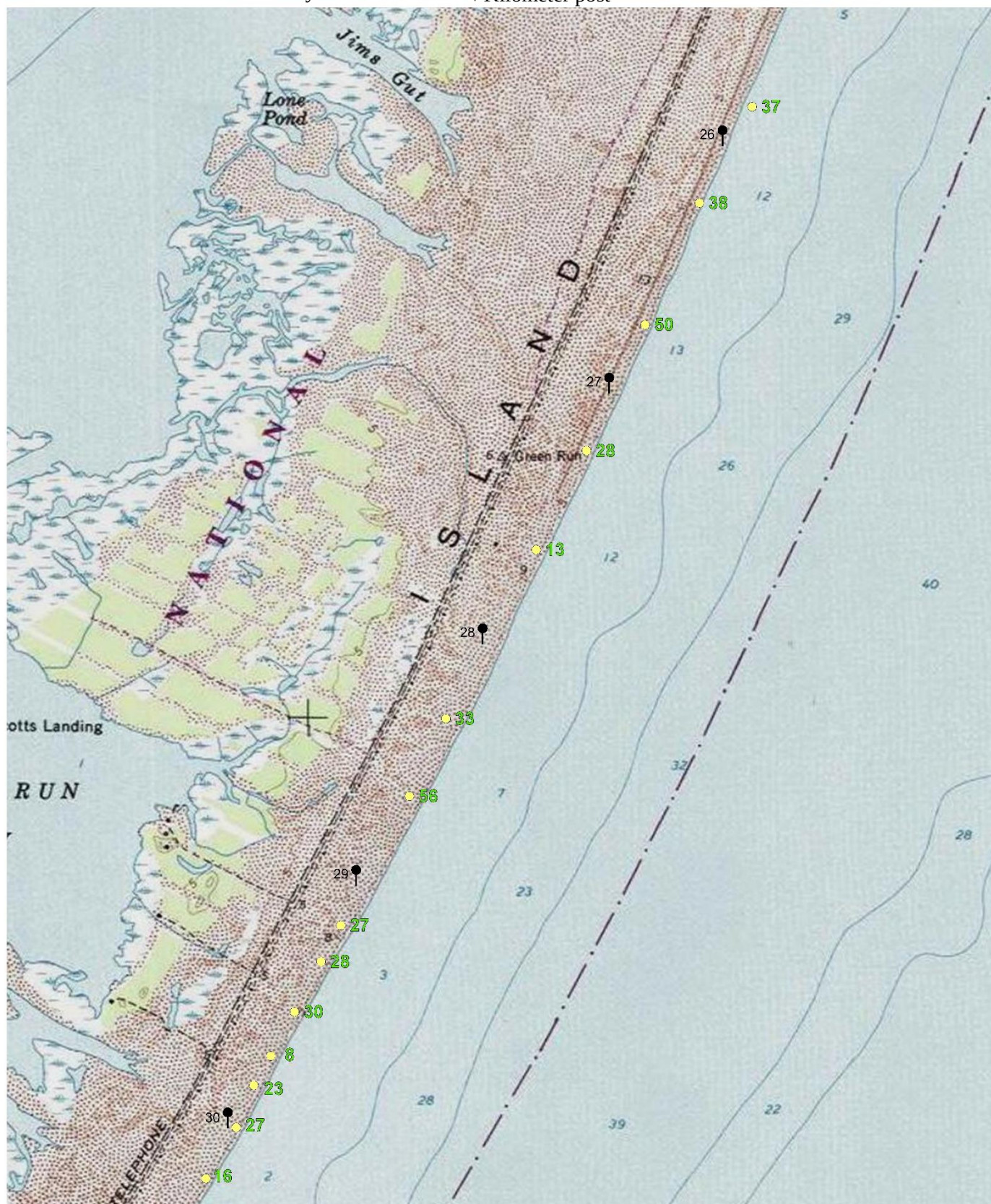
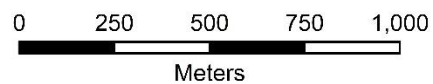


Figure 4b. AINS Tiger Beetle Survey 2016

Green numbers indicate tally of *C. dorsalis media* adults

Red numbers indicate tally of *C. lepida* adults

Yellow circles indicate survey location

↑ Kilometer post

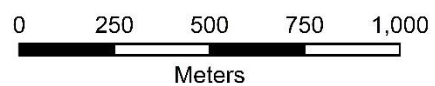


Figure 5a. AINS Tiger Beetle Survey 2016

Green numbers indicate tally of *C. dorsalis media* adults

Red numbers indicate tally of *C. lepida* adults

Yellow circles indicate survey location

↑ Kilometer post

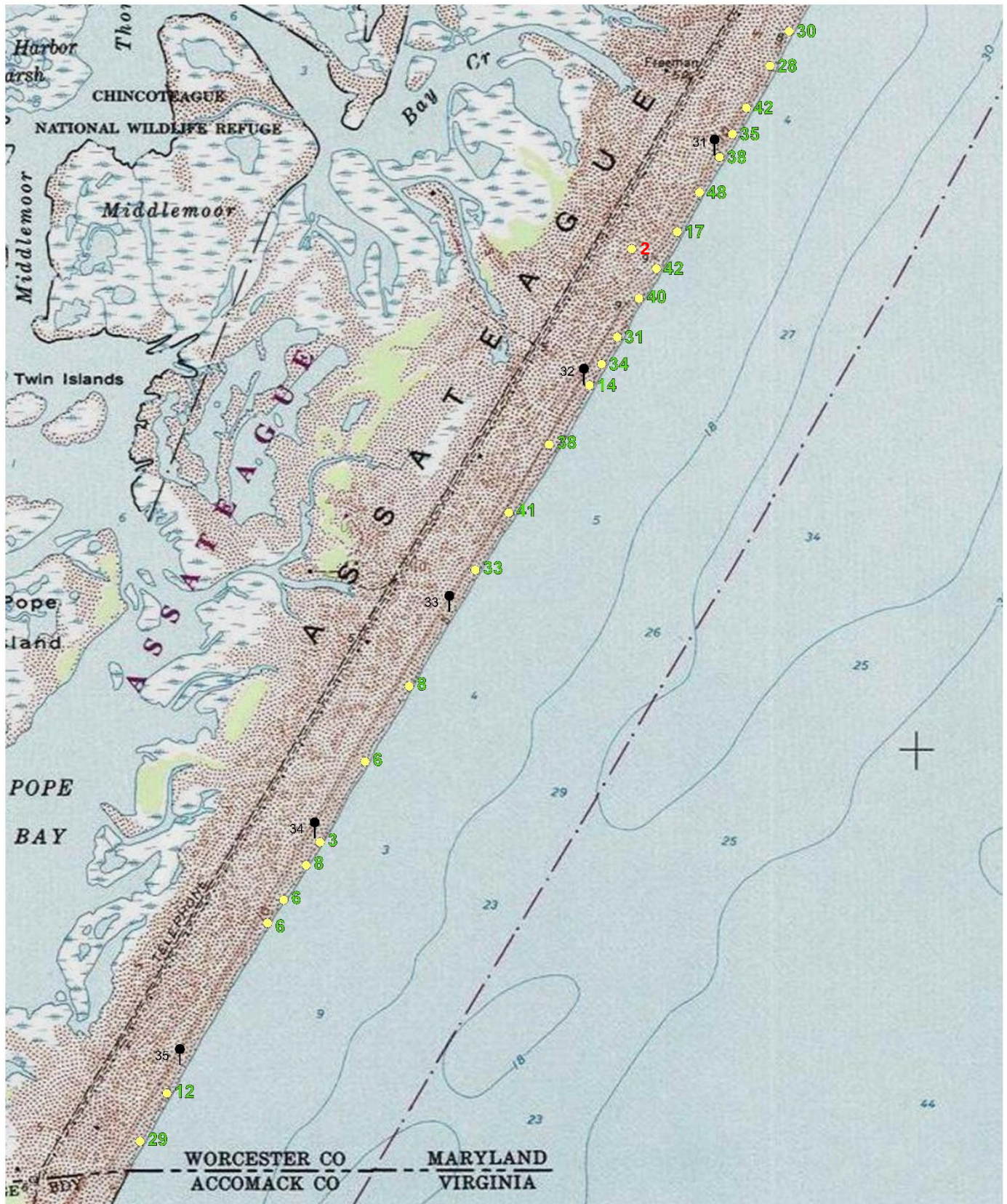
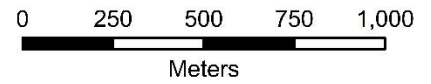


Figure 5b. AINS Tiger Beetle Survey 2016

Green numbers indicate tally of *C. dorsalis media* adults

Red numbers indicate tally of *C. lepida* adults

Yellow circles indicate survey location

↑ Kilometer post

