

**U.S. Army Corps of Engineers – Portland District**

# **East Sand Island Biological Assessment: 2010-2012**

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## ***Final Technical Memorandum***



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**FINAL TECHNICAL MEMORANDUM**  
**EAST SAND ISLAND**  
**BIOLOGICAL ASSESSMENT, 2010-2012**

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**Island areas and land cover classes**

The island area available to nesting and roosting waterbirds on East Sand Island comprises both upland and intertidal habitat. The amount of intertidal habitat, defined as the island area below the maximum high tide line, varies by tidal phase, with more habitat available to waterbirds during ebb and low tides. This habitat is primarily used by roosting waterbirds, yet occasionally waterbirds will nest in the upper intertidal zone only to have their nests inundated and destroyed during extreme high tide or storm events. The minimum estimate of intertidal habitat available during low tide stages on East Sand Island during 2010-2012 was between 84 and 92 acres, nearly twice the amount of upland habitat available on the island during those years (Table 1).

The amount of island-wide upland habitat, defined as the East Sand Island above the maximum high tide line, was estimated to be approximately 49 acres (ca. 20 ha) during 2010-2012 (Table 1). The upland habitat consisted of 4 different land cover classes; herbaceous vegetation, bare substrate, trees/shrubs, and rip rap/large woody debris. Of these land cover classes, herbaceous vegetation occupied the largest upland land area (ca. 19 acres [ca. 7.5 ha], or 39% of the total upland habitat), followed by bare substrate (ca. 14 acres [ca. 5.5 ha], or 28% of the total upland habitat), trees/shrubs substrate (ca. 11 acres [ca. 4.5 ha], or 22% of the total upland habitat), and rip rap/large woody debris (ca. 5 acres [ca. 2 ha], or 11% of the total upland habitat; Table 1).

The double-crested cormorant use area, defined as all of the upland area west of the eastern-most habitat used by cormorants (nesting or roosting) based on aerial photography of the island in August, was restricted to the western half of East Sand Island. The cormorant use area consists of about 21 acres [ca. 8.5 ha], or 43% of the total upland land area of East Sand Island during 2010-2012 (Table 1). Cormorants have not utilized the eastern half of East Sand Island for nesting; however, occasionally small groups of cormorants (< 100 individuals) have used habitat on the east end for roosting or collecting nest material. The dominant land cover class in the cormorant use area was bare substrate (ca. 11 acres [ca. 4.5 ha], or 53% of the total upland habitat in the cormorant use area), followed by rip rap/large woody debris (ca. 5 acres [ca. 2 ha], or 22% of the total upland habitat in the cormorant use area), herbaceous vegetation (ca. 4 acres [1.5 ha], or 19% of the total upland habitat in the cormorant use area), and trees/shrubs (ca. 1 acre [ca. 0.4 ha], or 5% of the total upland habitat in the cormorant use area; Table 1).

The double-crested cormorant nesting area, defined as all of the land area west of the eastern-most cormorant nest identified in aerial photography taken of the island during May, comprised roughly 16 acres [ca. 6.5 ha], or 76% of the total upland land area in the cormorant use area, or 33% of all of the upland area of East Sand Island during 2010-2012 (Table 1). The dominant land cover class in the cormorant nesting area was bare substrate (ca. 11 acres [ca. 4.5 ha], or 66% of the total upland habitat in the cormorant nesting area), followed by rip rap/large woody debris (ca. 4 acres [ca. 1.5 ha], or 26% of the total upland habitat in the cormorant nesting area), herbaceous vegetation (ca. 1 acre [0.4 ha], or 7% of the total upland habitat in the cormorant nesting area), and trees/shrubs (ca. 0.03 acres [ca. 0.01 ha], or < 1% of the total upland habitat in the cormorant nesting area; Table 1).

### **Double-crested cormorants**

During the study period, East Sand Island was home to the largest breeding colony of double-crested cormorants in western North America, and perhaps the world. The colony is located on the western portion of the island, primarily on bare substrate, rip-rap revetment, and amongst large woody debris deposited on the island during winter storms (Table 2). Cormorants first arrive on East Sand Island in late March – early April and begin to disperse from the island after the breeding season in July, with the last cormorants leaving the island as late as October. The number of cormorant nests (either double-crested or Brandt's cormorants) counted in aerial photography taken at the peak of nesting (May-June) was about 14,293 nests in 2010, 13,4367 nests in 2011, and 14,024 nests in 2012 (Table 2). Because Brandt's cormorants nest in amongst nesting double-crested cormorants, and because the two species are indistinguishable in aerial photography, we made no attempt to separate the two species in this analysis. Based on our estimates of colony size, double-crested cormorants make up the vast majority of cormorants included in this analysis (ca. 90%). The land cover classes used by nesting cormorants during the late nesting period (July) were generally the same as was observed during peak nesting; however, the counts of cormorant nests were lower due to nest abandonment associated with the onset of chick fledging and nest failure, the latter of which was believed to be greater in 2011 and 2012 compared to 2010 (Table 2).

By August, most cormorants have either left the island or can be found roosting with their young throughout the western half of the island. Many roosting individuals (adults and chicks) disperse from the colony area to the intertidal zone (ca. 44%); however, most (ca. 52%) remain in the same or similar habitats utilized for nesting (Table 3). The number of cormorants (either double-crested or Brandt's cormorants; adults and chicks) counted in aerial photography taken at the peak of fledging (August) was 46,443 individuals in 2010, 33,267 individuals in 2011, and 31,680 individuals in 2012 (Table 3).

Of the upland area of the island available in the cormorant nesting area, defined as the area west of eastern-most cormorant nest identified in the May 2010 aerial photography, only 17-19% was actually occupied by nesting cormorants during the peak nesting period (Table 4). The density of cormorant nests did not vary much between the most utilized land cover classes (i.e., bare substrate and

rip-rap/large woody debris) or between years, ranging between 1.2 and 1.3 nests/m<sup>2</sup> in the cormorant nesting area during the peak nesting period.

### **Brandt's cormorants**

During the study period, Brandt's cormorants nested on East Sand Island entirely within the double-crested cormorant colony on the western half of the island. Like double-crested cormorants, Brandt's cormorants were found primarily within the bare substrate and rip rap/large woody debris land cover classes (Table 5). Brandt's cormorant temporal use of the island generally coincides with that of double-crested cormorants (April – October), but their peak nesting period (June) is somewhat delayed in comparison to double-crested cormorants (May-June). The number of Brandt's cormorant nests counted in ground-truthed aerial photography taken at the peak of nesting was 985 nests in 2010, 1,491 nests in 2011, and 1,684 nests in 2012 (Table 5).

### **Glaucous-winged/western gulls**

Glaucous-winged/western gulls utilized East Sand Island for nesting and roosting during the study period. Of all the nesting colonial waterbirds found on East Sand Island, glaucous-winged/western gulls are the only species that nest on both the eastern and western halves of the island, although the majority (61-69%) nested within the cormorant use area on the western half of the island during 2010-2012 (Table 6). Glaucous-winged/western gulls were found primarily in the herbaceous vegetation and bare substrate land cover classes (Table 6). Of all the colonial waterbirds that utilize East Sand Island, glaucous-winged/western gulls are the first to arrive on the island (before March) and initiate nest territory defense (early March). The peak nesting period is in May and June, with some individuals remaining on the island as late as November. The number of glaucous-winged/western gulls counted in aerial photography taken at the peak of nesting was 6,966 individuals in 2010, 6,776 individuals in 2011, and 3,369 individuals in 2012 (Table 6). The reason for the apparent decline in the number of gulls counted in 2012 relative to 2010 and 2011 is not known.

### **Ring-billed gulls**

Ring-billed gulls utilized East Sand Island for nesting during 2010-2012. Nesting chronology of ring-billed gulls on East Sand Island is similar to that of Caspian terns, with nesting ring-billed gulls present on the island from April through July. Ring-billed gull nesting activity is restricted to the eastern end of East Sand Island in and just above the rack line. The number of nesting ring-billed gulls counted in aerial photography taken during May-June was 1,417 individuals in 2010, 1,944 individuals in 2011, and 1,472 individuals in 2012 (Table 7). Although ring-billed gulls may occasionally roost elsewhere on the island, we have not observed large numbers of roosting ring-billed gulls on East Sand Island during the study period outside of the vicinity of the breeding colony.



## **California brown pelicans**

During the study period (2010-2012), large numbers of brown pelicans continued to use East Sand Island as a post-breeding roost site, especially during the night. Brown pelican numbers generally increase throughout the cormorant breeding season, beginning at very low numbers (typically < 100 individuals) in April and usually peaking at more than 10,000 individuals by late summer (i.e., August or September). Use of the island, particularly the intertidal zone and adjacent upland habitat, by roosting brown pelicans is widespread. Brown pelicans tend to avoid roosting on broad mud flats, such as areas along the northeast shoreline of the island, and do not use densely vegetated interior portions of the island. During 2010-2012, the abundance of brown pelicans using East Sand Island as roosting habitat was estimated based on the average of multiple boat-based surveys per month (n = 1 – 5 surveys) conducted late in the evening. Average counts for the entire study period (May-August) were calculated for each zone and for a combination of zones (i.e., East Beach, South Beach, West End, Interior/Lagoon, North Beach, and Total; Table 8; see Figure 21 for a map showing pelican count zones).

Throughout the study period brown pelicans were more abundant on the East Beach and South Beach during the early months of the field season (i.e., May and June), with other areas (i.e., West End, and North Beach) becoming more populated in later months as the total numbers of roosting brown pelicans increased island-wide. Average island-wide counts peaked in August during 2010-2012, with maximum counts of 10,655, 11,377, and 9,750 individual pelicans recorded in each year (Table 8). Substantially increased use of the East Beach region by brown pelicans was noted in 2012, and may have been due to more favorable microclimates at the east end of the island due to greater protection from prevailing winds. In addition, researchers have significantly reduced activity on and access to the southern shore of the east end of East Sand Island. This restriction of researcher activity has opened up a significant amount of shoreline roosting habitat for pelicans that previously experienced a greater level of researcher disturbance.

The primary zones where active dissuasion of nesting cormorants (hazing) occurred in 2011 (S3) and 2012 (S1 - S4) were subject to variable and continuous (except for S4) use by brown pelicans (Table 8). Due to the extensive area included in these survey zones, only a portion of the pelicans using these areas may have been adversely affected by daytime nest dissuasion activities in 2011 and 2012. There appeared to be ample alternative roosting habitat for brown pelicans available elsewhere on East Sand Island, nonetheless pelicans continued to roost in and near the dissuasion areas even while active hazing was occurring (May and June).

## **Horned larks**

Streaked horned larks, a songbird species of conservation concern, have not been regularly seen on East Sand Island. Although there are earlier records of streaked horned larks on East Sand Island, the field crew did not report observing any horned larks on the island during the study period (2010-2012).

## TABLES

Table 1. Land cover area (ha and acres) and percent of the total area (%) by land cover class on East Sand Island for (1) the entire island, (2) the cormorant use area, and (3) the cormorant nesting area in 2010-2012. Land cover area calculations were from aerial photos taken of East Sand Island in May, 2010-2012. The cormorant use and nesting areas are based on the distribution of nesting and roosting cormorants on East Sand Island in 2010, prior to the large scale nest dissuasion experiments on East Sand Island in 2011 and 2012. Cormorant use area defined as all island area west of the eastern-most cormorant identified in the August 2010 photo. Cormorant nesting area defined as all the island area west of the eastern-most active cormorant nest identified in the May 2010 photo.

Land cover class	2010								
	Entire island			Cormorant use area			Cormorant nesting area		
	Area (ha)	Area (acres)	Area (%)	Area (ha)	Area (acres)	Area (%)	Area (ha)	Area (acres)	Area (%)
<b>Upland<sup>1</sup></b>	20.0	49.4		8.4	20.7		6.5	16.1	
Herbaceous vegetation	8.0	19.8	40.0%	1.9	4.8	23.0%	0.6	1.5	9.1%
Bare substrate	5.6	13.9	28.2%	4.3	10.5	50.9%	4.2	10.4	64.5%
Trees/shrubs	4.2	10.3	20.8%	0.3	0.9	4.2%	0.01	0.01	0.1%
Rip rap/large woody debris	2.2	5.4	11.0%	1.8	4.5	22.0%	1.7	4.2	26.3%
<b>Intertidal<sup>2</sup></b>	37.0	91.5		16.4	40.6		13.5	33.3	

Land cover class	2011								
	Entire island			Cormorant use area			Cormorant nesting area		
	Area (ha)	Area (acres)	Area (%)	Area (ha)	Area (acres)	Area (%)	Area (ha)	Area (acres)	Area (%)
<b>Upland<sup>1</sup></b>	20.2	49.9		8.4	20.9		6.6	16.2	
Herbaceous vegetation	7.6	18.7	37.4%	1.4	3.4	16.4%	0.3	0.7	4.2%
Bare substrate	6.0	14.8	29.6%	4.7	11.7	56.1%	4.6	11.4	69.9%
Trees/shrubs	4.6	11.4	22.8%	0.5	1.2	5.9%	0.01	0.03	0.2%
Rip rap/large woody debris	2.1	5.1	10.2%	1.8	4.5	21.5%	1.7	4.2	25.7%
<b>Intertidal<sup>2</sup></b>	36.7	90.8		16.4	40.5		13.4	33.2	

Land cover class	2012								
	Entire island			Cormorant use area			Cormorant nesting area		
	Area (ha)	Area (acres)	Area (%)	Area (ha)	Area (acres)	Area (%)	Area (ha)	Area (acres)	Area (%)
<b>Upland<sup>1</sup></b>	19.9	49.2		8.5	20.9		6.6	16.3	
Herbaceous vegetation	7.9	19.5	39.7%	1.6	4.0	18.9%	0.5	1.3	8.0%
Bare substrate	5.3	13.0	26.4%	4.4	10.9	52.2%	4.3	10.6	64.9%
Trees/shrubs	4.6	11.3	22.9%	0.5	1.3	6.4%	0.02	0.06	0.4%
Rip rap/large woody debris	2.2	5.4	11.0%	1.9	4.7	22.5%	1.8	4.4	26.7%
<b>Intertidal<sup>2</sup></b>	34.0	84.1		15.4	38.0		12.6	31.0	

<sup>1</sup> Defined as the island area above the maximum high tide line.

<sup>2</sup> Defined as the island area below the maximum high tide line. This measure varies depending on when during the tide cycle the aerial photo was taken (which varied), and is not meant to be compared across times or years.

Table 2. Number of active cormorant nests (both double-crested and Brandt's cormorants) and proportion of the total number of active nests (%) by land cover class on East Sand Island during 2010-2012. Nest counts were from aerial photography taken of the cormorant nesting area on East Sand Island during peak nesting (May-June) and late nesting (July), prior to the fledging period during 2010-2012. Cormorant nesting area was defined as all of the island area west of the eastern-most active cormorant nest identified in aerial photography of East Sand Island in May 2010, prior to the large scale nest dissuasion experiments on East Sand Island in 2011 and 2012. Because Brandt's cormorants nest amongst nesting double-crested cormorants and because the two species are indistinguishable in aerial photography, we made no attempt to separate them in this analysis. Based on our estimates of colony size, double-crested cormorants make up the vast majority of cormorants included in this analysis (ca. 90%).

Land cover class	2010			
	Peak nesting		Late nesting	
	No. nests	No. nest (%)	No. nests	No. nest (%)
<b>Upland<sup>1</sup></b>				
Herbaceous vegetation	1,554	10.9%	1,089	9.6%
Bare substrate	6,729	47.1%	5,164	45.3%
Trees/shrubs	2	0.01%	2	0.02%
Rip-rap/large woody debris	5,994	41.9%	5,122	45.0%
<b>Intertidal<sup>2</sup></b>	14	0.1%	10	0.1%
<b>TOTAL</b>	<b>14,293</b>	<b>100.0%</b>	<b>11,387</b>	<b>100.0%</b>

Land cover class	2011			
	Peak nesting		Late nesting	
	No. nests	No. nest (%)	No. nests	No. nest (%)
<b>Upland<sup>1</sup></b>				
Herbaceous vegetation	49	0.4%	0	0.0%
Bare substrate	7,138	53.1%	4,707	54.7%
Trees/shrubs	0	0.0%	0	0.0%
Rip-rap/large woody debris	6,227	46.3%	3,893	45.3%
<b>Intertidal<sup>2</sup></b>	23	0.2%	0	0.0%
<b>TOTAL</b>	<b>13,437</b>	<b>100.0%</b>	<b>8,600</b>	<b>100.0%</b>

Land cover class	2012			
	Peak nesting		Late nesting	
	No. nests	No. nest (%)	No. nests	No. nest (%)
<b>Upland<sup>1</sup></b>				
Herbaceous vegetation	1,241	8.8%	124	1.5%
Bare substrate	7,662	54.6%	5,505	65.3%
Trees/shrubs	0	0.0%	0	0.0%
Rip-rap/large woody debris	5,107	36.4%	2,803	33.2%
<b>Intertidal<sup>2</sup></b>	14	0.1%	3	0.04%
<b>TOTAL</b>	<b>14,024</b>	<b>100.0%</b>	<b>8,435</b>	<b>100.0%</b>

<sup>1</sup> Defined as the island area above the maximum high tide line.

<sup>2</sup> Defined as the island area below the maximum high tide line. This measure varies depending on when during the tide cycle the aerial photography was taken (which varied), and is not meant to be compared across times or years.

Table 3. Number of cormorants (both double-crested and Brandt's cormorants; adults and chicks) and proportion of the total number of cormorants (%) by land cover class on East Sand Island during 2010-2012. Cormorant counts were from aerial photography of the cormorant use area on East Sand Island during the peak fledging period (August), 2010-2012. Cormorant use area was defined as all of the island area west of the eastern-most cormorant identified in aerial photography of East Sand Island in August 2010, prior to the large scale nest dissuasion experiments on East Sand Island in 2011 and 2012. Because Brandt's cormorants nest and roost amongst double-crested cormorants and because the two species are indistinguishable in aerial photography, we made no attempt to separate them in this analysis. Based on our estimates of colony size, double-crested cormorants make up the vast majority of cormorants included in this analysis (ca. 90%).

Land cover class	2010		2011		2012	
	No. cormorants	No. cormorants (%)	No. cormorants	No. cormorants (%)	No. cormorants	No. cormorants (%)
<b>Upland<sup>1</sup></b>						
Herbaceous vegetation	3,663	7.9%	376	1.1%	350	1.1%
Bare substrate	18,983	40.9%	10,385	31.2%	11,659	36.8%
Trees/shrubs	83	0.2%	5	0.02%	0	0.0%
Rip rap/large woody debris	10,536	22.7%	5,054	15.2%	3,079	9.7%
<b>Intertidal<sup>2</sup></b>	13,178	28.4%	17,447	52.4%	16,592	52.4%
<b>TOTAL</b>	<b>46,443</b>	<b>100.0%</b>	<b>33,267</b>	<b>100.0%</b>	<b>31,680</b>	<b>100.0%</b>

<sup>1</sup> Defined as the island area above the maximum high tide line.

<sup>2</sup> Defined as the island area below the maximum high tide line. This measure varies depending on when during the tide cycle the aerial photography was taken (which varied), and is not meant to be compared across times or years.

Table 4. Total land cover area (m<sup>2</sup>), number of active nests (both double-crested and Brandt's cormorants), occupied nesting area (m<sup>2</sup>), and nesting density (nest/m<sup>2</sup>) by land cover class in the cormorant nesting area on East Sand Island during 2010-2012. Land cover area calculations were from aerial photography taken of the East Sand Island cormorant nesting area in May, 2010-2012. Nesting area calculations were from aerial photography taken of the East Sand Island cormorant nesting area during peak nesting (May-June) and late nesting (July), prior to the fledging period, 2010-2012. Cormorant nesting area was defined as all of the island area west of the eastern-most active cormorant nest identified in aerial photography of East Sand Island in May 2010, prior to the large scale nest dissuasion experiments on East Sand Island in 2011 and 2012. Because Brandt's cormorants nest amongst nesting double-crested cormorants and because the two species are indistinguishable in aerial photography, we made no attempt to separate the two cormorant species in this analysis. Based on our estimates of colony size, double-crested cormorants make up the vast majority of cormorants included in this analysis (ca. 90%).

2010							
Land cover class	Land cover area (m <sup>2</sup> )	Peak nesting			Late nesting		
		No. nests	Occupied nesting area (m <sup>2</sup> )	Nesting density (nests/m <sup>2</sup> )	No. nests	Occupied nesting area (m <sup>2</sup> )	Nesting density (nests/m <sup>2</sup> )
<b>Upland<sup>1</sup></b>	65,144	14,279	12,248	1.2	11,377	10,827	1.1
Herbaceous vegetation	5,922	1,554	1,468	1.1	1,089	1,171	0.9
Bare substrate	42,024	6,729	5,608	1.2	5,164	4,807	1.1
Trees/shrubs	61	2	4	0.5	2	3	0.6
Rip rap/large woody debris	17,137	5,994	5,169	1.2	5,122	4,846	1.1
<b>Intertidal<sup>2</sup></b>	134,788	14	16	0.9	10	17	0.6

2011							
Land cover class	Land cover area (m <sup>2</sup> )	Peak nesting			Late nesting		
		No. nests	Occupied nesting area (m <sup>2</sup> )	Nesting density (nests/m <sup>2</sup> )	No. nests	Occupied nesting area (m <sup>2</sup> )	Nesting density (nests/m <sup>2</sup> )
<b>Upland<sup>1</sup></b>	65,751	13,414	11,483	1.2	8,600	7,682	1.1
Herbaceous vegetation	2,778	49	54	0.9	0	0	0.0
Bare substrate	45,970	7,138	6,150	1.2	4,707	4,175	1.1
Trees/shrubs	121	0	0	0.0	0	0	0.0
Rip rap/large woody debris	16,882	6,227	5,279	1.2	3,893	3,507	1.1
<b>Intertidal<sup>2</sup></b>	134,181	23	35	0.7	0	0	0.0

2012							
Land cover class	Land cover area (m <sup>2</sup> )	Peak nesting			Late nesting		
		No. nests	Occupied nesting area (m <sup>2</sup> )	Nesting density (nests/m <sup>2</sup> )	No. nests	Occupied nesting area (m <sup>2</sup> )	Nesting density (nests/m <sup>2</sup> )
<b>Upland<sup>1</sup></b>	66,082	14,010	11,206	1.3	8,432	6,534	1.3
Herbaceous vegetation	5,289	1,241	1,018	1.2	124	100	1.2
Bare substrate	42,896	7,662	6,190	1.2	5,505	4,345	1.3
Trees/shrubs	233	0	0	0.0	0	0	0.0
Rip rap/large woody debris	17,664	5,107	3,998	1.3	2,803	2,090	1.3
<b>Intertidal<sup>2</sup></b>	125,644	14	21	0.7	3	4	0.7

<sup>1</sup> Defined as the island area above the maximum high tide line.

<sup>2</sup> Defined as the island area below the maximum high tide line. This measure varies depending on when during the tide cycle the aerial photo was taken (which varied), and is not meant to be compared across times or years.

Table 5. Number of active Brandt's cormorant nests and proportion of the total number of active nests (%) by land cover class on East Sand Island for (1) the entire island, (2) the cormorant use area, and (3) the cormorant nesting area during 2010-2012. Nest counts were from ground-based observations and aerial photography taken of East Sand Island during peak nesting (June), 2010-2012. The cormorant use and nesting areas were based on the distribution of nesting and roosting cormorants on East Sand Island in 2010, prior to the large scale nest dissuasion experiments on East Sand Island in 2011 and 2012. Cormorant use area was defined as all of the island area west of the eastern-most cormorant identified in the August 2010 photo. Cormorant nesting area was defined as all of the island area west of the eastern-most active cormorant nest identified in the May 2010 photo.

Land cover class	2010					
	Entire island		Cormorant use area		Cormorant nesting area	
	No. nests	No. nests (%)	No. nests	No. nests (%)	No. nests	No. nests (%)
<b>Upland<sup>1</sup></b>						
Herbaceous vegetation	0	0.0%	0	0.0%	0	0.0%
Bare substrate	264	26.8%	264	26.8%	264	26.8%
Trees/shrubs	0	0.0%	0	0.0%	0	0.0%
Rip-rap/large woody debris	721	73.2%	721	73.2%	721	73.2%
<b>Intertidal<sup>2</sup></b>	0	0.0%	0	0.0%	0	0.0%
<b>TOTAL</b>	<b>985</b>	<b>100.0%</b>	<b>985</b>	<b>100.0%</b>	<b>985</b>	<b>100.0%</b>

Land cover class	2011					
	Entire island		Cormorant use area		Cormorant nesting area	
	No. nests	No. nests (%)	No. nests	No. nests (%)	No. nests	No. nests (%)
<b>Upland<sup>1</sup></b>						
Herbaceous vegetation	0	0.0%	0	0.0%	0	0.0%
Bare substrate	730	49.0%	730	49.0%	730	49.0%
Trees/shrubs	0	0.0%	0	0.0%	0	0.0%
Rip-rap/large woody debris	761	51.0%	761	51.0%	761	51.0%
<b>Intertidal<sup>2</sup></b>	0	0.0%	0	0.0%	0	0.0%
<b>TOTAL</b>	<b>1,491</b>	<b>100.0%</b>	<b>1,491</b>	<b>100.0%</b>	<b>1,491</b>	<b>100.0%</b>

Land cover class	2012					
	Entire island		Cormorant use area		Cormorant nesting area	
	No. nests	No. nests (%)	No. nests	No. nests (%)	No. nests	No. nests (%)
<b>Upland<sup>1</sup></b>						
Herbaceous vegetation	35	2.1%	35	2.1%	35	2.1%
Bare substrate	1,160	68.9%	1,160	68.9%	1,160	68.9%
Trees/shrubs	0	0.0%	0	0.0%	0	0.0%
Rip-rap/large woody debris	489	29.0%	489	29.0%	489	29.0%
<b>Intertidal<sup>2</sup></b>	0	0.0%	0	0.0%	0	0.0%
<b>TOTAL</b>	<b>1,684</b>	<b>100.0%</b>	<b>1,684</b>	<b>100.0%</b>	<b>1,684</b>	<b>100.0%</b>

<sup>1</sup> Defined as the island area above the maximum high tide line.

<sup>2</sup> Defined as the island area below the maximum high tide line. This measure varies depending on when during the tide cycle the aerial photography was taken (which varied), and is not meant to be compared across times or years.

Table 6. Number of glaucous-winged/western gulls and proportion of the total number of gulls (%) by land cover class on East Sand Island for (1) the entire island, (2) the cormorant use area, and (3) the cormorant nesting area in 2010-2012. Glaucous-winged/western gull counts were from aerial photography taken of East Sand Island during peak nesting (May-June), 2010-2012. The cormorant use and nesting areas were based on the distribution of nesting and roosting cormorants on East Sand Island in 2010, prior to the large scale nest dissuasion experiments on East Sand Island in 2011 and 2012. Cormorant use area was defined as all of the island area west of the eastern-most cormorant identified in the August 2010 photography. Cormorant nesting area was defined as all of the island area west of the eastern-most active cormorant nest identified in the May 2010 photo.

Land cover class	2010					
	Entire island		Cormorant use area		Cormorant nesting area	
	No. gulls	No. gulls (%)	No. gulls	No. gulls (%)	No. gulls	No. gulls (%)
<b>Upland<sup>1</sup></b>						
Herbaceous vegetation	3,163	45.4%	1,153	27.0%	749	20.5%
Bare substrate	2,685	38.5%	2,598	60.8%	2,551	69.8%
Trees/shrubs	45	0.6%	24	0.6%	6	0.2%
Rip-rap/large woody debris	697	10.0%	351	8.2%	254	6.9%
<b>Intertidal<sup>2</sup></b>	376	5.4%	144	3.4%	97	2.7%
<b>TOTAL</b>	<b>6,966</b>	<b>100.0%</b>	<b>4,270</b>	<b>100.0%</b>	<b>3,657</b>	<b>100.0%</b>

Land cover class	2011					
	Entire island		Cormorant use area		Cormorant nesting area	
	No. gulls	No. gulls (%)	No. gulls	No. gulls (%)	No. gulls	No. gulls (%)
<b>Upland<sup>1</sup></b>						
Herbaceous vegetation	2,942	43.4%	890	21.0%	468	12.9%
Bare substrate	2,714	40.1%	2,672	62.9%	2,590	71.2%
Trees/shrubs	55	0.8%	29	0.7%	6	0.2%
Rip-rap/large woody debris	583	8.6%	308	7.3%	244	6.7%
<b>Intertidal<sup>2</sup></b>	482	7.1%	349	8.2%	332	9.1%
<b>TOTAL</b>	<b>6,776</b>	<b>100.0%</b>	<b>4,248</b>	<b>100.0%</b>	<b>3,640</b>	<b>100.0%</b>

Land cover class	2012					
	Entire island		Cormorant use area		Cormorant nesting area	
	No. gulls	No. gulls (%)	No. gulls	No. gulls (%)	No. gulls	No. gulls (%)
<b>Upland<sup>1</sup></b>						
Herbaceous vegetation	1,497	44.4%	642	27.7%	376	19.5%
Bare substrate	1,263	37.5%	1,230	53.0%	1,191	61.6%
Trees/shrubs	26	0.8%	18	0.8%	4	0.2%
Rip-rap/large woody debris	398	11.8%	286	12.3%	229	11.9%
<b>Intertidal<sup>2</sup></b>	185	5.5%	144	6.2%	132	6.8%
<b>TOTAL</b>	<b>3,369</b>	<b>100.0%</b>	<b>2,320</b>	<b>100.0%</b>	<b>1,932</b>	<b>100.0%</b>

<sup>1</sup> Defined as the island area above the maximum high tide line.

<sup>2</sup> Defined as the island area below the maximum high tide line. This measure varies depending on when during the tide cycle the aerial photography was taken (which varied), and is not meant to be compared across times or years.



Table 7. Number of ring-billed gulls and proportion of the total number of gulls (%) by land cover class on East Sand Island for (1) the entire island, (2) the cormorant use area, and (3) the cormorant nesting area during 2010-2012. Ring-billed gull counts were from aerial photography taken of East Sand Island during peak nesting (May-June), 2010-2012. The cormorant use and nesting areas were based on the distribution of nesting and roosting cormorants on East Sand Island in 2010, prior to the large scale nest dissuasion experiments on East Sand Island in 2011 and 2012. Cormorant use area was defined as all of the island area west of the eastern-most cormorant identified in the August 2010 photography. Cormorant nesting area was defined as all of the island area west of the eastern-most active cormorant nest identified in the May 2010 photography.

Land cover class	2010					
	Entire island		Cormorant use area		Cormorant nesting area	
	No. gulls <sup>3</sup>	No. gulls (%)	No. gulls	No. gulls (%)	No. gulls	No. gulls (%)
<b>Upland<sup>1</sup></b>						
Herbaceous vegetation	0	0.0%	0	0.0%	0	0.0%
Bare substrate	176	12.4%	0	0.0%	0	0.0%
Trees/shrubs	0	0.0%	0	0.0%	0	0.0%
Rip rap/large woody debris	1,089	76.9%	0	0.0%	0	0.0%
<b>Intertidal<sup>2</sup></b>	152	10.7%	0	0.0%	0	0.0%
<b>TOTAL</b>	<b>1,417</b>	<b>100.0%</b>	<b>0</b>	<b>0.0%</b>	<b>0</b>	<b>0.0%</b>

Land cover class	2011					
	Entire island		Cormorant use area		Cormorant nesting area	
	No. gulls <sup>3</sup>	No. gulls (%)	No. gulls	No. gulls (%)	No. gulls	No. gulls (%)
<b>Upland<sup>1</sup></b>						
Herbaceous vegetation	0	0.0%	0	0.0%	0	0.0%
Bare substrate	613	31.5%	0	0.0%	0	0.0%
Trees/shrubs	0	0.0%	0	0.0%	0	0.0%
Rip rap/large woody debris	822	42.3%	0	0.0%	0	0.0%
<b>Intertidal<sup>2</sup></b>	509	26.2%	0	0.0%	0	0.0%
<b>TOTAL</b>	<b>1,944</b>	<b>100.0%</b>	<b>0</b>	<b>0.0%</b>	<b>0</b>	<b>0.0%</b>

Land cover class	2012					
	Entire island		Cormorant use area		Cormorant nesting area	
	No. gulls <sup>3</sup>	No. gulls (%)	No. gulls	No. gulls (%)	No. gulls	No. gulls (%)
<b>Upland<sup>1</sup></b>						
Herbaceous vegetation	451	30.6%	0	0.0%	0	0.0%
Bare substrate	0	0.0%	0	0.0%	0	0.0%
Trees/shrubs	0	0.0%	0	0.0%	0	0.0%
Rip rap/large woody debris	424	28.8%	0	0.0%	0	0.0%
<b>Intertidal<sup>2</sup></b>	597	40.6%	0	0.0%	0	0.0%
<b>TOTAL</b>	<b>1,472</b>	<b>100.0%</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>

<sup>1</sup> Defined as the island area above the maximum high tide line.

<sup>2</sup> Defined as the island area below the maximum high tide line. This measure varies depending on when during the tide cycle the aerial photography was taken (which varied), and is not meant to be compared across times or years.

<sup>3</sup> Ring-billed gulls nested only on the east end of East Sand Island (i.e., outside cormorant use and nesting areas).

Table 8. Number of California brown pelicans by month and zone on East Sand Island during 2010-2012. Counts of roosting pelicans were carried out during periodic boat-based surveys conducted in the evening from May through August, 2010-2012. Monthly counts were based on the average of multiple counts (n = 1 – 5) carried out throughout the month. Average counts for the entire study period (May-August) were calculated for each zone and for a combination of zones (i.e., East End, South Beach, West End, Interior/Lagoon, North Beach, and Total; see Figure 1 for a map showing the zones). Zones most affected by cormorant nest dissuasion experiments in 2011 and 2012 were S3 and S1-S4, respectively.

2010																	
Month	East End <sup>1</sup>			South Beach					West End						Interior/ Lagoon <sup>2</sup>	North Beach <sup>3</sup>	TOTAL
	E1	E2	E3	S1	S2	S3	S4	S5	W1	W2	W3	W4	W5	W6			
May	402	1	0	1,188	9	648	74	0	0	0	15	27	161	0	570	0	3,092
June	1,113	1	0	2,155	0	1,045	745	75	0	0	0	0	1	0	1,220	0	6,355
July	1,755	10	0	1,845	156	940	687	180	895	161	209	830	1,180	29	1,350	130	10,357
August <sup>4</sup>	1,584	486	427	1,693	37	372	506	100	1,240	50	67	695	958	255	1,125	1,063	10,655
AVERAGE	1,214	125	107	1,720	50	751	503	89	534	53	73	388	575	71	1,066	298	7,615
	482			623					282								

2011																	
Month	East End <sup>1</sup>			South Beach					West End						Interior/ Lagoon <sup>2</sup>	North Beach <sup>3</sup>	TOTAL
	E1	E2	E3	S1	S2	S3	S4	S5	W1	W2	W3	W4	W5	W6			
May <sup>5</sup>	512	0	0	803	8	480	0	0	215	0	0	10	60	0	0	32	2,120
June	258	0	0	1,900	52	603	116	21	348	13	150	559	504	39	49	619	5,228
July	473	36	1	1,952	36	690	311	91	875	10	58	282	219	123	141	689	5,987
August <sup>4</sup>	1,150	1,233	551	2,345	84	863	450	268	1,447	28	49	603	867	212	590	637	11,377
AVERAGE	598	317	138	1,750	45	659	219	95	721	13	64	364	412	93	195	494	6,178
	351			554					278								

2012																	
Month	East End <sup>1</sup>			South Beach					West End						Interior/ Lagoon <sup>2</sup>	North Beach <sup>3</sup>	TOTAL
	E1	E2	E3	S1	S2	S3	S4	S5	W1	W2	W3	W4	W5	W6			
May <sup>6</sup>	1,139	1,043	0	682	1	135	0	0	0	1	6	313	22	0	0	0	3,342
June <sup>6</sup>	965	1,805	45	2,020	35	25	0	0	0	0	0	0	0	0	0	0	4,895
July	1,043	1,978	333	1,615	14	1,270	296	238	223	3	0	283	200	5	0	75	7,573
August <sup>4</sup>	1,510	1,570	500	930	65	330	130	55	80	115	75	680	430	180	100	3,000	9,750
AVERAGE	1,164	1,599	219	1,312	29	440	107	73	76	30	20	319	163	46	25	769	6,390
	994			392					109								

<sup>1</sup> Increase in number of pelicans counted on the East End in 2012 was likely due to changes in island access by researchers and monitoring activities during that year

<sup>2</sup> Cause of declining trend in the number of pelicans counted in the Interior/Lagoon portion of the island are unknown, but were not associated with the cormorant nest dissuasion experiments in 2011 or 2012

<sup>3</sup> Majority of pelicans counted on North Beach were on the western portion

<sup>4</sup> Peak island-wide pelican counts were in August during 2010-2012, declining thereafter (BRNW, unpubl. data)

<sup>5</sup> Month when hazing occurred as part of the nest dissuasion experiment in 2011

<sup>6</sup> Months when hazing occurred as part of the nest dissuasion experiment in 2012

## FIGURES



Figure 1. Base map of East Sand Island in the Columbia River estuary that was used in this report (aerial photography taken in 2010).



Figure 2. The cormorant use area and cormorant nesting area on East Sand Island. The cormorant use and nesting areas were based on the distribution of nesting and roosting cormorants on East Sand Island in 2010, prior to the large-scale nest dissuasion experiments on East Sand Island in 2011 and 2012. Cormorant use area was defined as all of the island area west of the eastern-most cormorant identified in the August 2010 photography. Cormorant nesting area was defined as all of the island area west of the eastern-most active cormorant nest identified in the May 2010 photography.





Figure 3. Island areas on East Sand Island by land cover class in 2010. Land cover classes include herbaceous vegetation, bare substrate, trees/shrubs, rip-rap/large woody debris, and intertidal.



Figure 4. Island areas on East Sand Island by land cover class in 2011. Land cover classes include, herbaceous vegetation, bare substrate, trees/shrubs, rip-rap/large woody debris, and intertidal.





Figure 5. Island areas on East Sand Island by land cover class in 2012. Land cover classes include, herbaceous vegetation, bare substrate, trees/shrubs, rip-raft/large woody debris, and intertidal.



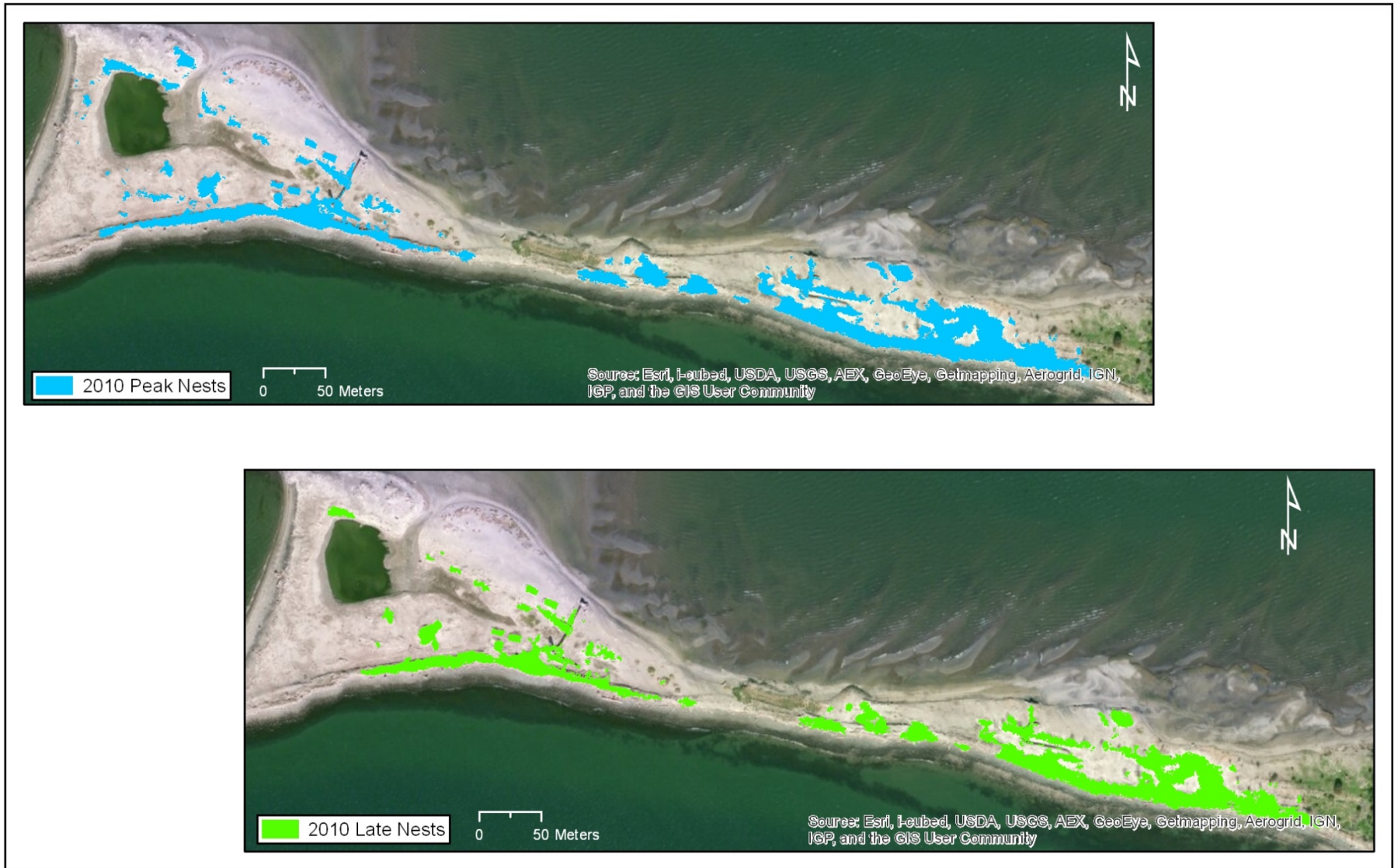


Figure 6. Distribution of active cormorant nests (both double-crested and Brandt’s cormorants) on East Sand Island in 2010. Nest counts were from aerial photography taken of the cormorant nesting area on East Sand Island during peak nesting (May-June) and late nesting (July), prior to the fledging period, 2010. Cormorant nesting area was defined as all of the island area west of the eastern-most active cormorant nest identified in aerial photography of East Sand Island in May 2010, prior to the large-scale nest dissuasion experiments on East Sand Island in 2011 and 2012.



Figure 7. Distribution of active cormorant nests (both double-crested and Brandt's cormorants) on East Sand Island in 2011. Nest counts were from aerial photography taken of the cormorant nesting area on East Sand Island during peak nesting (May-June) and late nesting (July), prior to the fledging period, 2011. Cormorant nesting area was defined as all of the island area west of the eastern-most active cormorant nest identified in aerial photography of East Sand Island in May 2010, prior to the large-scale nest dissuasion experiments on East Sand Island in 2011 and 2012.



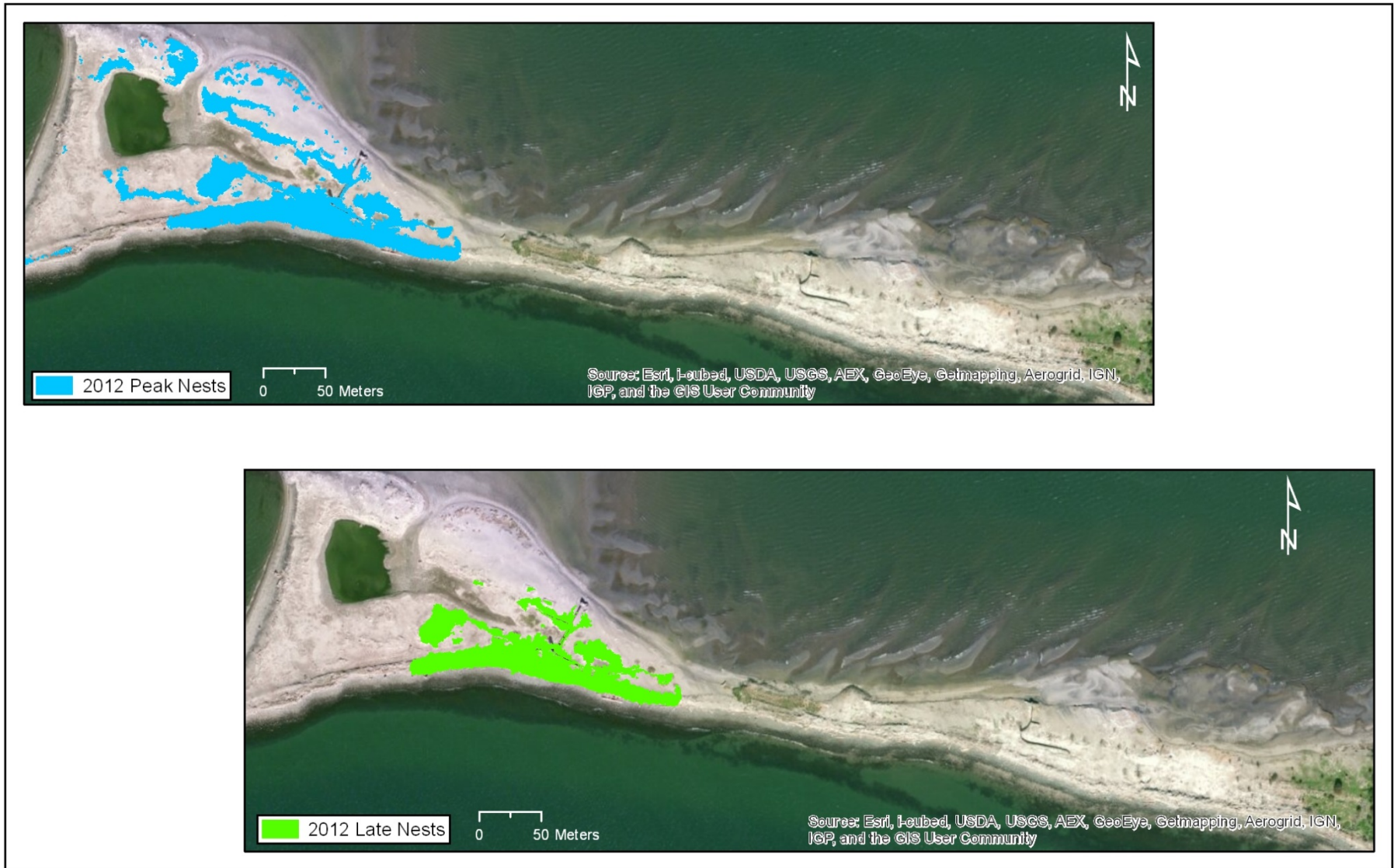


Figure 8. Distribution of active cormorant nests (both double-crested and Brandt's cormorants) on East Sand Island in 2012. Nest counts were from aerial photography taken of the cormorant nesting area on East Sand Island during peak nesting (May-June) and late nesting (July), prior to the fledging period, 2012. Cormorant nesting area was defined as all of the island area west of the eastern-most active cormorant nest identified in aerial photography of East Sand Island in May 2010, prior to the large-scale nest dissuasion experiments on East Sand Island in 2011 and 2012.



Figure 9. Distribution of individual cormorants (both double-crested and Brandt's cormorants) on East Sand Island in 2010. Cormorant counts (adults and juveniles) were from aerial photography of the cormorant use area on East Sand Island during the peak fledging period (August), 2010. Cormorant use area was defined as all of the island area west of the eastern-most cormorant identified in aerial photography of East Sand Island in August 2010, prior to the large-scale nest dissuasion experiments on East Sand Island in 2011 and 2012.





Figure 10. Distribution of individual cormorants (both double-crested and Brandt's cormorants) on East Sand Island in 2011. Cormorant counts (adults and juveniles) were from aerial photography of the cormorant use area on East Sand Island during the peak fledging period (August), 2011. Cormorant use area was defined as all of the island area west of the eastern-most cormorant identified in aerial photography of East Sand Island in August 2010, prior to the large-scale nest dissuasion experiments on East Sand Island in 2011 and 2012.





Figure 11. Distribution of individual cormorants (both double-crested and Brandt's cormorants) on East Sand Island in 2012. Cormorant counts (adults and juveniles) were from aerial photography of the cormorant use area on East Sand Island during the peak fledging period (August), 2012. Cormorant use area was defined as all of the island area west of the eastern-most cormorant identified in aerial photography of East Sand Island in August 2010, prior to the large-scale nest dissuasion experiments on East Sand Island in 2011 and 2012.



Figure 12. Distribution of active Brandt's cormorant nests on East Sand Island in 2010. Nest counts were from ground-based observations and aerial photography taken of the cormorant nesting area on East Sand Island during peak nesting (June), 2010. Cormorant nesting area was defined as all the island area west of the eastern-most active cormorant nest identified in aerial photography of East Sand Island in May 2010, prior to the large-scale nest dissuasion experiments on East Sand Island in 2011 and 2012.





Figure 13. Distribution of active Brandt's cormorant nests on East Sand Island in 2011. Nest counts were from ground-based observations and aerial photography taken of the cormorant nesting area on East Sand Island during peak nesting (June), 2011. Cormorant nesting area was defined as all of the island area west of the eastern-most active cormorant nest identified in aerial photography of East Sand Island in May 2010, prior to the large-scale nest dissuasion experiments on East Sand Island in 2011 and 2012.





Figure 14. Distribution of active Brandt's cormorant nests on East Sand Island in 2012. Nest counts were from ground-based observations and aerial photography taken of the cormorant nesting area on East Sand Island during peak nesting (June), 2012. Cormorant nesting area was defined as all of the island area west of the eastern-most active cormorant nest identified in aerial photography of East Sand Island in May 2010, prior to the large-scale nest dissuasion experiments on East Sand Island in 2011 and 2012.



Figure 15. Distribution of glaucous-winged/western gulls nesting on East Sand Island in 2010. Glaucous-winged/western gull counts were from aerial photography of East Sand Island during the peak of nesting (May-June), 2010.





Figure 16. Distribution of glaucous-winged/western gulls nesting on East Sand Island in 2011. Glaucous-winged/western gull counts were from aerial photography of East Sand Island during the peak of nesting (May-June), 2011.



Figure 17. Distribution of glaucous-winged/western gulls nesting on East Sand Island in 2012. Glaucous-winged/western gull counts were from aerial photography of East Sand Island during the peak of nesting (May-June), 2012.





Figure 18. Distribution of ring-billed gulls nesting on East Sand Island in 2010. Ring-billed gull counts were from aerial photography of East Sand Island during the peak of nesting (May-June), 2010.



Figure 19. Distribution of ring-billed gulls nesting on East Sand Island in 2011. Ring-billed gull counts were from aerial photography of East Sand Island during the peak of nesting (May-June), 2011.





Figure 20. Distribution of ring-billed gulls nesting on East Sand Island in 2012. Ring-billed gull counts were from aerial photography of East Sand Island during the peak of nesting (May-June), 2012.



Figure 21. Zones used to count roosting California brown pelicans on East Sand Island during 2010-2012. Zones most affected by cormorant nest dissuasion experiments in 2011 and 2012 were S3 and S1-S4, respectively.