0024138

From:	Britta Muiznieks
To:	Thayer Broili
Subject:	CAHA ORV Chapt 3
Date:	09/25/2009 11:39 AM
Attachments:	2000-2009 AMOY Breeding Success.xls CAHA CH3 with Buxton Comments.doc

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Thayer-
They are using Shiloh's AMOY report for their numbers. We have gone through all of our raw data and think our numbers are correct. The question is do they want to use Shiloh's numbers from NC State's Report or our numbers. I'm attaching our files justifying the changes that I made to the tables in Chapt 3.


2000-2009 AMOY Breeding Success.xls

I did not recalculate the totals and averages when I added in the 2009 data. I did a strikethrough indicating that they need to be recalculated.


CAHA CH3 with Buxton Comments.doc

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Nest #	Pair #	Band Numbers	Result	Date Found	Hatch Date	Fledge Date	Loss Date	Total Eggs	Total Hatched	Total Fledged	Location	Comment	Latitude	Longitude
1	B1		Lost	5/12/2000	N/A	N/A	6/1/2000	1	0	0	Oregon Inlet	6/01/00: Nest lost to weather		
2	B1		Lost	6/12/2000	N/A	N/A	6/24/2000	1	0	0	Oregon Inlet	6/24/00: Nest lost to unknown		
3	B2		Lost	6/8/2000	N/A	N/A	6/13/2000	1	0	0	Oregon Inlet	6/13/00: Nest lost to unknown		
25	H20		Lost	7/1/2000	N/A	N/A	7/12/2000	2	0	0	0.8 miles s R30	7/12/00: Nest lost to unknown		
26	H21		Lost	5/6/2000	N/A	N/A	6/1/2000	3	0	0	0.7 miles s r27	6/01/00: Nest lost to weather		
27	H22		Lost	5/17/2000	5/20/2000	N/A	6/1/2000	3	2	0	1 mile s r27	6/1/00: 2 chicks lost to weather		
28	H22		Lost	6/14/2000	N/A	N/A	7/4/2000	1	0	0	0.9 miles s r27	7/4/00: Nest lost to unkown		
29	H23		Lost	5/24/2000	unknown	N/A	6/6/2000	3	3	0	1.5 miles s R23	Unknown Hatch found 5/4, Chick lost 6/6/00		
1	H1		Lost	5/19/2000	N/A	N/A	5/21/2000	3	0	0	Hatteras Inl	5/21/00: Nest lost, probable pred by raccoon (many tracks seen in area)		
2	H1		Lost	6/8/2000	N/A	N/A	6/10/2000	3	0	0	Hatteras Inl	6/10/00: Nest lost to unkown		
3	H2		Lost	5/4/2000	5/25/2000	N/A	6/1/2000	3	1	0	Hatteras Inl	6/1/00: Chick lost possibly from severe storm previous two days		
4	H3		Fledge (1)	4/25/2000	5/20/2000	7/9/2000	N/A	2	1	1	Hatteras Inl	7/9/2000: Chick fledged		
5	H4		Lost	5/14/2000	N/A	N/A	6/1/2000	3	0	0	Hatteras Inl	6/1/00: Nest lost to overwash		
6	H4		Lost	6/19/2000	N/A	N/A	6/25/2000	3	0	0	Hatteras Inl	6/25/00: Nest lost to unknown		
7	H5		Lost	5/3/2000	5/21/2000	N/A	5/29/2008	3	3	0	Hatteras Inl	5/29/00: 1 chick lost during a storm, 6/5/00 chick lost to unk, 6/6/00 chick lost to unk		
8	H6		Lost	5/5/2000	N/A	N/A	6/1/2000	3	0	0	Hatteras Inl	6/1/00: Nest lost to overwash		
9	H7		Lost	5/3/2000	5/29/2000	N/A	6/1/2000	3	3	0	Ramp 57 encl	6/1/00: 3 chicks lost during severe storm previous two days		
10	H8		Lost	5/11/2000	N/A	N/A	6/7/2000	3	0	0	Ramp 57 encl	6/7/00: Nest lost unknown		
11	H9		Lost	5/21/2000	N/A	N/A	6/1/2000	3	0	0	Ramp 57 encl	6/1/00: Nest lost to overwash		
12	H10		Lost	4/21/2000	N/A	N/A	5/20/2000	3	0	0	2.2 miles no r49	5/20/00: Nest lost to unkown		
13	H10		Lost	5/29/2000	N/A	N/A	6/6/2000	2	0	0	2.2 miles no r49	6/6/00: Nest lost to ghost crab (confirmed by digging in hole and found eggs)		
14	H11		Lost	4/22/2000	5/24/2000	N/A	6/1/2000	3	1	0	South Beach	6/1/00: 1 chick lost during storm		
15	H11		Lost	6/17/2000	N/A	N/A	6/21/2000	3	0	0	South beach	6/21/00: Nest lost to avian predation		
16	H12		Lost	4/25/2000	5/28/2000	N/A	6/10/2000	3	1	0	South Beach	6/10/00: chick lost to unknown		
17	H13		Lost	4/29/2000	N/A	N/A	5/3/2000	3	0	0	South beach	5/3/00: Nest lost to unknown mammalian predator, eggs broken in half		
18	H14		Lost	4/29/2000	N/A	N/A	5/19/2000	3	0	0	Cape Point enc	5/19/00: Nest lost unknown		
19	H14		Lost	6/20/2000	N/A	N/A	7/1/2000	3	0	0	Cape Point enc	7/1/00: nest abandoned		
20	H15		Lost	5/28/2000	N/A	N/A	6/1/2000	3	0	0	Cape Point enc	6/1/00: Nest lost		
21	H16		Lost	5/6/2000	N/A	N/A	5/11/2000	3	0	0	Cape Point	5/11/00: Nest lost to avian predation		
22	H17		Fledge (1)	5/1/2000	5/21/2000	7/10/2000		3	2	1	Haulover	6/1/00: 1 chick lost during storm		
23	H18		Lost	5/4/2000	N/A	N/A	5/7/2000	3	0	0	Haulover	5/7/00: Nest lost to unknown		
24	H19		Lost	4/29/2000	5/28/2000	N/A	6/1/2000	3	3	0	0.8 miles no r34	6/1/00, two chicks lost during storm previous two days; 6/15/00 one chick lost to unk causes		
1	O1		Lost	5/10/2000	N/A	N/A	5/31/2000	3	0	0	Ramp 59 enc	5/31/00: Nest lost likely lost in storm		
2	O1		Lost	6/12/2000	N/A	N/A	6/20/2000	2	0	0	Ramp 59 enc	6/20/00: one egg gone; 7/8/00: nest lost likely to crow predation		
3	O2		Lost	5/11/2000	N/A	N/A	5/13/2000	1	0	0	2.5 miles N R70	5/13/00: Nest lost to Unknown		
4	O2		Fledge (1)	6/3/2000	6/13/2000	7/20/2000	6/23/2000	2	2	1	2 miles N R70	6/23/00: 1 Chick lost to UNK		
5	O3		Lost	5/12/2000	N/A	N/A	5/23/2000	3	0	0	2.5 miles S R59	5/23/00: Nest lost to Unknown		
6	O4		Fledge (3)	5/13/2000	5/23/2000	7/3/2000	N/A	3	3	3	1 mile S R59	7/3/00 Three fledglings		
7	O5		Lost	5/13/2000	6/12/2000	N/A	6/23/2000	3	3	0	2.8 miles N R67	6/23/00: Chicks lost unknown		
8	O6		Lost	5/13/2000	N/A	N/A	5/23/2000	2	0	0	Outside SE corner R72 enc	5/23/00: Nest lost, unknown, skimmers moved in to same area at time nest loss		
9	O6		Lost	5/28/2000	N/A	N/A	6/1/2000	1	0	0	Ramp 72 encl	6/1/00: Nest lost likely overwashed		
10	O6		Fledge (1)	6/14/2000	7/11/2000	8/20/2000	N/A	2	1	1	Ramp 72 encl	8/20/00 One fledgling		
11	O7		Lost	5/16/2000	N/A	N/A	6/3/2000	3	0	0	1 mile N R72	6/3/00: Nest lost, likely to storm		
12	O8		Lost	5/16/2000	N/A	N/A	6/26/2000	2	0	0	2 miles N R72	6/26/2000 nest abandoned		
13	O9		Fledge (1)	5/16/2000	6/16/2000	8/1/2000	N/A	3	1	1	Ramp 72 Encl	8/1/00 One chick fledged		

14	O10		Lost	5/26/2000	N/A	N/A	6/17/2000	3	0	0	2.75 m S of R59	6/17/00: Nest lsot, broken eggs, UNK predator, human tracks up dune and broken-wing gull on dune near egg shells		
15	O10		Lost	6/21/2000	N/A	N/A	6/22/2000	2	0	0	3 miles N R67	6/22/00: Nest lost to Unknown		
16	O11		Lost	6/16/2000	N/A	N/A	6/20/2000	3	0	0	Behind dunes R59 enc	6/20/2000: Nest lost to Unknown		
17	O12		Fledge (1)	7/5/2000	7/11/2000	8/28/2000	N/A	2	1	1	Ramp 72 encl	8/28/00: One fledgling		
1	B1		Lost	5/11/2001	N/A	N/A	5/14/2001	2	0	0	Bodie flats N side Oreg Inlet	5/14/01: Nest predated fox tracks leading up to nest		
2	B1		Lost	5/23/2001	N/A	N/A	6/9/2001	2	0	0	Bodie Flats N side Oreg Inlet	6/9/01: Red Fox tracks at nest		
3	B2		Fledge	5/23/2001	6/17/2001	7/28/2001	N/A	2	2	1	Bodie Flats N side Oreg Inlet	6/26/01: 1 Chick lost to unknown		
1	BH22		Fledge	5/11/2001	5/29/2001	7/16/2001	N/A	3	3	1	0.6 mi. S of R27	6/18/01: 1 chick lost to UNK, 6/20/01: 1 chick lost to UNK, 7/16/01: 1 chick fledged		
2	BH23		Fledge	5/11/2001	5/26/2001	7/16/2001	N/A	3	2	1	1 mile S of R27	6/4/01: 1 chick lost to UNK, 7/16/01: 1 chick fledged		
3	BH24		Lost	6/1/2001	N/A	N/A	6/16/2001	2	0	0	2.0 mi. S of R23	6/16/01: Crow tracks at nest, broken egg nearby		
1	H1		Lost	4/25/2001	N/A	N/A	5/5/2001	2	0	0	1 mile S of R55	5/5/01: Nest lost UNK		
2	H2		Lost	4/29/2001	5/27/2001	N/A	6/10/2001	2	2	0	.3 miles S of R30	6/10/01: 2 chicks lost to unknown		
3	H3		Lost	5/4/2001	N/A	N/A	5/12/2001	3	0	0	Cape Pt closure; s beach	5/12/01: UNK, possible fox predation, fox tracks in area.		
4	H4		Lost	5/4/2001	N/A	N/A	5/12/2001	1	0	0	Cape Point closure; s beach	5/12/01: UNK, possible fox predation, fox tracks in area.		
5	H5		Lost	5/5/2001	N/A	N/A	5/?/2001	3	0	0	South beach .9 miles S of R45	Cause and Date lost UNK.		
6	H6		Lost	5/5/2001	6/4/2001	N/A	6/20/2001	3	2	0	South beach 1.4 miles S of R45	Chicks lost 6/20/01; unknown		
7	H7		Lost	5/6/2001	5/6/2001	N/A	5/17/2001	3	0	0	.1 mile S of R57	5/17/01: UNK		
8	H8		Lost	5/6/2001	N/A	N/A	5/17/2001	1	0	0	.2 miles S of R57	5/17/01: UNK		
9	H9		Lost	5/6/2001	N/A	N/A	5/17/2001	3	0	0	.8 miles S of R57	5/17/01: UNK		
10	H10		Lost	5/10/2001	N/A	N/A	6/4/2001	2	0	0	Hatt Inlet; just N of R57	6/4/01: Nest lost UNK		
11	H11		Lost	5/10/2001	5/23/2001	N/A	6/4/2001	3	1	0	Hatt Inlet; .8 miles S of R55	Chick lost 6/04/01; unknown (cats trapped)		
12	H12		Fledge	5/13/2001	5/31/2001	7/28/2001	N/A	3	3	1	.3 miles S of R57	6/10/01: 1 chick lost UNK, 6/22/01: 1 chick lost UNK		
13	H13		Lost	5/14/2001	N/A	N/A	5/24/2001	1	0	0	Cape Point; .2 mi S of R44	5/24/01: Fox predation		
14	H14		Lost	5/18/2001	N/A	N/A	6/3/2001	1	0	0	Cape Point; .8 miles S of R44	6/3/01: loss UNK		
15	H15		Lost	5/22/2001	6/17/2001	N/A	6/23/2001	1	1	0	Hatt Inlet; .3 miles S of R55	6/23/01: Chick lost to UNK		
16	H5		Unknown	5/23/2001	Unknown	Unknown	Unknown				South beach; .9 miles S of R45	Very little data		
17	H1		Fledge	5/21/2001	6/17/2001	7/28/2001	N/A	3	1	1	.9 miles S of R55	7/28/01: Chick fledged		
18	H16		Lost	5/27/2001	N/A	N/A	5/31/2001	1	0	0	1.1 mile S of R45; South beach	5/31/01: Nest empty after heavy rains from tropical depression		
19	H17		Lost	5/28/2001	N/A	N/A	6/10/2001	2	0	0	Hatteras Inlet; behind pond	6/10/01: loss UNK		
20	H9		Lost	5/31/2001	N/A	N/A	6/16/2001	1	0	0	.7 miles S of R57	6/16/01: UNK		
21	H18		Lost	6/4/2001	N/A	N/A	6/19/2001	2	0	0	.6 miles N of R43	6/19/01: possible fox predation, fox tracks throughout the area.		
22	H19		Fledge	Unknown	6/4/2001	6/27/2001	N/A	UNK	2	1	ca. 1/2 mile S of Haulover	6/10/01: Chick lost UNK		
23	H9		Lost	6/16/2001	N/A	N/A	7/11/2001	1	0	0	Hatteras Inlet; SE corner	7/11/01: gull tracks in the area		
24	H20		Lost	6/18/2001	N/A	N/A	6/25/2001	1	0	0	South beach; .1 mile S of R45	6/25/01: Loss UNK		
25	H21		Fledge	Unknown	6/22/2001	6/26/2001	N/A	UNK	UNK	1	Washover N of Buxton	Unknown hatch date		
1	O1		Lost	4/30/2001	N/A	N/A	5/19/2001	2	0	0	Ramp 59	5/19/01: cause of loss UNK, Predator tracks (mink) in area. Description and GPS don't match		
2	O2		Fledge	4/30/2001	6/5/2001	7/1/2001	N/A	2	2	2	1.7 miles South of Ramp 67	7/1/01: 2 chicks fledged.		
3	O3		Fledge	4/30/2001	5/30/2001	7/1/2001	N/A	4	3	2	1.5 miles South of Ramp 70	6/5/01: 1 chick lost to UNK		
4	O4		Fledge	5/12/2001	6/13/2001	7/11/2001	N/A	3	3	3	.9 miles South of Ramp 72	7/11/01: 2 chicks fledged, 3rd chick not seen but assumed fledged based on age. Calculated from est. hatch date of 6/7		
5	O5		Fledge	5/15/2001	6/6/2001	7/20/2001	N/A	3	2	2	1.3 miles South of Ramp 68	7/20/01: 2 fledglings		
6	O6		Lost	5/15/2001	N/A	N/A	5/25/2001	2	0	0	.9 miles South of Ramp 59	5/25/01: Nest lost to UNK causes		
7	O7		Fledge	5/15/2001	6/13/2001	7/17/2001	N/A	3	2	2	2.0 miles South of Ramp 72	7/17/01: 2 fledglings		
8	O8		Lost	5/19/2001	5/24/2001	N/A	6/5/2001	2	2	0	3.7 miles South of Ramp 59	6/5/01: 2 chicks lost to UNK causes		
9	O9		Fledge	5/23/2001	6/25/2001	7/30/2001	N/A	2	2	2	2.3 miles south of Ramp 59	7/30/01: 2 chicks fledged		
10	O10		Fledge	5/24/2001	5/22/2001	6/23/2001	N/A	UNK	2	2	4 miles South of Ramp 59	5/24/01: Adult was found brooding chicks, 6/23/01: unable to locate group. Chicks were assumed fledged based on age.		
11	O11		Fledge	5/29/2001	6/27/2001	8/1/2001	N/A	2	2	2	.5 miles North of Ramp 59	8/1/01: 2 fledglings		
12	O12		Lost	6/5/2001	7/4/2001	N/A	7/11/2001	2	1	0	1.5 miles South of Ramp 59	7/11/01; chick/adults not in area; unknown		
13	O6		Lost	6/10/2001	7/4/2001	N/A	7/22/2001	2	1	0	Ramp 59 closure	7/22/01 closure flooded parents and chick missing		

14	O8		Lost	6/19/2001	N/A	N/A	7/1/2001	2	0	0	3.7 miles South of Ramp 59	7/1/01: nest lost to ghost crab predation		
15	O13		lost	6/20/2001	N/A	N/A	7/11/2001	2	0	0	.8 miles North of Ramp 67	7/11/01: enclosure abandoned; possibly due to heavy day use traffic		
1	B1		Lost	5/1/2002	N/A	N/A	5/8/2002	1	0	0	Oregon Inlet flats	5/8/01: Nest lost to fox predation		
2	B2		Lost	5/12/2002	N/A	N/A	5/22/2002	2	0	0	Oregon Inlet flats; SE side	5/22/02: weather/nest abandoned		
3	B1		Lost	5/20/2002	N/A	N/A	5/25/2002	3	0	0	Out SE corner of Oregon Inlet	5/25/02: lost to fox or ORV		
4	B2		Lost	5/26/2002	N/A	N/A	6/4/2002	3	0	0	Off east side of Oregon Inlet	6/4/02: lost to fox		
5	B1		Fledge	6/4/2002	7/1/2002	8/13/2002	N/A	2	2	2	south side of Oregon Inlet	8/13/02: 2 chicks fledged		
1	BH15		Lost	4/27/2002	N/A	N/A	5/6/2002	3	0	0	.8 miles south of Ramp 27	5/6/02: Fox predation		
2	BH16		Lost	4/29/2002	N/A	N/A	5/6/2002	3	0	0	1 mile south of Ramp 27	5/6/02: Fox predation		
3	BH17		Lost	5/20/2002	N/A	N/A	5/27/2002	2	0	0	1.1 miles north of Ramp 27	5/27/02: Fox predation		
1	H1		Lost	4/18/2002	N/A	N/A	5/17/2002	3	0	0	South Beach, 1.2 mi s of R45	5/17/02: lost to UNK		
2	H2		Lost	4/25/2002	N/A	N/A	5/18/2002	3	0	0	South Beach; .8 mi s of R45	5/18/02: lost to UNK		
3	H3		Lost	4/25/2002	N/A	N/A	5/3/2002	3	0	0	South Beach; just s of SPR	5/3/02: lost to UNK: wrong GPS location		
4	H4		Lost	4/26/2002	N/A	N/A	5/4/2002	2	0	0	.8 miles south of R55	5/4/02: lost to UNK		
5	H5		Lost	4/27/2002	N/A	N/A	5/8/2002	3	0	0	Hatteras Inlet; Ramp 57;	5/8/02: Lost to UNK		
6	H6		Lost	4/27/2002	N/A	N/A	5/3/2002	1	0	0	Hatteras Inlet	5/3/02: Lost to UNK		
7	H7		Lost	4/28/2002	N/A	N/A	5/3/2002	1	0	0	.9 miles south of Ramp 44	5/3/02: Lost to UNK		
8	H8		Lost	5/6/2002	N/A	N/A	5/10/2002	3	0	0	Cape Point; ca. .9 mi s of R44	5/10/02: Lost to UNK		
9	H9		Lost	5/7/2002	N/A	N/A	5/15/2002	3	0	0	Cape Point	5/15/02: Lost to fox predation		
10	H10		Lost	5/11/2002	N/A	N/A	5/19/2002	2	0	0	1.5 miles south of ramp 30	5/19/02: lost possibly to weather		
11	H11		Lost	5/13/2002	N/A	N/A	5/20/2002	2	0	0	Hatteras Inlet	5/20/02: lost possibly to weather		
12	H4		Lost	5/15/2002	N/A	N/A	5/20/2002	2	0	0	.8 miles south of ramp 55	5/20/02: lost possibly to weather		
13	H3		Lost	5/17/2002	N/A	N/A	6/7/2002	3	0	0	South Beach; .2 mi s of SPR	6/7/02: Lost to fox predation		
14	H5		Lost	5/18/2002	N/A	N/A	5/20/2002	2	0	0	Hatteras Inlet; Ramp 57	5/20/02: lost possibly to weather		
15	H12		Lost	5/24/2002	N/A	N/A	5/29/2002	3	0	0	Hatt Inlet sound side n pond	5/29/02: lost to UNK, incorrect GPS location		
16	H9		Lost	5/25/2002	N/A	N/A	6/7/2002	2	0	0	Cape Pt .1 mi e of shipwreck	6/7/02: Lost to fox predation		
17	H13		Fledge	5/4/2002	Unknown	7/26/2002	N/A	2	2	1	1.8 miles south of Ramp 38	Unknown hatch date, 6/6/02: 1 chick lost to UNK, 7/26/02: 1 chick fledged		
18	H14		Fledge	5/31/2002	Unknown	6/24/2002	N/A	2	2	2	Buxton washout .2 mi s of R38	Unknown hatch date, 6/24/02: 2 chicks fledged		
19	H1		Lost	5/31/2002	N/A	N/A	6/11/2002	2	0	0	South Beach, 1.1 mi s of R45	6/11/02: Lost to fox predation		
20	H2		Lost	5/31/2002	N/A	N/A	6/9/2002	3	0	0	South Beach; .8 mi s of R45	5/3/02: Lost to fox predation		
21	H6		Lost	6/5/2002	N/A	N/A	6/10/2002	1	0	0	Hatteras Inlet, just S of interdunal road	6/10/02: Lost to fox predation		
22	H10		Fledge	5/13/2002	Unknown	8/22/2002	N/A	1	1	1	1.5 miles south of ramp 30	Unknown hatch date		
1	O1		Lost	4/24/2002	N/A	N/A	4/26/2002	2	0	0	1.4 miles SW of ramp 70	4/26/02: Lost to UNK		
2	O2		Fledge	4/24/2002	5/21/2002	7/1/2002	N/A	3	3	1	1.9 miles NE of ramp 70	5/21/02: 2 chicks lost to UNK		
3	O3		Lost	4/27/2002	N/A	N/A	6/17/2002	3	0	0	1.55 miles NE of ramp 70	6/17/02: cat tracks, ghost crab, crow		
4	O4		Lost	4/27/2002	5/14/2002	N/A	6/7/2008	3	2	0	.5 miles NE of ramp 67	5/17/02: 1 chick lost, 6/7/02: 1 chick lost		
5	O5		Lost	4/27/2002	N/A	N/A	5/6/2002	2	0	0	5.7 miles NE of ramp 67	5/6/02: lost to UNK		
6	O6		Lost	4/29/2002	N/A	N/A	5/17/2002	2	0	0	2.2 miles SW of ramp 72	5/17/02: flooding, bad weather		
7	O7		Lost	4/30/2002	N/A	N/A	5/6/2002	2	0	0	Just NE of ramp 59	5/6/02: Lost to UNK, heavy traffic in area.		
8	O8		Lost	5/6/2002	N/A	N/A	5/20/2002	2	0	0	1.5 miles SW of ramp 72	5/20/02: Lost to UNK, bad weather, GPS location incorrect, heads up digi.		
9	O5		Lost	5/8/2002	N/A	N/A	5/21/2002	2	0	0	3.1 miles SW of ramp 59	5/21/02: Nest lost to UNK		
10	O9		Lost	5/8/2002	N/A	N/A	5/20/2002	2	0	0	Southpoint	5/20/02: Windy, bad weather		
11	O7		Fledge	5/17/2002	6/6/2002	7/14/2002	N/A	3	2	1	.3 miles NE of ramp 59	6/11/02: 1 chick lost to UNK, 7/14/02: 1 chick fledged		
12	O10		Lost	5/22/2002	N/A	N/A	5/29/2002	3	0	0	7.4 miles NE of ramp 67	5/29/02: high, high tide		
13	O1		Lost	5/24/2002	N/A	N/A	6/4/2002	2	0	0	1.3 miles SW of ramp 70	6/4/02: Lost to UNK		
14	O11		Lost	6/3/2002	N/A	N/A	6/21/2002-6/25/2002	3	0	0	3 miles SW of ramp 59	6/21-6/25/02: Nest lost to UNK b/t these days		
15	O6		Lost	6/4/2002	6/26/2002	N/A	6/29/2002	3	1	0	Southpoint enclosure	6/29/02: Chick lost; windy, bad weather		
16	O9		Fledge	6/7/2002	7/1/2002	8/19/2002	N/A	3	2	1	Southpoint	7/16/02: 1 chick lost to UNK, 8/19/02: 1 chick fledged		
17	O12		Lost	6/11/2002	N/A	N/A	7/2/2002	1	0	0	1 mile SW of ramp 59	7/2/02: Nest lost to UNK		
18	O1		Lost	6/13/2002	7/13/2002	N/A	7/20/2002	2	2	0	1.2 miles SW of ramp 70	7/20/02: 2 chicks lost to UNK		
4	B1		Lost	5/10/2003	N/A	N/A	5/31/2003	3	0	0	Oregon Inlet Flats	5/31/03: Nest possibly lost to storm		
5	B2		Lost	5/11/2003	N/A	N/A	5/27/2003	3	0	0	Oregon Inlet Flats	5/27/03: nest lost to fox predation		
7	B3		Lost	5/21/2003	N/A	N/A	6/7/2003	3	0	0	Oregon Inlet Flats	6/7/03: Nest lost to possiby weather		

11	B4		Lost	6/9/2003	7/7/2003	N/A	7/26/2003	2	2	0	Oregon Inlet Flats SE	7/26/03: 2 Chicks lost to possible fox		
12	B5		Lost	6/9/2003	N/A	N/A	6/25/2003	2	0	0	Oregon Inlet Flats	6/25/03: Nest lost to fox predation		
11	BH1		Lost	4/23/2003	5/19/2003	N/A	6/10/2003	3	3	0	1.0 mi S of R27	6/1/03: 2 chick lost to UNK, 6/10/03: 1 chick lost to UNK		
12	BH2		Fledge	4/26/2003	5/26/2003	6/29/2003	N/A	3	3	1	0.8 mi S of R27	5/31/03: 1 chick lost to UNK, 6/7/03: 1 chick lost to UNK, 6/29/03: 1 chick fledged		
13	BH3		Lost	4/29/2003	5/26/2003	N/A	6/17/2003	1	1	0	1.2 mi S of R23	6/17/03: 1 chick lost to UNK		
14	BH4		Lost	5/13/2003	6/10/2007	N/A	6/29/2003	3	3	0	0.7 mi N of R30	6/18-22/03: 1 chick lost to UNK, 6/29/03: 2 chicks hit by car outside protective closure		
15	BH5		Fledge	6/23/2003	Unknown	6/23/2003	N/A	unk	1	1	3.4 mi S of R23	Unknown hatch date		
16	BH6		Fledge	6/23/2003	Unknown	6/23/2003	N/A	unk	1	1	3.7 mi S of R23	Unknown hatch date		
8	G1		Unknown	5/24/2003	6/22/2003	Unknown	Unknown	3	?		central dune; Green Island	Presumed hatch date		
9	G2		Unknown	5/24/2003	Unknown	Unknown	Unknown	2	?		NE side of Green Island	Very little data		
10	G3		Unknown	5/24/2003	Unknown	Unknown	Unknown	2	?		W side Green Island	Very little data		
1	H1		Lost	4/17/2003	5/15/2003	N/A	6/6/2003	3	2	0	3.2 mi S of R38	6/6/03: 2 chicks lost possible cat		
2	H2		Fledge	5/1/2003	5/22/2003	7/6/2003	N/A	3	2	1	3 mi S of R38	Chick loss UNK		
3	H3		Lost	5/3/2003	N/A	N/A	5/9/2003	2	0	0	.4 mi S drain ramp S. beach	5/9/03: Nest lost to fox predation		
4	H4		Lost	5/4/2003	N/A	N/A	5/8/2003	2	0	0	Cp. Pt. Salt Pond Rd.	5/8/03: Nest lost to UNK		
5	H5		Lost	5/5/2003	N/A	N/A	6/5/2003	3	0	0	Hatteras Inlet, Inlet Proper	6/5/03: adverse weather conditions		
6	H6		Lost	5/16/2003	N/A	N/A	5/22/2003	2	0	0	Just S of drain ramp, S. beach	5/22/03: Nest lost to fox predation		
7	H7		Lost	5/17/2003	N/A	N/A	6/12/2003	3	0	0	.8 mi S of R55	6/12/03: Nest lost to UNK		
8	H3		Lost	5/22/2003	N/A	N/A	5/26/2003	3	0	0	.5 mi S drain ramp S. beach	5/26/03: adverse weather conditions		
9	H8		Lost	5/24/2003	6/21/2003	N/A	6/22/2003	3	3	0	Hatt Inlet, N end interdunal	6/22/03: 3 chicks lost to UNK		
10	H9		Lost	5/23/2003	N/A	N/A	5/31/2003	2	0	0	0.3 mi E of Salt Pond Rd.	5/31/03: Nest lost to UNK		
11	H10		Fledge	6/6/2003	6/29/2003	8/16/2003	N/A	2	2	2	3.4 mi S of R30	8/5/03: 1 chick fledged, 8/16/03: 1 chick fledged		
12	H3		Lost	6/6/2003	N/A	N/A	6/19/2003	3	0	0	1.1 mi S drain ramp S. beach	6/19/03: Nest lost to UNK		
13	H5		Lost	6/12/2003	N/A	N/A	6/23/2003	3	0	0	Hatteras Inlet Proper	6/23/03: Nest lost to possible racoon		
14	H4		Lost	6/22/2003	N/A	N/A	6/28/2003	1	0	0	Cp. Pt. Bird closure	6/28/03: UNK mammalian predator		
15	H3		Lost	7/5/2003	N/A	N/A	7/10/2003	2	0	0	.5 mi S drain ramp S. beach	7/10/03: possible avian or mammalian predator		
16	H1		Lost	7/6/2003	N/A	N/A	8/10/2003	2	0	0	Buxton Washout	8/10/03: abandoned during storm		
17	H5		Lost	7/10/2003	N/A	N/A	7/12/2003	2	0	0	Hatteras Inlet Spit	7/12/03: overwash by storm tide		
1	O1		Lost	5/5/2003	6/10/2003	N/A	6/11/2003	2	1	0	0.1 miles north of 59	6/11/03: 1 chick lost to cat		
2	O2		Lost	5/10/2003	N/A	N/A	5/19/2003	2	0	0	5 miles north of 67	5/19/03: Nest lost to weather		
3	O3		Lost	5/10/2003	N/A	N/A	5/16/2003	2	0	0	6.3 miles north of 67	5/16/03: Nest lost to UNK		
4	O4		Lost	5/14/2003	6/14/2003	N/A	6/23/2003	2	1	0	Ocracoke Inlet flats	6/23/03: Chick lost to weather		
5	O5		Lost	5/19/2003	N/A	N/A	5/27/2003	2	0	0	1.4 miles north of 70	5/27/03: Nest lost to washout		
6	O6		Lost	5/20/2003	N/A	N/A	5/6/2003	1	0	0	0.8 miles north of 67	5/6/03: Nest lost to wind		
7	O7		Lost	5/20/2003	N/A	N/A	5/30/2003	1	0	0	Ocracoke Inlet flats	5/30/03: Nest lost to UNK		
8	O2		Lost	5/26/2003	N/A	N/A	6/3/2003	2	0	0	4.1 miles north of 67	6/3/03: Nest lost to UNK		
9	O8		Lost	5/31/2003	6/28/2003	N/A	7/17/2003	3	1	0	2.7 miles south of 59	6/13/03: clutch reduction, 7/17/03: 1 chick lost to UNK		
10	O3		Lost	6/14/2003	N/A	N/A	7/6/2003	2	0	0	0.9 miles south of 59	7/6/03: Nest lost to Crow		
11	O1		Lost	6/14/2003	N/A	N/A	6/28/2003	2	0	0	0.12 miles north of 59	6/28/03: Nest lost to UNK		
12	O7		Fledge	6/13/2003	7/15/2003	8/10/2003	N/A	2	1	1	Ocracoke Inlet flats	8/10/03: 1 chick fledged		
1	B1		Lost	5/4/2004	N/A	N/A	5/6/2004	2	0	0	Oregon Inlet Flats	5/6/04: Nest lost to fox	35.779670	75.538270
2	B1		Lost	5/12/2004	N/A	N/A	5/30/2004	2	0	0	Oregon Inlet flats, S of dunes	5/30/04: Nest lost to UNK	35.779090	75.536130
3	B2		Lost	5/10/2004	N/A	N/A	5/24/2004	1	0	0	N side cove Oregon Inlet flats	5/24/04: Nest lost to domestic dog	35.783250	75.539560
4	B3		Lost	Unknown	N/A	N/A	Unknown				Oregon Inlet W side bridge	No data - GPS point	35.779990	75.545750
5	B1		Lost	6/12/2004	N/A	N/A	6/26/2004	2	0	0	Oregon Inlet flats, S of dunes	6/26/04: Nest lost to UNK	35.779580	75.535210
6	B3		Lost	5/24/2004	N/A	N/A	6/16/2004	3	0	0	Oregon Inlet flats, S of dunes	6/16/04: Nest lost to UNK	35.778190	75.538190
7	B3		Lost	6/21/2004	N/A	N/A	6/26/2004	2	0	0	Oregon Inlet flats, S of dunes	6/26/04: Nest lost to UNK	35.778750	75.536450
BH1	BH1	Green 28	Fledge (1)	4/23/2004	5/20/2004	7/4/2004	N/A	2	1	1	1.0 mi s r27	7/4/04: 1 chick fledged		
BH2	BH2		Fledge (3)	5/1/2004	5/28/2004	7/5/2004	N/A	3	3	3	0.8 mi s r27	7/5/04: 3 chicks fledged		
BH3	BH3	Green 59	Fledge (2)	5/6/2004	5/30/2004	7/7/2004	N/A	3	3	2	1.4 mi s r27	7/7/04: 2 chicks fledged		
BH4	BH4		Lost	5/6/2004	5/28/2004	N/A	5/30/2004	2	1	0	1.5 mi s R23	5/30/04: 1 chick lost to UNK		
1	G1	Green 10	Fledge (2)	4/23/2004	5/14/2004	6/29/2004	N/A	3	3	2	Green Island southeast corner	5/10/04: 1 chick lost to UNK, 6/29/04: 2 chicks fledged	35.761280	75.529010
2	G2	Green 11	Lost	5/10/2004	N/A	N/A	5/24/2004	3	0	0	Southwest side of Green Island	5/24/04: Nest lost to UNK	35.761830	75.531430
3	G2	Green 11	Lost	7/8/2004	7/25/2004	N/A	7/25/2009	2	1	0	West side of Green Island	7/25/04: Chick not seen after hatch		
1	H1	Green 24	Lost	4/18/2004	5/15/2004	N/A	5/16/2004	3	3	0	2.6 miles South of R38	5/16/04: 3 chicks lost to cat predation	35.283640	75.515910

2	H2	Green 02	Fledge (1)	4/22/2004	5/20/2004	6/27/2004	N/A	3	3	1	Hatteras Inlet 2.7 mi S R55	5/20/04: 1 Chick lost to UNK, 5/24/04: 1 Chick lost to UNK, 6/27/04: 1 Chick fledged	35.189690	75.749010
3	H3	Green 23	Lost	4/22/2004	5/20/2004	N/A	6/14/2004	3	3	0	Buxton washout; 3 mi S R38	6/5/04: 2 chicks lost, 6/14/04: 1 chick lost, probably cat predation	35.278560	75.517090
4	H4	-;DB/S:LG;LG	Lost	4/25/2004	5/28/2004	N/A	6/28/2004	3	1	0	0.6 mi S R55	5/17/04: 1 egg lost to UNK, 5/27/04: 1 egg lost to UNK, 6/28/04: 1 chick lost, possibly hit by ORV	35.201870	75.714890
5	H5	Green 07	Lost	4/30/2004	N/A	N/A	5/10/2004	2	0	0	Cape Pt, 0.3 mi S of point	5/10/04: probable mammalian predation (fox or domestic dog)	35.225270	75.534100
6	H6	WH;S:WH;DG/DG, Green 12	Lost	4/30/2004	N/A	N/A	5/7/2004	2	0	0	between Salt Pond Rd.& R45	5/7/04: Nest lost to UNK	35.229980	75.542920
7	H7	Green 26, Green 27	Fledge (1)	5/1/2004	5/27/2004	7/10/2004	N/A	3	3	1	Avon, 0.9 miles N of R34	5/27/04: 1 chick lost to UNK, 7/10/04: 1 chick lost and 1 chick fledged	35/39027	75.488980
8	H8		Lost	5/1/2004	6/2/2004	N/A	6/2/2004	3	3	0	Hatteras Inlet, 2.3 mi S R55	6/2/04: 1 chick found dead in nest, 2 chicks UNK	35.191010	75.742910
9	H9	Green 25	Lost	5/8/2004	6/6/2004	N/A	6/10/2004	3	2	0	Hatteras Inlet 2.8 mi S R55	6/10/04: 2 chicks lost to UNK	35.189980	75.750350
10	H10	RD;S:DB;RD/RD	Lost	5/10/2004	N/A	N/A	5/24/2004	3	0	0	Sound side at "Sandy Bay"	5/24/04: nest lost to human destruction	35.219910	75.661430
11	H5	Green 07	Lost	5/24/2004	N/A	N/A	6/18/2004	2	0	0	Cape Pt, just N Salt Pond Rd	6/18/04: nest lost to human destruction	35.228120	75.539020
12	H6	WH;S:WH;DG/DG, Green 12	Lost	5/24/2004	6/11/2004	N/A	6/21/2004	2	2	0	S Beach 0.5 m S of "the drain"	6/16/04: 1 chick lost to UNK, 6/21/04: 1 chick run over by ORV	35.232510	75.552380
13	H1	DG;GF/S:RD;WH	Lost	6/1/2004	6/25/2004	N/A	7/1/2004	2	2	0	Buxton washout, 2.7 m S of R38	7/1/04: 2 chicks lost to UNK	35.282500	75.516100
14	H11		Fledge (1)	Unknown	7/5/2004	7/24/2004	N/A	1	1	1	1.6 m S of R30	7/24/04: 1 chick fledged, date found UNK	35.433010	75.484250
1	O1	Green 22	Lost	4/19/2004	5/21/2004	N/A	6/4/2004	3	1	0	3.2 miles south of 59	06/04/04: Chick lost to UNK	35.163310	75.830760
2	O2	Green 21	Fledge (2)	4/20/2004	5/24/2004	6/26/2004	N/A	3	2	2	0.8 mi south of 72	6/26/04: 2 chicks fledged	35.079980	75.999730
3	O3		Lost	4/28/2004	N/A	N/A	5/24/2004	3	0	0	0.1 miles north of 67	5/24/04: Nest lost to UNK		
4	O4		Lost	5/2/2004	N/A	N/A	5/24/2004	3	0	0	0.3 miles north of 59	5/24/04: Nest lost to UNK		
5	O5		Fledge (1)	5/2/2004	6/1/2004	7/6/2004	N/A	3	2	1	2.5 miles north of 67	7/6/04: 1 Chick fledged (Gr - 50)		
6	O6		Fledge (1)	5/2/2004	5/25/2004	6/28/2004	N/A	3	2	1	0.8 miles south of 59	6/28/04: 1 Chick fledged (Gr - 51)		
7	O7	Green 14, OR;DG(B)/S:OR;-	Fledge (2)	5/9/2004	Unknown	6/2/2004	N/A	2	2	2	1.2 miles norht of 70	6/2/04: 2 chicks fledged, UNK hatch date		
8	O8	Green 13	Lost	5/10/2004	6/12/2004	N/A	6/13/2004	2	1	0	0.7 miles north of 72	6/13/04: 1 chick lost to UNK		
9	O4		Lost	6/1/2004	N/A	N/A	6/10/2004	3	0	0	0.4 miles north of 59	6/10/04: Nest overwashed		
10	O3		Fledge (2)	6/8/2004	7/6/2004	8/10/2004	N/A	2	2	2	0.7 miles north of 67	8/10/04: 2 chicks fledged (Gr 83 and 84)		
11	O9		Lost	6/9/2004	N/A	N/A	6/9/2004	3	0	0	Ocracoke Spit, Near point	6/9/04: Nest found overwashed.		
B1	B1	Green C9	Lost	5/1/2005	N/A	N/A	5/21/2005	2	0	0	Oregon Inlet, NW side of Cove	5/21/05: Nest lost to raccoon		
B2	B6		Lost	5/12/2005	6/12/2005	N/A	6/27/2005	3	2	0	Oregon Inlet, SE side	6/14/05: 1 chick lost to crow, 6/27/05: 1 chick lost to UNK		
B3	B1	Green C9	Lost	6/4/2005	N/A	N/A	6/17/2005	2	0	0	Oregon Inlet, East of dunes	6/17/05: Nest lost to cat		
G1	B4	Green 10	Lost	Unknown	5/7/2005	N/A	6/13/2005	1	1	0	Green Island, SE side	5/11/05: chick last seen. Number of eggs assumed		
G2	B5	Green 11	Lost	5/11/2005	N/A	N/A	5/11/2005	?	0	0	Green Island, N side	5/11/05: Nest lost to UNK. Number of eggs UNK		
G3	B5	Green 11	Fledge (2)	6/13/2005	6/13/2005	Unknown	N/A	3	2	2	Green Island, NE side	6/13/05: nest found with 2 newly hatched chicks and 1 egg starred.		
BH1	B2	Green A2	Lost	5/3/2005	N/A	N/A	5/10/2005	2	0	0	1 mile North of R30	5/10/05: Nest lost to Cat predation		
BH2	B3	Green C8	Fledge (1)	5/8/2005	5/29/2005	7/9/2005	N/A	3	2	1	1.1 mile North of R30	6/13/05: chick lost to UNK, 7/9/05: 1 chick fledged		
BH3	B7	Green 27	Fledge (1)	5/16/2005	6/10/2005	7/27/2005	N/A	3	3	1	1.4 miles South of R27	6/24/05: 1 chick lost to UNK, 7/7/05: 1 chick lost to UNK, 7/27/05: 1 chick fledged		
BH4	B2	Green A2	Lost	5/29/2005	6/17/2005	N/A	7/9/2005	3	2	0	1 mile North of R30	7/9/05: 2 chicks lost to cat predation, nest is a re-nest		
BH5	B8	Green A3	Lost	5/30/2005	6/18/2005	N/A	6/20/2005	2	2	0	1.5 miles South of R23	6/20/05: 2 chicks lost to UNK		
H1	H1	Red C9, Green A6	Lost	4/19/2005	N/A	N/A	4/25/2005	1	0	0	N. of Buxton Washout	4/25/05: Nest lost to UNK		
H2	H2	Green 02, Green 88	Lost	4/20/2005	N/A	N/A	4/20/2005	1	0	0	Hatteras Inlet Spit	4/20/05: Nest abandoned, Nest 3 could be clutch continuation from the same pair. Data was obtained from field notes. Very little information		
H3	H2	Green 02, Green 88	Lost	4/21/2005	5/22/2005	N/A	5/27/2005	2	1	0	Hatteras Spit - Narrows	5/27/05: Chick lost to UNK		
H4	H4	Green A7, Green O7	Lost	4/29/2005	N/A	N/A	5/27/2005	3	0	0	Cape Point - In dunes NE	5/27/05: Nest lost to UNK		
H5	H5	WH;S:WH;DG/DG, Green 12	Fledge (2)	4/29/2005	5/27/2005	7/7/2005	N/A	3	3	2	South Beach - 0.3m S of R45	6/18/05: 1 chick lost, 7/7/05: 2 chicks fledged		
H6	H1	Red C9, Green A6	Lost	5/10/2005	N/A	N/A	6/18/2005	2	0	0	N. of Buxton Washout	6/18/05: Nest lost to UNK		
H7	H6	-;DB/S:LG;LG, Green 92	Lost	5/15/2005	N/A	N/A	5/18/2005	2	0	0	Hatteras Breach; 0.6m S of R55	5/18/05: Nest lost to UNK		
H8	H7	Green 06	Lost	5/18/2005	N/A	N/A	6/14/2005	1	0	0	Hatteras Breach; 1m S of R55	6/14/05: Nest lost to UNK		
H9	H8	Green F7, Green 23	Fledge (2)	5/18/2005	6/16/2005	8/1/2005	N/A	3	2	2	South Beach - 0.6m S of R45	6/13/05: 1 egg lost, 8/1/05: 2 chicks fledged		
H10	H9		Lost	5/19/2005	N/A	N/A	6/9/2005	3	0	0	Hatt Spit, Narrows behind dune	6/9/05: Nest lost to Raccoon		

H11	H10		Lost	5/20/2005	6/18/2005	N/A	6/24/2005	3	3	0	0.5m N of R43	6/24/05: 3 chicks lost to predation, mink tracks present		
H12	H6	-;DB/S:LG;LG, Green 92	Lost	5/30/2005	N/A	N/A	6/9/2005	2	0	0	Hatteras Breach; 0.6m S of R55	6/9/05: Nest lost to UNK		
H13	H11	Green A5	Lost	5/20/2005	N/A	N/A	5/20/2005	1	0	0	Sound-side, 1m S of Fr Bath	5/20/05: Nest abandoned		
H14	H4	Green A7, Green O7	Fledge (1)	6/7/2005	7/2/2005	8/6/2005	N/A	2	2	1	Cape Point - In dunes SW	7/11/05: 1 Chick lost to UNK, 8/6/05: 1 chick fledged		
H15	H12	Green 24	Lost	5/30/2005	5/30/2005	N/A	5/30/2005	1	1	0	N. of Buxton Washout	5/30/05: chicks found predated after nest hatched		
H16	H12	Green 24	Fledge (1)	6/8/2005	7/7/2005	8/20/2005	N/A	3	3	1	N. of Buxton Washout	7/10/05: 1 chick lost to UNK, 7/11/05: 1 chick lost to UNK, 8/20/05: 1 chick fledged		
H17	H3	Green 02, Green 88	Lost	6/8/2005	N/A	N/A	6/9/2005	1	0	0	Hatteras Spit	6/9/05: Nest lost to UNK		
H18	H3	Green 02, Green 88	Lost	6/10/2005	N/A	N/A	7/1/2005	3	0	0	Hatteras Spit	7/1/05: Nest lost to raccoon		
H19	H6	-;DB/S:LG;LG, Green 92	Lost	6/16/2005	N/A	N/A	6/24/2005	1	0	0	Hatteras Breach; 0.8m S of R55	6/24/2005: egg abandoned		
H20	H1	Red C9, Green A6	Lost	7/9/2005	7/29/2005	N/A	8/6/2005	2	2	0	N. of Buxton Washout	Chicks lost 8/1; 2 unknown, 8/6; 1 g crab		
O1	O1	Green 14, OR;DG(B)/S:OR;-	Lost	4/28/2005	N/A	N/A	5/9/2005	2	0	0	1.7 miles north of Ramp 70	5/9/05: Nest lost to UNK		
O2	O2		Lost	4/29/2005	N/A	N/A	5/7/2005	1	0	0	Ocracoke Spit soundside dune	5/7/05: Nest lost to UNK		
O3	O3	Green 49	Lost	4/30/2005	N/A	N/A	4/30/2005	2	0	0	0.5 miles North of Ramp 68	4/30/05: Nest lost to pedestrians (stepped on)		
O4	O4		Lost	5/3/2005	N/A	N/A	5/10/2005	1	0	0	1.8 mi S R72, Ocracoke Spit	5/10/05: Nest lost to UNK		
O5	O5		Lost	5/4/2005	6/2/2005	N/A	7/2/2005	3	3	0	3.3 miles North of Ramp 67	6/6/05: 2 chicks lost to UNK, 7/2/05: 1 chick lost to UNK		
O6	O3	Green 49	Lost	5/18/2005	N/A	N/A	6/17/2005	3	0	0	1.5 miles North of Ramp 67	6/17/05: Nest lost to UNK		
O7	O1	Green 14, OR;DG(B)/S:OR;-	Lost	5/27/2005	N/A	N/A	6/3/2005	1	0	0	1.8 miles North of Ramp 70	6/3/05: Nest lost to UNK		
O8	O2	Green 21	Lost	5/28/2005	6/21/2005	N/A	6/21/2005	2	1	0	Sound side dune, Ocracoke Spit	6/21/2005; Chick dead in nest		
O9	O4		Lost	5/28/2005	N/A	N/A	6/21/2005	2	0	0	Ocean side Ocracoke Spit	6/21/05: Nest lost to UNK		
O10	O1	Green 14, OR;DG(B)/S:OR;-	Fledge (1)	6/14/2005	7/9/2005	8/14/2005	N/A	2	2	1	1.6 miles North of Ramp 70	7/31/05: 1 Chick lost to UNK, 8/14/05: 1 chick fledged.		
B1	B1	Green C9	Lost	5/27/2006	6/23/2006	N/A	6/28/2006	1	1	0	Oregon Inlet	6/28/06: 1 chick lost to UNK		
B2	B2		Lost	6/1/2006	N/A	N/A	6/4/2006	2	0	0	Oregon Inlet	6/4/06: Nest lost to fox predation		
BH01	BH01	Green C8	Lost	4/23/2006	N/A	N/A	5/2/2006	2	0	0	0.8 mi S of R 27	5/2/06: Nest lost to storm		
BH02	BH02	Green 27	Fledge (1)	5/6/2006	5/14/2006	6/27/2006	N/A	1	1	1	1.4 mi S R 27	6/27/06: 1 chick fledged		
BH03	BH03	Green A2	Lost	5/11/2006	N/A	N/A	5/14/2006	1	0	0	1 mi S R 27	5/14/06: Nest lost to UNK		
BH05	BH03	Green A2	Lost	5/20/2006	N/A	N/A	5/21/2006	3	0	0	1 Mi S R 27	5/21/06: Nest lost to UNK		
BH04	BH01	Green C8	Fledge (1)	Unknown	6/12/2006	7/30/2006	N/A	3	3	1	0.3 m S R 27	6/15/06: 1 chick lost to UNK, 6/22/06: 1 chick lost to UNK, 7/30/06: 1 chick fledged.		
G1	G1	Green 10	Fledge (1)	4/12/2006	Unknown	8/6/2006	N/A	3	1	1	Green Island (Shore-side)	8/6/06: 1 chick fledged		
G2	G2	Green 11	Fledge (1)	Unknown	Unknown	8/6/2006	N/A	1	1	1	Green Island (west-side)	8/6/06: 1 chick fledged. Very little data		
H1	H1	Green 02, Green 88	Fledge (1)	4/18/2006	5/17/2006	6/24/2006	N/A	4	2	1	Hatteras Inlet South End	6/8/06: 1 chick lost to UNK, 6/24/06: 1 chick fledged.		
H2	H2	Red C9	Lost	4/20/2006	5/16/2006	N/A	6/28/2008	3	2	0	North of Buxton Washout	6/25/06: 1 chick lost to UNK, 6/28/06: 1 chick lost to UNK		
H3	H3	WH;S:WH;DG/DG, Green 12	Lost	4/21/2006	5/18/2006	N/A	6/20/2006	3	2	0	0.3 mi S of Ramp 45	6/20/06: 2 chicks lost to mammalian predator		
H4	H4	-;DB/S:LG;LG, Green 92	Lost	4/24/2006	5/20/2006	N/A	5/23/2006	3	2	0	0.5 mi S R 55	5/23/06: 2 chicks lost to disturbance, hypothermia, predation		
H5	H5		Lost	4/24/2006	N/A	N/A	5/8/2006	1	0	0	Hatteras Inlet, northern end	5/8/06: nest abandoned		
H6	H6	Green F7, Green 23	Fledge (2)	4/25/2006	5/22/2006	6/25/2006	N/A	3	2	2	0.8 mi S of Ramp 45	6/25/06: 2 chicks fledged		
H7	H7	Green A7, Green O7	Lost	4/27/2006	N/A	N/A	5/21/2006	2	0	0	Cape Point	5/21/06: nest lost to raccoon predation		
H8	H8		Lost	5/2/2006	5/29/2006	N/A	6/28/2006	2	1	0	1.5 mi S R 38	6/28/06: 1 chick lost to UNK		
H9	H9	Green 06	Lost	5/8/2006	6/7/2006	N/A	6/11/2006	1	1	0	0.8 m S R 55	6/11/06: 1 chick lost to sickly exposure		
H10	H5		Lost	5/15/2006	6/13/2006	N/A	6/28/2006	3	2	0	Hatteras Spit Narrows	6/28/06: 2 chicks lost to UNK		
H11	H10	Green 01, Green 26	Lost	5/18/2006	6/13/2006	N/A	6/18/2006	3	2	0	1.0 mi N R 34	6/18/06: 2 chicks lost to UNK		
H12	H7	Green A7, Green O7	Lost	6/3/2006	N/A	N/A	6/18/2006	2	0	0	Cape Point	6/18/06: Nest lost to UNK		
H13	H4	-;DB/S:LG;LG, Green 92	Lost	6/17/2006	N/A	N/A	6/22/2006	1	0	0	0.5 mi S R 55	6/22/06: nest abandoned		
H14	H11		Lost	6/18/2006	N/A	N/A	6/24/2006	3	0	0	Behind Hatteras Coast Guard	6/24/06: nest lost to UNK		
O1	O1	Green 21	Lost	4/13/2006	N/A	N/A	5/4/2006	3	0	0	Ocracoke Inlet Spit	5/4/06: Nest lost to Storm		
O2	O2	Green 14, OR;DG(B)/S:OR;-	Lost	4/23/2006	N/A	N/A	5/4/2006	2	0	0	1.5 mi N R 70	5/4/06: Nest lost to Storm		
O3	O3	Green 49	Fledge (2)	4/30/2006	5/20/2006	6/26/2006	N/A	3	3	2	0.9 mi N R 67	6/18/06: 1 chick lost to UNK, 6/26/06: 2 chicks fledged		
O4	O1	Green 21	Lost	5/15/2006	6/1/2006	N/A	6/6/2006	3	3	0	Ocracoke Inlet Spit	6/6/06: 3 chicks lost to avian (gulls/owl)		
O5	O2	Green 14, OR;DG(B)/S:OR;-	Lost	5/18/2006	N/A	N/A	5/22/2006	3	0	0	1.5 mi N R 70	5/22/06: Nest lost to UNK (maybe crow)		
O6	O4		Lost	5/24/2006	6/14/2006	N/A	6/22/2006	2	2	0	1.4 mi N R 67	6/22/06: 2 chicks lost to UNK		

O7	O5		Lost	5/24/2006	5/25/2006	N/A	6/14/2006	2	2	0	3.2 mi S R 59	06/14/06: 2 chicks lost to UNK		
O8	O2	Green 14, OR;DG(B)/S:OR;-	Lost	6/1/2006	6/30/2006	N/A	7/6/2006	3	3	0	1.5 mi N R 70	7/6/06: 3 chicks lost to UNK		
BHAM01	BH1	Green A2, Unbanded	Lost	4/18/2007	N/A	N/A	5/15/2007	2	0	0	1.2 mi N R30; behind first dune line	5/15/07: Nest lost to cat predation	35.455860	-75.483350
BHAM08	BH1	Green A2, Unbanded	Fledge (1)	5/24/2007	6/19/2007	7/29/2007	N/A	3	2	1	1.2 mi S R27	7/13/07: 1 chick lost to UNK, 7/29/07: 1 chick fledged.	35.453170	-75.483260
BHAM02	BH2	Green 27, Green T4	Lost	4/19/2007	N/A	N/A	5/8/2007	3	0	0	.7 mi N R30, in washout	5/8/07: Nest lost to overwash	35.448870	-75.483710
BHAM06	BH2	Green 27, Green T4	Lost	5/20/2007	N/A	N/A	5/22/2007	1	0	0	.7 mi N R30	5/22/07: Nest lost to UNK.	35.448840	-75.483510
BHAM07	BH2	Green 27, Green T4	Lost	5/23/2007	N/A	N/A	6/17/2007	2	0	0	.7 mi N R30	6/17/07: 1 egg lost to UNK, remaining egg infertile and abandoned.	35.449953	-75.483523
BHAM03	BH3	Green C8, Unbanded	Lost	4/20/2007	N/A	N/A	5/15/2007	3	0	0	.7 mi S of R27; in small washout behind small dune	5/15/07: Eggs gone; cut tracks in area/ UNB amoy severly limping	35.460670	-75.483110
BHAM10	BH3	Green C8, Unbanded	Fledge (2)	5/29/2007	6/25/2007	7/31/2007	N/A	2	2	2	0.6 mi S R27	7/31/07: 2 chicks fledged.	35.463678	-75.482519
BHAM04	BH4	Green 52, RD/SLV:DB-OR	Lost	5/5/2007	N/A	N/A	5/8/2007	1	0	0	.1 mi S R27, in washout	5/8/07: Nest lost to overwash	35.467740	-75.482290
BHAM09	BH4	Green 52, RD/SLV:DB-OR	Lost	5/25/2007	6/20/2007	N/A	7/27/2007	2	2	0	.1 mi N R27	7/27/07: Chicks could not be located.	35.471856	-75.481884
BHAM05	BH5	Unbanded, Unbanded	Lost	5/6/2007	N/A	N/A	5/15/2007	1	0	0	.1 mi N R30	5/15/07: Nest lost to UNK.	35.439620	-75.484716
BIAM01	BI1	Green C9, Unbanded	Lost	5/17/2007	N/A	N/A	6/4/2007	3	0	0	In O. I. bird closure, NE end of Dune; South of bait pond	6/4/07: Nest lost to overwash.	35.780062	-75.535737
BIAM02	BI2	Unbanded, Unbanded	Lost	5/22/2007	6/18/2007	N/A	6/20/2007	3	1	0	in O.I. marshy area closer to bridge	6/20/07: 1 chick dead, predator tracks in area. No other eggs or chicks found.	35.778530	-75.540730
GIAM01	GI1	Green 11, Unbanded	Fledge (2)	4/24/2007	6/1/2007	N/A	N/A	3	3	2	Green Island		35.762410	-75.531220
GIAM02	GI2	Green 69, Unbanded	Lost	6/1/2007	N/A	N/A	7/8/2007	3	0	0	Green Island	7/8/07: Nest overwashed	35.762000	-75.529800
HIAM01	HI1	Red C9, Unbanded	Lost	4/15/2007	N/A	N/A	4/16/2007	1	0	0	0.8 mi N of Buxton	4/16/07: Nest lost to weather.	35.280072	-75.516586
HIAM02	HI1	Red C9, Unbanded	Fledge (1)	4/17/2007	5/17/2007	6/19/2007	N/A	2	2	1	0.7 mi N of Buxton	5/31/07: 1 chick lost to UNK, 6/19/07: 1 chick fledged.	35.278870	-75.516785
HIAM11	HI10	Green 12, Unbanded (R9)	Fledge (3)	5/19/2007	6/15/2007	7/25/2007	N/A	3	3	3	S.B. Closure (.4 mi S R45)		35.233235	-75.553483
HIAM03	HI2	Unbanded, Unbanded	Lost	4/24/2007	N/A	N/A	5/15/2007	3	0	0	.1 mi NW of Hatteras Boundary	5/15/07: Nest lost to UNK	35.190700	-75.746194
HIAM13	HI2	Unbanded, Unbanded	Lost	5/25/2007	N/A	N/A	6/13/2007	3	0	0	Hatteras Inlet	6/13/07: Nest lost to UNK	35.190740	-75.745280
HIAM04	HI3	Green 88, Green 02	Fledge (1)	4/28/2007	5/19/2007	6/26/2007	N/A	3	2	1	Hatteras Inlet	5/24/07: 1 chick lost to predation (possibly ghost crab), 6/26/07: 1 chick fledged.	35.190277	-75.747648
HIAM05	HI4	Green 25, Unbanded	Lost	4/28/2007	N/A	N/A	5/22/2007	3	0	0	Isabel Overwash	5/22/07: Nest lost to UNK.	35.219947	-75.660546
HIAM06	HI5	Green 01, Green 26	Lost	5/1/2007	N/A	N/A	5/8/2007	3	0	0	.8 mi N of R34	5/8/07: Nest lost to weather	35.387832	-75.489979
HIAM12	HI5	Green 01, Green 06	Lost	5/20/2007	6/17/2007	N/A	7/23/2007	2	2	0	Hatteras Inlet	6/24/07: 1 chick found dead in wrackline, 7/23/07: 1 chick died prior to fledging.	35.386893	-75.490285
HIAM07	HI6	Green A7, Green 07	Fledge (1)	5/1/2007	5/29/2007	7/12/2007	N/A	3	2	1	Cape Point	7/8/07: 1 chick lost to cat predation	35.225928	-75.534917
HIAM08	HI7	Green A5, Unbanded (RO)	Lost	5/2/2007	6/6/2007	N/A	6/9/2007	3	1	0	Ramp 45 (.1 mi E)	6/9/07: 1 chick lost to UNK.	35.230451	-75.543891
HIAM09	HI8	Green F7, Green 57	Lost	5/8/2007	6/5/2007	N/A	6/11/2007	2	2	0	S.B. Enclosure (1.1 mi S R45)	6/11/07: 2 chicks lost. Transmitters found in dunes. Cat tracks around area.	35.234458	-75.563369
HIAM10	HI9	Green R5, Green R6	Lost	5/12/2007	N/A	N/A	6/2/2007	2	0	0	Haulover Beach	6/2/07: Nest abandoned. Eggs not developed.	35.301100	-75.511914
OIAM01	OI1	Green 21, Unbanded	Lost	4/11/2007	N/A	N/A	4/15/2007	2	0	0	South end flats: sound corner of closure	4/15/07: Nest lost to overwash	35.073531	-76.016057
OIAM05	OI1	Green 21, Unbanded	Lost	4/30/2007	N/A	N/A	5/8/2007	3	0	0	behind main dunes in south end closure	5/8/07: Nest lost to storm	35.079580	-76.000460
OIAM09	OI1	Green 21, Unbanded	Lost	5/25/2007	N/A	N/A	6/2/2007	3			on S. Pt. inside pre-nest closure on a small dune at N end of string of dunes	6/2/07: mink tracks in vicinity and leading to nest	35.068846	-76.005192
OIAM12	OI1	Green 21, Unbanded	Fledge (1)	6/26/2007	7/9/2007	8/13/2007	N/A	2	1	1	.8 mi S R72	7/2/07: 1 egg lost, 8/13/07: 1 chick fledged.	35.076270	-75.997150
OIAM02	OI2	Green 14, O/G'B':O/X	Lost	4/13/2007	N/A	N/A	4/13/2007	1	0	0	.1 mi S of R68	4/13/07: nest found in morning; egg gone by afternoon: suspected avian predation	35.115780	-75.937000
OIAM03	OI2	Green 14, O/G'B':O/X	Lost	4/17/2007	N/A	N/A	4/18/2007	1	0	0	100ft S original closure for Nest 2	4/18/07: Nest lost to UNK	35.114430	-75.939510
OIAM04	OI2	Green 14, O/G'B':O/X	Lost	4/21/2007	N/A	N/A	5/8/2007	2	0	0	.1 mi S of square post high on dune; 1 mi S R68	5/8/07: Nest lost to storm	35.114900	-75.938560
OIAM08	OI2	Green 14, O/G'B':O/X	Lost	5/20/2007	N/A	N/A	6/1/2007	3	0	0	~1 mi S R68	6/1/07: nest lost: mink tracks lead up to nest, cat track also in vicinity	35.117280	-75.934220
OIAM10	OI2	Green 14, O/G'B':O/X	Lost	6/15/2007	7/16/2007	N/A	8/10/2007	2	1	?	1.4 mi N R70	Very little information	35.114900	-75.938580
OIAM06	OI3	Unbanded, Unbanded	Lost	5/1/2007	N/A	N/A	5/2/2007	1	0	0	~3.2 mi S R59	5/2/07: egg gone; suspected avian predation	35.162990	-75.831420
OIAM11	OI3	Unbanded, Unbanded	Lost	6/15/2007	6/17/2007	N/A	6/18/2007	2	1	0	Dredged dunes on NW side of island by ferry	6/18/07: 1 chick lost to UNK.	35.190710	-75.783570

OIAM07	OI4	Green 49, Unbanded	Lost	5/2/2007	N/A	N/A	5/22/2007	3	0	0	1.62 mi N R67	5/15/2007: 1 egg gone (nest only has 2); 5/22/2007: nest gone; avian predation: 3 crows	35.142340	-75.881880
BHAM01	BH1	Green A2, Unbanded	Fledge (1)	4/26/2008	5/26/2008	7/5/2008	N/A	3	2	1	1.1 mi n R30	Fledged Chick banded (Gr LO)	35.45442581040	-75.48334845030
BHAM02	BH2	Green C8, Green L9	Lost	4/28/2008	N/A	N/A	5/14/2008	3	0	0	0.4 mi s R27	Lost to storm event	35.46392010460	-75.48250993910
BHAM03	BH3	Gr 52, RD;S:DB;OR/DG	Lost	5/1/2008	5/31/2008	N/A	6/5/2008	3	1	0	0.2 mi s R27	Chick lost to UNK	35.46626005330	-75.48243998390
BHAM04	BH4	Green 27, Green T4	Lost	5/5/2008	N/A	N/A	5/14/2008	3	0	0	0.8 mi n R30	Lost to storm event	35.44964999870	-75.48343000090
BHAM04 b	BH4	Green 27, Green T4	Lost	5/15/2008	N/A	N/A	5/17/2008	1	0	0	0.8 mi n R30	Salvaged egg, not an actual nest.	35.44954002670	-75.48359003000
BHAM05	BH4	Green 27, Green T4	Fledge (3)	5/24/2008	6/20/2008	8/6/2008	N/A	3	3	3	0.8 mi n R30	Chicks banded (Gr EJ, Gr EK, Gr EL)	35.44953998990	-75.48359000100
BHAM06	BH2	Green C8, Green L9	Lost	5/25/2008	6/22/2008	N/A	6/29/2008	2	2	0	0.7 mi s R27		35.45954999910	-75.48275000200
BIAM01	BI1	Unbanded, Unbanded	Lost	4/25/2008	N/A	N/A	4/26/2008	1	0	0	North Bait Pond	Single egg lost	35.78060389000	-75.54385909050
BIAM01 b	BI1	Unbanded, Unbanded	Lost	4/28/2008	N/A	N/A	5/9/2008	3	0	0	North Bait Pond	Lost to high tides	35.78023508300	-75.54460941820
BIAM02	BI2	Green C9, Unbanded	Lost	5/11/2008	N/A	N/A	5/13/2008	1	0	0	Bodie Spit	Lost to storm event	35.77992797090	-75.53771147040
BIAM02 b	BI2	Green C9, Unbanded	Lost	5/14/2008	N/A	N/A	5/17/2008	1	0	0	Bodie Spit	Predated (avian?)	35.78006000090	-75.53603000490
BIAM03	BI1	Unbanded, Unbanded	Lost	5/21/2008	N/A	N/A	5/31/2008	3	0	0	Bodie Spit	Predated by fox	35.77708001110	-75.54162004050
BIAM04	BI3	Green C0, Unbanded	Fledge (1)	6/4/2008	7/4/2008	8/9/2008	N/A	2	1	1	0.3 mi s R4	Chick banded (Gr EX)	35.79334000670	-75.53915001120
BIAM05	BI1	Unbanded, Unbanded	Fledge (1)	6/12/2008	7/6/2008	8/12/2008	N/A	2	1	1	Bodie Spit	Chick banded (Gr EY)	35.77925000630	-75.53550005580
GIAM01	GI1	Green 11, Unbanded	Lost	4/25/2008	N/A	N/A	5/14/2008	2	0	0	NW Green Island	Lost to storm event	35.76266001810	-75.53075999420
GIAM02	GI2	Unbanded, Unbanded	Lost	4/25/2008	N/A	N/A	5/2/2008	2	0	0	SE Green Island	Lost to UNK	35.76194000710	-75.52901999740
GIAM03	GI1	Green 11, Unbanded	Fledge (2)	5/27/2008	6/20/2008	8/1/2009	NA	2	2	2	Green Island	Chick banded (Gr EW)	35.76250000510	-75.53097999880
GIAM04	GI2	Unbanded, Unbanded	Lost	6/20/2008	N/A	N/A	7/4/2008	2	0	0	Green Island	Lost to predation	35.76079015700	-75.52909993720
HIAM01	HI01	Red C9, Green L5	Fledge (2)	4/22/2008	5/21/2008	7/7/2008	N/A	3	2	2	North Buxton	1 chick dead - head wound	35.28136659670	-75.51646451590
HIAM02	HI02	Green 88, Green 02	Lost	4/24/2008	N/A	N/A	5/13/2008	3	0	0	Hatteras Inlet	Lost to high surf	35.19088242480	-75.74589744900
HIAM03	HI03	Green L4, Unbanded	Fledge (2)	4/24/2008	5/22/2008	7/12/2008	N/A	3	3	2	Hatteras Inlet	3 eggs hatched	35.19138875770	-75.74357131720
HIAM04	HI04	Green F7, Green 57	Lost	4/27/2008	N/A	N/A	5/5/2008	1	0	0	South Beach		35.23376696330	-75.56031233880
HIAM04 b	HI04	Green F7, Green 57	Lost	5/2/2008	N/A	N/A	5/5/2008	1	0	0	South Beach	Single egg found away from nest site	35.23420944420	-75.56313192740
HIAM05	HI05	Green R6, Unbanded	Fledge (2)	4/28/2008	5/30/2008	7/8/2008	N/A	2	2	2	Sandy Bay	Only 2 eggs	35.21981672000	-75.66094133890
HIAM06	HI06	Green 12, Green R0	Lost	5/5/2008	N/A	N/A	5/17/2008	1	0	0	South Beach		35.23304536450	-75.55505848100
HIAM07	HI07	Green A7, Green O7	Fledge (1)	5/8/2008	6/5/2008	7/17/2008	N/A	2	2	1	Cape Point	Only 2 eggs	35.22293467760	-75.53198416410
HIAM08	HI08	Green H3, Unbanded	Lost	5/16/2008	N/A	N/A	5/16/2008	1	0	0	0.2 mi s R43	Single egg predated	35.23285291280	-75.52742343970
HIAM09	HI06	Green 12, Green R0	Lost	5/20/2008	N/A	N/A	7/5/2008	1	0	0	South Beach	Only 1 egg	35.23222997450	-75.54988718140
HIAM10	HI04	Green F7, Green 57	Lost	5/22/2008	6/25/2008	N/A	7/23/2008	2	1	0	South Beach	Only 2 eggs	35.23446693410	-75.56396341770
HIAM11	HI09	Green O1, Green L8	Lost	5/22/2008	N/A	N/A	6/19/2008	2	0	0	0.6 mi n R34	Only 2 eggs	35.38441999570	-75.49084999370
HIAM12	HI10	Green O6, Unbanded	Lost	5/23/2008	N/A	N/A	6/12/2008	2	0	0	1.3 mi s R55	Only 2 eggs	35.19748001150	-75.72585000030
HIAM13	HI02	Green 88, Green 02	Lost	5/25/2008	N/A	N/A	6/17/2008	3	0	0	Hatteras Inlet		35.19107417940	-75.74613363410
HIAM14	HI11	Green A5, Green L6	Lost	6/4/2008	N/A	N/A	7/8/2008	1	0	0	Cape Point		35.22327676530	-75.53342915820
OIAM01	OI1	Green 14, Green L7	Fledge (2)	5/2/2008	6/1/2008	7/23/2008	N/A	3	2	2	1.0 mi s R68		35.11720893060	-75.93423949790
OIAM02	OI2	Green 86, Green 76	Lost	5/7/2008	N/A	N/A	5/10/2008	0	0	0	South Point		35.07876005650	-75.99501007720
OIAM02 b	OI2	Green 86, Green 76	Lost	5/10/2008	N/A	N/A	5/13/2008	0	0	0	South Point		35.07914003240	-75.99398003960
OIAM03	OI3	Green 87, Unbanded	Lost	6/5/2008	N/A	N/A	6/22/2008	2	0	0	North Point Ocracoke		35.18557999960	-75.77228000240
GIAM01	GI01	UNB/UNB	Fledged (3)	4/17/2009	5/15/2009	7/10/2009	N/A	3	3	3	Green Island	6/27/09: 2 chicks fledged, 7/10/09: 1 chick fledged.		
GIAM02	GI02	Gr 11/UNB	Lost	5/1/2009	N/A	N/A	5/29/2009	3	N/A	N/A	Green Island	5/29/09: Nest lost to UNK		
BIAM01	BI01	UNB/UNB-1	Lost	4/23/2009	NA	N/A	5/5/2009	3	N/A	N/A	S of Bait Pond	5/5/09: Nest lost to Grackle Predation		
BIAM02	BI02	Gr CO/UNB	Fledged (1)	5/4/2009	6/7/2009	7/16/2009	N/A	3	2	1	0.3 mi S of R4	7/16/09: 1 chick fledged, banded (Gr CM)		
BIAM03	BI03	UNB/UNB-2	Lost	5/30/2009	NA	N/A	6/16/2009	3	N/A	N/A	2.1 mi S of R4.	6/16/09: Nest lost to UNK		
BIAM04	BI04	Gr C9/UNB	Lost	6/2/2009	NA	N/A	6/10/2009	2	N/A	N/A	1.1 mi S of R4.	6/10/09: Nest lost to Fox		
BHAM01	BH01	Gr A2/UNB	Fledged (1)	4/22/2009	5/21/2009	7/3/2009	N/A	3	2	1	1.0 mi N of R30	5/23/2009: Egg lost to Raccoon, 6/22/2009: Chick lost to UNK, 7/3/2009: Chick fledged		
BHAM02	BH02	Gr C8/Gr L9	Lost	4/24/2009	NA	N/A	4/27/2009	1	NA	N/A	1.3 mi N of R30	4/27/09: Nest lost to cat		
BHAM02-A	BH02	Gr C8/Gr L9	Lost	4/29/2009	5/28/2009	N/A	6/1/2009	1	1	N/A	1.3 mi N of R30	6/1/09: 1 chick lost to UNK		
BHAM06	BH02	Gr C8/Gr L9	Lost	6/18/2009	N/A	N/A	6/24/2009	3	N/A	N/A	1.3 mi N of R30	6/24/09: Nest lost to Crow Predation		
BHAM03	BH03	GrT4/Gr27	Lost	4/28/2009	5/27/2009	N/A	5/28/2009	3	2	N/A	1.4 mi S of R27	5/28/09: 2 chicks lost to Cat Predation		
BHAM05	BH03	GrT4/Gr27	Fledged (1)	6/11/2009	7/7/2009	8/20/2009	NA	3	2	1	0.8 mi N of R30.	8/7/2009: 1 chick lost to Cat Predation, 8/20/2009: 1 chick fledged		
BHAM04	BH04	Gr 50/Gr 52	Lost	4/29/2009	NA	N/A	4/30/2009	1	N/A	N/A	0.2 mi S of R27	4/30/09: Nest lost Ghost Crab/ opossum		
BHAM04-A	BH04	Gr 50/Gr 52	Lost	5/2/2009	NA	N/A	5/3/2009	1	N/A	N/A	0.2 mi S of R27	5/3/09: Nest lost to Ghost Crab		
BHAM04-B	BH04	Gr 50/Gr 52	Lost	5/8/2009	6/4/2009	N/A	7/12/2009	2	1	N/A	0.2 mi S of R27	7/12/09: Chick (Gr CN) lost to UNK		

HIAM01	HI01	Rd C9/Gr L5	Lost	4/17/2009	N/A	N/A	4/20/2009	3	N/A	N/A	1.0 mi N of Buxton	4/20/09: Nest lost to opossum predation		
HIAM02	HI02	Gr A7/Gr 07	Lost	4/26/2009	N/A	N/A	5/21/2009	3	N/A	N/A	Cape Point, marker "D"	5/21/09: Nest lost to opossum predation		
HIAM03	HI03	Gr AT/UNB	Fledged (1)	4/29/2009	5/26/2009	7/6/2009	N/A	3	2	1	Sandy Bay	6/6/2009: 1 chick lost to UNK, 7/6/2009: Fledged Chick Banded (Gr HT)		
HIAM04	HI04	Gr 02/UNB	Lost	4/30/2009	N/A	N/A	6/18/2009	4	N/A	N/A	Hatteras Inlet	6/17/2009: 2 eggs lost to mink and ghost crab predation, 6/18/2009: 2 eggs lost to predation		
HIAM05	HI05	Gr R0/Gr 12	Fledged (3)	5/1/2009	5/31/2009	6/13/2009	N/A	3	3	3	South Beach, marker "2"	6/12/09: 2 chicks fledged, 6/13/09: 1 chick fledged. Chicks banded (Gr HE, Gr HC, and Gr HW)		
HIAM06	HI06	Gr L4/UNB	Lost	5/3/2009	6/1/2009	N/A	6/5/2009	3	3	N/A	Hatteras Inlet	6/4/2009: 2 Chicks lost to UNK, 6/5/2009: 1 chick lost to UNK		
HIAM07	HI07	Gr F7/Gr 57	Fledged (1)	5/7/2009	6/7/2009	7/26/2009	N/A	2	2	1	South Beach, marker "14"	6/28/2009: 1 Chick lost to raccoon, 7/26/2009: Fledged chick banded (Gr HY)		
HIAM08	HI08	Gr A5/Gr L6	Lost	5/9/2009	N/A	N/A	5/19/2009	3	N/A	N/A	Cape Point, marker "E"	5/13/09: Nest lost to opossum predation		
HIAM09	HI09	Gr H3/Gr AW	Fledged (2)	5/9/2009	6/7/2009	7/16/2009	N/A	3	2	2	R43/44	7/16/09: 2 chicks fledged, banded (Gr AX, Gr AY)		
HIAM10	HI01	Rd C9/Gr L5	Lost	5/13/2009	N/A	N/A	6/5/2009	2	N/A	N/A	1.0 mi N of Buxton	6/5/09: Nest lost to opossum predation		
HIAM11	HI02	Gr A7/Gr 07	Lost	6/2/2009	N/A	N/A	6/12/2009	2	N/A	N/A	Cape Point, marker "D"	6/12/09: Nest lost to opossum predation		
HIAM12	H08	Gr A5/Gr L6	Lost	6/2/2009	N/A	N/A	7/14/2009	1	N/A	N/A	R45	7/14/09: Egg infertile		
HIAM13	HI01	Rd C9/ Gr L5	Lost	6/19/2009	7/13/2009	N/A	7/15/2009	2	1	N/A	S of R38	7/15/09: Chick lost to UNK		
OIAM01	OI01	Gr 14/Gr L7	Lost	5/3/2009	6/3/2009	N/A	6/19/2009	3	2	N/A	1.0 mi. S of R68	6/9/2009: 1 Chick lost to Avian, 6/19/2009: 1 chick lost to UNK		
OIAM02	OI02	Gr 54/UNB	Lost	5/7/2009	N/A	N/A	7/7/2009	2	N/A	N/A	2.7 mi. S of R59	7/7/2009: Nest abandoned		
OIAM03	OI03	Gr 86/Gr 76	Lost	5/12/2009	NA	N/A	5/20/2009	4	N/A	N/A	South Point	5/20/09: Nest overwashed		
OIAM04	OI04	Gr 87/UNB	Lost	5/12/2009	NA	N/A	5/21/2009	1	N/A	N/A	0.5 mi. N of R59	5/21/09: Nest abandoned		
OIAM05	OI04	Gr 87/UNB	Lost	6/1/2009	NA	N/A	6/22/2009	2	N/A	N/A	0.6 mi N of R59	6/22/09: Nest overwashed		
OIAM06	OI03	Gr 86/Gr 76	Lost	6/3/2009	6/28/2009	N/A	7/2/2009	3	3	N/A	1.0 mi S of R72	6/28/2009: 1 chick lost to UNK, 7/2/2009: 2 chicks lost to UNK		

Style Definition: tabletext

CHAPTER 3: AFFECTED ENVIRONMENT

The "Affected Environment" describes existing conditions for those elements of the natural and cultural environments that would be affected by the implementation of the actions considered in this *Off-Road Vehicle Management Plan/Environmental Impact Statement* (plan/EIS). The natural environment components addressed include wetlands and floodplains; rare, unique, threatened, or endangered species; state listed and special status species; wildlife and wildlife habitats (with a focus on birds and invertebrate species that could be affected by ORV use or management); soundscapes; visitor use and experience (including night skies); socioeconomic resources; and Seashore management and operations. Impacts for each of these topics are analyzed in "Chapter 4: Environmental Consequences."

WETLANDS AND FLOODPLAINS

WETLANDS

Wetlands include areas inundated or saturated by surface or groundwater for a sufficient length of time during the growing season to develop and support characteristic soils and vegetation. NPS classifies wetlands based on the U.S. Fish and Wildlife Service (USFWS) Classification of Wetlands and Deepwater Habitats of the United States (the Cowardin classification system). Based on this classification system, a wetland must have one or more of the following attributes:

- The habitat at least periodically supports predominantly hydrophytic (wetland) vegetation.
- The substrate is predominantly undrained hydric soil.
- The substrate is nonsoil and saturated with water, or is covered by shallow water at some time during the growing season. (Cowardin et al. 1979).

The majority of the undeveloped acreage within the Seashore can be classified as a wetland. The predominant wetland types at the Seashore are marine and estuarine. Marine wetlands occur along the beaches on the oceanside of the Seashore, and estuarine wetlands generally occur along the soundside, adjacent to the many tidal creeks that are prevalent along the islands.

Marine wetlands at the Seashore are located in the intertidal zone (from extreme high tide to extreme low tide) and in the subtidal zone, which includes areas permanently submerged below shallow coastal waters (Cowardin et al. 1979). Marine wetlands are found along the entire length of the ocean shoreline and are typical of a sandy beach environment, subject to high wind and wave energy. Estuarine wetlands consist of deepwater and adjacent tidal wetland areas that are often partially enclosed by land but are influenced by marine waters and freshwater runoff from adjacent uplands (Cowardin et al. 1979). Estuarine wetlands

at the Seashore typically fall into two classes: emergent or scrub–shrub. Emergent wetlands, also referred to as tidal marshes, are characterized by herbaceous perennial vegetation such as salt marsh cordgrass (*Spartina alterniflora*), black needlerush (*Juncus roemerianus*), bulrush (*Scirpus* spp.), and cattail (*Typha* spp.) (NCDENR 2008). Scrub–shrub wetlands are typically dominated by woody vegetation less than 20 feet tall. Typical vegetation species found in these wetlands include wax myrtle (*Myrica cerifera*) and Eastern red cedar (*Juniperus virginiana*) (Sutter 1999). Although most wetlands at the Seashore are tidal, there are also some areas of nontidal wetlands, located primarily on Hatteras Island near the village of Buxton and Buxton Woods Coastal Reserve. These wetland areas include forested and emergent wetlands and are predominantly freshwater swamps and marshes that are not influenced by the tides.

Wetland areas provide substantial environmental and economic benefits to the Seashore and surrounding areas of coastal North Carolina. For example, wetlands trap sediment and pollutants from stormwater runoff and provide a natural filter before this runoff can enter local waterways. Wetlands also store large volumes of water and function like sponges to reduce the likelihood of flooding during storm events. Wetlands also protect the shoreline from erosion and provide excellent habitat for fish and wildlife species, many of which are threatened or endangered (NCDENR 2008b). As required by Director's Order 77-1, the NPS must avoid adverse impacts on wetlands to the extent practicable, must minimize any impacts that cannot be avoided, and must compensate for any remaining unavoidable adverse impacts on wetlands (NPS 2008b).

FLOODPLAINS

North Carolina's barrier islands have historically been and continue to be affected by coastal forces and flooding events. The barrier islands that comprise the Seashore are flat and narrow and lie adjacent to the shallow and wide Pamlico Sound. The widest part of the Seashore islands is near Cape Point, between Buxton and Frisco (Pendleton et al. 2005). According to Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps, the entire Seashore is within the 100-year floodplain.

Generally, lands along the ocean beaches and adjacent to the sound (at wide points) are in flood zone "VE," which is the flood insurance rate zone that corresponds to 100-year coastal floodplains that have additional hazards associated with storm waves. Zone "VE" is also referred to as the "Coastal High Hazard Area." The remainder of the Seashore not directly adjacent to the ocean or sound lies within the "AE" zone, which is within the 100-year floodplain and subject to waves less than 3 feet high (NCDCCPS 2008).

Because the Seashore is entirely within the 100-year floodplain and is subject to high-water-table conditions, many areas are conducive to drainage and flooding that often result from storm events. Areas

near Buxton Woods and Cape Point Campground have been documented as historically flood-prone and are examples of popular Seashore destinations that experience flooding during times of above-average precipitation events (NPS 2003b). As required by Director's Order 77-2, the NPS must protect and preserve the natural resources and functions of floodplains, must avoid environmental effects associated with the occupancy and modification of floodplains, must avoid actions that could adversely affect wetland functions, and must restore floodplain values previously affected by activities in floodplains (NPS 2003c).

RARE, UNIQUE, THREATENED, OR ENDANGERED SPECIES

This section addresses species present at the Seashore that are listed by USFWS as either endangered or threatened. In some cases, the species may also be listed by the state of North Carolina. These species include the federally and state listed piping plover (*Charadrius melodus*); federally and state-listed loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and leatherback sea turtles (*Dermochelys coriacea*); and federally and state-listed seabeach amaranth (*Amaranthus pumilus*).

Species listed only by the state, and not federally listed as threatened and endangered, are discussed in the State Listed and Special Status Species section.

PIPING PLOVER

The piping plover is a small (6 to 7 inches long, weighing 1.5 to 2.2 ounces), highly camouflaged, sand-colored shorebird endemic to North America. The USFWS recognizes three distinct piping plover population segments: (1) the Atlantic Coast (from the Maritime Provinces of Canada to the Outer Banks of North Carolina), (2) the Great Lakes (along Lake Superior and Lake Michigan), and (3) the Great Plains (from southern, prairie Canada to Iowa). Wintering populations are found on the Atlantic Coast from North Carolina to Florida, on the Gulf Coast from Florida to Mexico, and in the Caribbean, with the greatest number of wintering birds found in Texas. Fewer than 3,000 breeding pairs of piping plovers were detected in the United States and Canada in 2001, although the most recent breeding census estimated breeding pairs in excess of 3,500 (Elliott-Smith et al. 2009). Piping plovers were common along the Atlantic Coast during much of the 19th century, but nearly disappeared due to excessive hunting for decorative feathers. Following passage of the Migratory Bird Treaty Act in 1918, plover numbers recovered to a 20th century peak in the 1940s. Increased development and beach recreation after World War II caused a population decline that led to federal protection for the plover (USFWS 2007b). Habitat loss caused by human development and recreation, and low reproductive rates caused by disturbance and predation, were considered to be the primary causes of the decline (Elliot-Smith and Haig 2004). The Atlantic Coast population was federally listed in 1986 as threatened (Federal Register 1985). At the time

of listing, there were approximately 790 Atlantic Coast pairs, and the species was in decline. Therefore, a recovery target of 2,000 pairs was established in the 1996 Revised Recovery Plan for the Atlantic Coast population (USFWS 1996a). Disturbance and predation were intensively managed after the listing, and the Atlantic Coast population rose to 1,890 pairs by 2007 (USFWS 2007c, 1), but was still short of the recovery goal of 2,000 pairs (USFWS 1996a; USFWS, Hecht, pers. comm. 2008).

Piping plover density is lower south of New Jersey; the Atlantic Coast Southern Region population was estimated at 333 pairs in 2007, which was the highest since 1986, but still short of the regional goal of 400 pairs (table 1). North Carolina experienced more than a 50% decline in breeding pairs from 1989 (55 pairs) to 2003 (24 pairs) (USFWS 2004a) for reasons discussed in the "Risk Factors" section later in this document; however, the number of breeding pairs has since climbed to a 22-year high of an estimated 64 pairs in 2008 (NCWRC 2008a).

Piping Plover in North Carolina

North Carolina is currently the only state on the Atlantic Coast that hosts piping plovers during all phases of their annual cycle, including the establishment and holding of territories, courtship and copulation, nest scraping and nest building, egg laying and incubation, chick rearing and fledging, and migration and wintering (Cohen 2005a). Band sightings indicate that plovers from all three North American breeding populations depend on Cape Hatteras during migration and/or the winter. Plovers from the endangered Great Lakes population have been observed in fall and spring migration and during the wintering period (Cohen 2005a). Early nesting records indicate that plovers were nesting at Pea Island in 1901 and 1902 (Golder 1986). The first published account of breeding piping plovers in North Carolina is from 1960, when a young bird was photographed in early June on Ocracoke Island (Golder 1985).

TABLE 1. SOUTHERN REGION (INCLUDING NORTH CAROLINA) PIPING PLOVER POPULATION TRENDS, NUMBERS OF BREEDING PAIRS

	Delaware	Maryland	Virginia	North Carolina	South Carolina	Southern Region Total
1986	8	17	100	30[a]	3	158
1987	7	23	100	30[b]	—	160
1988	3	25	103	40	—	171
1989	3	20	121	55[a]	—	199
1990	6	14	125	55	1	201
1991	5	17	131	40	1	194
1992	2	24	97	49	—	172
1993	2	19	106	53	1	181
1994	4	32	96	54	—	186
1995	5	44	118	50	—	217
1996	6	61	87	35	0	189
1997	4	60	88	52	—	204
1998	6	56	95	46	—	203
1999	4	58	89	31	—	182
2000	3	60	96	24	—	183
2001	6	60	119	23	0	208
2002	6	60	120	23	—	209
2003	6	59	114	24	—	203
2004[c]	7	66	152	20	—	245
2005[d]	8	63	192	37	—	300
2006[e]	9	64	202	46	—	321
2007[f]	9	64	199	61	—	333
2008[g]	10	49	208	64	—	331

Source of 1986–2001 data is USFWS 2002a.

Source of 2002–2003 data is USFWS 2004a.

[a]The recovery team believes that the apparent 1986–1989 increase in the North Carolina population was because of an intensified survey effort.

[b]No actual surveys were made in 1987; estimate is that from 1986.

[c]USFWS 2004b, Preliminary 2004 Atlantic Coast Piping Plover Abundance and Productivity Estimates (Updated March 2007). Figures are preliminary estimates.

[d]USFWS 2005. Preliminary 2005 Atlantic Coast Piping Plover Abundance and Productivity Estimates.

[e]USFWS 2006b. 2006 Atlantic Coast Piping Plover Abundance and Productivity Estimates.

[f]USFWS 2007c. 2007 Atlantic Coast Piping Plover Abundance and Productivity Estimates.

[g]USFWS 2008. 2008 Preliminary Atlantic Coast Piping Plover Abundance and Productivity Estimates.

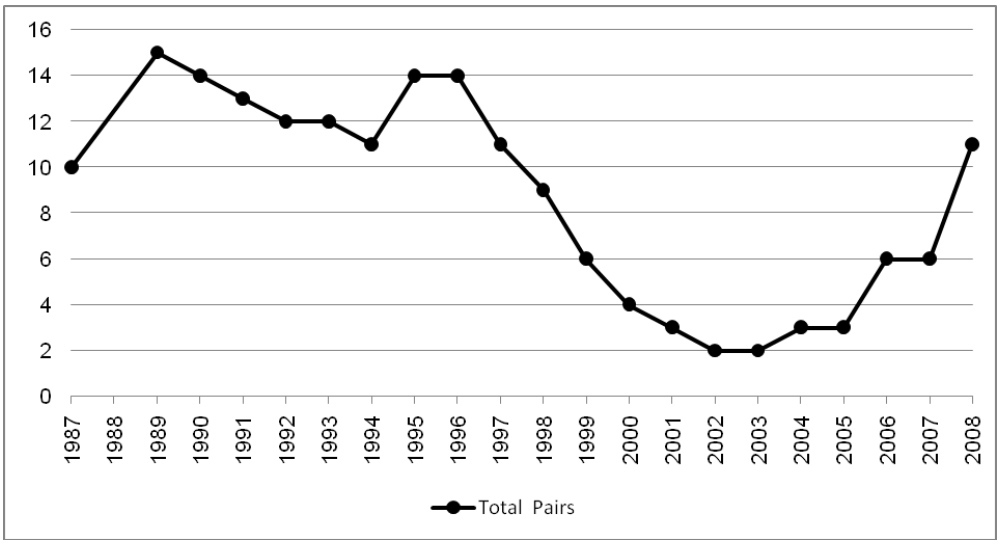
— = No data available.

Comment [bdm1]: Check with Anne Hecht to see if 2009 numbers are available yet.

At the Seashore, four nests and one brood were observed in 1984, and five chicks were confirmed to have fledged that year. All four nests were located adjacent to least tern (*Sterna antillarum*) colonies on wide,

open, sandy flats (Golder 1985). Nine pairs were counted in 1985 (Golder 1986), and 10 pairs in the summer of 1987 (Cooper 1990). The piping plover population reached a high of 15 pairs at the Seashore in 1989, and subsequently varied between 11 and 14 pairs through 1996, after which a sharp decline began (see figure 1). The population at the Seashore reached a low of two breeding pairs in 2002 and 2003, with only three breeding pairs reported in 2004 and two in 2005 (NPS 2009b). The population increased to 6 pairs in 2006 and 2007 and to 11 pairs by 2008 (NPS 2009b, 6). **[Preparer's Note: Park to confirm discrepancies between 2007 and 2008 reports, which have a different number of pairs for 1993 and 1994.]**

Comment [bdm2]: The 2007 report is correct. In the 2008 report the correct numbers were used in Table 5a.

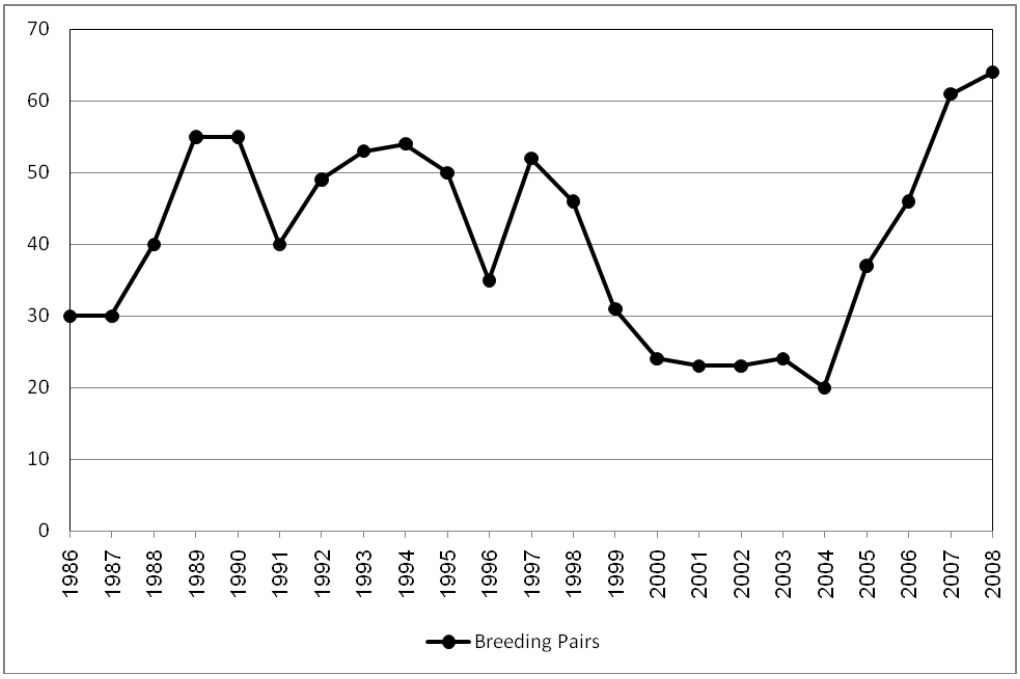


Source: NPS 2009b

FIGURE 1. NUMBERS OF PIPING PLOVER BREEDING PAIRS, CAPE HATTERAS NATIONAL SEASHORE, 1987–2008

North Carolina Wildlife Resources Commission (NCWRC) staff conducted a 2008 piping plover breeding census along the coast of North Carolina. The census included all suitable habitat on ocean and inlet beaches with the exception of Browns Island, which lies within a military live-fire training range. The census estimated a total of 64 pairs and five individuals, which is a 5% increase from the 2007 estimate of 61 pairs and is the highest number recorded in North Carolina in the years that complete surveys have been conducted (1986–2008; see figure 2). Statewide, the distribution of piping plovers was similar to previous years, with the majority of nesting pairs found at Cape Lookout National Seashore (NCWRC 2008a).

Comment [bdm3]: Should give more details as to the totals provided. Are they for the survey window or best estimate? Totals may be different than total breeding pairs in annual reports.



Source: USFWS 2004a, 2004b, 2005, 2006b, 2007c, 2008

FIGURE 2. NUMBERS OF PIPING PLOVER BREEDING PAIRS IN NORTH CAROLINA, 1986–2008

Comment [bdm4]: Are these totals from the census window or the "Best estimate" of pair numbers? The State usually asks us for both. From what I have seen these numbers don't always add up to the numbers in our annual report. State usually reports pair numbers and I think FWS is mistakenly reporting these as nesting pairs.

Habitat Description

On the Atlantic Coast, piping plovers nest in sand, gravel, or cobble substrates in backshore, dune, interdune blowout, overwash fan, and barrier flat zones of open or sparsely vegetated beaches. Nest sites may have little or no slope (Cairns 1982; Burger 1987), although nesting does occur on lower-elevation dunes (Cairns 1982). On wide beaches, piping plovers nest in the open to maintain a wide field of view, but on narrower beaches nests can be established under clumps of vegetation (Cairns 1982; USFWS 1996a).Where beaches are wide, piping plovers tend to nest far from the tide line to reduce risk of nest overwash, but this can place nests closer to vegetated dunes where the risk of predation is higher (Burger 1987). Piping plovers have also been observed nesting within least tern colonies, which could provide an added defense against predators due to the antipredator behavior of least terns (Burger 1987). (sidebar: photo of nest site, plover incubating)

All piping plover breeding sites at the Seashore were designated as critical habitat for wintering birds, as defined by the federal Endangered Species Act (ESA) (Federal Register 2001) until 2004, when a court decision vacated the designation for Oregon Inlet, Cape Point, Hatteras Inlet, and Ocracoke Island (*Cape*

Hatteras National Seashore Access Preservation Alliance versus U.S. Dept. of the Interior, 344 F. Supp. 2d 108 [D.D.C. 2004]). A rule to revise designated critical habitat for the wintering population of the piping plover in North Carolina was proposed in 2006 (71 FR 33703). That proposed rule described four coastal areas (named Units NC-1, NC-2, NC-4, and NC-5), totaling approximately 739 hectares (1,827 acres) entirely within the Seashore, as critical habitat for the wintering population of the piping plover. The USFWS also proposed to add 87 hectares (215 acres) of critical habitat to two previously proposed units. As a result, the proposed revised critical habitat designation for the species now includes four revised critical habitat units totaling approximately 826 hectares (2,042 acres). The final rule for the revised critical habitat designation became effective on November 20, 2008 (Federal Register 2008).

In the winter and on migration, piping plovers tend to be found in areas with wide beaches and inlet habitats, foraging in moist, substrate habitat that includes both low- and high-wave-energy intertidal zones, mudflats, moist sand flats, ephemeral pools, shores, and brackish ponds (Cohen 2005a; Elliot-Smith and Haig 2004; Nicholls and Baldassarre 1990; Wilkinson and Spinks 1994). During winter distribution surveys on the Atlantic Coast from 1986 to 1987, piping plovers were almost always found associated with other species of shorebirds, such as sanderlings (*Calidris alba*), least sandpipers (*C. minutilla*), or western sandpipers (*C. mauri*), in addition to other piping plovers (Nicholls and Baldassarre 1990). (sidebar: photo of foraging habitat)

Diet

Piping plovers feed primarily on freshwater, marine, terrestrial, and benthic invertebrates (Elliot-Smith and Haig 2004) such as marine worms, fly larvae, beetles, crustaceans, or mollusks (USFWS 1996a). Adults forage both day and night (Staine and Burger 1994), but young chicks are brooded during the night and therefore feed by day (Wolcott and Wolcott 1999). During territory establishment, foraging adults exhibit a preference for a moist substrate habitat that particularly includes mudflats, sand flats, ephemeral pools, and shores of brackish ponds and excludes the high-wave-energy intertidal zone (Cohen 2005a). Broods forage primarily on damp sand flats or moist substrate habitat, where the abundance of prey is much higher than in other habitats (Kuklinski et al. 1996). (sidebar: brooding)

Chicks with access to moist substrate habitat survived better than chicks without such access in Virginia (Loegering and Fraser 1995) and Rhode Island (Goldin and Regosin 1998). A study in New York in 1992 and 1993 found that piping plover broods had higher foraging rates in areas with ephemeral pools and tidal flats, which suggested that these habitats were superior. This study also documented higher incidences of arthropods in the moist substrate habitat, which could explain the increased plover numbers and survival rates in these habitat types. Management implications of this study include conserving a

variety of foraging habitat (Elias et al. 2000). Burger (1994) found that when broods had access to a diversity of foraging habitat zones, the impact of human disturbance was reduced because chicks had opportunities to escape disturbances and still forage.

Breeding Biology

On the Atlantic Coast, breeding territory establishment and courtship generally begin in late March, the first nests are initiated in late April, and the brood-rearing period extends from late May to mid-August (Cohen 2005b). On beaches with more birds in the northern end of the Atlantic Coast breeding range, most pairs establish breeding territory within a day or two of the birds' arrival in early spring, whereas pairs on sites with fewer birds can take several days or weeks longer to become established (Elliot-Smith and Haig 2004).

Piping plovers are primarily monogamous during the breeding season but often change mates between seasons. The nest is built by the male and consists of a shallow scrape in sandy substrate that may or may not be lined with pebbles and shell fragments. The normal clutch size is four (USFWS 2007b), and the average duration for egg laying is six days (Elliot-Smith and Haig 2004). Replacement of lost or destroyed eggs has not been reported. If one or more eggs are lost, the pair continues to incubate the remaining eggs. Incubation is shared by males and females and typically commences the day of clutch completion, but sometimes occurs when the next-to-last egg is laid (Elliott-Smith and Haig 2004).

The length of incubation ranges from 25 to 29 days, and a pair will re-nest multiple times if successive clutches are destroyed, but re-nesting after the chicks hatch is rare (Elliott-Smith and Haig 2004). Chicks leave the nest scrape within a few hours of hatching, except when a nest hatches at night, and they never return (Wolcott and Wolcott 1999). Broods may move hundreds of meters away from the nest site during the first week after hatching (USFWS 1996a). Chicks are vulnerable soon after hatching, and survival rates are lower if the brood is forced to move. Members of a breeding pair share brood-rearing duties, though some females desert broods within 5 to 17 days (Elliott-Smith and Haig 2004). Although chicks follow adults to a foraging habitat, chicks forage for themselves. Fledging time ranges from 25 to 35 days (USFWS 1996a), and most adults and young depart the breeding grounds between mid-July and early September (Cohen 2005a).

Breeding Chronology and Performance at Cape Hatteras National Seashore

Locally breeding piping plovers arrive at the Seashore in mid-March, begin courting and pairing in April, and begin to scrape and build nests in the third week of April. Bodie Island Spit, Cape Point, South Beach, Hatteras Inlet Spit, North Ocracoke Spit, and South Point Ocracoke (South Point) all contain

potential nesting habitat. Nesting has occurred in all but one of these areas in the last 10 years. Although there has not been a breeding pair on the north end of Ocracoke Island since 1996, resource management staff members ~~also~~ continue to monitor this area for potential plover activity. Seashore personnel generally begin monitoring for piping plover arrival and pre-nesting behavior in late March and early April. Monitoring and surveys of these sites are conducted a minimum of three times per week. Once nests are located, they are briefly approached once a week to inspect the exclosure, count eggs, and search for predator tracks. Morning and evening observations begin when clutches are expected to hatch. Monitors observe from a distance for evidence of hatching or chicks. All known nests are protected by predator exclosures, which have been in use at the Seashore since 1994. After hatching, the broods are monitored ~~from dawn to dusk~~ a few hours in the morning and a few hours in the afternoon until the chicks have fledged or are lost. Monitoring staff members document brood status, behavior, individual bird and/or brood movements, human disturbance, predator interactions, and other significant environmental events.

Comment [bdm5]: The Consent Decree (Pg. 10) now requires us to start monitoring on March 15. We monitor every 2 days from March 15 to April 15, and daily from April 16 to July 15. Bodie Island Spit is monitored daily from March 15 to July 15.

Table 2 shows the numbers of breeding pairs of piping plovers at the six primary nesting sites from 1987 to 2008. Table 3 provides data on piping plover hatching and fledging success at the Seashore from 1992 through 2008. The 11 nesting pairs identified in 2008 marks an 83% increase from the 6 pairs identified in 2007 (NCWRC 2008a).

Fledge rate (or reproductive rate) is defined as the number of chicks that survive until fledging age per breeding pair. Since 1989, reproductive rates at the Seashore have ranged from 0.00 to 2.00 chicks per breeding pair, with an average rate over the 17 years from 1992 to 2008 of 0.67 chicks per breeding pair (NPS 2009b), the highest in the state (NPS 2008c). During 2008, a total of 11 breeding pairs fledged 7 chicks (a rate of 0.64 chicks per pair) (NCWRC 2008a). However, a rate of 1.20 fledged chicks per breeding pair annually would be needed to sustain the population (USFWS 1996a), and the recovery goal set by the USFWS is 1.50 fledged chicks per breeding pair. Hence, the fledge rate at the Seashore has averaged less than half the recovery goal since 1992.

TABLE 2. NUMBERS OF PIPING PLOVER BREEDING PAIRS BY SITE, CAPE HATTERAS NATIONAL SEASHORE, 1987–~~2008~~2009

Year	Bodie Island Spit	Cape Point	South Beach	Hatteras Inlet Spit	North Ocracoke Spit	South Point	Total Pairs
1987	0	4	0	4	1	1	10
1989	—	—	—	—	—	—	15
1990	0	8	0	4	2	0	14
1991	0	5	0	3	5	0	13
1992	0	4	0	4	4	0	12
1993	0	5	1	3	3	0	12
1994	0	5	1	3	2	0	11
1995	0	6	1	4	2	1	14
1996	1	5	1	5	1	1	14
1997	1	4	1	3	0	2	11
1998	0	4	1	3	0	1	9
1999	0	3	1	1	0	1	6
2000	0	2	0	2	0	0	4
2001	1	1	0	1	0	0	3
2002	1	0	0	1	0	0	2
2003	0	0	0	1	0	1	2
2004	1	0	0	1	0	1	3
2005	0	0	1	1	0	1	3
2006	1	2	1	1	0	1	6
2007	1	4	0	0	0	1	6
2008	1	5	1	0	0	4	11
2009	0	5	0	0	0	4	9
Total (% of total pairs)	8 (4.8*)	67 (40.4*)	10 (6.0*)	45 (27.1*)	20 (12.0*)	16 (9.6*)	181 (100)

Source: NPS 2009b.

*Total number of pairs was 181, but locations were not available in 1989. Therefore, percentages from the specific sites are based on the 166 nests that were recorded at one of the six specific nesting areas.

— = No data available.

Comment [bdm6]: Need to recalculate if including the 2009 data.

TABLE 3. PIPING PLOVER HATCHING AND FLEDGING SUCCESS AT CAPE HATTERAS NATIONAL SEASHORE, 1992–~~2008~~2009

Year	# Total Pairs	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate[b]
				#	%	#	%[a]	#	%	
1992	12	14	49[c]	8	57	17	35	8	47	0.67
1993	12	21	69	9	43	27	39	8	30	0.67
1994	11	18	65[d]	10	56	32[e]	49	9	30	0.82
1995	14	19	63	13	68	30	48	7	23	0.50
1996	14	16	56[f]	10	63	30	53	3	10	0.21
1997	11	16	47[f]	10	63	32	68	3	9	0.27
1998	9	8	31	6	75	20	65	12	60	1.33
1999	6	6	23	3	50	11	48	7	64	1.20
2000	4	6	23	3	50	10	44	3	30	0.75
2001	3	3	10	1	33	3	30	2	67	0.67
2002	2	3	8	1	33	1	13	0	0	0.00
2003	2	2	5[f]	2	100	~~4~~[f]5[f]	100	1	20	0.50
2004	3	2	6	1	50	4	~~66~~67	0	0	0.00
2005	3	2	8	2	100	8	100	6	75	2.00
2006	6	4	15	3	75	9	60	3	33	0.50
2007	6	10[g]	29	6	60	17	59	4	23	0.67
2008	11	13	43	8	62	22	~~54~~51	7	32	0.64
2009	9	9	34	6	60	22	65	6	27	0.67

Source: NPS 2009b.

[a]Percentage of all known eggs.

[b]Fledge rate is defined as the number of fledged chicks per breeding pair (# Total Pairs).

[c]Assumes three eggs from a brood whose nest was not found.

[d]Assumes two eggs from a brood whose nest was not found.

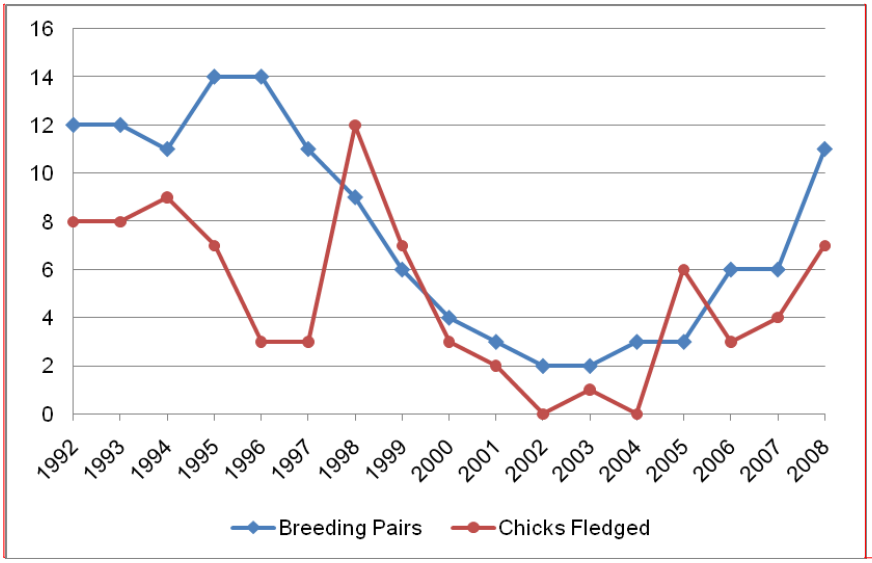
[e]Includes those presumed hatched.

[f]Assumes one egg from a brood whose nest was not found.

[g]Based on consultation with USFWS, it was determined that Nest 1 and Nest 2 were a single nesting attempt.

Comment [bdm7]: In the following tables the percentages have one decimal point

The decline in the local breeding population (figure 3 below) from 1995 to 2003 is likely a reflection of the low reproductive rate (NPS 2005a) and resultant lack of recruitment. However, the increase in the numbers of piping plover breeding pairs since 2003 is encouraging.



Source: NPS 2009b.

FIGURE 3. NUMBERS OF PIPING PLOVER BREEDING PAIRS AND FLEDGED CHICKS AT CAPE HATTERAS NATIONAL SEASHORE, 1992–~~2008~~2009

Hatching and Fledging Success at Primary Nesting Sites

The following tables (table 4 through table 9) provide a summary of hatching and fledging success at each of the individual primary breeding sites from the early to mid-1990s through 2008. Average fledge rates across the six breeding sites ranged from 0.13 at Bodie Island Spit to 0.90 at South Beach, and each site has a fledge rate below the 1.50 goal set by the 1996 revised recovery plan. However, there were eight instances of years when one or more sites did meet or exceed this goal, indicating that despite poor Seashore-wide recruitment, some primary nesting sites performed at or above this expectation in some years.

Comment [bdm8]: Y axis should be labeled.

Comment [bdm9]: In 2009 we had 9 breeding pairs and 6 chicks fledged.

TABLE 4. PIPING PLOVER HATCHING AND FLEDGING SUCCESS AT BODIE ISLAND SPIT, 1996–~~2008~~2009

Year	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate
			#	%	#	%	#	%	
1996	1	4	1	100.0	3	75.0	0	0.0	0.00
1997	2	6	0	0.0	0	0.0	0	0.0	0.00
1998	0	0	0	0.0	0	0.0	0	0.0	N/A
1999	0	0	0	0.0	0	0.0	0	0.0	N/A
2000	0	0	0	0.0	0	0.0	0	0.0	N/A
2001	1	3	0	0.0	0	0.0	0	0.0	0.00
2002	1	3	1	100.0	1	33.3	0	0.0	0.00
2003	0	0	0	0.0	0	0.0	0	0.0	N/A
2004	1	2	0	0.0	0	0.0	0	0.0	0.00
2005	0	0	0	0.0	0	0.0	0	0.0	N/A
2006	0	0	0	0.0	0	0.0	0	0.0	~~0.00~~N/A
2007	1	3	1	100.0	3	100.0	1	33.3	1.00
2008	1	3	0	0.0	0	0.0	0	0.0	0.00
2009	0	0	0	0.0	0	0.0	0	0.0	N/A
Average Fledge Rate at Bodie Island Spit = 0.13									

TABLE 5. PIPING PLOVER HATCHING AND FLEDGING SUCCESS AT CAPE POINT, 1992–~~2008~~2009

Year	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate
			#	%	#	%	#	%	
1992	5	19	4	80.0	11	57.9	4	36.4	1.00
1993	6	23	5	83.3	15	65.2	3	20.0	0.60
1994	6	24	5	83.3	16	66.7	5	31.3	1.00
1995	9	33	5	55.6	15	45.5	2	13.3	0.33
1996	5	16	3	60.0	7	43.8	3	42.9	0.60
1997	6	18	5	83.3	15	83.3	3	20.0	0.75
1998	5	19	3	60.0	10	52.6	6	60.0	1.50
1999	3	12	2	66.7	7	58.3	5	71.4	1.67
2000	3	11	2	66.7	6	54.5	2	33.3	1.00
2001	1	3	0	0.0	0	0.0	0	0.0	0.00
2002	0	0	0	0.0	0	0.0	0	0.0	N/A
2003	0	0	0	0.0	0	0.0	0	0.0	N/A
2004	0	0	0	0.0	0	0.0	0	0.0	N/A
2005	0	0	0	0.0	0	0.0	0	0.0	N/A
2006	2	7	2	100.0	6	85.7	3	50.0	1.50
2007	8	22	4	50.0	10	45.5	3	30.0	0.75
2008	6	22	4	66.7	12	54.5	4	33.3	0.80

2009	5	20	5	100.0	19	95.0	5	26.3	1.00
Average Fledge Rate at Cape Point = 0.86									

Comment [bdm10]: Needs to be recalculated if including 2009 data.

TABLE 6. PIPING PLOVER HATCHING AND FLEDGING SUCCESS AT SOUTH BEACH, 1992–~~2008~~2009

Year	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate
			#	%	#	%	#	%	
1992	0	0	0	0.0	0	0.0	0	0.0	N/A
1993	2	7	1	50.0	4	57.1	0	0.0	0.00
1994	1	2	1	100.0	2	100.0	1	50.0	1.00
1995	1	3	1	100.0	1	33.3	1	100.0	1.00
1996	1	3	1	100.0	2	66.7	0	0.0	0.00
1997	2	8	2	100.0	7	87.5	0	0.0	0.00
1998	1	4	1	100.0	4	100.0	2	50.0	2.00
1999	1	4	1	100.0	4	100.0	2	50.0	2.00
2000	0	0	0	0.0	0	0.0	0	0.0	N/A
2001	0	0	0	0.0	0	0.0	0	0.0	N/A
2002	0	0	0	0.0	0	0.0	0	0.0	N/A
2003	0	0	0	0.0	0	0.0	0	0.0	N/A
2004	0	0	0	0.0	0	0.0	0	0.0	N/A
2005	1	4	1	100.0	4	100.0	3	75.0	3.00
2006	1	4	0	0.0	0	0.0	0	0.0	0.00
2007	0	0	0	0.0	0	0.0	0	0.0	N/A
2008	1	4	1	100.0	2	50.0	0	0.0	0.00
2009	0	0	0	0.0	0	0.0	0	0.0	N/A
Average Fledge Rate at South Beach = 0.90									

TABLE 7. HATCHING AND FLEDGING SUCCESS AT HATTERAS INLET SPIT, 1992–2008

Year	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate
			#	%	#	%	#	%	
1992	5	16	2	40.0	5	31.3	2	40.0	0.50
1993	4	16	2	50.0	7	43.8	4	57.1	1.33
1994	6	24	3	50.0	10	41.7	3	30.0	1.00
1995	6	17	5	83.3	11	64.7	3	27.3	0.75
1996	7	26	4	57.1	14	53.8	0	0.0	0.00
1997	4	8	1	25.0	4	50.0	0	0.0	0.00
1998	1	4	1	100.0	2	50.0	0	0.0	0.00
1999	1	4	0	0.0	0	0.0	0	0.0	0.00
2000	3	12	1	33.3	4	33.3	1	25.0	0.50
2001	1	4	1	100.0	3	75.0	2	66.7	2.00
2002	2	5	0	0.0	0	0.0	0	0.0	0.00
2003	1	4	1	100.0	4	100.0	0	0.0	0.00
2004	1	4	1	100.0	4	100.0	0	0.0	0.00
2005	1	4	1	100.0	4	100.0	3	75.0	3.00
2006	0	0	0	0.0	0	0.0	0	0.0	~~0.00~~N/A
2007	0	0	0	0.0	0	0.0	0	0.0	~~0.00~~N/A
2008	0	0	0	0.0	0	0.0	0	0.0	N/A
2009	0	0	0	0.0	0	0.0	0	0.0	N/A
Average Fledge Rate at Hatteras Inlet Spit = 0.51									

Comment [bdm11]: Needs to be recalculated if including 2009 data.

TABLE 8. HATCHING AND FLEDGING SUCCESS AT NORTH OCRACOKE SPIT, 1992–2008

Year	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate
			#	%	#	%	#	%	
1992	4	14	2	50.0	5	35.7	2	40.0	0.50
1993	9	23	1	11.1	1	4.3	1	100.0	0.33
1994	5	15	1	20.0	4	26.7	0	0.0	0.00
1995	2	6	2	100.0	3	50.0	1	33.3	0.50
1996	1	3	0	0.0	0	0.0	0	0.0	0.00
1997	0	0	0	0.0	0	0.0	0	0.0	N/A
1998	0	0	0	0.0	0	0.0	0	0.0	N/A
1999	0	0	0	0.0	0	0.0	0	0.0	N/A
2000	0	0	0	0.0	0	0.0	0	0.0	N/A
2001	0	0	0	0.0	0	0.0	0	0.0	N/A
2002	0	0	0	0.0	0	0.0	0	0.0	N/A
2003	0	0	0	0.0	0	0.0	0	0.0	N/A
2004	0	0	0	0.0	0	0.0	0	0.0	N/A
2005	0	0	0	0.0	0	0.0	0	0.0	N/A
2006	0	0	0	0.0	0	0.0	0	0.0	N/A
2007	0	0	0	0.0	0	0.0	0	0.0	N/A
2008	0	0	0	0.0	0	0.0	0	0.0	N/A
2009	0	0	0	0.0	0	0.0	0	0.0	N/A
Average Fledge Rate at North Ocracoke Spit = 0.33									

Comment [bdm12]: Needs to be recalculated if including 2009 data.

TABLE 9. HATCHING AND FLEDGING SUCCESS AT SOUTH POINT, 1995–2008

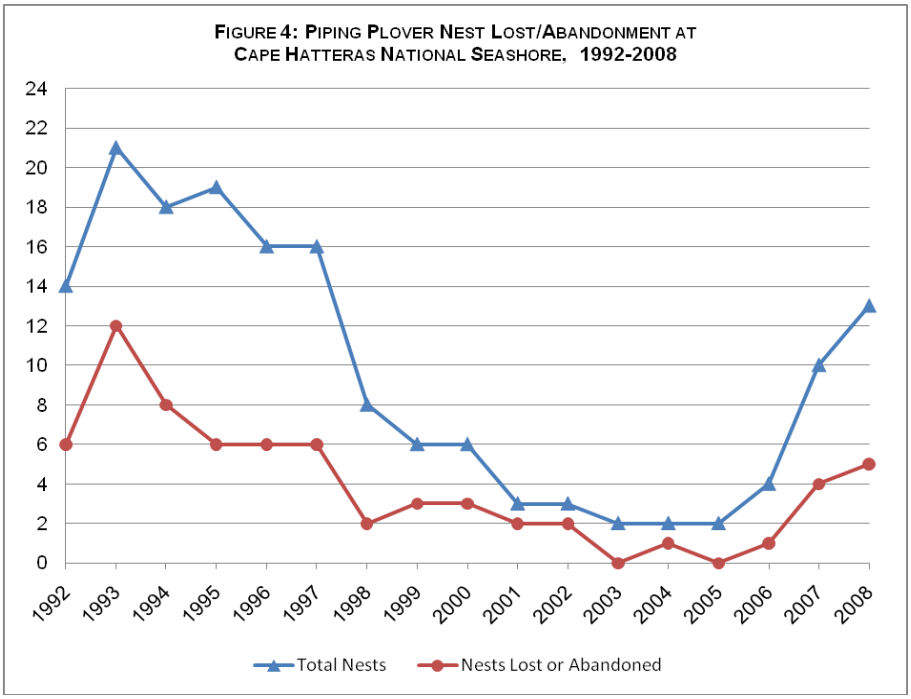
Year	# Nests	# Eggs	Nests Hatched		Eggs Hatched		Chicks Fledged		Fledge Rate
			#	%	#	%	#	%	
1995	1	4	0	0.0	0	0.0	0	0.0	0.00
1996	1	4	1	100.0	4	100.0	0	0.0	0.00
1997	2	7	2	100.0	6	85.7	0	0.0	0.00
1998	1	4	1	100.0	4	100.0	4	100.0	4.00
1999	1	3	0	0.0	0	0.0	0	0.0	0.00
2000	0	0	0	0.0	0	0.0	0	0.0	N/A
2001	0	0	0	0.0	0	0.0	0	0.0	N/A
2002	0	0	0	0.0	0	0.0	0	0.0	N/A
2003	1	1	1	100.0	1	100.0	1	100.0	1.00
2004	0	0	0	0.0	0	0.0	0	0.0	~~0.00~~N/A
2005	0	0	0	0.0	0	0.0	0	0.0	~~0.00~~N/A
2006	1	4	1	100.0	3	75.0	0	0.0	0.00
2007	1	4	1	100.0	4	100.0	0	0.0	0.00
2008	5	14	3	60.0	8	57.1	3	37.5	0.75
2009	4	14	1	25%	3	21.0	2	66.7	0.50
Average Fledge Rate at South Point = 0.53									

Comment [bdm13]: Needs to be recalculated if including 2009 data.

[Preparer's Note: 2004 PIPL report appendix B indicated 100 eggs in 1998, but this was assumed to be incorrect]

Nest Loss/Abandonment

Nest loss and abandonment have had significant impacts on piping plover reproduction at the Seashore. In the 17 seasons from 1992 through 2008, 41% of nests (of 163 discovered) were lost or abandoned (figure 4). Factors contributing to nest loss and abandonment include weather, predation, and human disturbance, which are discussed in detail under the "Risk Factors" section later in this document.



Source: NPS 2009b.

FIGURE 4. PIPING PLOVER NEST LOSS/ABANDONMENT AT CAPE HATTERAS NATIONAL SEASHORE, 1992–2008

Comment [bdm14]: In 2009 we had a total of 9 nests and 3 were lost/abandoned.

Nonbreeding Population

In addition to supporting a local breeding population, the Seashore also hosts migrating and wintering piping plovers from all three of the North American breeding populations (the threatened Atlantic Coast and Great Plains populations and the endangered Great Lakes population). The Outer Banks is an important stopover area for migrating shorebirds along the Atlantic coast. Fall migrants arrive at the Outer Banks in July, peak in August and September, and depart by November (Dinsmore et al. 1998). The distribution and abundance of nonbreeding populations at the Seashore are less well documented than the local breeding population. Documenting and protecting nonbreeding piping plovers and their habitats are priorities articulated in the recovery plans for all three North American breeding populations (USFWS 1988; USFWS 1996a, iii; USFWS 2003, iii). Recognizing the importance of the Outer Banks to wintering piping plovers, the USFWS designated 2,043 acres of critical habitat in Dare and Hyde counties in November 2008 (Federal Register 2008).

Wintering piping plovers on the Atlantic Coast select wide beaches in the vicinity of inlets that are associated with a high percentage of moist substrate habitat (Nicholls and Baldassarre 1990, 587;

Wilkinson and Spinks 1994, 36). Because tidal regimes and fall and winter storm patterns often cause piping plovers to move among habitat patches, a diversity of habitat patches may be important to wintering populations (Burger 1994, 698; Nicholls and Baldassarre 1990, 583).

Cohen (2005a) studied nonbreeding piping plovers at the Seashore from 2000 to 2005. The results of this study indicated that the greatest number of nonbreeding piping plovers at the Seashore occurs during the fall migration, which begins in July and peaks between July and September (see table 10). The fall migration counts were highest at South Point, followed by Oregon Inlet (Bodie Island Spit, Pea Island National Wildlife Refuge, and, formerly, Green Island, which is now largely unusable for plovers because of vegetation growth), then Hatteras Inlet Spit, and finally Cape Point (Cohen 2005a, 7).

TABLE 10. MONTHLY MEDIAN AND MAXIMUM NONBREEDING BIRDS SEEN DURING FALL, WINTER, AND SPRING DAILY SURVEYS, SELECTED SITES AT CAPE HATTERAS NATIONAL SEASHORE, 2000–2005

	Month	Bodie Island Spit	Cape Point/ South Beach	Hatteras Inlet Spit	South Point	All Sites
Median	Jul	0.49	0.18	0.45	2.21	5.7
	Aug	0.68	0.31	0.13	3.76	6.4
	Sept	0.66	0.07	0.38	4.22	5.7
	Oct	0.36	0.00	0.86	1.81	3.3
	Nov	0.82	0.00	0.07	1.00	4.2
	Dec	0.77	0.00	0.00	2.07	2.9
	Jan	0.25	0.00	0.00	1.00	1.2
	Feb	3.33	0.00	0.00	1.00	4.3
	Mar	1.25	0.00	0.00	0.75	2.8
	Apr	1.89	0.00	0.62	1.31	3.6
Maximum	Jul	32	5	21	56	56
	Aug	34	6	14	72	72
	Sept	16	5	4	37	37
	Oct	12	1	28	31	31
	Nov	15	0	8	12	15
	Dec	17	0	7	15	17
	Jan	18	0	1	11	18
	Feb	14	0	0	18	18
	Mar	12	3	4	8	12
	Apr	25	3	7	11	25

Source: Cohen 2005a, 56

NOTE: Not all sites were surveyed each day (typically, only one or two were surveyed), so the numbers in the table provide only a rough idea of the total size of the nonbreeding population (Cohen 2005a, 56).

During this time, the first banded winter residents appeared in August; however, other wintering birds could have arrived in July. Cohen suggested that the nonbreeding population from December to January probably consisted entirely of winter residents and estimated that, although the size of the resident wintering population at the Seashore was not precisely known, it may be on the order of 20 to 35 birds (Cohen 2005a). In the winter of 2004–2005, the maximum numbers seen were about 50% of the recent norm; however, whether this observed difference was because of a difference in survey methodology is unknown. The highest counts of wintering residents were at Bodie Island Spit and South Point. Based on a sample of banded birds, winter residents can be present until April (Cohen 2005a). Spring piping plover migrants first appear in February or early March, and their numbers peak in late March or April (table 10). Sites at Bodie Island Spit have had the highest abundance of spring migrants, followed by South Point, with fewer at Hatteras Inlet Spit and Cape Point/South Beach (Cohen 2005a, 7).

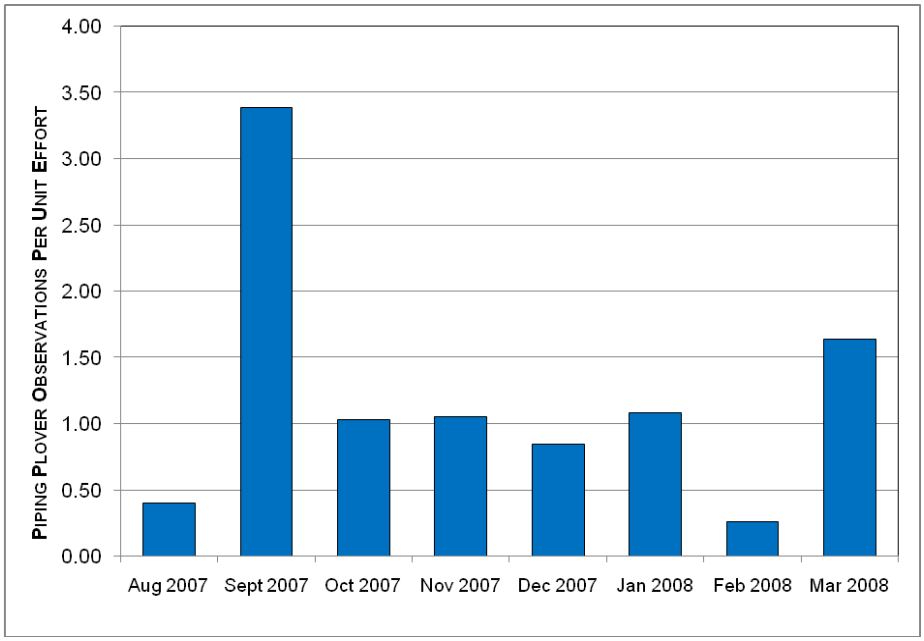
Park staff documented piping plover use of the Seashore throughout 2006. Migratory birds appeared to peak in August and September, with a high count of 93 birds at South Point on August 10 (table 11). South Point revealed the highest counts during fall migration. Three surveys at South Point were coordinated with Seashore surveys on North Core Banks to investigate bird abundance around Ocracoke Inlet (table 11).

TABLE 11. COUNTS OF PIPING PLOVER ON BOTH SIDES OF OCRACOKE INLET DURING FALL MIGRATION, 2006

Date	South Point	North Core Banks	Total	Tide
Aug 10, 2006	93	7	100	Mid
Aug 14, 2006	69	16	85	Low
Oct 2, 2006	15	16	31	Low

Source: NPS 2007d

Park staff also documented nonbreeding plovers' use of the Seashore beginning at the end of the breeding season in August 2007 through March 2008 (see figure 5). Migratory birds peaked in September, with a high of 33 counted on September 7, 2007, on South Point. After the migrants passed through the area in September, plover numbers appeared to stabilize over the winter months except in February 2008, when there was an unexplained drop in numbers.



Source: NPS 2009b

FIGURE 5. MONTHLY OBSERVATIONS OF PIPING PLOVERS PER SAMPLING EVENT FROM AUGUST 2007 TO MARCH 2008

Comment [bdm15]: This same info is avail for Aug 2008 to March 2009. Fig s 5a and 5B?

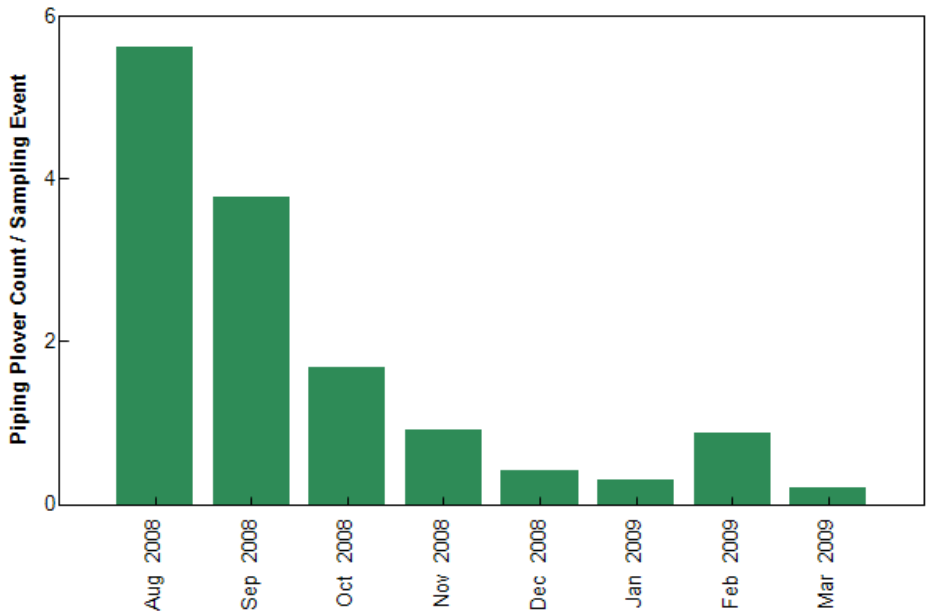
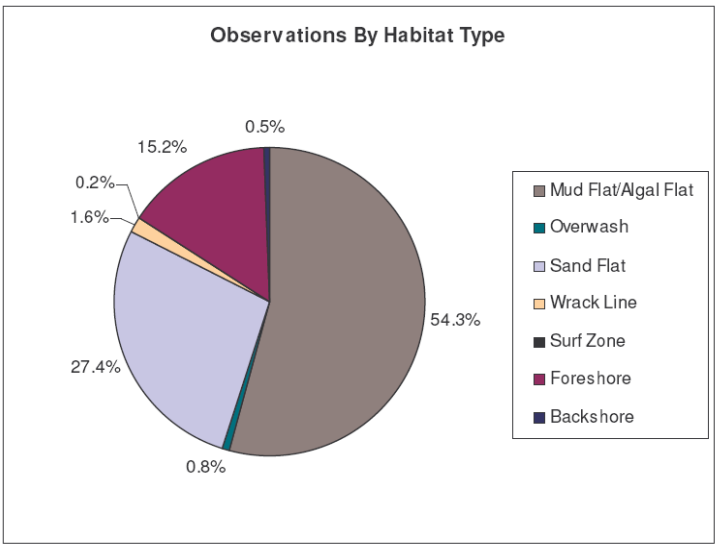


Fig. 5 b?

Park staff documented the habitat type in which migratory and wintering piping plovers were observed from August 2007 to March 2008 (figure 6A) and from August 2008 to March 2009 (figure 6B). Of the 387 observations, 210 were in mudflat/algal flat, 106 were in sand flat, 59 were in foreshore, 6 were in wrack line, 3 were in overwash, 2 were in backshore, and 1 was flying over the surf zone (NPS 2009b, 16).

Comment [bdm16]: Same could be generated for August 2008 to March 2009.



Source: NPS 2009b

FIGURE 6A. WINTERING OBSERVATIONS OF PIPING PLOVER BY HABITAT TYPE

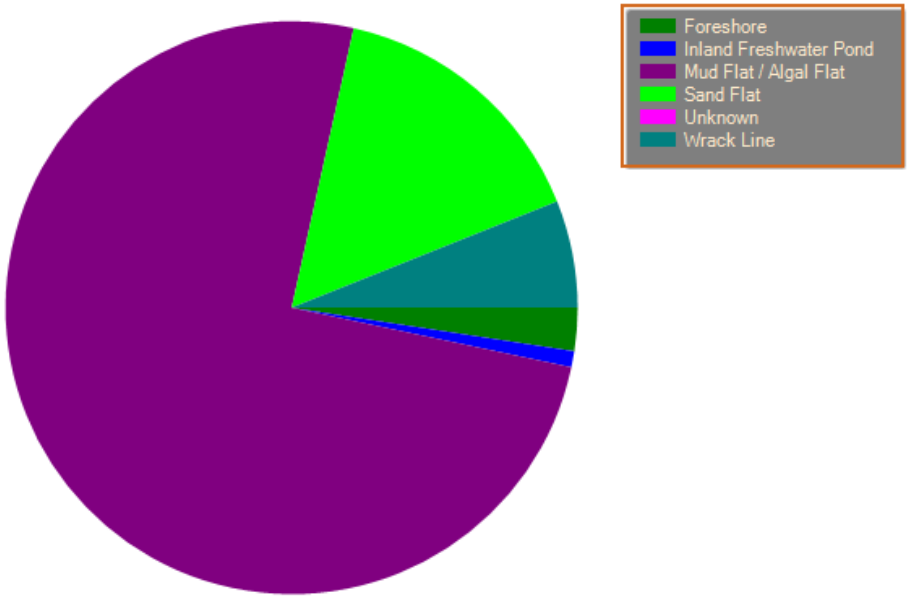
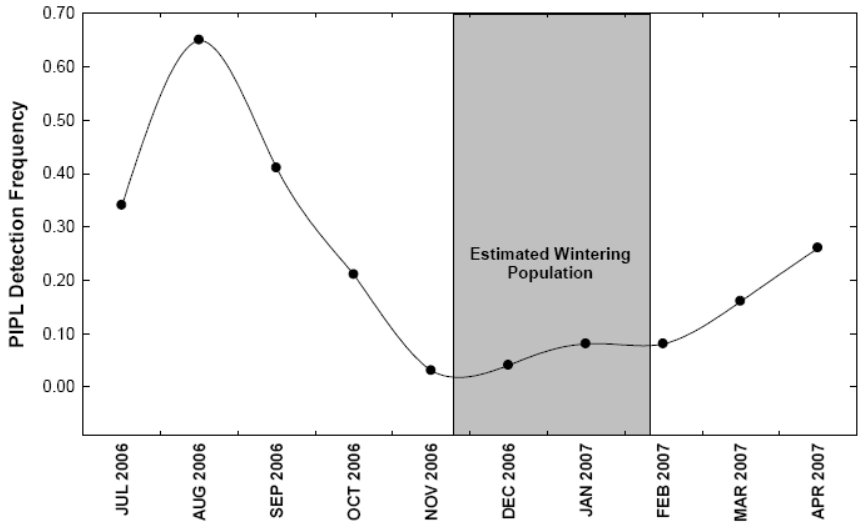


FIGURE 6B. WINTERING OBSERVATIONS OF PIPING PLOVER BY HABITAT TYPE (AUGUST 2008-MARCH 2009)

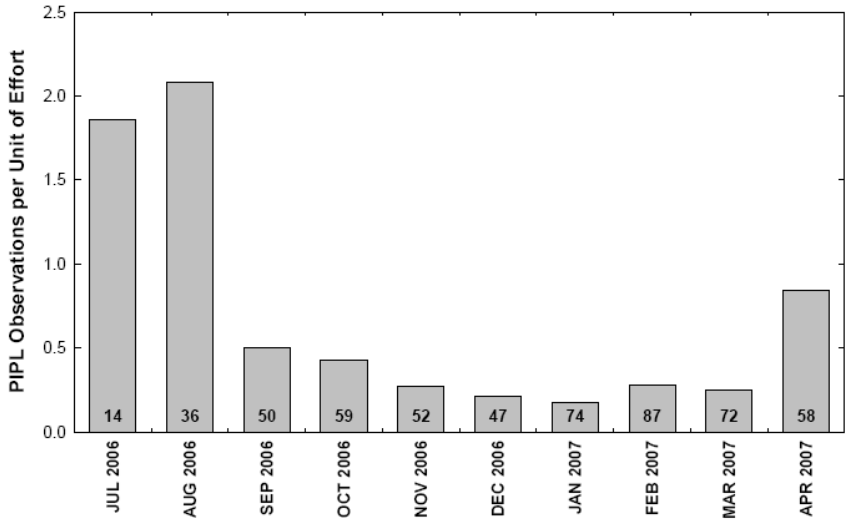
Comment [bdm17]: Table used for pie chart **Habitats**

In addition to the monitoring being conducted by Cohen (2005a) and park staff, the Southeast Coast Network (SECN) Inventory and Monitoring Program conducted a comprehensive study on wintering shorebirds at the Seashore. Pilot implementation of this long-term shorebird monitoring protocol began in mid-July 2006 and the first report was published in March 2009. The study found that the fall migration appeared to peak in August (figure 7) and the spring migration likely peaked in May, but nest initiation by piping plover and logistical issues precluded sampling later than April 2007. The three highest single-day counts (for sampled areas only) were 24 in July 2006, 50 in August 2006, and 14 in April 2007. Monthly normalized counts (number of birds observed per 30-minute sampling event) are shown on figure 8.



Source: Byrne et al. 2009.

FIGURE 7. DETECTION FREQUENCY FOR PIPING PLOVER (PIPL) AT BODIE ISLAND SPIT, CAPE POINT, HATTERAS INLET SPIT, NORTH OCRACOKE SPIT, AND SOUTH POINT—CAPE HATTERAS NATIONAL SEASHORE, 2006–2007



Source: Byrne et al. 2009.

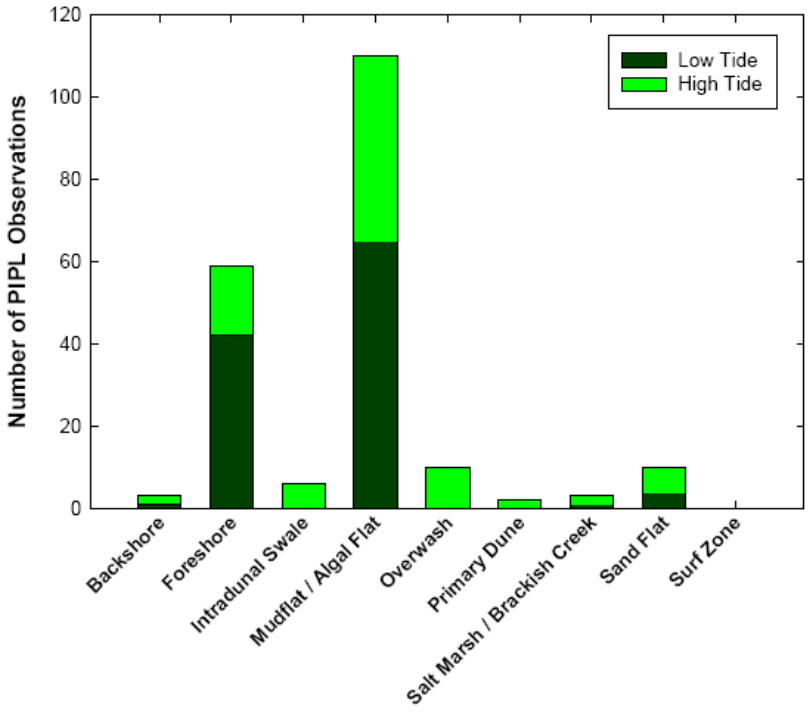
FIGURE 8. MONTHLY NORMALIZED COUNTS OF PIPING PLOVER AND NUMBER OF SAMPLING EVENTS AT CAPE HATTERAS NATIONAL SEASHORE, 2006–2007

[Preparer's Note: Waiting for raw wintering data from 2006-2009]

The SECN study found that the majority of piping plover observations occurred in mudflat/algal flat and foreshore habitat types (figure 9).

Comment [LBP18]: As with Fig. 6, please provide a legend explaining the numbers (number of surveys?) within the bars.

Comment [LBP19]: Months in x-axis labels should be title case. Also, this chart is quite fuzzy—better resolution available?



Source: Byrne et al. 2009.

FIGURE 9. NUMBERS OF PIPING PLOVER OBSERVATIONS BY HABITAT TYPE AND TIDE STAGE AT CAPE HATTERAS NATIONAL SEASHORE, 2006–2007

The results of the SECN study were consistent with previous studies that found that the moist substrate habitat type plays a vital role in the survival of nonbreeding piping plovers. It was also noted that migratory and wintering piping plovers occurred more frequently in accreted areas (i.e., the points and spits), which are popular spots for recreational ORV use at the Seashore (Byrne et al. 2009). The importance of protecting nonbreeding piping plovers was demonstrated in a research program by the Canadian Wildlife Service between 1998 and 2003, which primarily tracked migration patterns and survival rates of the Eastern Canada population of piping plovers. Individuals from this population were identified migrating and wintering at points along the east coast of the United States, including North Carolina (Amirault et al. 2006). The analysis of this research identified adult survival as the single most important factor influencing the population trends of this piping plover population and showed that expanding protection of nonbreeding habitat was an important factor in the recovery of the species (Amirault et al. 2006).

Risk Factors

Small populations such as the Atlantic Coast piping plover populations face a heightened risk of extinction compared to large populations because they are more vulnerable to the following: (1) random environmental variations, such as storms; (2) reduction in genetic variations that limit a species' ability to adapt to local conditions; (3) sudden, random drops in birth and death rates; and (4) an impaired ability to find suitable mates (Lande 1988).

Given the vulnerability of the small piping plover populations in North America to random events, the persistence of the populations will depend increasingly on controlling sources of mortality to adults, eggs, and chicks throughout their range. Predators, human disturbance, and limited or blocked access to foraging habitat have been identified in past research as contributing to impaired reproductive success for plovers using the Seashore (Kuklinski et al. 1996). There may be evidence that piping plovers are finding it increasingly difficult to attract mates (known as the "Allee effect"), because surveying reports from 2001 to 2003 and 2005 indicate that unpaired birds displaying territorial behavior were observed in the pre-laying period at several sites **[Preparer's Note: Waiting for full reports & appendices from 2001, 2002, 2003 and 2005 to confirm this].** Thus, providing a disturbance-free environment early in the season may help piping plovers to establish territories and attract mates (Cohen 2005b).

Rates and sources of mortality and disturbance, and the responses of piping plovers to disturbance in the nonbreeding season, have not been specifically assessed at the Seashore. However, it is known that piping plover foraging and roosting habitats are used by pedestrians and ORVs outside of the breeding season (Cohen 2005a). Therefore, the potential exists for piping plovers to be killed by being run over by ORVs (Melvin et al. 1994) or taken by domestic pets. Studies have shown that the density of wintering plovers is higher in areas with limited human presence (Cohen et al. 2008; Nicholls and Baldassarre 1990b). Furthermore, disturbance to roosting and foraging birds by ORVs, unleashed pets, and pedestrians may reduce foraging efficiency or alter habitat use, thereby increasing the risk of nutritional or thermal stress (Zonick 2000).

Weather and Tides. Nine named hurricanes affected the Outer Banks between 1993 and 2008 (NOAA 2009). Hurricane Isabel, which hit the coast in September 2003, renewed piping plover habitat on portions of the Seashore and may have resulted in a reduction in predator populations (NCWRC 2008a). In the years immediately following the storm, piping plover numbers and productivity increased. However, there have been no significant storms since that time, and much of the created habitat is now deteriorating due to revegetation (NCWRC 2008a). No significant weather events, such as hurricanes or tropical storms, occurred during the 2006 breeding season. However, smaller, localized events may have affected nesting. Nest 4 on South Point was partially buried by high wind and blowing sand. One egg was buried

by sand, and the nest was a deep cup rather than a scrape (June 29). One adult remained hunkered down on the nest during the strong winds, and the buried egg was visible again during the nest check. A strong thunderstorm was noted on the night before Nest 2 on South Beach was discovered lost; however, the loss is characterized as "unknown" because it cannot be shown conclusively that weather was the cause. Five nests were lost to weather, predation, or abandonment during the 2007 breeding season. Nest 1, a two-egg nest on Cape Point, was lost during a Nor'easter storm. It is unknown if the eggs were blown out of the nest scrape in the 50- to 60-mile-per-hour winds, buried under the sand, or taken by a predator. In 2008, a series of sandstorms with wind gusts over 35 miles per hour may have caused the pair from Nest 1 (Cape Point) to abandon the nest. A nest on Ocracoke was buried during a Nor'easter prior to the nest being located by resource management staff. One egg was found when compacted sand was removed from a scrape that had been maintained prior to the arrival of the storm (NPS 2009b). In 2009 there were high winds and rain prior to a single egg (first egg of a clutch) disappearing at Cape Point (B. Muiznieks, pers. comm).

Hurricanes and other ocean storms can lead to unusually high tides, and subsequent flooding can overwash piping plover nests (Cohen 2005a). In May 2000, a 3-day storm produced high winds, heavy rain, and ocean overwash. One clutch at Cape Point was buried under windblown sand and abandoned, while a second was lost to flooding at Hatteras Inlet Spit (NPS 2001b).Wave action and erosion caused the abandonment of a nest in 2002 when waves undermined a protective dune, resulting in the nest being flooded by ocean overwash. The eggs were scattered from the nest and the adults did not return to them (NPS 2003d). In 2009 a four egg nest discovered on June 8th on South Point, Ocracoke, was overwashed by spring tides on June 23rd (B. Muiznieks, pers. comm).

Indeed, some piping plovers that nest too close to mean high tide may lose their nests on normal high tides (Cohen 2005a). Storms can also result in widespread mortality of chicks (Houghton 2005). Besides these direct effects of storms on piping plover nests, flooding from extreme high tides or storm surges may alter habitat enough to render it unsuitable for nesting. This may lead to the abandonment of habitat within or between breeding seasons (Haig and Oring 1988).

Predation. Predation, especially by mammalian predators, continues to be a major factor affecting the reproductive success of the piping plover (Elliot-Smith and Haig 2004). Predators of eggs, chicks, and/or adults include mink (*Mustela vison*), nutria (*Myocastor coypus*), muskrat (*Ondatra zibethicus*), otter (*Lutrinae* spp.), gray fox (*Urocyon cinereoargenteus*), red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitis*), opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), domestic dogs (*Canis lupus familiaris*), feral and domestic cats (*Felis catus*), crows (Corvus brachyrhynchos), gulls (*Larus* spp.) (NPS 2008c), and birds of prey (Murphy et al. 2003). The impact of predation has been postulated to be greater

on beaches with high human use because the presence of pets and trash (which may attract wild predators) is correlated with the presence of humans (USFWS 1996a).

Fox activity was recorded at all active plover nesting areas in 2001 and one late nest initiation and two nest abandonments were linked to this activity (NPS 2002b). No direct evidence of predation of chicks or eggs was recorded from 2001 through 2006, although the presence or tracks of crows, grackles (*Quiscalus* spp.), gulls, ghost crabs (*Ocypode quadrata*), Virginia opossum, mink, raccoon, red fox, grey fox, and domestic cats and dogs were documented within many plover breeding territories. A fox den was discovered within the Bodie Island Spit bird closure in June 2006 (NPS 2007d). During the 2007 season, one egg in an exclosed nest was lost to a ghost crab and other eggs were missing from a nest at Cape Point. Staff observed both raccoon and opossum tracks in the area of the nest scrape (NPS 2008c). Predators or high winds generated by a Nor'easter storm are thought to be responsible for missing eggs and eggs observed eight feet from scrapes (NPS 2008c). In 2008, park staff documented the loss of two plover chicks at Cape Point due to avian predation. One chick was taken by a gull and another by a crow. Staff also documented the presence or tracks of crows, ghost crabs, grackles, gulls, opossum, mink, raccoon, red fox, grey fox, and feral cats within many of the piping plover breeding territories (NPS 2009b). In addition to causing direct mortality, predators in piping plover habitat can also lead to piping plovers' abandoning territories within and between breeding seasons (Cohen 2005b). In 2009, two chicks at Cape Point were lost to suspected opossum predation on day three (B. Muiznieks, pers. comm..)

Ghost crabs have occasionally been implicated in the loss of nests (Watts and Bradshaw 1995) and chicks (Loegering et al. 1995). Research on ghost crabs conducted in the lab and at a breeding site at Assateague Island in Virginia suggests that crab predation is generally uncommon. However, this study indicated that the presence of ghost crabs could have a more indirect effect on plover survival. For example, adult plovers may shepherd their broods away from the foreshore, where the best forage normally exists, due to the abundance of ghost crabs at that location (Wolcott and Wolcott 1999). Poor forage was found to be a more likely contributor to chick mortality than predation by ghost crabs (Wolcott and Wolcott 1999). However, anecdotal records indicate that ghost crabs may be more of a problem in North Carolina than at sites farther north (Cohen 2005a). In 2008, ghost crab predation was suspected in the loss of three piping plover nest because ghost crab holes were found inside and around the nests and predator exclosures (NPS 2009b). In 2009, a two–egg nest discovered on May 22nd on South Point, Ocracoke, was incubated well past its expected hatch date and was eventually predated by ghost crabs (B. Muiznieks, pers. comm.).

Human Activity. Human disturbance, both direct and indirect, can adversely affect piping plovers at the Seashore. Studies on piping plovers have demonstrated that reproductive success is lower in areas with high human disturbance (Burger 1991, 1994). Research has shown that plover behavior is altered by the

presence of humans, which ultimately results in chicks exhibiting less time feeding, brooding, and conserving energy. Plovers that are subject to human disturbance spend less than 50% of their foraging time searching for prey and feeding, where undisturbed plovers can spend up to 90% of that time feeding (Burger 1994). These human-caused behavioral changes result in depleted energy reserves, which could leave chicks more susceptible to predation or other stresses (Flemming et al. 1988; Loegering and Fraser 1995). At other sites, it was documented that fledging success did not differ between areas with and without recreational ORV use (Patterson et al. 1991), although pedestrians caused a decrease in brood-foraging behavior in New Jersey (Burger 1994).

Pedestrian and non-motorized recreational activities can be a source of both direct mortality and harassment of piping plovers. Potential pedestrians on the beach include those individuals driving and subsequently parking on the beach, those originating from off-beach parking areas (hotels, motels, commercial facilities, beachside parks, etc.), and those from beachfront and nearby residences. Vehicle impacts can extend to remote stretches of beach where human disturbance would be very slight if access were limited to pedestrians only (USFWS 1996a).

Even with resource closures in places, protected species are still at risk. Approximately 50 to 60 occurrences of ORVs entering protected areas at the Seashore were recorded each year from 2000 to 2002. In 2003, 13 bird closure posts/signs were driven over by an ORV, and several instances of ORVs within the protected area were observed (NPS 2003d, 2004e, 2005a). A total of 105 occurrences of ORVs entering posted bird closures were recorded in 2003. This number represents a substantial increase as compared to 52 recorded in 2001 and 63 in 2002 (NPS 2004e). In 2004, 227 pedestrians and 65 vehicle tracks were reported within posted bird resource closures, including those for piping plovers. However, no plover nests were known to be disturbed, and no plover chicks were known to be lost, although four other bird species were killed by ORVs in 2004 (NPS 2005a). In 2005, 135 pedestrian, 57 ORV, and 13 illegal dog entries into posted bird closures were recorded (NPS 2006d). In 2006 resource staff recorded 255 pedestrian, 47 ORV, 22 dog, and 5 horse violations of bird closures (NPS 2007d). In 2007, resource staff recorded 249 pedestrian, 25 ORV, 17 dog, and 1 horse violation of bird closures (NPS 2008c). During the 2008 breeding season, resource staff recorded 80 pedestrian, 11 ORV, 5 dog, and 1 boat violation of nesting plover closures (NPS 2009b). During the 2009 breeding season, resource staff documented 192 pedestrian, eight ORV, 19 dog, three horse and three boat violations in the pre-nesting closures (B. Muiznieks, pers. comm.). Most illegal entries were not witnessed but documented based on vehicle, pedestrian, or dog tracks left behind. (sidebar: symbolic fence definition)

In New York, the response of incubating adults to the presence of humans near the nest was found to be highly variable, and average nest success was unrelated to the number of disturbance sources observed

within 100 meters (328 feet) of nests (Houghton 2005). However, piping plovers may be more sensitive to disturbance in the Atlantic Coast southern recovery unit, as evidenced by longer flush distances in response to disturbance sources at Assateague Island National Seashore (Loegering 1992). Flushing can affect plover behavior and viability in a number of ways. Flushing of incubating plovers from nests can expose eggs to avian predators or excessive temperatures. Repeated exposure of eggs to direct sunlight on hot days can cause overheating, which can kill avian embryos (Bergstrom 1989). In Texas, piping plovers avoided foraging on sand flats close to areas of high human use (Drake et al. 2001). Zonick (2000) found that the number of piping plovers was lower on disturbed bayside flats than on undisturbed flats, and piping plovers experienced lower foraging efficiency when disturbed. Other unpublished data support the assertion that winter habitat selection is negatively correlated with human activities and development (Houghton 2005). (sidebar: flush distance)

Unleashed pets have the potential to flush piping plovers, and these flushing events may be more prolonged than those associated with pedestrians or pedestrians with dogs on leash. For example, a study conducted on Cape Cod, Massachusetts, found that the average distance at which piping plovers were disturbed by pets was 46 meters (151) feet, compared with 23 meters (75 feet) for pedestrians. Birds flushed by pets moved farther (an average of 57 meters [187 feet]) than plovers reacting to pedestrians (an average of 25 meters [82 feet]). Duration of observed disturbance behaviors stimulated by pets was significantly greater than that caused by pedestrians (USFWS 1996a). In 2002, there was evidence that a dog may have been responsible for the loss of a piping plover chick at Bodie Island. When a plover brood could not be found, large canid tracks were documented in the area where the brood was often seen foraging and resting. A professional trapper with the U.S. Department of Agriculture examined the prints and verified them as domestic dog tracks. The tracks were found running in a sharp turning pattern, seeming to indicate that the dog had been engaged in a chase. Scrape marks where the dog had clawed in the sand were also evident. The chick was not observed at the site thereafter (NPS 2004e). (sidebar: canid)

Vehicles have been documented running over nests (Patterson et al. 1991) and birds. In Massachusetts and New York, biologists found that 18 chicks and 2 adults were killed by vehicles between 1989 and 1993, even on beaches with only five to ten vehicles passes per day (Melvin et al. 1994). Piping plover chicks often move from the foredune area to forage along the wrack line and intertidal zone, which places them in the paths of vehicles. Chicks can end up in or near tire ruts, and sometimes have difficulty crossing or climbing out of them. The normal response of plover chicks to disturbance could increase their vulnerability to vehicles. Chicks sometimes stand motionless or crouch as vehicles approach, and their lack of rapid movement could lead to mortality (USFWS 1996a).

ORV use may also affect the beach through sand displacement and compaction (Anders and Leatherman 1987), which may lead to steeper dune profiles. This, in turn, may prove less suitable for piping plover nesting. Degradation of the wrack line is possible from as little as one vehicle pass (Leatherman and Godfrey 1979), and may negatively impact reproductive success due to the loss of important habitat used by foraging plovers. Also, the wrack line provides habitat for many beach invertebrates, which are a staple of the plover diet.

Beach and dune renourishment projects can alter the profile of beaches, causing increased erosion and habitat loss (Leatherman 1985). Important dune-creation projects have been carried out along most of the Seashore, beginning in the 1930s. These may be affecting the ability of the Seashore to support piping plovers (Steve Harrison and Bob Trick, NPS, pers. comm. with Richard Podolsky, LBG, September 4, 2005). A recent study theorized that beach nourishment projects may negatively impact plover habitat because the resulting dredge spoil is often fine-grained, reducing the availability of pebbles and cobbles, which are a preferred substrate for nesting plovers (Cohen, Wunker, and Fraser 2008). Furthermore, beach stabilization prevents normal storm processes, such as overwash fan formation, thereby leading to long-term loss of moist substrate habitat and to accelerated vegetative succession in potential nesting habitat (Dolan et al. 1973). Construction of artificial structures on beaches eliminates breeding territories and may result in an increased level of predation on and human disturbance of remaining pairs (Houghton 2005).

Research, surveying, and even protective management activities can sometimes expose piping plovers to a risk of disturbance at breeding sites. For example, adult birds may be more vulnerable to predation within exclosures (Murphy et al. 2003), depending on the local predator pool and the type of exclosure used. Adults may also abandon exclosed nests more frequently (Haig and Elliot-Smith 2004).

SEA TURTLES

Sea turtles are large marine reptiles found in subtropical, tropical, and temperate oceans, as well as subarctic areas. They spend the majority of their time in ocean waters, with females coming ashore only to nest on sandy beaches. Five of the seven sea turtle species existing in the world today occur in the coastal waters of North Carolina and the Seashore, and all are listed as either federally threatened or endangered. These five species are the loggerhead sea turtle, the green sea turtle, the Kemp's ridley sea turtle, the leatherback sea turtle, and the hawksbill sea turtle. Of the five species, only three are known to nest at the Seashore: the loggerhead, green, and leatherback sea turtles. The other two species, Kemp's ridley and hawksbill, are known to occur on the beaches of the Seashore only through occasional

stranding, usually either due to death or incapacitation due to hypothermia, and are therefore not discussed further.

In 1978, the loggerhead turtle was federally listed as threatened (NMFS and USFWS 2008). The National Marine Fisheries Service (NMFS) and the USFWS are currently considering petitions to reclassify the loggerheads in the Northwest Atlantic as endangered. Also in 1978, the green turtle was federally listed as threatened, except for the breeding populations in Florida and on the Pacific Coast of Mexico, which were listed as endangered (NMFS and USFWS 1991b). The leatherback turtle was listed as federally endangered in 1970 (NMFS and USFWS 1992). All three species carry the same state listings as their federal listings (NCWRC n.d.).

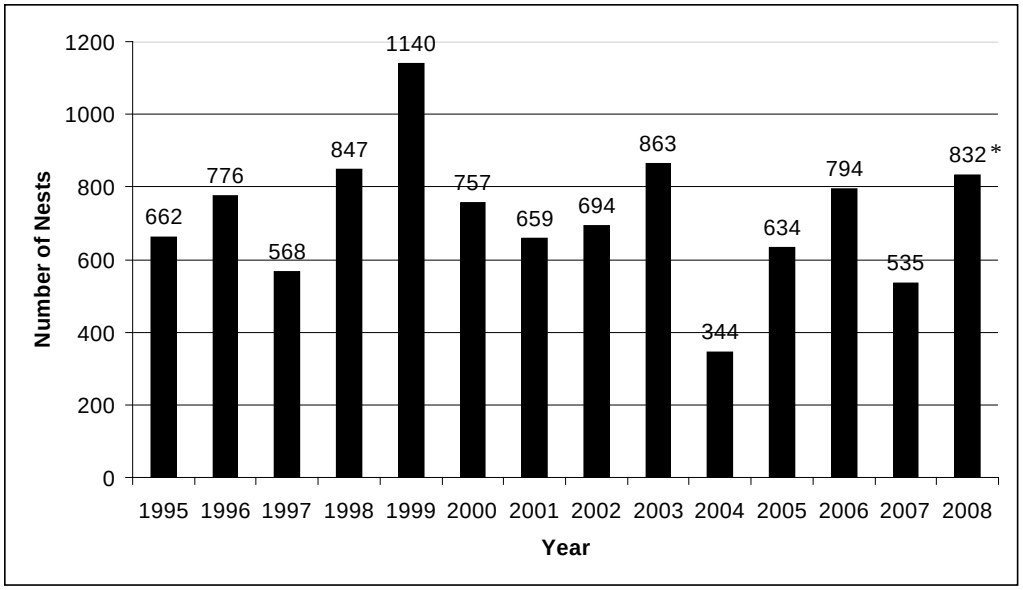
The Seashore staff has been consistently monitoring for sea turtle nests since 1987. However, over the years both monitoring and managing techniques have changed, making data comparison difficult; therefore, only nesting data from 2000 to 2008 is presented, for this data is known to be accurate. The number of nests recorded at the Seashore from 2000 to 2008 has fluctuated greatly, with only 43 nests recorded in 2004 and 112 nests recorded in 2008 (NPS 2008 turtle report). Of the three species that nest at the Seashore, the loggerhead turtle is by far the most numerous, comprising approximately 94% of the known nests between 2000 and 2008 (NPS turtle reports 2005, 2007, 2008; M. Baker, NPS, pers. comm., 2009). Green turtles and leatherbacks breed primarily in the tropics, with only small numbers nesting at higher latitudes. Green turtles have nested regularly at Cape Hatteras, but in fewer numbers, comprising only about 5% of the nests between 2000 and 2008, while leatherback turtles have nested infrequently at the Seashore, comprising only about 1% of the nests (NPS turtle reports 2005, 2007, 2008; M. Baker, NPS, pers. comm., 2009). Of the three districts that make up the Seashore, Hatteras District with approximately 30 miles of shoreline) receives the most nests annually (on average approximately 59%), followed by Ocracoke with approximately 19 miles of shoreline (approximately 27%) and Bodie with approximately 18 miles of shoreline (approximately 14%) (NPS 2009 – 2008 turtle report).

Loggerhead Turtle

The loggerhead sea turtle occurs throughout the temperate and tropical regions of the Atlantic,

Pacific, and Indian oceans. However, the two largest nesting rookeries occur along the western rims of the Atlantic and Indian oceans. Within the United States, the loggerhead turtle nests from Texas to Virginia, with the primary nesting concentrations found on the coastal islands of North Carolina, South Carolina, and Georgia, and on the Atlantic and Gulf coasts of Florida (NMFS and USFWS 2008). Over the last decade, the total estimated nesting in the United States has fluctuated between 47,000 and 90,000 nests per year, with about 80% of the loggerhead nesting activity occurring in six counties in the state of Florida (NMFS and USFWS 2008). Within the northern recovery unit as defined in the loggerhead recovery plan (Florida/Georgia border to southern Virginia), studies of annual nest totals in South Carolina and Georgia have documented a decline in the number of nests (Ehrhart et al. 2003). However, since standardized surveying began in North Carolina in the mid-1990s, the number of loggerhead nests per season has remained fairly stable, averaging 722 nests from 1995 to 2008 (figure 10) (M. Godfrey, NCWRC, pers. comm., 2005 and 2008). (photo of loggerhead)

Comment [MDB20]: Inserted above. Photo credit to Cape Hatteras National Seashore 2009.



Source: M. Godfrey, NCWRC, pers. comm., 2005 and 2008.

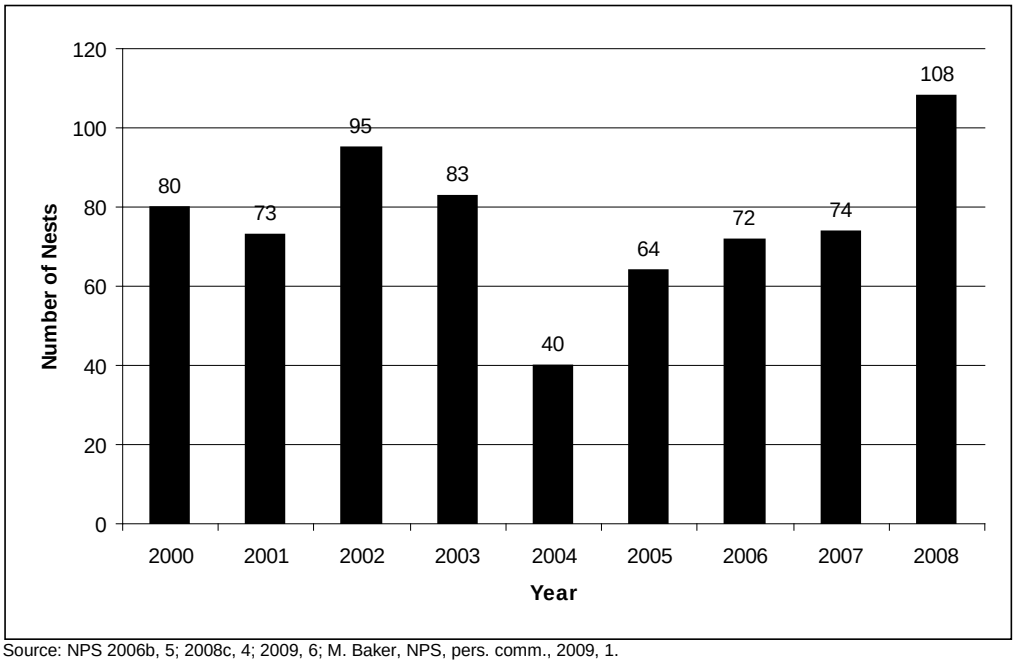
*Preliminary results.

FIGURE 10. NUMBERS OF LOGGERHEAD TURTLE NESTS IN NORTH CAROLINA, 1995–2008

Between 2000 and 2008 the average number of loggerhead nests at the Seashore was 77, with the lowest number of nests occurring in 2004 and the highest number of nests occurring in 2008 (figure 11) (NPS

2006b; NPS 2008c; NPS 2009; M. Baker, NPS, pers. comm., 2009). While only 43 loggerhead nests were laid at Cape Hatteras in 2004, it was a poor nesting year for the entire southeast Atlantic Coast (Lyons 2005).

Loggerhead turtles spend the majority of their life at sea, with only mature females coming ashore to nest every two to three years, on average (Schroeder et al. 2003). The first turtle nests (all turtle species included) typically begin to appear at Cape Hatteras in mid-May, and the last nests are usually deposited in late August (Lyons and Altman 2000; Sayles 2002; Gosh and Lyons 2002; Altman and Lyons 2003; Lyons 2005; K. Sayles, NPS, pers. comm., 2005; NPS 2006b, 2008c, 2009). Typical nesting areas for loggerheads tend to be sandy, wide, open beaches, backed by low dunes (Miller et al. 2003). Some factors that have been found to determine nest selection include beach slope, temperature, distance to the ocean, sand type, and moisture, though results were occasionally contradictory (Miller et al. 2003).



Source: NPS 2006b, 5; 2008c, 4; 2009, 6; M. Baker, NPS, pers. comm., 2009, 1.

FIGURE 11. NUMBERS OF LOGGERHEAD TURTLE NESTS AT CAPE HATTERAS NATIONAL SEASHORE, 2000–2008

Comment [bdm21]: In 2009 we had 103 nests.

Although the process of nest site selection is not well understood, a successful nest must be laid in a low salinity, high humidity, well-ventilated substrate that is not prone to flooding or burying because of tides

and storms and where temperatures are optimal for development (Miller et al. 2003). At the Seashore, between 2000 and 2008, on average, 28% of the nests found (all turtle species included) were relocated from their original location by Seashore staff. Of those nests, 79% were relocated for natural causes (e.g., in areas prone to flooding [below the high tide line], in an area prone to erosion, etc.), while the rest were relocated because of potential human disturbance, primarily because they were within one mile of a lighted fishing pier (Lyons and Altman 2000; Sayles 2002; Gosh and Lyons 2002; Altman and Lyons 2003; Lyons 2005; K. Sayles, NPS, pers. comm., 2005; NPS 2006b; NPS 2008c; NPS 2009). The practice of relocating nests for recreation or lighting issues is not encouraged by the USFWS; therefore, beginning in 2006 nests were no longer relocated for these purposes. As a result, the average number of nests relocated each year from 2006 to 2008 decreased to 18% of the nests found (NPS 2006b; NPS 2008c; NPS 2009).

Loggerheads are nocturnal nesters. Females emerge from the ocean and crawl toward the dune line until they encounter a suitable nest site. The female clears away surface debris with her front flippers, creating a "body pit," and then excavates a flask-shaped nest cavity with her hind flippers. Loggerheads throughout the southeastern United States lay an average of 100 to 126 eggs per nest (NMFS and USFWS 2008). After laying her eggs, the female covers the nest with sand, and she crawls back to the sea.

Individual females may nest one to six times per nesting season, at an average interval of 12 to 15 days (NMFS and USFWS 2008). Loggerheads do not produce clutches in successive years very often. Typically nesting years are separated by one to three years of foraging in between. (NMFS and USFWS 2008). The nest incubation period (from laying to hatching) depends on temperature and ranges on average from 63 to 68 days in North Carolina (NMFS and USFWS 1991a). The sex ratio of hatchlings also depends on temperature during incubation. Below 84.6 °F, more males are produced than females, and above that temperature, more females are produced (Mrosovsky 1988). For this reason, the northern part of the U.S. Atlantic population, which includes North Carolina, apparently provides a disproportionate number of males to the larger population ~~(Mrosovsky et al. 1984; Hanson et al. 1998)~~which is important for the stability of the population as a whole. (Mrosovsky et al. 1984; Hanson et al. 1998),~~.~~

Hatchling emergence occurs almost exclusively at night (Mrosovsky 1968; Witherington et al. 1990) and may occur over several nights. Upon emerging from the nest, hatchlings primarily use light cues to find and move towards the sea (Witherington and Martin 1996). Once in the water, they swim incessantly out to sea to offshore habitats where they will spend the next phase of their life history.

Comment [bdm22]: In 2009 32 turtle nests were relocated at the time of nest discovery. A few additional nests (i.e. the leatherback nest) were relocated prior to a storm event

Comment [MDB23]: Change to new 2009 Recovery Plan

Formatted: Highlight

Green Turtle

The green turtle is a circumglobal species in tropical and subtropical waters. The major green turtle nesting colonies in the Atlantic Ocean occur on Ascension Island, Aves Island, Costa Rica, and Surinam (NMFS and USFWS 1991b). Nesting in the United States occurs in small numbers in the U.S. Virgin Islands and on Puerto Rico and in larger numbers along the east coast of Florida, particularly in Brevard, Indian River, St. Lucie, Martin, Palm Beach, and Broward counties. North Carolina is near the northern limits of its nesting area. (sidebar: photo of green turtle)

Comment [MDB24]: Inserted below. Photo credit to Back Bay National Wildlife Refuge, 2005.

Nesting habits for the green turtle are very similar to those of the loggerhead turtle, with only slight differences. Average clutch sizes range from 110 to 115 eggs, although this varies by population, and females produce clutches in successive years only occasionally. Usually two to four years or more occur between breeding seasons (NMFS and USFWS 1991b).

From 2000 to 2008, there was an annual average of four green turtle nests at the Seashore, with a peak of nine nests in 2005 (NPS 2006b, NPS 2008c, NPS 2009; M. Baker, NPS, pers. comm., 2009).

Comment [bdm25]: In 2009 the Seashore had 3 green turtle nests.

Leatherback Turtle

Leatherback nesting grounds are distributed circumglobally, with the largest known nesting area occurring on the Pacific Coast of southern Mexico. Nesting in the United States occurs primarily in Puerto Rico, the U.S. Virgin Islands, and southeastern Florida (NMFS and USFWS 1992). (sidebar: photo of leatherback turtle)

Comment [MDB26]: Inserted below. Photo credit unknown….from a cell phone of a tourist on the beach 2009.

Leatherback nesting at the Seashore was first documented in 1998 and has subsequently been documented in 2000, 2002,, ~~and~~ 2007, and 2009 totaling six~~five~~ nests since 2000 (Lyons and Altman 2000; Lyons NPS 2006b; NPS 2008c, 2009; M. Baker, NPS, pers. comm., 2009). Since the species has a minimum of two years between nesting cycles, it is not known if more than one female of the species uses the Seashore as a nesting ground. The Seashore remains the northernmost nesting location on record for this species (Rabon et al. 2003), however in 2009 a leatherback nested in Kill Devil Hills, which currently represents the northernmost nest ever found from this species. ~~.~~

Leatherback nesting habits are very similar to those of the loggerhead turtle, although they tend to begin and end nesting earlier in the year than the loggerhead (NMFS and USFWS 1992). Since 1999, the only two nests laid in April at the Seashore have been leatherbacks (NPS 1999, 2008c). Leatherbacks are thought to migrate to their nesting beach about every two to three years (NMFS and USFWS 1992; Miller 1997). Clutch size averages 116 eggs, and the incubation period averages 55 to 75 days. It is also reported that leatherback turtles nest an average of five to seven times per year, with an average interval of nine to ten days between nesting (NMFS and USFWS 1992).

Potential Threats—Nesting Environment

Threats to the loggerhead turtle on nesting grounds, as outlined in their recovery plan (NMFS and USFWS 1991), are representative of those also faced by green and leatherback turtles.

Storm events, including hurricanes, may destroy nests because of flooding or piling of eroded sand on the nest site. Beach erosion due to wave action may decrease the availability of suitable nesting habitats (NMFS and USFWS 1991a), which can lead to a decline in the nesting rate.

A number of predators such as foxes, raccoons, and ghost crabs dig into nests and prey upon incubating eggs, while some predators, including birds, may take considerable numbers of hatchlings just prior to and/or during their emergence from nests.

Crowding of nesting beaches by pedestrians can disturb nesting females and prevent laying of eggs (NMFS and USFWS 1991a). Furthermore, the use of flashlights and beach fires may deter females from

Comment [MDB27]: Switch to new 2009 recovery plan

coming up on a beach, or may interfere with the sea-finding behavior of hatchlings (Witherington and Martin 1996).

Beach driving can disturb adult females and cause them to abort nesting attempts and can interfere with the sea-finding behavior of hatchlings when headlights are used at night (NMFS and USFWS 1991a). ORV beach driving may harm sea turtles when nests are run over, killing pre-emergent hatchlings or increasing sand compaction and thereby decreasing hatching success (NMFS and USFWS 1991a). Beach driving also poses a risk of injury to hatchlings by leaving ruts that trap or disorient hatchlings attempting to reach the ocean (Hosier et al. 1981). When artificial lighting impairs the behavior of nesting females and emerging hatchlings, the affected animals potentially face increased exposure to the elements, exhaustion, and predation.

Comment [MDB28]: Switch to new 2009 Recovery Plan

Comment [MDB29]: Switch to new 2009 Recovery Plan

Artificial lighting on human structures may deter females from coming up on a beach or may disorient hatchlings as they emerge from nests and try to find the sea (Witherington and Martin 1996). Beach cleaning can directly destroy nests. Poaching is a problem in some countries, but it occurs at a low level in the United States.

An increased human presence may lead to an increase in the presence of domestic pets (which can depredate nests) and may lead to an increase in litter (which may attract wild predators). Trampling can increase sand compaction, which may damage nests or hatchlings.

Recreational beach equipment and furniture can also cause turtles to forego egg-laying by hampering or trapping animals attempting to locate a nesting site. They can also trap emerging hatchlings.

The rate of habitat loss because of erosion and escarpment may be increased when humans attempt to stabilize the shoreline, either through renourishment or through placement of hard structures, such as sea walls or pilings. ORV traffic also contributes to habitat loss through erosion, especially during high tides or on narrow beaches where driving is often concentrated on the high beach and foredune (NMFS and USFWS 1991a). Improperly placed erosion-control structures, such as drift-fencing, can act as a barrier to nesting females. Humans may also introduce exotic vegetation in conjunction with beach development that can overrun nesting habitat or make the substrate unsuitable for digging nest cavities.

Comment [MDB30]: Switch to new 2009 Recovery Plan

Threat Occurrences at Cape Hatteras National Seashore

The following data and discussions are from the Seashore annual sea turtle surveying reports, 1999 to 2008, and include all turtle species (Lyons and Altman 2000; Sayles 2002; Gosh and Lyons 2002; Altman and Lyons 2003; Lyons 2005; K. Sayles, NPS, pers. comm., 2005; NPS 1999, 2006b, 2008c, 2009).

The majority of nest losses at the Seashore from 1999 to 2007 were weather-related, particularly due to hurricanes and other storms. During this time, six hurricanes caused impacts to nests. In 2003, Hurricane Isabel destroyed 52 of the 87 nests (34 had hatched before the storm); there was so much water and sand movement along the beaches that no evidence of any nests could be found afterwards. The Seashore also felt the effects of numerous tropical storms and hurricanes as they passed by offshore.

Foxes were first seen at the Seashore in 1999 and on Hatteras Island in the winter of 2001–2002. Foxes disturbed or destroyed nests in 5 of the 10 years between 1999 and 2008, with the number of nests disturbed or destroyed ranging from one to nine nests per year. Ghost crab predation has been reported sporadically from 1999 to 2008, with 0 to 26 nests per year recorded as having either ghost crab holes burrowed deep into the nest cavity and/or eggshell fragments found on top of the sand in association with crab tracks.

Pedestrian tracks have been recorded inside closures, with counts ranging from 8 to 92 intrusions per year. Pedestrians disturbed or destroyed two to six nests per year from 1999 to 2008 by digging at the nest site; however, no pedestrian disturbances occurred in 2003, and no data ~~were~~ was available for 2005.

Violation of closed areas by ORVs has become increasingly common, with 13 to 109 sets of tracks inside closures, and 4 to 146 incidents of fencing vandalism, recorded per year. ORVs drove over four to five nests per year from 2000 to 2002; however, the nests survived. In 2007, two nests were known to have been run over by ORVs before they were found during the morning turtle patrol and fenced off. One nest appeared undamaged, while four eggs were crushed in the second nest. In 2004, a total of ten hatchlings were inadvertently killed by vehicles in two separate incidents.

Dogs disturbed or destroyed two nests in 2000, and 5 to 60 sets of dog tracks per year have been recorded inside closures. ~~Cats have not been observed to predate eggs or hatchlings, but 10 to 50 sets of cat tracks per year were counted inside closures from 2000 to 2002.~~ In 2008, cats were documented predating on emerging hatchlings at several nests, all within the villages. This was~~is~~ the first year in which this was~~is~~ documented, however, 10 to 50 sets of cat tracks per year were counted inside turtle closures from 2000 to 2002.

The total number of pedestrian, vehicle, and pet violations are conservative estimates, for often the actual numbers could not be determined. Footprints and tracks are often recorded as a single violation, when an undeterminable number of tracks through an area may actually represent multiple violations. Also, tracks below the expanded nest closures are often washed out by the tide before being discovered by the turtle patrol.

Documented beach fires totaled 174 in 2000 and 773 in 2001. Such fires may misdirect adults and emergent hatchlings. In 2006 an adult turtle crawl was discovered going into the coals of a beach fire, and in 2007, a turtle approached a beach fire, which visitors quickly extinguished prior to the turtle laying her nest about 2 feet from the fire site. In 2008 several hatchlings were found entering a fire and were recovered and released. It was unknown how many died prior to the hatchlings being noticed. Hatchlings being misdirected by lights from villages and other human structures is a common occurrence at the Seashore.

There have also been documented reports in 2000, 2001, 2007, and 2008, and an unconfirmed report in 2006, of adult turtles aborting nesting attempts when visitors approached the turtles with flashlights, vehicle lights, or flash photography. Because the beaches are not patrolled 24 hours a day, it is likely that more disturbances of this nature occur but go undocumented.

Since 2001, Seashore staff members have been tying notices to personal property found on the beach after dawn, advising owners of the threats to nesting sea turtles, and then removing the items when possible if they remain on the beach 24 hours after tagging (NPS 2008c).

SEABEACH AMARANTH

Seabeach amaranth is an annual plant native to barrier-island beaches along the U.S. Atlantic Coast, including those within the Seashore. Historically, seabeach amaranth was found in nine states, from Massachusetts to South Carolina. It was federally listed as threatened by the USFWS in 1993 because of its vulnerability to human and natural impacts and the fact that it had been eliminated from two-thirds of its historic range (USFWS 1996b). Since its listing, seabeach amaranth has reappeared in several states and is currently found in New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, and South Carolina. Despite its reappearance in several states, the plant remains highly vulnerable to the threats that caused its listing, and in some states, populations continue to decline (USFWS 2005).

(sidebar: photo of seabeach amaranth)

This species is listed as threatened by the State of North Carolina (NCNHP 2006). Within North Carolina, from 2002 to 2003, the number of plants increased from 5,700 to 9,300 along 112 miles of beach (Marion n.d.), only a fraction of the approximately 40,000 plants reported in the late 1980s and 1995. Within the Seashore, seabeach amaranth numbers ranged from 550 to nearly 16,000 plants between 1985 and 1990 (table 12). However, in the last 10 years a maximum of only 93 plants was observed in 2002. More recently, only one plant was found in 2004 and two plants in 2005. Since 2005 no plants have been found within the Seashore.

TABLE 12. NUMBERS OF NATURALLY OCCURRING PLANTS OF SEABEACH AMARANTH AT CAPE HATTERAS NATIONAL SEASHORE, 1985–2008

	1985	1986	1987	1988	1990	1993	1994
Number of seabeach amaranth	550	600	6,883	15,828	3,332	0	0

	1995	1996	1997	1998	1999	2000	2001
Number of seabeach amaranth	1	98	81	265	8	2	51

	2002	2003	2004	2005	2006	2007	2008
Number of seabeach amaranth	93	30	1	2	0	0	0

Source: NPS 2008h, 2.

Seabeach amaranth is a low-growing annual, with stems that trail along the ground but do not root. The stems are reddish in color, fleshy, grow to 4 to 24 inches in length, and have round, fleshy, dark green leaves (0.4 to 0.6 inches long) clustered near the tips. Plants must recruit annually from seed banks, either in place or from other source populations dispersed by wind, water, or sediments distributed by anthropogenic (human) factors, such as beach renourishment (Jolls et al. 2004). Seeds must be scarified (the seed coat broken by nicking or abrasion) or cold stratified (chilling for weeks) before germination can occur (Marion n.d.). Germination takes place from April through July: Initially, a small sprig forms, which soon begins to branch into a clump. At the Seashore, seedlings are usually visibly detectable beginning in June (M. Lyons, NPS, pers. comm., 2005). Plants are typically 10 to 12 inches in diameter, consisting of 5 to 20 branches, though occasionally a clump may get as large 3 feet or more across, with more than 100 branches (USFWS 1993; NJDEP 2005).

Flowering begins when plants are of sufficient size, often in June but more typically in July, and continues until the plants die in late fall or early winter. The species is a prolific seed producer, with seed production beginning in July or August and usually reaching a peak in September. Seed production continues until the plant dies. The seeds are relatively large (0.1 inch), believed to be viable for long periods of time (decades), and contained in indehiscent utricles (a fruit pouch that does not split open spontaneously at maturity to release its seed). Though the utricles are normally indehiscent, it is not unusual to see them splitting open, either before or after their detachment from the plant. Splitting or fragmentation of the utricle occurs under conditions of agitation (by wind), abrasion (by sand), or simple loss of integrity over time (USFWS 1996b). (sidebar: seabeach amaranth seeds; indehiscent utricle)

Seed dispersal may occur by wind or water, and naked seeds do not disperse nearly as far from the parent plants as seeds retained in utricles. Seeds may also be dispersed by human activities, such as beach replenishment programs. Many utricles remain attached to the plant and never disperse, allowing seeds and fruit to pile up around the bases of the parent plants. This primarily occurs at the end of the growing season when the plant dies (USFWS 1996b).

Seabeach amaranth occupies a fairly narrow habitat niche. It is found on sandy ocean beaches, where its primary habitat consists of overwash flats at accreting ends of islands, and at the sparsely vegetated zone between the high-tide line and the toe of the primary dune on non-eroding beaches. It is intolerant of competition and does not occur on well-vegetated sites. It is also intolerant of even occasional flooding or overwash. Populations are occasionally found in other habitats, including back dunes, soundside beaches, blowouts in foredunes, and beach-replenishment areas, but these populations tend to be small and temporary (USFWS 1996b; NJDEP 2005). In general, in order to survive, this species needs extensive areas of barrier island beaches and inlets, functioning in a relatively natural and dynamic manner, to allow it to move around in the landscape, occupying suitable habitat as it becomes available (USFWS 1993).

Since 2000, locations where seabeach amaranth has been found within the Seashore include the upper, dry-sand flats at Cape Hatteras Point (Cape Point and South Beach), in a line of small dunes adjacent to the flats at Hatteras Inlet Spit, at Bodie Island Spit, and at the base of dunes on the beach on the northern half of Ocracoke Island. Most areas where the plants have been found were either in established bird closures or other areas closed to vehicular traffic (NPS 2000b; Lyons 2001; M. Lyons, NPS, pers. comm., 2005). Despite continuous protection (though the use of summer and winter resource closures) the area on Bodie Island Spit where the plants were found in 2004 and 2005, as well as the area on Cape Point where the plant was historically found, no plants have been found since 2005. Additionally, large portions of the historic range of the plant at Hatteras Inlet Spit no longer exist due to continued erosion, and the plant is currently thought to be extirpated from the Seashore (NPS 2008h).

The predominant threat to seabeach amaranth is the destruction or alteration of suitable habitat, primarily because of beach stabilization efforts and storm-related erosion (USFWS 1993). Other important threats to the plant include beach grooming and some forms of “soft” beach stabilization, such as sand fencing and planting of beach-grasses; vehicular traffic, which can easily break or crush the fleshy plant and bury seeds below depths from which they can germinate; and predation by webworms (caterpillars of small moths) (USFWS 1993). Webworms feed on the leaves of the plant and can defoliate the plants to the point of either killing them or at least reducing their seed production. Beach vitex (*Vitex rotundifolia*) is another threat to seabeach amaranth, as it is an aggressive, invasive, woody plant that can occupy habitat similar to seabeach amaranth and outcompete it (ISSG 2009).

STATE-LISTED AND SPECIAL-STATUS SPECIES

This section addresses the habitat, diet, reproduction, population trends, and impacts on several species of shorebirds that are listed or recognized as special-status species by the State of North Carolina but are not federally listed as endangered or threatened. These species breed on Cape Hatteras as well as in other areas of North Carolina. Species described include American oystercatcher, red knot, Wilson's plover, and several colonial waterbirds such as least tern, common tern, gull-billed tern, Forster's tern (*Sterna forsteri*), black skimmer, and sooty tern (*Sterna fuscata*).

AMERICAN OYSTERCATCHER

The American oystercatcher is a large (16–18 inches long, 14−24 ounces) and conspicuous shorebird with long pink legs and a long, bright reddish-orange bill. The upper body is covered with black feathers that contrast with white feathers on the breast and sides. The sexes are similar in appearance, although females are slightly larger than males. (sidebar: photos)

Oystercatchers are restricted to the coastal zone throughout the year, where they inhabit salt marshes and coastal islands along the southeastern United States coast (Schulte et al. 2007). They feed primarily on bivalves, mollusks, worms, and other marine invertebrates that inhabit intertidal areas (Nol and Humphrey 1994; Meyers 2005). This specialized diet is the reason that American oystercatchers are primarily found in coastal areas that support intertidal shellfish beds (Schulte et al. 2007).

Oystercatchers form pair bonds in February and early March. Courtship takes place in salt marshes and on dunes, beaches, dredge spoils, and oyster bars. They breed from March to August along the Atlantic Coast, from Massachusetts to Florida, in relatively high, open, sandy areas with sparse to no vegetation (Nol and Humphrey 1994; Meyers 2005). They also breed along the Gulf Coast from Florida to Mexico and winter from central New Jersey south to the Gulf of Mexico (Simons and Schulte 2008).

American Oystercatcher in North Carolina

A 2007 breeding season survey estimated North Carolina's summer American oystercatcher population at 717 individuals, with 339 breeding pairs (Simons and Schulte 2008), and a 2005 survey estimated a winter population of oystercatchers in North Carolina at 647 birds (Brown et al. 2005). Cape Lookout and Cape Hatteras national seashores are estimated to support 90 breeding pairs (Simons and Schulte 2008), or 27% of the state's breeding oystercatchers. Barrier islands continue to be an important habitat, and supported 43% of the oystercatchers in North Carolina in 2007. Most of the barrier island nesters were found on undeveloped islands, although inlet spits on many developed islands continued to support nesting birds (NCWRC annual report 2008). Oystercatcher reproductive success in North Carolina has

been extremely low, as studies conducted between 1995 and 2008 demonstrated an average of 0.31 chicks per nesting pair surviving to fledge (Simons and Schulte 2008). Other studies conducted at Cape Lookout National Seashore between 1997 and 1999 documented fledge rates ranging from as low as 0.04 to 0.15 (Davis et al. 2001). The American oystercatcher is classified as a Species of High Concern in the U.S. Shorebird Conservation Plan because of its small population (11,000 individuals), widespread habitat loss, and the threats it faces both during the breeding and nonbreeding seasons (Schulte et al. 2007). The oystercatcher was designated as a Species of Special Concern in North Carolina on May 1, 2008 (Pipkin, pers. comm., 2009).

HABITAT DESCRIPTION

In North Carolina, oystercatchers generally nest on sandy sites characterized by open substrate and little vegetation, far from the water, and slightly elevated to afford at least a 180° view (Nol and Humphrey 1994; Shields and Parnell 1990; Meyers 2005). However, there is evidence that oystercatchers have begun to use less traditional nesting habitats such as dredge spoil islands and vegetated marshes (McGowan et al. 2005; Traut et al. 2006). A breeding season study in Virginia documented that over half of the oystercatcher breeding pairs were located on storm-deposited shell rakes (Wilke et al. 2005). Elevation of nest habitat and distance to the water are both important to nest success because nests can be destroyed by tidal flooding (Lauro and Burger 1989). Oystercatchers are more common in habitat with few predators or no terrestrial predators (e.g., feral or domestic predators) (Nol and Humphrey 1994). Oystercatcher foraging habitats include oyster and mussel bars and intertidal sand flats and mudflats. Winter and summer foraging habitats are similar (Nol and Humphrey 1994). (sidebar: photos of foraging and nesting habitats)

DIET

The elongated and laterally compressed bill of the oystercatcher is especially suited to allow the bird to prey upon and open marine bivalves (class Bivalvia), including oysters (family Ostreidae), soft-shell clams (*Mya arenaria*), razor clams (*Ensis directus*), stout razor clams (*Tagelus plebeius*), and ribbed mussels (*Geukensia demissa*) Other items the oystercatcher consumes include marine worms (phylum Platyhelminthes), mole crabs (*Emerita talpoida*), sandworms (*Nereis virens*), limpets (order Patellogastropoda) jellyfish (phylum Cnidaria), sea urchins (phylum Echinoderma), and crabs (order Decapoda) (Bent 1929; Johnsgard 1981; Nol 1989; Nol and Humphrey 1994).

Breeding Biology

The major stages of the oystercatcher nesting cycle include the following: establishment and holding of nesting territories, courtship and copulation, nest scraping and nest building, egg laying and incubation, chick rearing, and fledging. Breeding pairs of oystercatchers begin nesting in late February and early March by establishing and holding a nesting territory and then scraping multiple shallow depressions in the sand. Eventually, they choose one scrape to build a nest (Nol and Humphrey 1994; McGowan et al. 2005). Nests are 1.5–2.5 inches deep and 7.0–8.0 inches across. They may contain shell fragments, dead plants, small stones, and beach debris (Baicich and Harrison 1997). Oystercatchers are typically monogamous and may mate for life (Nol and Humphrey 1994). Oystercatchers can nest in proximity to colonial waterbirds, including but not limited to common tern, least tern, and black skimmer.

Both sexes incubate three eggs (rarely two or four) for 24–28 days, and incubation may begin after the second egg is laid (Nol and Humphrey 1994) or after the last egg (Baicich and Harrison 1997). Oystercatchers will re-nest if eggs or nestlings are lost early in the season. Both adults brood nestlings, which crouch motionless when alarmed, making them difficult to see. Nestlings remain in the nest for 1–2 days and then move with adults within their nesting territory or into nearby foraging areas, which can be 150 to 600 feet away, depending on the habitat. Chicks fledge in about 35 days, but fledglings rely on adults almost entirely until they are 60 days old (Nol and Humphrey 1994).

American Oystercatcher Breeding Performance at Cape Hatteras National Seashore

At the Seashore, the oystercatcher population has sustained declines in numbers of breeding pairs since the 1990s. As seen in table 13, from 1999 to 2008, the number of nesting pairs declined 42% from 41 to 23 pairs on Ocracoke, Hatteras, Bodie, and Green Island (Simons and Schulte 2008; see table 13). From 1996 to 2008 on Ocracoke Island, there were a total of 99 breeding pairs, 135 clutches, 61 hatched nests, a nest survival rate of 0.452, 52 fledged chicks, and fecundity of 0.49. From 1997 to 2008 on Hatteras Island, there were a total of 204 breeding pairs, 265 clutches, 108 hatched nests, a nest survival rate of 0.426, 71 fledged chicks, and fecundity of 0.38. On Bodie Island, there were a total of 28 breeding pairs, 39 clutches, 9 hatched nests, a nest survival rate of 0.269, 7 fledged chicks, and fecundity of 0.257 from 1996 through 2008. From 2004 through 2008 on Green Island, there were a total of 10 breeding pairs, 14 clutches, 8 hatched nests, a 0.596 nest survival rate, 8 fledged chicks, and fecundity of 0.80 (Simons and Schulte 2008; see table 14). (sidebar: fecundity)

TABLE 13. OYSTERCATCHER ~~BREEDING~~ NESTING PAIR COUNT COMPARISON, CAPE HATTERAS NATIONAL SEASHORE, 1996–2008

Year	Ocracoke Island	Hatteras Island	Bodie Island	Green Island	Total
1996	12	22	2	—	36
1999	15	24	2	—	41
2000	12	23	2	—	37
2001	13	24	2	—	39
2002	12	~~21~~ 17	~~3~~2	—	36
2003	8	16~~4~~	~~5~~ 4	3~~—~~	27
2004	9	15	3	2	29
2005	5	17	2	1~~2~~	26
2006	5	14	2	2	23
2007	~~5~~4	15	2	2	24
2008	3	15	3	2	23
2009	4	13	4	2	
Total	~~99~~	~~204~~	~~28~~	~~10~~	~~341~~

Source: Simons and Schulte 2007, 48; 2008, 81.

NOTE: Data available only for years listed.

TABLE 14. OYSTERCATCHER BREEDING DATA SUMMARY, CAPE HATTERAS NATIONAL SEASHORE, 1996–2008

Year	~~Breeding Pairs~~Nesting Pairs	~~Clutches~~Nests	Nests Hatched	Nest Survival	Chicks Fledged	Fecundity
Ocracoke Island						
1996	12	12	8	0.667	8	0.67
1999	15	17	7	0.412	2	0.13
2000	12	17	6	0.353	7	0.58
2001	13	15	11	0.733	17	1.31
2002	12	18	6	0.333	3	0.25
2003	8	12	4	0.333	1	0.13
2004	9	11	7	0.636	8	0.89
2005	5	10	3	0.300	1	0.20
2006	5	8	5	0.625	2	0.40
2007	~~5~~4	12	3	0.250	1	0.20
2008	3	3	1	0.333	2	0.66
2009	4	6	2	0.333	0	0.00
Total/*average	~~99~~	~~135~~	~~61~~	~~*0.452~~	~~52~~	~~*0.49~~
Hatteras Island						

Comment [bdm31]: Should we be calling these nesting pairs to avoid confusion?

Comment [bdm32]: Depending on whose numbers you use, new totals would need to be recalculated.

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Comment [bdm33]: We have found errors in the Simons report. We can provide you with raw data to support our numbers.

Comment [bdm34]: Need to recalculate if using 2009 data.

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TABLE 13. OYSTERCATCHER ~~BREEDING~~ NESTING PAIR COUNT COMPARISON, CAPE HATTERAS NATIONAL SEASHORE, 1996–2008

Year	Ocracoke Island	Hatteras Island	Bodie Island	Green Island	Total
1997	22	26	13	0.500	8	0.36
1999	24	31	7	0.226	3	0.13
2000	23	29	10	0.345	2	0.09
2001	24	28	10	0.357	6	0.25
2002	~~21~~ 17	25	3	0.120	4	0.19
2003	~~14~~ 16	~~21~~23	8	0.381	64	0.29
2004	15	18	14	0.778	9	0.60
2005	17	~~25~~ 24	13	0.520	~~10~~ 8	0.59
2006	14	19	11	0.579	5	0.36
2007	15	23	10	0.435	9	0.60
2008	15	20	9	0.450	11	0.73
2009	13	19	11	0.579	9	0.69
Total/*average	~~204~~	~~265~~	~~108~~	~~*0.426~~	~~71~~	~~*0.38~~
Bodie Island						
1996	2	2	1	0.500	2	1.00
1999	2	2	0	0.000	0	0.00
2000	2	3	0	0.000	0	0.00
2001	2	3	1	0.333	1	0.50
2002	~~3~~ 2	5	1	0.200	2	0.67
2003	~~5~~4	5	1	0.200	0	0.00
2004	3	7	0	0.000	0	0.00
2005	2	3	1	0.333	0	0.00
2006	2	2	1	0.500	0	0.00
2007	2	2	1	0.500	0	0.00
2008	3	5	2	0.400	2	0.6~~6~~7
2009	4	4	1	0.250	1	0.25
~~**Total/*average**~~	~~28~~	~~39~~	~~9~~	~~*0.269~~	~~7~~	~~*0.257~~
Green Island						
2004	2	3	2	0.667	2	1.00
2005	~~2~~1	~~3~~ 2	2	0.667	0	0.00
2006	2	2	2	1.000	2	1.00
2007	2	2	1	0.5	2	1.00
2008	2	4	1	0.~~150~~250	2	1.00
2009	2	2	2	1.000	3	1.50
Total/*average	~~10~~	~~14~~	~~8~~	~~*0.596~~	~~8~~	~~*0.80~~

Comment [bdm31]: Should we be calling these nesting pairs to avoid confusion?

Comment [bdm35]: This is the wrong heading for this table

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TABLE 13. OYSTERCATCHER ~~BREEDING~~ NESTING PAIR COUNT COMPARISON, CAPE HATTERAS NATIONAL SEASHORE, 1996–2008

Year	Ocracoke Island	Hatteras Island	Bodie Island	Green Island	Total

Source: Simons and Schulte 2007, 48; 2008, 81.

NOTE: Data available only for years listed.

* = Average.

Since 1999, the number of breeding pairs at the Seashore has generally declined, with the exception of very small increases in 2001, 2004, and 2007 (see figure 12). The annual number of fledged chicks has ranged from a low of 5 in 1999 to a high of 20 in 2001. The rapid decrease in chick survival in 2002 is thought to correspond to the arrival of the fox as a predator on Hatteras Island. The advent of predator control efforts at the Seashore in 2003 is thought to be a contributing factor to the noticeable increase in chick survival between the 2003 and 2004 seasons (Simons and Schulte 2008). However, in the absence of hurricane events (which sometimes provide improved habitat) a recent demographic model projected a rapid decline for oystercatchers in North Carolina in the next 50 years (Simons and Schulte 2008, 60).

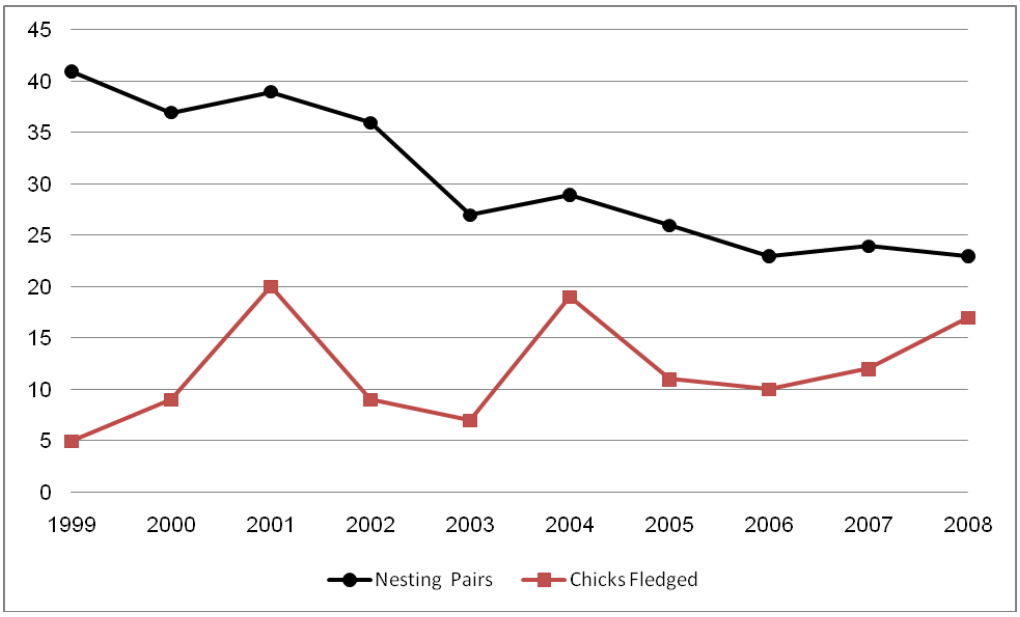


FIGURE 12. AMERICAN OYSTERCATCHER NESTING PAIRS AND CHICKS FLEDGED, CAPE HATTERAS NATIONAL SEASHORE, 1999–2008

Comment [bdm31]: Should we be calling these nesting pairs to avoid confusion?

Comment [bdm36]: This header needs to be deleted from this page.

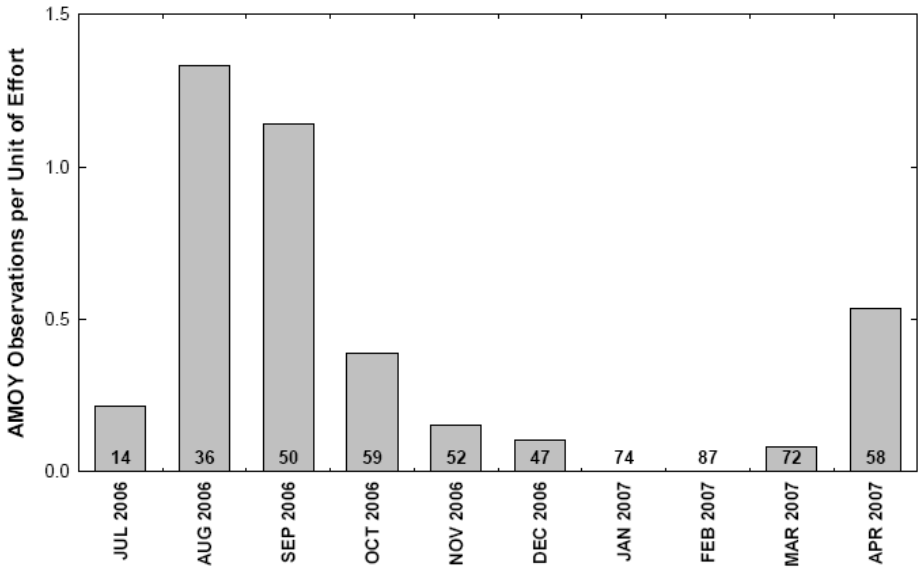
Comment [bdm37]: In 2009 we had 23 nesting pairs and fledged 13 chicks.

NONBREEDING OYSTERCATCHERS

American oystercatcher migration generally begins at the end of August and occurs gradually through November. American oystercatchers are short-distance, partial migrants and generally winter along the southeast coast of the United States (Schulte et al. 2007).

Winter and migratory habitat appear to be similar to breeding habitat, although additional research is needed to determine preferred habitat in the winter, especially for birds on migration. Limited observations indicate that winter birds roost on open ground without vegetation in areas near foraging habitat (Nol and Humphrey 1994). A study conducted during the winter of 2002–2003 found that oystercatchers commonly use shell rakes as winter roost sites (Brown et al. 2005). Other habitat types used by wintering oystercatchers include sand islands, inlet beaches, sand spits, edges and interior mudflats on marsh islands, and occasionally docks and jetties (Brown et al. 2005; Schulte et al. 2007)

The NPS Southeast Coast Network (SECN) Winter Monitoring Program is conducting a more comprehensive study on wintering shorebirds. Pilot implementation of this SECN shorebird monitoring protocol at the Seashore began in mid-July 2006. Results for the oystercatcher, which are depicted on figure 13, are discussed below.



Source: NPS Byrne et al. 2009.

FIGURE 13. MONTHLY NORMALIZED COUNTS OF AMERICAN OYSTERCATCHERS (AMOY) AND NUMBER OF SAMPLING EVENTS AT CAPE HATTERAS NATIONAL SEASHORE, 2006–2007 (NORMALIZED COUNTS ARE CALCULATED AS NUMBER OF BIRDS OBSERVED PER 30-MINUTE SAMPLING EVENT)

[Preparer's Note: Waiting for raw wintering data from 2006-2009]

Comment [bdm38]: This data would not be comparable because when SECN was conducting the surveys they were surveying the entire seashore. When we took over the migratory and wintering monitoring we are only surveying the points and spits.

From July 2006 through April 2007, the majority of American oystercatchers were observed in foreshore and mudflat/algal flat habitat types (figure 14). American oystercatchers appeared to use the foreshore during both tidal extremes and used the mudflat/algal flat habitat only during high tide. The highest numbers of birds appeared to occur in August, and the data indicated that the Seashore does not appear to have a wintering population of oystercatcher. The two highest single-day oystercatcher counts were 13 in October 2006 and 12 in August 2006.

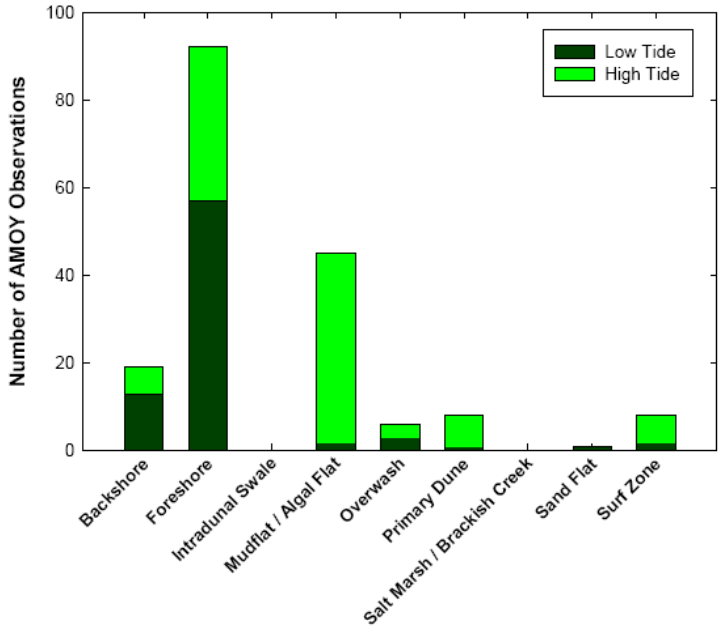


FIGURE 14: NUMBERS OF AMERICAN OYSTERCATCHER (AMOY) OBSERVATIONS BY HABITAT TYPE AND TIDAL STAGE AT CAPE HATTERAS NATIONAL SEASHORE, 2006–2007

RISK FACTORS TO AMERICAN OYSTERCATCHERS

In addition to direct habitat loss, the American oystercatcher faces pressure from recreational disturbance, increases in predators, potential contamination of food resources, and alteration of habitat through beach stabilization (Schulte et al. 2007). Causes of American oystercatcher nest failure on the Outer Banks from 1998 through 2008 could not be determined for 49% of nest failures. However, the causes of failure that could be determined were predation by mammals (54%), predation by ghost crabs (3%), avian predation

(4%), direct human disturbance (4%), abandonment (6%), and overwash (29%) (Simons and Schulte 2008).

Human Activity. Oystercatchers need large, undisturbed beach areas for successful nesting. Research has shown that disturbance by pedestrians, kayakers, vehicles, and unleashed pets can cause the abandonment of nest habitat as well as direct loss of eggs and chicks (Meyers 2005; Sabine et al. 2006, 2008; Toland 1999; Hodgson et al. 2008). Studies of the effects of humans and vehicles on American oystercatchers have indicated lower nest survival and higher chick mortality in places with higher levels of disturbance (McGowan 2004; Sabine 2005; Simons and Schulte 2008). A study at Cape Lookout National Seashore documented lower nesting success for oystercatchers in areas where human disturbance was higher, and also noted that oystercatchers avoided nesting in areas with high levels of human activity (Davis 1999). Another study in North Carolina found evidence that oystercatcher nests that were frequently disturbed by beach vehicles suffered higher rates of nest predation (McGowan and Simons 2006). In addition to direct impacts or mortality, reasons for lower reproductive success in areas of high disturbance may include reduced time spent foraging (Sabine et al. 2008), thermal stress to eggs caused by a lack of incubation when reacting to disturbance (Sabine 2006), and expenditure of energy reserves during flushing or defensive displays (Toland 1999). Studies at Cumberland Island National Seashore (CINS) in Georgia found that chick foraging behavior was lower in the presence of vehicular activity, which could alter chick provisioning and ultimately affect chick survival. Researchers recommended prohibiting beach driving in oystercatcher territories when chicks are present (Sabine 2005). Research on flush responses of oystercatchers to human disturbance indicates that protection of this species requires a buffer distance of up to 600 feet from nesting areas (Meyers 2005; see table 15).

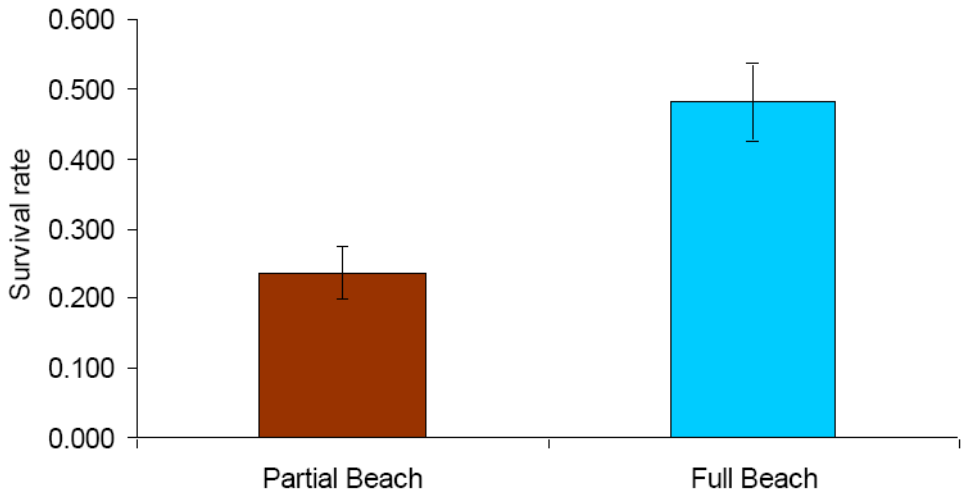
TABLE 15. BUFFER DISTANCES RECOMMENDED FOR FORAGING AND NESTING AMERICAN OYSTERCATCHERS IN FLORIDA, GEORGIA, AND MAINE

Buffer	Disturbance Types	Behavior	Region
450 ft (137 m) (Sabine 2005)	Pedestrians, ORVs/other vehicles, boats, pets	Nesting	Cumberland Island National Seashore, Georgia
492 ft (150 m) (Sabine 2005)	Pedestrians, ORVs/other vehicles, boats, pets	Brood rearing	Cumberland Island National Seashore, Georgia
100 ft (30 m) (Dept. Env. Protection 2008)	Development, vegetation removal	Foraging	Maine

TABLE 15. BUFFER DISTANCES RECOMMENDED FOR FORAGING AND NESTING AMERICAN OYSTERCATCHERS IN FLORIDA, GEORGIA, AND MAINE

Buffer	Disturbance Types	Behavior	Region
250 ft (76 m) (Dept. Env. Protection 2008)	Development, vegetation removal	Roosting	Maine
338 ft (103 m) (Rodgers and Schwikert 2002)	Personal watercraft	Foraging and loafing	West and east coasts of Florida

The reproductive success of oystercatchers at Cape Hatteras has been impacted by vehicle and pedestrian disturbance. From 1999 to 2008, 48% of chicks in full beach closures on Cape Hatteras survived to fledging, while only 24% survived when the beach had an open lane for vehicles and pedestrians (Simons and Schulte 2008; see figure 15). Seashore staff also documented that the highest hatching rate (87%) was found at sites that did not have ORV use or concentrated pedestrian use (NPS 2005b).



Source: Simons and Schulte 2008.

FIGURE 15. AMERICAN OYSTERCATCHER CHICK SURVIVAL BY CLOSURE TYPE AT CAPE HATTERAS NATIONAL SEASHORE, 1999–2008

Direct mortality of oystercatcher chicks from vehicles has been documented since 1995, when three chicks were found crushed in a set of vehicle tracks at the Seashore (Simons and Schulte 2008). Similar events have been documented at neighboring Cape Lookout National Seashore, where studies documented five chick deaths related to vehicles in 1995 (Davis 1999) and one chick and two clutches lost in 1997 when they were run over by vehicles (Davis et al. 2001). Three oystercatcher chicks were killed during the 2003 and 2004 breeding seasons at the Seashore by being run over by vehicles (NPS 2004f, 2005b), as documented by Seashore resource protection staff. A recent radio telemetry study conducted at Cape Hatteras and Cape Lookout national seashores identified human activity as the source of 16% of known chick mortality from 2005 through 2007 (Simons and Schulte 2008), with 8% of that related to vehicle collisions and 8% to other human disturbance.

Weather and Tides. Nine named hurricanes have affected the Outer Banks between 1993 and 2008 (NOAA 2009). Storms and associated high tides during breeding season can reduce nesting success. Overwash and other weather-related events accounted for 29% of documented nest failures at Cape Hatteras from 1999 through 2008. However, periodic hurricanes (outside the breeding season) can benefit oystercatcher nesting success in the long term through the creation of new habitat and the reduction of predators. For example, on Cape Lookout National Seashore, nests lost to predators dropped significantly after Hurricane Isabel flooded the island in September 2003. This drop was attributed to the reduction of the predator population due to hurricane-related flooding (Simons and Schulte 2008).

Predation. Numerous studies and reports have identified nest predation as a major source of oystercatcher nest failure (Davis et al. 2001; Sabine et al. 2006; McGowan et al. 2005; McGowan 2004; Hodgson et al. 2008; Traut et al. 2006; Wilke et al. 2007). Mammalian predation was the major identifiable cause of nest failure for study sites in North Carolina from 1998 through 2008 (Simons and Shulte 2008). Predators include grey fox, red fox, raccoon, mink, striped skunks, dogs, cats, American crows, and gulls (Nol and Humphrey 1994). More recently, video nest recordings have documented raccoon, bobcat (*Lynx rufus*), and ghost crab predation of oystercatcher eggs and nestlings at Cumberland Island National Seashore, Georgia (Sabine et al. 2006). Oystercatchers may lay another clutch if their eggs are lost or destroyed (Nol and Humphrey 1994).

Comment [bdm39]: Remove since striped skunks don't occur on the Seashore?

As previously discussed, predation of oystercatchers is thought to be associated with human activities such as ORV use and pedestrian recreation (McGowan and Simons 2006; Simons and Schulte 2007; Sabine et al. 2008). McGowan and Simons (2006) hypothesized that human recreation might increase the activity of incubating oystercatchers, thereby leading to increased predation rates. Their research found a clear association between recreation and incubation behavior at Cape Hatteras and Cape Lookout during the 2002 and 2003 breeding seasons (McGowan and Simons 2006). ORV traffic was associated with

increased numbers of trips parents made back and forth to nests and a decrease in duration of incubation. Recreational activities such as truck use and pedestrian traffic showed a weaker association with nesting behaviors, although the proximity of the disturbance to the nest was a factor. Evidence points to a reduction of nest success as the result of an alteration of incubation behavior due to recreational disturbance. McGowan and Simons (2006) hypothesized that mammals, which were found to be the main nest predators during this study (Davis et al. 2001), can better locate disturbed nests because adults leave a scent trail when going back and forth to nests. Human behavior and actions may also result in higher predator populations. For example, raccoon sightings and signs were greater in areas of increased human activity at Cape Lookout (Davis et al. 2001), and raccoon and bobcat signs appeared to be more abundant around areas of frequent human activity at Cumberland Island National Seashore, Georgia (Sabine et al. 2006). (sidebar: sign)

In areas of frequent human activity, pedestrians were commonly observed in close proximity to nests, causing oystercatchers to leave their nests and exposing eggs and chicks to temperature extremes and greater risk of predators (Sabine et al. 2006).

COLONIAL WATERBIRDS

Colonial waterbirds at the Seashore include gull-billed terns, common terns, least terns, and black skimmers. Gull-billed terns are considered to be threatened in North Carolina, while the other three are listed as Species of Special Concern by the NCWRC and the NPS (Erwin 2005). None of these species is federally listed. (sidebar: define colonial waterbirds)

The Seashore was designated a Globally Important Bird Area by the American Bird Conservancy (NPS 2004d). This designation recognizes those areas with populations and habitat important at the global level but does not carry any regulatory obligations. Ground-nesting colonial waterbirds breed along the Seashore beaches, which also host nesting sites for other birds, as well as a range of recreational activities for humans. Studies have documented that populations of some species of colonial waterbirds are declining. Beach nesters such as common terns, gull-billed terns, and black skimmers have shown the most significant declines. Coastal development, disturbances by humans, and increased nest predation all contribute to the decline in numbers of colonial waterbirds (NCWRC 2005).

Colonial Waterbirds—Descriptions

GULL-BILLED TERN

The gull-billed tern is a medium-sized (13 to 15 inches long, weighing about 5.6 to 7.0 ounces), black-capped waterbird found widely in Eurasia, the Mediterranean, northern Europe, and the United States. In

the United States, it occurs as two subspecies, with the Atlantic Coast and Gulf subspecies being designated *Sterna nilotica aranea* and the *S. n. vanrossemi* subspecies occurring from the Salton Sea in California south to western Mexico (Parnell et al. 1995).

COMMON TERN

The common tern is a widespread species that can be found across the temperate region of the northern hemisphere. It also occurs in Bermuda and the southern Caribbean region (Nisbet 2002). It is one of the medium-sized, black-capped terns (12 to 14 inches long, weighing 3.8 to 5.1 ounces) (Nisbet 2002). In North America, it is distributed along the Atlantic Coast, the St. Lawrence River, and in most of the Great Lakes (Nisbet 2002).

LEAST TERN

The least tern is the smallest of the black-capped terns in North America. Five races are recognized in North America, although there are few differences genetically or morphologically among them (Thompson et al. 1997). The least tern weighs only about 1.7 ounces, on average, and is only 8 to 9 inches in length (Thompson et al. 1997). (sidebar: photo of terns)

BLACK SKIMMER

Black skimmers are the only waterbirds on the Atlantic Coast that feed by skimming along the surface of the water with their lower jaw. They are also unique in that males are on average 35% to 40% larger than females, and both exhibit a high degree of nocturnal behavior. Females average about 9.3 ounces and are 16 to 24 inches long, while males average about 13 ounces and are 19 to 24 inches long (Gochfeld and Burger 1994). (sidebar: photo)

BEACH-NESTING COLONIAL WATERBIRDS IN NORTH CAROLINA

The Outer Banks region of North Carolina supports a large number of colonial waterbird species that depend upon its extensive sounds and the nearshore waters for feeding, and its relatively undisturbed islands for nesting. Most species of colonial waterbirds are in jeopardy in North Carolina (Parnell and Committee 1977) because of a decline in numbers over the past 20 to 30 years. During the period from 1977 to 2007, the number of gull-billed tern nests declined from approximately 268 to only 90, common tern nests from 2,761 to 498, and black skimmer nests from 976 to 555. The number of least tern nests, however, increased from 1,925 to 2,827 (NCWRC 2008). Numbers of most breeding, colonially nesting shorebirds within North Carolina have declined over the past 20 to 30 years (Erwin 2005; see table 16). For example, from 1977 to 2007, a period of 28 years, colonial waterbird nesting declined 30%, from 7,068 to 5,004 nests (table 16). Barrier island beaches provide important habitat for gull-billed terns,

common terns, least terns, and black skimmers. Many of these beaches are severely degraded due to coastal development and associated increases in human disturbance and in predation by overabundant species. These factors have most likely contributed to the decline in colonial waterbird numbers in North Carolina (Cameron and Allen 2008).

TABLE 16. NUMBERS OF COLONIAL WATERBIRD NESTS IN NORTH CAROLINA, 1977–2007

Species	1977	1983	1988	1993	1995	1997	1999	2001	2004	2007	Average
Gull-billed tern	268	233	161	155	249	137	154	258	99	90	180.4
Common tern	2,761	2,247	2,618	2,122	1,699	952	888	1,131	570	498	1,548.6
Least tern	1,925	1,653	1,528	2,188	1,993	882	1,271	1,742	2,408	2,827	1,841.7
Black skimmer	976	797	743	1,084	819	570	681	594	623	555	744.2
Total	7,068	5,866	5,983	7,159	5,877	3,408	3,806	4,811	4,528	5,004	N/A

Source: NCWRC 2008.

N/A = Not applicable.

The beaches of the Seashore have been important in providing suitable habitat for these colonial nesters. In 2004, more than half of all nesting black skimmers and common terns in North Carolina were found at the Seashore, as well as one-third of the state's gull-billed terns (see tables 16 and 17).

Descriptions of Breeding, Foraging, and Nonbreeding Habitats

GULL-BILLED TERN

Breeding Habitat. Gull-billed terns typically nest among other tern and skimmer species on open, sandy shell beaches, on large barrier islands, on dredge-spoil islands, or on overwash fans (also used by piping plovers) that are mostly devoid of vegetation. They also nest on elevated-shell ridges ("rakes") along the edges of marsh islands, which they share with American oystercatchers and common terns (Erwin et al. 1998b; Erwin 2005; Molina et al. 2009). (sidebar: dredge-spoil islands)

Foraging Habitat. In contrast to other terns, gull-billed terns do not feed primarily on fish but are opportunistic, taking insects on the wing and feeding on a variety of invertebrates, including fiddler crabs (*Uca* spp.), decapods, marine worms, and clams, as well as small marsh fish (Erwin 2005; Molina et al. 2009). Consequently, gull-billed terns can be seen feeding over marshes and creeks and along ocean and bay beaches, as well as over agricultural fields many miles from their nesting sites (Erwin 2005; Molina et al. 2009). (sidebar: decapod)

Nonbreeding Habitat. North American birds winter along the Gulf Coast, the Pacific Coast of Mexico, and into Central and South America. Little is known of gull-billed tern use of habitat while migrating, except that the habitat is generally considered similar to nesting habitat (i.e., open beach, sand spits)

(Erwin 2005). Nonbreeding Gull-billed turns can be found in coastal ponds, lagoons, mudflats, and flooded inland fields (Molina et al. 2009). (sidebar: photos of habitats)

COMMON TERN

Breeding Habitat. Common terns typically nest on open, sandy shell beaches on ocean coastal islands, as well as at inland island sites in freshwater lakes, or, as in Europe, on rivers (Nisbet 2002). However, they also nest in salt marshes, either on shell or on wrack, especially where human disturbance along the beaches is significant, and even on man-made structures, including large rooftops in urban areas (Erwin 1980).

Foraging Habitat. Common terns prey on small fish and shrimp in inlets and along the coast, often within a few miles of their breeding colonies (Nisbet 2002).

Nonbreeding Habitat. There is little information on habitats used by migrating common terns. However, most continue to feed close to shore. Migration staging areas are known at large sandy spits and bars at a number of North Atlantic sites, with concentrations numbering in the thousands at some places (Nisbet 2002). In winter, common terns migrate to the Caribbean and South America; both coasts of Africa; coasts and islands in the Indian Ocean; and the western Pacific from Japan to the Solomon Islands, New Guinea, and Australia (Nisbet 2002), where they often concentrate in large numbers in coastal lagoons (Nisbet 2002).

LEAST TERN

Breeding Habitat. Least terns typically select the barest sand- and shell-covered substrates available on coastal, riverine, or dredge-spoil islands (Thompson et al. 1997). They also nest on rooftops in a number of coastal areas, where pea gravel is used as part of the roofing material (Thompson et al. 1997). On coastal barrier islands, they often select colony sites either adjacent to inlets or in overwash areas that are often interspersed among piping plover nests. Unlike common terns, least terns are typically found in small single-species colonies, where their nests are often widely spaced (Thompson et al. 1997). In New Jersey, inter-nest distance ranged from 2 to 66 meters (6 to 216 feet) at the time of egg-laying and from 1 to 60 meters (3 to 197 feet) at the end of incubation (Burger and Gochfeld 1990).

Foraging Habitat. Least tern foraging habitat is similar to that of common terns, except that least terns seldom feed in large flocks.

Nonbreeding Habitat. Least terns migrate from the Outer Banks in August and September, with migration flocks staging at certain sandy island sites (Thompson et al. 1997). In late July or August,

remote sandbars or sandy spits serve as roost sites. Least terns winter from Florida through the Caribbean and into Central and South America (Thompson et al. 1997).

BLACK SKIMMER

Breeding Habitat. Black skimmers prefer to nest on open, sandy substrates on barrier and dredge-spoil islands or at the tips of barrier islands (Gochfeld and Burger 1994). They invariably nest with other tern species along the Atlantic Coast (Erwin 1977, 2005). Black skimmers occasionally nest on wrack or on shell ridges in salt marshes and even on rooftops with least terns (Gochfeld and Burger 1994).

Foraging Habitat. Black skimmers feed on small fish, shrimp, and other invertebrates that they capture by skimming the surface with their lower jaws just below the surface of the water. They typically feed very close to their nesting colonies and prefer quiet waters in salt marsh creeks, lagoons, or protected coves and inlets near barrier islands (Erwin 1977, 2005; Gochfeld and Burger 1994).

Nonbreeding Habitat. Black skimmers migrate from the Outer Banks region from September to November, forming very large concentrations on sandy spits and sandbars (Gochfeld and Burger 1994). They winter from Florida through the Caribbean and South America (Erwin 2005; Gochfeld and Burger 1994).

Breeding Biology

GULL-BILLED TERN

Birds arrive in North Carolina by mid-April. The mating system is monogamous, and like many other waterbirds, gull-bills probably have long-lasting pair bonds. Nest-site establishment and egg-laying usually occur in mid- to late May. The nests consist of a shell-lined scrape in the sand or sometimes on wrack in salt marshes. Nests contain from two to three brownish-blotched eggs (in the United States, the mean is around 2.2 eggs per nest [Molina et al. 2009]) that are incubated for 22 to 23 days. Members of a pair share incubation duties, but females take the dominant role. Gull-billed terns appear to be less tolerant of disturbance and less faithful to nest sites than other *Sterna* terns (Molina et al. 2009). Both parents share brooding duties, and both feed the young, often for an extended period after fledging occurs (birds generally fledge at 26 to 30 days of age). The chicks are highly camouflaged and more precocial (mobile and independent) than either common tern or black skimmer chicks, with which they coexist. The young may leave the immediate area of the nest within a few days if disturbance is high. Pairs may re-nest if a nest is lost early in the breeding season (Erwin 2005).

Common Tern

Birds arrive in North Carolina in late April to early May and begin nesting most years from mid-May to early June (Nisbet 2002). The mating system is monogamous, and like many other waterbirds, common terns probably have long-lasting pair bonds. Clutch sizes vary, but three medium-dark-brown-mottled eggs are the norm. The eggs are incubated for 22 to 23 days. Both sexes incubate and feed the brood. As in other terns, feeding of the young occurs after fledging and can continue into the fall migration. Upon hatching, the young remain near the nest (unless disturbed) for the entire pre-fledging period. Re-nesting may occur if early nests fail. Fledging ranges from about 25 to 30 days. Common terns appear to serve as a social locus for mixed-species colony formation, possibly because of their aggressively protective nature (Erwin 1979; Erwin 2005; Nisbet 2002). Hence, gull-billed terns and black skimmers often nest among common terns (Erwin 2005).

Least Tern

Birds arrive in North Carolina from late March to mid-April. Unlike most other Outer Banks terns, least terns usually nest in single-species colonies, with nests often spread far apart. Courtship lasts for two to three weeks in April and May, and egg-laying occurs from late May until June. Clutch sizes range from one to three eggs, with two being the norm in North Carolina. Eggs are highly camouflaged, with the background color beige to light olive-brown. Members of a pair share incubation duties, but females take the dominant role. Incubation lasts for 21 to 22 days, and the highly mobile young move from the nest within a few days. They are able to fly at about 20 days of age. Post-fledging parental feeding can occur for several weeks away from the colony (Thompson et al. 1997; Erwin 2005).

Black Skimmer

Birds arrive in North Carolina from late April to mid-May, and nest-building and egg-laying usually occur from late May to mid-June (Erwin 1977; Erwin 2005; Gochfeld and Burger 1994). Clutch sizes range from two to four eggs (Erwin 1977). Eggs are light buff with black blotches, and are laid and hatch at different times. Both sexes incubate the eggs, brood, and feed the young. Incubation ranges from 22 to 25 days. The young remain near the nest (unless disturbed) for most of the pre-fledging period of 28 to 30 days (Erwin 1977). As with other waterbirds, if nests fail early in the season, skimmers will re-nest (sometimes several times). Skimmers are sometimes seen incubating eggs as late as August in the mid-Atlantic region (Burger and Gochfeld 1990). Fledged young are fed by their parents, often right up until migration (Erwin 1977; Erwin 2005). Human disturbance can seriously affect the breeding success of black skimmers (Gochfeld and Burger 1994). Pre-laying skimmers have been known to abandon a colony that is frequently disturbed (Erwin 1980; Safina and Burger 1983). Research has indicated that disturbed

subcolonies of black skimmers had lower nest density, later nesting dates, and lower hatching and fledging success (Safina and Burger 1983).

Breeding Performance at Cape Hatteras National Seashore

Colonial waterbird breeding at Cape Hatteras generally occurs between the beginning of May and the middle of August. In many cases, colonial waterbirds use areas that were colonized in previous seasons, which include areas protected as pre-nesting closures for piping plovers. Colonies are commonly composed of small groups of least terns, but more diverse colonies sometimes occur.

Although different survey protocols have been used at the Seashore between 1977 and 2008, recent estimates of colonial waterbird nests at the Seashore are clearly much lower than they were 30 years ago (see table 17). Common terns, gull-billed terns, and black skimmers have shown the greatest declines over the last 30 years, both statewide and at the Seashore.

TABLE 17. NUMBERS OF COLONIAL WATERBIRD NESTS AT CAPE HATTERAS NATIONAL SEASHORE, 1977–2008

Species	1977[a]	1983[a]	1988[a]	1992[a]	1993[a]	1995	1997	1998	1999	2000	2001	2004[b]	2007[b]	2008	Avg.
Gull-billed tern	27	7	26	0	12	58	84	21	103	3	108	31	~~60~~	0	~~34.3~~
Common tern	802	763	678	278	422	503	718	715	440	129	573[c]	376	~~18~~109	~~33~~19	~~460.6~~
Least tern	121	508	450	454	761	342	278	173	355	184	202	212	194	~~333~~232	~~331.5~~
Black skimmer	286	296	144	30	226	139	454	366	306	149	193	342	~~0~~11	~~5~~4	~~209.7~~
Total	1,236	1,574	1,298	762	1,421	1,042	1,534	1,275	1,204	465	1,076[c]	1,035	~~212~~320	255~~371~~	N/A

[a]Surveys conducted by J. Parnell, University of North Carolina, Wilmington.

[b]Surveys conducted by NCWRC using non-NPS protocol.

[c]Updated from 2001 report to include nests found on Green Island at Oregon Inlet, which is now included in the Seashore boundary.

N/A = Not applicable.

[Preparer's Note: Waiting for confirmation of 2008 CWB counts]

Within the Seashore, ~~no~~ 6 gull-billed tern nests were recorded in 2007 ~~or 2008~~on Green Island and none were found in 2008 or 2009, representing a decline from the Seashore's average of approximately 40 nests during surveys between 1977 and 2004. A total of ~~33~~ 53 common tern nests were found in ~~2008~~2009, compared to an average of 487 nests from 1997 to 2004. Black skimmer nest numbers have sharply declined at the Seashore, with only ~~5~~ 4 nests counted in 2008 and 61 nests counted in 2009, compared to an average of about 245 nests recorded at sampling events between 1977 and 2004 (table 17). The number of nests recorded in 2007 for ~~all~~ three of the four species was the lowest in the history of waterbird surveys in North Carolina (Cameron and Allen 2008). These species are early nesters that require habitats of bare sand or shell with little or no vegetation for nesting. Historically, these

Comment [bdm40]: 2009 preliminary data has 0 GBTE, 53 COTE, 578 LETE,and 61 BLSK.

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Comment [bdm41]: These numbers should not change anymore! The 2007, 2008, 2009 totals represent highest counts for colonies between May 25-June 7. It is not the highest count for individual colonies.

species have nested primarily on barrier island beaches and have suffered declines most likely due to habitat loss and degradation (Cameron and Allen 2008). Other reasons for the decline in North Carolina's colonial waterbirds include mammal and bird predation, human development, beach stabilization, recreational disturbances on the outer and village beaches, and perhaps, impacts on the wintering grounds (Parnell et al. 1995; Erwin 2005). Recommended methods for colonial waterbird conservation include continued monitoring and management, habitat protection and restoration, predator management, and protection from human disturbance (Cameron and Allen 2008).

Nonbreeding

Gull-Billed Tern

Fledged young and adults usually leave North Carolina's colonies by August, moving north for a short period before turning south for the fall and winter. Little is known of concentration areas during migration or winter, although wintering birds are known in Florida and the Gulf coastal region, from western Florida all the way south to Honduras and to Panama on the west coast. The gull-billed tern occasionally winters along the Atlantic Coast of North America as far north as North Carolina (Parnell et al. 1995; Erwin 2005).

Common Tern

Fledged young and adults usually leave North Carolina's colonies in late July to August. They often move north before staging at sandbars near inlets in September and then heading south. Little information is known about winter range, but they are known from Florida south through the Caribbean to Peru and southern Brazil, where tens of thousands have been recorded in late winter (Nisbet 2002).

Least Tern

Fledged young and adults usually leave North Carolina's colonies in late July to August after breeding and also move northward into the New York to New England region before turning south to South America and the Caribbean. However, data are very limited on winter ranges (Thompson et al. 1997). Like other terns, least terns tend to congregate at staging areas along the Gulf Coast in August before departing for the winter (Thompson et al. 1997; Erwin 2005).

Black Skimmer

Fledged young and adults usually leave North Carolina's colonies by early August and disperse northward before heading south. Large flocks congregate at staging areas, often with terns. Adults may remain with their young during fall migration. Most birds from the mid-Atlantic region winter from

southern North Carolina to Florida, the Caribbean, and into Central and South America (Gochfeld and Burger 1994; Erwin 2005).

Risk Factors

Human Activity. Ground-nesting colonial waterbirds are particularly vulnerable to impacts from human activities undertaken by ORV riders, pedestrians, photographers, wildlife managers and scientists, and poachers, because of the birds' usually high colony density and co-occurrence with human recreation (Erwin 1980, 2005; Rodgers and Smith 1995; Rodgers and Schwikert 2002). Disturbances affect the animals' ability to feed, rest, and breed by evoking a flush response (Rodgers and Smith 1995; Rodgers and Schwikert 2002). Human activities that have indirect effects include sonic booms from military operations, aircraft disturbances, the presence of both domestic and feral animals, and the leaving of garbage that subsequently attracts both bird and mammal predators. Early in the spring, when the birds are first arriving and prospecting for breeding sites, even modest disturbances can be highly disruptive to colonial species (Buckley and Buckley 1976). Studies indicate that buffer distances between nesting areas and sources of human disturbances should be approximately 600 feet (Rodgers and Smith 1995; Erwin 1989, 2005).

Human disturbance to waterbirds is frequently documented at the Seashore. At Cape Hatteras, four least tern chicks between Ramps 23 and 30 and seven black skimmer chicks at Ocracoke Inlet were found dead or dying in ORV tracks during the 2003 breeding season. In all cases, the chicks were found adjacent to, but outside of, posted closures (NPS 2004g). Chicks become mobile after hatching, increasing their vulnerability. Colonial waterbird chick mortality from beach vehicles was documented every season from 2001 through 2004. Several chicks were killed by vehicles in 2001, 6 were killed in 2002, 11 were killed in 2003, and 6 were killed in 2004 (2001–2004 CWB reports). Although no colonial waterbird deaths were directly attributed to impacts of human activity, instances of human disturbance to birds were reported in each colonial waterbird annual report from 2005 through 2008 (2005–2008 CWB reports). Although informational signs are posted around all resource closures (including those for colonial waterbirds), violations by pedestrians, ORVs, and dogs are common at the Seashore. In 2008, there were several violations involving vehicles in colonial waterbird closures, including one that resulted in the crushing of a least tern egg by an ATV (July 31 CAHA Press Release).

Weather and Tides. Nine named hurricanes affected the Outer Banks between 1993 and 2007 (NOAA 2009). Flooding and high winds from storms can result in nest loss or failure, which was demonstrated in 1999 when Hurricane Dennis hit the North Carolina coast. Impacts from the hurricane flooded the entire Ocracoke Inlet colony, resulting in the loss of all chicks and eggs (1999 CWB report). Winter storms can

also impact shorebirds. High mortality of many coastal bird species was noted after a snowstorm swept the entire North Carolina coast in 1989 (USFWS 1996a). Storms can also result in beneficial impacts to shorebirds, as seen in 2003 when Hurricane Isabel's passing resulted in the creation of a great deal of suitable beach nesting habitat (2003 CWB report).

Predation. Resource Management staff at the Seashore assumes that the leading cause of colonial waterbird nest and brood failure is predation (2008 CWB Report). Predators of colonial waterbirds at Cape Hatteras include red fox, grey fox, mink, opossum, skunk, dogs, cats, rats, American crows, gulls, and raccoon. Foxes, raccoons,opossum, rats, and feral cats have increased in recent years as human populations have grown in coastal regions (Buckley and Buckley 1976; Erwin et al. 2001; Erwin 2005). The result of this predation has been poor reproduction or major redistributions of species such as gull-billed terns, common terns, least terns, and black skimmers (Erwin et al. 2001, 2003; Erwin 2005). In addition, gulls are often predators of terns as well as competitors for nesting space (Nisbet 2002). These include great black-backed gulls (*Larus marinus*), herring gulls (*Larus argentatus*), and the smaller laughing gulls (*Leucophaeus atricilla*). In addition, in certain areas other bird species may prey on terns and skimmers (or their eggs), such as peregrine falcons (*Falco peregrinus*), great-horned owls (*Bubo virginianus*), fish crows (*Corvus ossifragus*), and others (Erwin 2005). In 2008 the Seashore implemented a well-developed predator trapping program, which was unavailable in previous seasons. The trapping program deflated populations of raccoons, opossums, feral cats, red and grey foxes, and minks, which are all known predators of colonial waterbirds. However, raccoons at the Cape Point colony and mink at the South Ocracoke colonies severely hampered waterbird breeding success in those areas during the 2008 season (NPS 2009).

Comment [bdm42]: Skunks are known predators but not at Cape Hatteras.

Comment [bdm43]: Not documented as predators at Cape Hatteras.

Comment [bdm44]: Rats are known predators but not at Cape Hatteras.

Comment [bdm45]: Gulls are predators but they do not compete for nesting space here at Cape Hatteras.

WILSON'S PLOVER

Wilson's plover is a medium-sized, ringed plover of coastal habitats. Its overall length is 6.5 to 7.5 inches, and its weight ranges between 2 and 2.5 ounces. At all times of the year and in all plumages, its bill is entirely black, large, and heavy; its upperparts are generally grayish to grayish brown, and its underparts are white, with a black-to-brownish breast-band. Its legs and feet are flesh-colored to pinkish. It is readily distinguished from other, similar, ringed plovers by its larger size; by its large, heavy, all-black bill; and by its flesh-colored legs. The piping plover is smaller than Wilson's plover, having obviously paler upperparts, orange legs, and a much smaller, stubbier, two-toned bill that has an orange-yellow base and a black tip (Corbat and Bergstrom 2000; Hayman et al. 1986; Howell and Webb 1995). Wilson's plover has no federal protection status in the United States; however, it was classified as a species of conservation concern by the USFWS in 2002. Birds that appear on this list are those that, without additional conservation actions, are likely to become candidates for listing under the ESA

(USFWS 2002a; 16 U.S.C. 1531–1544). Brown et al. (2001) list Wilson's plover as a species of high concern in their prioritization of shorebird species according to relative conservation status and risk. Wilson's plover is listed as endangered in Virginia and Maryland, threatened in South Carolina, rare in Georgia, state protected in Alabama (Audubon 2005), and as a species of special concern in North Carolina (NCAC 10I.0105, Subchapter 101 15A). (photo of Wilson's and piping plover to show difference)

Distribution

Breeding. Wilson's plover is distributed locally along the Atlantic Coast, from Virginia south to southern Florida, including the Florida Keys, and from southern Florida west along the Gulf Coast to Veracruz, Mexico, the Yucatán, and Belize (Stevenson and Anderson 1994). Breeding locations are uncertain farther south along the Caribbean coast of Central America.

In South America, Wilson's plover breeds locally along the Atlantic Coast, from Colombia south to Brazil, and includes the islands of Trinidad, Aruba, Bonaire, Margarita, and Curaçao, located off the coast of Venezuela (Meyer de Schauensee and Phelps 1978). In the West Indies, it breeds throughout the Bahamas, the Greater Antilles, the Virgin Islands, the Lesser Antilles, and in the Grenadines (Raffaele et al. 1998).

Along the Pacific Coast, Wilson's plover breeds locally along the west coast of Baja California, and from the Gulf of California south to Nayarit, Mexico (Howell and Webb 1995). Farther south along the Pacific Coast, it breeds from Mexico to Ecuador and Peru (Hilty and Brown 1986).

Nonbreeding. Wintering occurs mainly in northeast and central Florida (Corbat and Bergstrom 2000) as well as in west Louisiana and south Texas throughout the remainder of the breeding range (see above), to northern South America (Hayman et al. 1986).

Wilson's Plover in North Carolina and at Cape Hatteras National Seashore

A 2004 survey of the entire coast of North Carolina yielded 232 pairs of Wilson's plover. Of those, the Seashore supported just two pairs of Wilson's plover on Ocracoke Island. In contrast, in 2004, Cape Lookout National Seashore supported 61 pairs and two individuals, which represented 26% of North Carolina's population of Wilson's plover (S. Cameron, pers. comm., November 20, 2005). Wilson's plovers are often seen by Seashore staff during their piping plover observations, but no indications of nesting had been documented until 2009 when a three-egg nest was found in June. The nest hatched in July and produced one chick. ~~No adults or chicks~~The chick was not observed during subsequent

observations and is not believed to have fledged ~~were seen in the area a few days later and it is not known if the chick fledged~~ (B. Muiznieks pers. comm. 2009).

More comprehensive surveying of wintering shorebirds is being conducted per the NPS's SECN Winter Monitoring Program. Implementation of the SECN Migratory, Wintering, and Beached Shorebird Monitoring Protocol at Cape Hatteras began in mid-July 2006. Only a few Wilson's plovers were observed at the Seashore from July to early December, and all birds were seen in foreshore habitat at low tide. SECN staff attributed the low numbers to insufficient training of field staff on the proper identification of Wilson's plover (Byrne et al. 2009).

[Preparer's Note: Waiting for raw wintering data from 2006-2009]

Comment [bdm46]: Again, I don't think our data is comparable to the surveys conducted in '06 and '07.

Habitat Description

Wilson's plovers are typically associated with coastal areas of high salinity and sparse vegetation, including salt flats, coastal lagoons, sand dunes, foredunes, and overwash areas above the high-tide line (Tomkins 1944; Hayman et al. 1986; Corbat and Bergstrom 2000). At the Seashore, Wilson's plover breeding sites have only been known to occur within piping plover closures. Hence, all closures, and much of the management of piping plovers, also apply indirectly to Wilson's plover.

Diet

Wilson's plover is a visual feeder on crustaceans, particularly fiddler crabs, and some insects (Strauch and Abele 1979; Morrier and McNeil 1991; Thibault and McNeil 1994), which they prey upon at intertidal mudflats, sand flats, ephemeral pools, and shores of brackish ponds. They usually forage at low tide on intertidal mudflats (Strauch and Abele 1979; Thibault and McNeil 1994; Corbat and Bergstrom 2000).

Breeding Biology

Before territories are established in mid-March to early April (Tomkins 1944; Corbat and Bergstrom 2000), Wilson's plovers form pairs, and most breeding territories are established by mid-April. As with the piping plover, the nest is a scrape in sand that requires little construction (Bergstrom 1988). Egg-laying peaks from late April through late May (Bergstrom 1988). Re-nesting after failure of a first nest can continue through the end of June. The estimated time required to complete a clutch of three eggs is four to six days (Bergstrom 1988; Corbat and Bergstrom 2000).

Reproductive Success at Cape Hatteras National Seashore

There are no data pertaining to Wilson's plover reproductive success at the Seashore.

Risk Factors

Because Wilson's plovers commonly nest on beaches with wide berms, which are also favored by birds like piping plover, Wilson's plovers are subject to disturbances at their nests and roosts by the same factors as those that affect the piping plover, including beachgoers, pets, and ORV traffic on beaches. Wilson's plovers leave their nests when disturbed and are extremely reluctant to return when intruders are anywhere near, a practice that exposes eggs to predation and overheating (Corbat and Bergstrom 2000).

RED KNOT

The red knot is a shorebird that breeds in the Canadian Arctic and is known to visit only North Carolina, the Outer Banks, and the Seashore, as well as the entire eastern seaboard of the United States, as a migrant and an occasional winter resident (Harrington 2001). There are five subspecies currently recognized (*Calidris canutus canutus*, *C.c. rufa*, *C.c. islandica*, *C.c. rogersi*, *C.c. roselaari*) (Harrington 2001). Two of these (*C.c. rufa* and *C.c. roselaari*) are found in the United States but only during migration and in the winter. Southward migration of *C.c. rufa* and *C.c. roselaari* begins in mid-July, with staging occurring along the United States Atlantic Coast (Harrington 2001). Only those aspects of the red knot's life pertinent to its management and conservation in North Carolina, the Outer Banks, and the Seashore are covered in this section. The red knot is not listed as threatened or endangered by the USFWS, but it is a federal candidate species. The red knot does not carry state status in North Carolina. (photo: red knot)

Emergency Endangered Listing and Taxonomy

On August 1, 2005, in response to the 80% decline in red knot population over the past 10 years, leading conservation groups filed an emergency petition asking the USFWS to list the red knot as an endangered species under the ESA. The listing request came from an alliance of wildlife groups, including Defenders of Wildlife, New Jersey Audubon Society, American Bird Conservancy, the National Audubon Society, Delaware Audubon Society, Citizens Campaign for the Environment, Audubon New York, Audubon Maryland–DC, and the Virginia Audubon Council. On September 12, 2006, the USFWS announced that it had designated the red knot as a candidate for ESA protection. On February 27, 2008, conservation groups again petitioned the Department of the Interior to list as endangered the *rufa* subspecies of the red knot, and a broader taxon comprising both the *rufa* subspecies and the *roselaari* subspecies.

Another indication of conservation concern for the red knot is the fact that in August of 2004, the U.S. Shorebird Conservation Plan (2004) published its list of U.S. and Canadian shorebird populations that are considered highly imperiled or of high conservation concern. The Canadian Arctic–Atlantic Coast

population of the red knot was one of eight taxa classified as Highly Imperiled. In 2008, the USFWS, which proposes candidates for listing under the ESA, determined that the ranking for the red knot should be raised from 6 to 3. The species' listing priority dictates the relative order in which proposed listing rules are prepared, with the species at greatest risk (listing priority 1 through 3) being proposed first (McDowell 2008).

Description

The red knot is characteristically found along the East Coast of the United States, with its greatest population staging on Delaware Bay (Tsipoura and Burger 1999) on its migration from its breeding ground in the Canadian Arctic to the Tierra del Fuego region of Chile and Argentina in South America. It is this subspecies that is the subject of the emergency petition.

Males in breeding plumage have a dark red or salmon breast, throat, and flanks, with a white belly. Their crowns and backs are flecked with gray and salmon (Harrington 1996, 2001; Paulson 1993). Female coloration is similar to that of males, but is typically less intense. Nonbreeding plumage is a plain gray on the head and back, with light fringes of gray and white along the wings, giving an appearance of a white line running the length of the wing when in flight. The breast is white, mottled with gray, and the belly is dull white. For both male and female, the bill is black (year-round), and the legs are dark gray to black (Harrington 1996, 2001). The average weight of the red knot is 5 ounces (which varies considerably through the year), with a body length between 9 and 10 inches.

Range and Migration

Red knots are found in the Arctic regions of Canada during the breeding season, which is mid-June through mid-August. They winter from November to mid-February primarily in two separate areas in South America—Tierra del Fuego in Chile and Argentina, and in Maranhão, northern Brazil (American Bird Conservancy 2005). Additional, smaller numbers of red knots also winter farther northwest in French Guiana and in the coastal, southeastern United States, including North Carolina, the Outer Banks, and the Seashore.

Red knots have one of the longest migrations of any shorebirds. Those individuals that winter in southern South America embark on their northern migration in February, with peak numbers leaving Argentina and southern Chile in mid-March to mid-April (Harrington 1996, 2001). The first stopover is along the coast of southern Brazil (Vooren and Chiaradia 1990) and the final stopover is the Delaware Bay. Their southward migration from the Canadian Arctic begins in mid-July. They arrive in South America along the coast of the Guianas in mid- to late August (Spaans 1978). From the Guianas, red knots continue to

move southward along the Atlantic coastline of South America, and the greater part of the population will continue on to Tierra del Fuego to winter (Morrison et al. 2004).

These long-distance migrations can only occur when the birds have access to productive refueling stops, particularly on their northern migrations, which involve fewer stops than the southern ones. For red knots on the eastern seaboard of the United States, Delaware Bay is the most crucial spring stopover because it is the primary final stop at which the birds can refuel in preparation for their nonstop leg to the Arctic. When they arrive at their final destination, weather conditions can be harsh, and food is scarce. Their fat reserves from the Delaware Bay must sustain them not only during their 2,400-kilometer (1,488-mile) final flight, but also upon arrival in the Arctic until food resources become more plentiful (Baker et al. 2004).

According to representatives from the National Audubon Society, red knots within the Seashore use oceanside beaches for resting and foraging, especially those that are low-angle beaches near larger intertidal zones, including such areas as South Beach (just above the Frisco Ramp), and on the east and west sides of Ocracoke on the oceanside, as well as the soundside areas (inside of the no-ORV closures) on Ocracoke and Bodie Island. Red knots only use the Seashore in the winter and during spring and fall migration.

Nonbreeding Habitat

Harrington (1996, 2001) describes how, during the winter, the red knot frequents intertidal habitats, notably along ocean coasts and large bays. Both areas usually display high waves or strong currents while supplying a sandy habitat. These areas are selectively chosen in South America, with the most abundant population on the island of Tierra del Fuego in Argentina and Chile (Morrison and Ross 1989).

On migration, the red knot principally uses marine habitats in both North and South America. Coastal habitats along the mouths of bays and estuaries are preferred, providing sandy beaches on which to forage (Harrington 1996, 2001). High wave energy is associated with these areas (Harrington 2001; Vooren and Chiaradia 1990; Blanco et al. 1992). Red knots are also known to use tidal flats in more sheltered bays or lagoons in search of benthic invertebrates or horseshoe crab eggs (Harrington 1996, 2001; Tsipoura and Burger 1999). In some cases, beach habitats are preferred because of high densities of benthic bivalves (Harrington 1996). Red knots also use tidal flats in more sheltered bays or lagoons, where they hunt for benthic invertebrates (Harrington 2001) or for special foods, such as horseshoe crab eggs (Harrington 1996; Tsipoura and Burger 1999). Delaware Bay hosts the largest number of spawning horseshoe crabs (a primary food source for the red knot) in the United States. At Delaware Bay, the red knots feed and put on weight needed for winter migration. The increasing human harvest of the horseshoe crab has reduced this

food source for red knots, and this dearth is believed to be contributing to the red knot's failure to reach its needed threshold departure weight of 6.3 to 7.0 ounces. Hence, there has been a systematic reduction in the body weight of red knots leaving Delaware Bay for the Arctic, which negatively impacts their ability to survive and breed (Baker et al. 2004).

Nonbreeding Observations at Cape Hatteras National Seashore

During their wintering shorebird study, SECN staff observed red knots at the Seashore from August 2006 through February 2007. Monthly counts were highly variable (figure 16), with the two highest single-day counts 230 in February 2007 and 170 in November 2006. Almost all red knots documented during this time were located in the foreshore habitat type (figure 17).

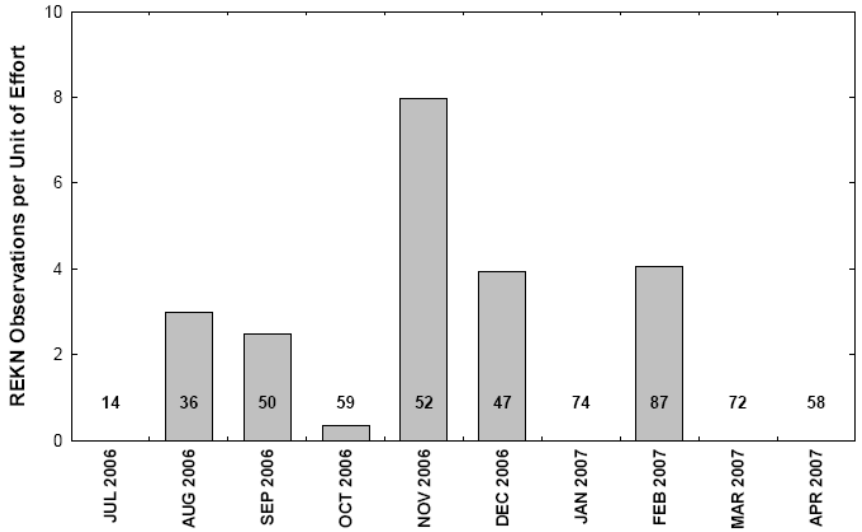


FIGURE 16. MONTHLY NORMALIZED COUNTS OF RED KNOT (REKN) AND NUMBER OF SAMPLING EVENTS AT CAPE HATTERAS NATIONAL SEASHORE, 2006–2007 (NORMALIZED COUNTS ARE CALCULATED AS NUMBER OF BIRDS OBSERVED PER 30-MINUTE SAMPLING EVENT)

[Preparer's Note: Waiting for raw wintering data from 2006-2009]

Comment [bdm47]: Recent year's data would not be comparable since we only survey the points and spits which is not primary REKN habitat.

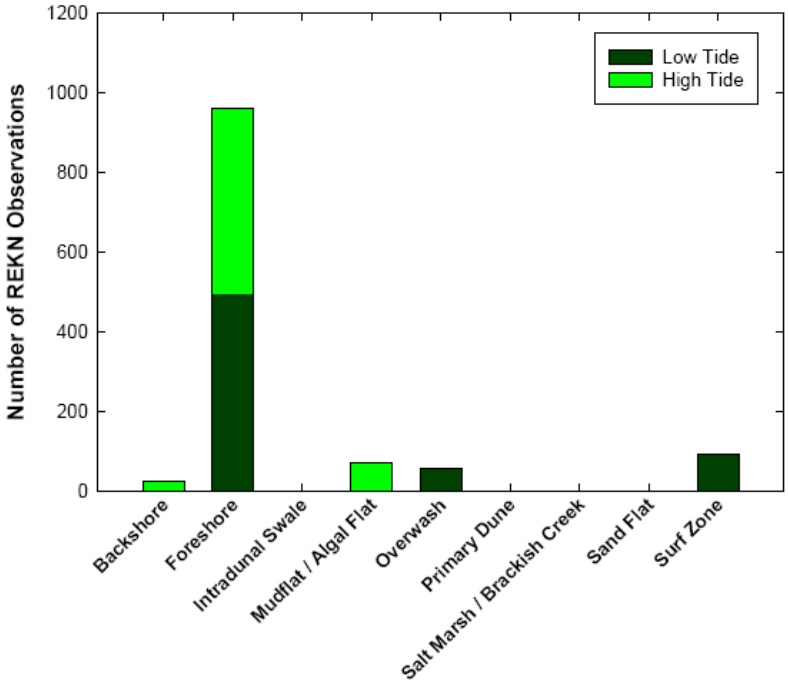


FIGURE 17: NUMBERS OF RED KNOT OBSERVATIONS BY HABITAT TYPE AND TIDAL STAGE AT CAPE HATTERAS NATIONAL SEASHORE, 2006–2007

Risks

Red knots are highly vulnerable to degradation of the resources on which they depend to accomplish their migrations. Morrison et al. (2004) have identified four factors that cause this vulnerability: (1) a tendency to concentrate in a limited number of locations during migration and on the wintering grounds so that deleterious changes can affect a large proportion of the population at once; (2) a limited reproductive output, subject to vagaries of weather and predator cycles in the Arctic, which, in conjunction with a long lifespan, suggests slow recovery from population declines; (3) a migration schedule closely timed to seasonally abundant food resources, such as horseshoe crab eggs during spring migration in Delaware Bay (Tsipoura and Burger 1999), suggesting that there may be limited flexibility in migration routes or schedules; and (4) occupation and use of coastal wetland habitats that are affected by a wide variety of human activities and developments (Bildstein et al. 1991).

Most disturbingly, 2004 research by Baker et al. (2004) indicates that if red knot populations continue to decline at their present rate, the bird will approach extremely low numbers by 2010, and the probability of

near-term extinction will be correspondingly higher than it was in 2004. Research by Niles et al. (2005) supports this extinction trajectory. The evidence strongly suggests that the decline of the red knot closely corresponds to the massive increase in the harvesting of the horseshoe crab on the Delaware Bay over the past decade.

WILDLIFE AND WILDLIFE HABITATS

In addition to the federally listed threatened and endangered species and other protected species detailed in previous sections of this chapter, other wildlife species depend on the habitats within the Seashore. This section describes those invertebrate species and other bird species that could be found in the study area and could be affected by ORV management alternatives. (photos to be added)

INVERTEBRATES

The Seashore beach ecosystem is home to a vast quantity of invertebrates, which form a valuable link in the coastal food chain. Many of the protected bird species found within the Seashore, including the piping plover, Wilson's plover, red knot, American oystercatcher, and gull-billed tern, feed on invertebrates in areas that are open to ORV use, such as the intertidal zone and the wrack line. High-energy, intertidal beaches in the southeastern United States generally support approximately 20 to 30 types of invertebrate species (Ruppert and Fox 1988), with the most identifiable being mole crabs, ghost crabs, and coquina clams (*Donax variabilis*). Both mole crabs and coquina clams are a primary prey base for fish, crabs, and shorebirds, and the population density of some predators may actually be dependent on the availability these invertebrate species (Green 2002). Other invertebrates within the Seashore beach ecosystem include clamworms (*Nereis succinea*), limpets (*Patella vulgata*), which can be found in the intertidal zone, and varieties of jellyfish sea urchins and sea stars (class Asteroidea), all of which spend their entire lives in the water.

Ghost crabs are sand-colored, terrestrial animals with square-shaped bodies, which are generally no more than 2 to 3 inches wide (Lippson and Lippson 1997). Ghost crabs are a top predator of the beach ecosystem and can be used as an indicator species to analyze the health of the beach ecosystem, due to their prominence and high susceptibility to anthropogenic disturbances (Hobbs et al. 2008). They are primarily nocturnal and create burrows for shelter from heat and desiccation (drying) stress during the warmer afternoon periods. Burrows are usually 0.6 to 1.2 meters in length and are generally located in an area from the high-tide line landward up to 400 meters. Ghost crabs emerge from their burrows at night to feed in the intertidal zone, and travel up to 300 meters while foraging (Hobbs et al. 2008). Ghost crabs retreat deep into their burrows during the winter months (Lippson and Lippson 1997).

Like ghost crabs, mole crabs are a common inhabitant of the high-energy, exposed beach environment. In contrast to other species of crabs, they do not have claws or pincers. Mole crabs are generally less than 2 inches in length and have egg-shaped bodies that allow for rapid digging in wet sand (Ruppert and Fox 1988, 251). Mole crabs are filter feeders that burrow and anchor themselves into the sands within the swash zone, collecting organic matter that they trap within their feeding antennae when water recedes over the buried crabs. Unlike ghost crabs, mole crabs move off the beach to deeper offshore waters during the winter (Lippson and Lippson 1997).

Marine bivalves such as oysters (*Crassostrea virginica*), razor clams, coquina clams, and ribbed mussels (*Geukensia demissa*) also inhabit the Seashore, forming the diet for many birds. Clams characteristically lie buried just beneath the surface of the sand, although they can burrow to greater depths as necessary. Much like the mole crab, coquina clams are filter feeders and migrate up and down the ocean beach in the intertidal area during the spring and summer (Ruppert and Fox 1988). Due to its importance in food webs, the coquina clam is considered an indicator species for the sandy beach oceanfront habitat. It feeds on small particles such as unicellular algae and detritus and in turn, is consumed by fish and birds (SCDNR 2009).

In addition to the intertidal zone, another important habitat for invertebrates is the wrack line. A wrack line is a line of stranded debris along a beach face marking the point of maximum run-up during a previous high tide. The wrack line is often composed of drying seaweed, tidal marsh plant debris, decaying marine animals, shells, and miscellaneous debris washed up and deposited on the beach. The wrack line provides a habitat suitable for many invertebrates such as amphipods, beetles, mites, flies, and spiders. Studies have demonstrated that ORV use in and around the wrack line reduces the density of invertebrates in beach environments. (sidebar: photos of beach zones, intertidal zone, wrack line)

A 3-year study on Cape Cod and Fire Island, New York (Kluft and Ginsberg 2009), found that the shrimp-like crustaceans called amphipods are particularly vulnerable to drying out in immature stages, and use the wrack line as cover. Several species of flies also use the site to lay their eggs, and wolf spiders (family Lycosidae) migrate back and forth from the beach grass to the wrack line to feed on these amphipods. The study observed that higher ORV traffic resulted in dispersal and desiccation of the wrack line, thereby reducing the populations of invertebrates in these areas. (sidebar: amphipods)

OTHER BIRD SPECIES

The Outer Banks of North Carolina provide a critical link in the migratory path of several shorebird species. The barrier island ecosystems at the Seashore provide habitat for large numbers of migratory and nesting bird species, and coastal marshes are critical to wintering populations of many waterbirds. Nearly

400 species of birds have been sighted within the Seashore and its surrounding waters (Fussell et al. 1990). Migration routes for many raptor species include southeastern barrier islands. Thousands of migrating shorebirds use the barrier islands as a stopover point to rest, forage, or spend the winter (Manning 2004). In 1999, the American Bird Conservancy designated Cape Hatteras National Seashore as a Globally Important Bird Area in recognition of the Seashore's value in bird migration, breeding, and wintering (NPS 2004d).

Studies have recorded 21 species of shorebirds (table 18) on the beaches of the Outer Banks of North Carolina, such as whimbrels (*Numenius phaeopus*), willets (*Catoptrophorus semipalmatus*), and sanderlings (*Calidris alba*). These shorebirds are most abundant in May and August. Least terns, common terns, gull-billed terns, black skimmers, piping plovers, Wilson's plovers, willets, and American oystercatchers can all be found nesting on North Carolina beaches (North Carolina Audubon 2008). Several of these species are designated as state-listed and/or federally listed threatened or endangered species and are discussed in a previous section of this chapter. However, nonlisted shorebirds such as willets have similar nesting and foraging habitats to those of state- and federally listed species. The eastern willet, for instance, breeds in coastal salt marshes and nests on the ground, often in colonies, usually in well-hidden locations in short grass. These birds forage on mudflats or in shallow water, probing or picking up food by sight. Their diet consists of insects, crustaceans, and marine worms, as well as some plant material. Although not state or federally listed, several of the shorebirds found at the Seashore appear on the USFWS Birds of Conservation Concern list, which identifies migratory birds that, without additional conservation actions, are likely to become candidates for listing under the ESA (USFWS 2008b). Other waterbirds found at the Seashore include gulls, pelicans (*Pelecanus* spp.), terns, and egrets (family Ardeidae) (NCWRC 2005).

Migratory birds are often found at the Seashore throughout the year. During the winter months, the common loon (*Gavia immer*), pied-billed grebe (*Podilymbus podiceps*), northern gannet (*Morus bassanus*), tundra swan (*Cygnus columbianus*), and Canada goose (*Branta canadensis*) are common sights at the Seashore. During the summer migratory season, several varieties of herons (*Ardea* spp.), Audubon's shearwater (*Puffinus lherminieri*), and the barn swallow (*Hirundo rustica*) populate the Cape Hatteras shores. While less frequently sighted, grebes (*Podiceps auritus*), mallard ducks (*Anas platyrhynchos*), hawks (genus *Accipiter*), bald eagles (*Haliaeetus leucocephalus*), peregrine falcons, and various species of sandpipers also inhabit the Seashore at one point or another throughout the year. Studies have demonstrated the importance of the Outer Banks as a staging area for piping plovers, whimbrels, and sanderlings when compared to other areas along the Atlantic Coast and confirmed that the area provides a critical link in the migratory path of several shorebird species (Dinsmore et al.1998).

TABLE 18. SHOREBIRDS ON THE OUTER BANKS OF NORTH CAROLINA, 1992–1993

Scientific Name	Common Name
Pluvialis squatarola	Black-bellied plover
Charadrius wilsonia	Wilson's plover
Charadrius semipalmatus	Semipalmated plover
Charadrius melodus	Piping plover
Haematopus palliatus	American oystercatcher
Catoptrophorus semipalmatus	Willet
Numenius phaeopus	Whimbrel
Limosa fedoa	Marbled godwit
Arenaria interpres	Ruddy turnstone
Calidris canutus	Red knot
Calidris alba	Sanderling
Calidris pusilla	Semipalmated sandpiper
Calidris mauri	Western sandpiper
Calidris minutilla	Least sandpiper
Calidris alpine	Dunlin
Limnodromus griseus	Short-billed dowitcher
Charadrius vociferus	Killdeer
Tringa melanoleuca	Greater yellowlegs
Tringa flavipes	Lesser yellowlegs
Actitis macularia	Spotted sandpiper
Calidris fuscicollis	White-rumped sandpiper

Source: Dinsmore et al. 1998.

SOUNDSCAPES

According to the NPS, the acoustical environment is comprised of a combination of acoustic resources, including natural, cultural and historic sounds. A soundscape is defined as the way in which humans perceive this acoustic environment (NPS 2009x). Specifically, the natural soundscape encompass all of the natural sounds that occur in parks, including the physical capacity for transmitting those natural sounds and the interrelationships among park natural sounds of different frequencies and volumes (NPS Management Policies 2006 [NPS 2006f, sec 4.9]). Natural sounds may range from bird calls, insect chirps, and bats to sounds produced by physical processes like wind rushing through leaves on trees, thunder, and rushing and falling water through rivers, creeks and streams within a park. According to the

NPS, 72% of visitors indicate that a crucial reason for the need to preserve national parks is that parks provide opportunities to experience natural peace and the sound of nature (NPS 2009x). Therefore, the NPS works to preserve, to the greatest extent possible, the natural soundscapes of parks.

NOISE FUNDAMENTALS

According to the National Park Service, "although *noise* has been used as a synonym for sound, it is essentially the negative evaluation of sound by people, is extraneous, or undesired. Humans perceive *sound* as an auditory sensation created by pressure variations that move through a medium such as water or air and is measured in terms of amplitude and frequency" (NPS, 2009x). Sources of noise within national parks are dependent upon the particular park and may include vehicular sources (cars, buses, or other vehicles) used for tours and access to trails and campgrounds, aircraft overflights from planes, helicopters and military jets along with airport development, snowmobiles and watercraft, park operations and energy development (NPS 2009xxx).

The magnitude of noise is usually described by its sound pressure. Since the range of sound pressure varies greatly, a logarithmic scale is used to relate sound pressures to some common reference level, usually the decibel (dB). Sound pressures described in decibels are called sound pressure levels and are often defined in terms of frequency-weighted scales (A, B, C, or D).

The A-weighted decibel scale is commonly used to describe noise levels because it reflects the frequency range to which the human ear is most sensitive (1,000-5,000 Hertz) (CALTRANS 1998). Sound levels measured using an A-weighted decibel scale are generally expressed as dBA. Throughout this section, all noise levels are expressed in dBA. Several examples of sound pressure levels in the A-weighted (dBA) scale are listed in table 19 while table 20 presents examples of sound pressure levels measured in national parks.

TABLE 19
EXAMPLES OF COMMON SOUNDS

A-weighted Sound Level (dBA)	Overall Level	Noise Environment
120	Uncomfortably loud (32 times as loud as 70 dBA)	Military jet airplane takeoff at 50 feet
100	Very loud (8 times as loud as 70 dBA)	Jet flyover at 1000 feet Locomotive pass-by at 100 feet
80	Loud (2 times as loud as 70 dBA)	Propeller plane flyover at 1000 feet. Diesel truck 40 mph at 50 feet
70	Moderately loud	Freeway at 50 feet from pavement edge at 10 a.m. Vacuum cleaner (indoor)
60	Relatively quiet (1/2 as loud as 70 dBA)	Air condition unit at 100 feet. Dish washer at 10 feet (indoor)
50	Quiet (1/4 as loud as 70 dBA)	Large transformers Small private office (indoor)
40	Very quiet (1/8 as loud as 70 dBA)	Birds calls. Lowest limit of urban ambient sound
10	Extremely quiet	Just audible (1/64 as loud as 70 dBA)
0		Threshold of hearing

Source: Federal Agency Review of Selected Airport Noise Analysis Issues, 1992.
Modified by: The Louis Berger Group, Inc., Oct. 1998.

TABLE 20
SOUND PRESSURE LEVELS MEASURED IN NATIONAL PARKS

Sound	dBA
Threshold of human hearing	0
Haleakala NP: Volcano crater	10
Canyonlands NP: Leaves rustling	20
Zion NP: Crickets (5 m)	40
Whitman Mission: Conversational speech (5 m)	60
Yellowstone NP: Snowcoach (30 m)	80
Arches NP: Thunder	100
Yukon-Charley Rivers NP: Military jet (100 m AGL)	120

Source: NPS 2009xx

HUMAN AND WILDLIFE RESPONSE TO CHANGES IN NOISE LEVELS

Noise may have adverse effects on the human population in a variety of ways. Noise may interfere with human activities, such as sleep, speech communication, and tasks requiring concentration or coordination. At a physiological level, noise may also cause annoyance, hearing damage, and other health-related problems. The degree of disturbance from unwanted sound depends essentially on: 1) the amount and nature of the intruding noise; and 2) the type of activity occurring where the noise is heard. In considering the first of these factors, it is important to note that individuals have different sensitivity to noise. Loud noises bother some people more than others, and some patterns of noise also affect a person's perception of whether or not a noise is offensive. With regard to the second factor, individuals tend to judge the annoyance of noise relative to the natural sounds (i.e. without the intruding noise source) and activities occurring where the noise is heard. For example, if regions of a park are dedicated to enjoying the tranquility and serenity of the natural environment, sounds from motor boating and hunting would be distracting to the visitor experience. However, if these activities are consistent with the purpose of a particular region of the park, these sounds would be considered appropriate. Therefore, noise is a subjective term, and it is important to characterize the activities essential to the park's purpose (NPS 2000).

It is widely accepted that the average healthy ear can barely perceive noise level changes of 3 dBA or less. A change of 5 dBA is readily perceptible and an increase or decrease of 10 dBA is perceived as being twice or half as loud, respectively (see table 21).

TABLE 21
DECIBEL CHANGES, LOUDNESS AND ENERGY LOSS

Sound Level Change	Relative Loudness	Acoustic Energy Loss
0 dBA	Reference	0.0%
- 3 dBA	Barely Perceptible Change	50.0%
- 5 dBA	Readily Perceptible Change	67.0%
- 10 dBA	Half as Loud	90.0%
- 20 dBA	1/4 as Loud	99.0%
- 30 dBA	1/8 as Loud	99.9%

Source: FHWA Highway Traffic Noise Analysis and Abatement Policy and Guidance, 1995.

In addition to its effect on humans, studies have shown that intrusive and other human-induced noises can result in adverse physiological and behavioral changes in wildlife communities; however the severity of impacts is dependent upon the particular species. For example, some sound sources have been associated with increased stress levels as well as suppression of the immune system in wildlife. Additionally, increases in ambient noise levels may interrupt important communication networks for survival and reproduction between insects, birds and mammals. Specifically, wildlife communications may signify mating calls, danger from predators, and territorial claims (NPS 2009xxxx). An increase in ambient noise levels from the presence of intrusive noise sources may also reduce the listening area over which predators can hear their prey as well as reduce the distance at which prey can begin to hear their predators (F. Turina and R. Stanley, NPS, pers. Comm., 2009).

EXISTING SOUND LEVELS

The presence of millions of visitors to the Seashore engaging in various activities, coupled with the vehicular traffic through this park along NC-12 and associated ramps, including ORV usage on the beaches, serve as sources of unnatural sounds within this park. However, these sources are also considered to be consistent with the park's purpose.

In order to determine the natural ambient sound levels within the park and characterize the natural soundscape, the NPS Natural Sounds Program assisted the Seashore to conduct acoustical monitoring within the park. The sound level data collected by the Natural Sounds Program will facilitate the estimation of noise impacts from the use of ORV, serving as a comparative baseline condition to ORV noise.

A summary report of the sound level measurements, known as an "Acoustical Monitoring Snapshot," was developed by the NPS Natural Sounds Program and includes the locations of two representative sites where measurements were conducted, as well as a brief vegetative description for the sites and measured sound levels. The measured sound levels represent exceedance levels (L_x) that describe the measurement data in terms of the decibel level that is exceeded x percent of the time during a given measurement period (i.e. an L_{10} value of 55 dBA indicates that the sound level is 55 dBA for 90% of the measurement and exceeds this level 10% of the measurement period). As the NPS is required to protect the natural soundscape, impact assessment is based on comparisons against the natural ambient sound levels. Natural ambient sound levels represent the natural environment, absent human cause sounds and may be well estimated based on the L_{90} metric. The L_{90} metric represents the sound level exceeded 90 percent of the time.

Sound level measurements were conducted at two sites over a period of 31 days between May 2008 and June 2008. Sound level data was collected during a daytime (7:00 AM to 7:00 PM) and nighttime (7:00 PM to 7:00 AM) period. Monitors were placed in secure locations, away from traffic and the beaches.

Site one, labeled CH1 (figure 18), was located on Bodie Island Bone Yard just north of the fishing center and west of NC-12 on the side of the island near the sound. The site is comprised of woody wetlands and mixed forest. Daytime existing L_{90} sound levels are 33.6 dBA while nighttime L_{90} sound levels are 33.8 dbA. Site CH2 (figure 19) is located at Cape Point on the ocean side within woody wetlands and shrublands. Existing L_{90} sound levels are 33.4 dBA during the daytime and 41.0 dBA during the nighttime period.

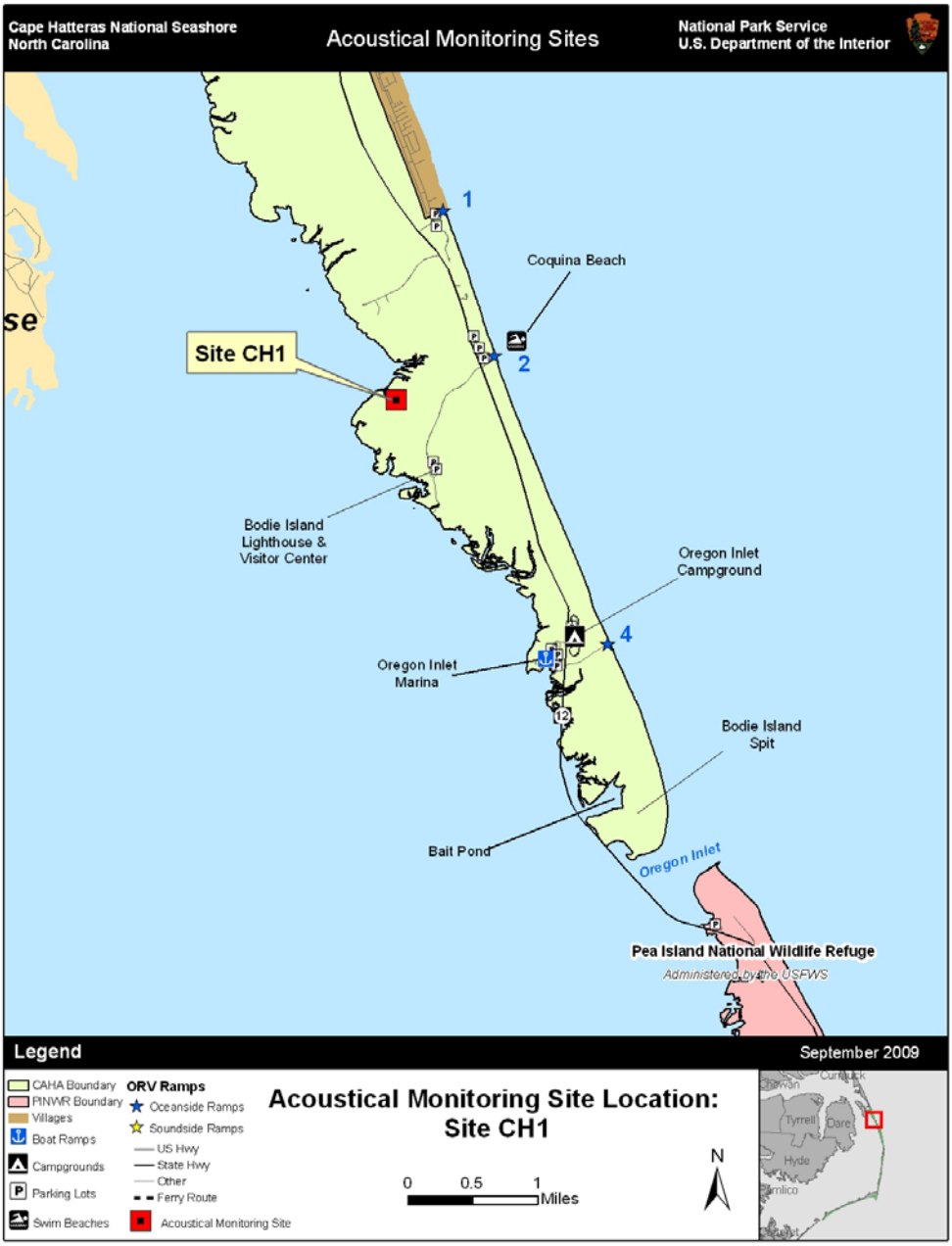


FIGURE 18: ACOUSTICAL MONITORING SITE LOCATION FOR CH1

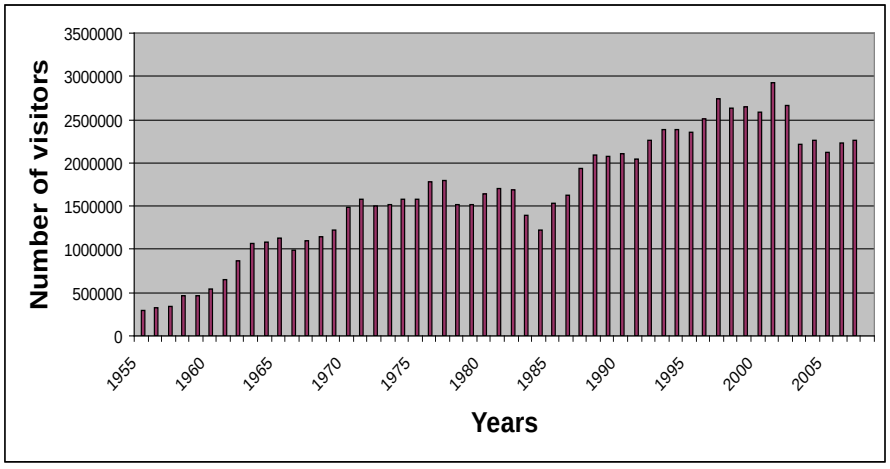
FIGURE 19: ACOUSTICAL MONITORING SITE LOCATION FOR CH2

[Preparers Note: Text to be inserted about why measurements were not conducted on the beach itself, when received from the Sounds Program]

As noise from the surf is a predominant natural sound source along the beaches within this park, the NPS Natural Sounds Program also provided published information on surf sounds to further characterize the natural soundscape within The Seashore. Sounds from the surf vary depending on how active the surf is (i.e. during high tide or stormy conditions the surf has more acoustic energy), and therefore sound levels may range between 20 dBA during less active periods and 55 dBA during more active periods (F. Turina and R. Stanley, NPS, pers. Comm., 2009). Additionally, surf noise is predominant on the beaches, but diminishes with increasing distance from the beaches, where vehicular noise sources may prevail from NC-12 and associated ramps and smaller feeder roadways.

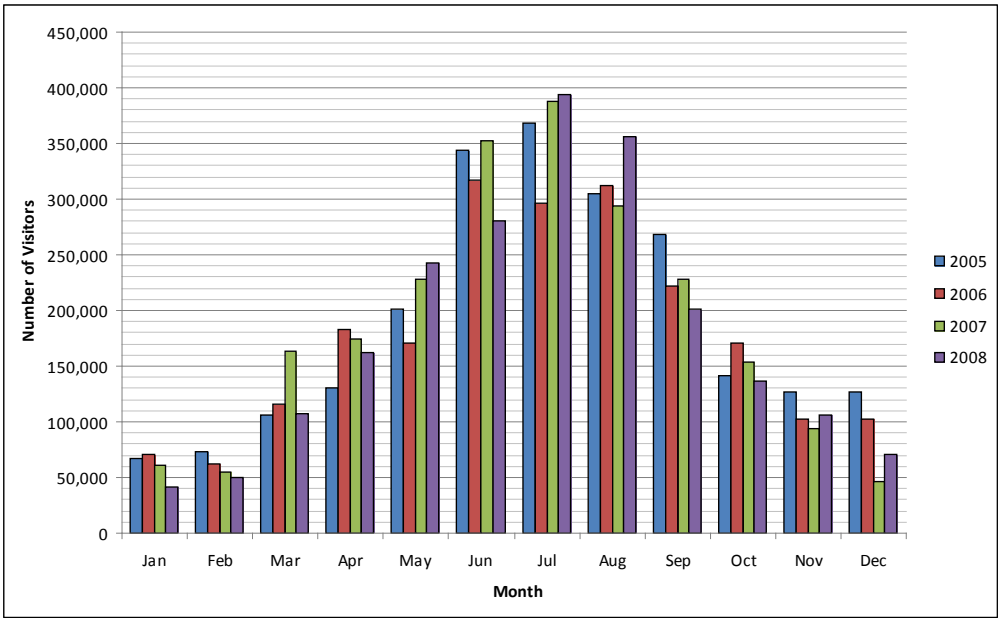
VISITOR USE AND EXPERIENCE

Visitation to the Seashore has shown a relatively steady increase, with occasional dips, particularly in the mid-1980s and recently from 2003 to the present. More than 2 million visitors have recreated at the Seashore every year since 1990 (see figure 20). Figure 21 illustrates visitor use data for 2005 through 2008, which indicate that highest use occurs during June, July, and August; this accounts for approximately 46% of the annual recreation visits (based on 2007 data). Another 21% of annual visitation occurs during the fall (September, October, and November), 25% in the spring (March, April, and May), and 7% in the winter (December through February) (NPS 2008f).



Source: NPS 2008f.

FIGURE 20. ANNUAL VISITATION STATISTICS AT CAPE HATTERAS NATIONAL SEASHORE, 1955–2008



Source: NPS 2008F

FIGURE 21. MONTHLY VISITATION FIGURES FOR CAPE HATTERAS NATIONAL SEASHORE, 2005–2008

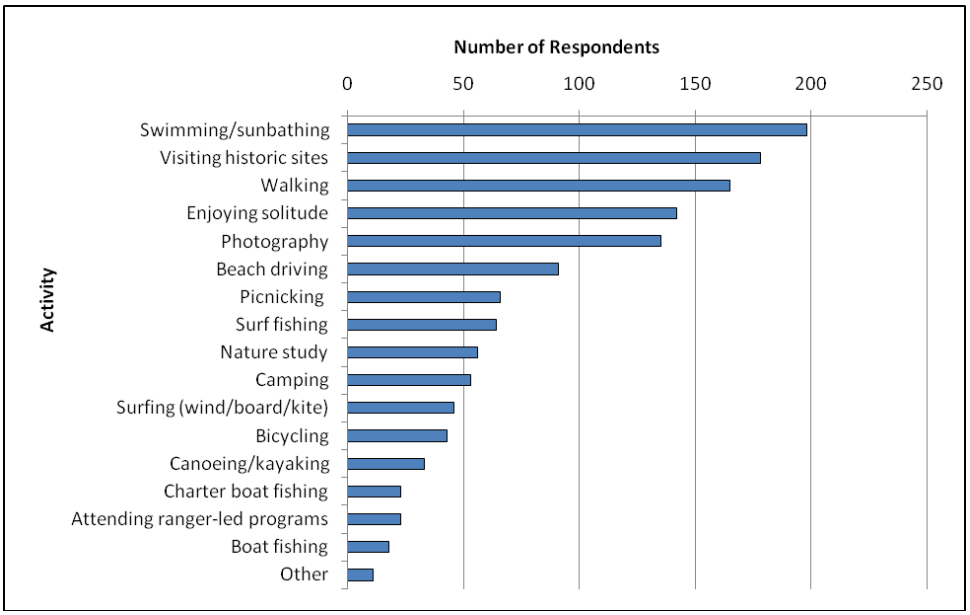
VISITOR CHARACTERISTICS

A study conducted by the University of Idaho during 1 week in July 2002 showed that many visitors (44%) were from North Carolina and Virginia, approximately 10% were from Ohio, and smaller proportions of visitors came from 29 other states and Washington DC. Over 50% of visitors were between 30 and 50 years of age (University of Idaho 2003).

RECREATIONAL OPPORTUNITIES AND USE AT CAPE HATTERAS NATIONAL SEASHORE

The Seashore provides a diverse range of recreational opportunities including auto touring, biking, bird-watching, boating, camping, fishing, hiking, hunting, kayaking, taking nature walks, horseback riding, stargazing, swimming, wildlife viewing, surfing, kite boarding, and wind surfing. According to the study conducted by the University of Idaho in 2002, the three most important reasons mentioned by visitors for visiting the Seashore were the lighthouses, the beach/beachcombing, and fishing. Historical significance and swimming followed closely (University of Idaho 2003). This study also asked visitor groups to list

the activities in which they participated during their visit to the Seashore. The results are displayed in figure 22. Other activities that respondents participated in included viewing the "Lost Colony" play, family time/reunion, clamming/crabbing, shelling, shopping, and history study.



Source: University of Idaho 2003.

FIGURE 22: VISITOR ACTIVITIES SURVEY RESULTS

Major developed facilities, such as visitor centers and campgrounds, as well as more informal visitor use areas at the Seashore that provide for these recreational activities, are shown on the Seashore map in the "Purpose and Need" chapter. Visitor centers are located on each island in association with Ocracoke, Cape Hatteras, and Bodie Island lighthouses, and campgrounds include Ocracoke, Frisco, Cape Point, and Oregon Inlet. Fishing piers are located near Frisco and at Avon and Rodanthe on Hatteras Island, and a major marina is located at Oregon Inlet on Bodie Island. Bathhouses and/or designated swimming beaches are available near Frisco on Cape Hatteras Island, Coquina Beach on Bodie Island, and on Ocracoke Island north of the village. Information stations, day use areas, and informal recreation opportunities, such as nature trails, are also found throughout the Seashore.

RECREATIONAL FISHING

The cold Labrador Current and the warm waters of the Gulf Stream meet adjacent to the Outer Banks of North Carolina. The waters off the Seashore are known throughout the world as highly productive fishing areas. The fish that congregate in the waters off the Outer Banks attract anglers from throughout the

region, but largely from North Carolina and Virginia. In the spring and fall, when bluefish (*Pomatomus saltatrix*), spotted sea trout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), and other species are present in offshore waters, surf fishermen line the beaches to cast their baits and lures over the incoming breakers and into the schooling fish. Most of the beach and sound are open to fishing as are the fishing piers in the villages of Rodanthe, Frisco, and Avon. NPS boat ramps are located at the Oregon Inlet Marina and near the ferry office in Ocracoke village. Charters and head-boat services (boats that carry a large number of anglers who pay by the person) are available at local marinas.

Particularly productive and high-demand fishing areas include Ocracoke, Hatteras and Oregon inlets, and Cape Point, which are often accessed via ORVs. ORV counts at ramps accessing these inlets exceeded those of other beach access ramps. This use is discussed in the "Off-Road Vehicle Use and Access" section that follows below.

Typically, fishing tournaments occur in the spring and fall in locations throughout the Seashore, as shown in table 22. Tournament data from 2001 to 2008 indicate that, normally, about eight or nine fishing tournaments occur annually (S. Thompson, NPS, pers. comm., 2008). While data are not available for actual attendance, the fall events are well attended. For 2005, estimates indicate that more than 720 people participated in one event that lasted for 2 days. Some tournaments may only have 25 participants, depending on the availability of fish and weather. Restrictions are placed upon the events as to location and times to ensure the availability of recreational areas for other Seashore visitors. These restrictions change from time to time depending on the time of the year, seasonal visitation figures, past experience with the sponsors, and how the proposed event is structured. Typically, Seashore beaches 0.5 mile on either side of Cape Point and 0.5 mile on either side of an inlet are closed to tournament fishing.

Like other Seashore visitors, tournament participants are not allowed in any resource closure areas. Tournaments take place in the designated ORV corridor, which has presented conflict with recreational anglers during the tournaments on a few occasions (NPS 2006e).

TABLE 22. FISHING TOURNAMENTS, 2004–2008

Applicant/Event	Tournament Date	# People Authorized	Tournament Location within the Seashore
4 Plus Four Wheel Drive Club	Late April from 2004 to 2008	600	Ocean beaches excluding 0.5 mile either side of Cape Point, 0.5 mile from Hatteras Inlet and Ocracoke Inlet, and 0.5 mile on the north side of Oregon Inlet
Ocracoke Invitational Surf Fishing Tournament	Late April/early May from 2004 to 2008	240	Ocean beach between Ramps 68 and 72
Outer Banks Association of Realtors	5/20/2005	150	Ocean beach from Coquina Beach to Ramp 4
Hatteras Village Invitational	Early September from 2006 to 2008	540	Hatteras Island
Hatteras Village Civic Association	9/10/2004 9/9/2005	240	Ocean beaches on Hatteras Island open to 4×4 vehicles from Ramp 43 south and west to 0.5 mile from Hatteras Inlet, but excluding 0.5 mile either side of Cape Point
Salt Water Grill	9/28/2008	120	Bodie Island
Nags Head Surf Tournament	Early October from 2004 to 2008	240	Ocean beach from Coquina Beach to Ramp 4
FFFF Tournament	Early October from 2006 to 2008	120	Bodie Island
Capitol City Four Wheelers	Mid-October from 2004 to 2008	600	Ocean beaches excluding 0.5 mile either side of Cape Point, 0.5 mile from Hatteras Inlet, and all areas closed to vehicular access including ramps temporarily closed due to flooding
Outer Banks Association of Realtors	Mid-October from 2006 to 2008	240	Bodie Island
Red Drum Tournament	10/24/2007 10/22/2008	600	Parkwide
Cape Hatteras Anglers Club	11/4/2004 11/3/2005	600	Public ocean beaches excluding 0.5 mile either side of Cape Point, 0.5 mile from Hatteras Inlet and Ocracoke Inlet, and 0.5 mile on the north side of Oregon Inlet; also excluding 0.2 mile on either side of Ramps 1, 4, 23, 27, 30, 34, 43, 49, and 55, and the beaches of Pea Island National Wildlife Refuge
Cape Hatteras Anglers Club	11/8/2007 11/6/2008	720	Hatteras Island
Outer Banks Angler	11/30/2007 12/5/2008	600	Parkwide
Surf Fishing Info.	12/2/2005	240	Ocean beaches excluding 0.5 mile either side of Cape Point, 0.5 mile from Hatteras Inlet and Ocracoke Inlet, 0.5 mile on the north side of Oregon Inlet, and other closures ordered by the Seashore

Source: S. Thompson, NPS, pers. comm., 2008.

Off-Road Vehicle Use and Access

As noted in the "Purpose and Need" section, before 1954, local residents and visitors used the beaches and sound trails for vehicular transportation purposes because there were few formal roads in this remote area. With the paving of NC-12, the completion of the Bonner Bridge connecting Bodie and Hatteras islands, and the introduction of the North Carolina Department of Transportation Ferry System to Ocracoke Island, visitor access to the islands resulted in increased vehicle use on beaches for recreational purposes. ORVs were used by residents to facilitate commercial netting of fish, and sport fishermen used ORVs to pursue migrating schools of game fish and to reach more productive areas such as Cape Point or the inlets, which are often a mile or more from the nearest paved surface. ORVs are currently used at the Seashore for commercial and recreational fishing, sightseeing, travel to and from swimming and watersport areas, and pleasure driving (NPS 2004b).

ORVs access the beach via a system of ramps located off NC-12. This vehicular beach access ramp system provides controlled entry and exit to beach areas. Originally, planks were placed on the dune crossing site to prevent the sand from moving and to prevent the dune from being further breached. The ramps began as an informal system of unimproved access points connecting the roadway to the beaches. Over time, this system was formalized and ramps are now numbered, maintained, and identified on the Seashore's ORV route maps as official vehicle routes for beach access. In 1978 there were 28 identified ramps, 22 of which were located on NPS lands. Although the NPS opened a new ramp to the public in 1998, the number of ramps has decreased since 1978 as some were lost to erosion and others were closed to the public and are now used for administrative vehicle access only (NPS 2004a). The NPS currently has 17 oceanside access ramps available for public ORV use. These ramps are listed on table 23. Each ramp number on the map (figure 23) refers to the approximate mile on NC-12 south of Nags Head on Bodie Island.

TABLE 23. OCEAN BEACH ACCESS

Ramp	Open to Public Use
Ramp 2 (Coquina)	Seasonal
Ramp 4	Year-round
Ramp 23	Year-round
Ramp 27	Year-round
Ramp 30	Year-round
Ramp 34	Year-round
Ramp 38	Year-round
Ramp 43	Year-round
Ramp 44	Year-round
Ramp 45	Year-round
Ramp 49	Year-round
Ramp 55	Year-round
Ramp 59	Year-round
Ramp 67	Year-round
Ramp 68	Seasonal
Ramp 70	Year-round
Ramp 72 (South Point Road)	Year-round

Source: http://www.nps.gov/caha/planyourvisit/googleearthmap.htm

1

2

FIGURE 23: OFF-ROAD VEHICLE RAMPS AT CAPE HATTERAS NATIONAL SEASHORE

Number and Distribution of ORVs at the Seashore

From 2007–2008, the Seashore installed infrared counters at ORV ramps to determine the number of ORVs using the Seashore as well as their distribution in the park. However, in addition to counting ORVs, the counters were found to count anything that breaks the infrared beam, including pedestrians, rain, and untrimmed plants. The counters also fail to register some counts, and must be properly aligned

to count. Testing showed that the ramp counters overestimated the number of ORVs substantially and that pedestrian crossings often added to the inaccurate counts. For these reasons, the data from the ramp counters were deemed not reliable for constructing estimates of ORV use at the seashore (RTI 2009a).

On Memorial Day and the Fourth of July, the Seashore counts the number of ORVs on the beach by an aerial survey. Research Triangle International (RTI) (2009a) used this information, along with assumptions based on rental occupancy and patterns of use, to create a range of estimates for the total number of ORVs using the Seashore in a year. Based on their analysis, the annual ORV-use estimate is 100,000 to 395,000. Appendix X provides the analysis and assumptions used to derive this estimate**.**

[Preparer's Note: Berger to work with RTI to provide this information as an appendix.]

The data from the aerial counts were used to provide counts for ORVs at the following locations, which include some of the most popular ramps leading to the points and spits:

- Ramp 4: Includes Bodie Island Spit
- Ramp 23 to Ramp 27: Approximately 4-mile area directly south of Salvo
- Ramp 27 to Ramp 38: Approximately 11 mile area including Avon
- Ramp 43 to Ramp 49: Includes Cape Point
- Ramp 55: Includes Hatteras Inlet Spit
- Ocracoke: All of Ocracoke Island

Figure 24 shows the distribution of ORVs across these areas on Memorial Day and the Fourth of July in 2008. About 75% of the ORVs counted on those days were located around the points and spits (including all of Ocracoke as one count); over half of the ORVs were located around Cape Point and the Bodie Island Spit.

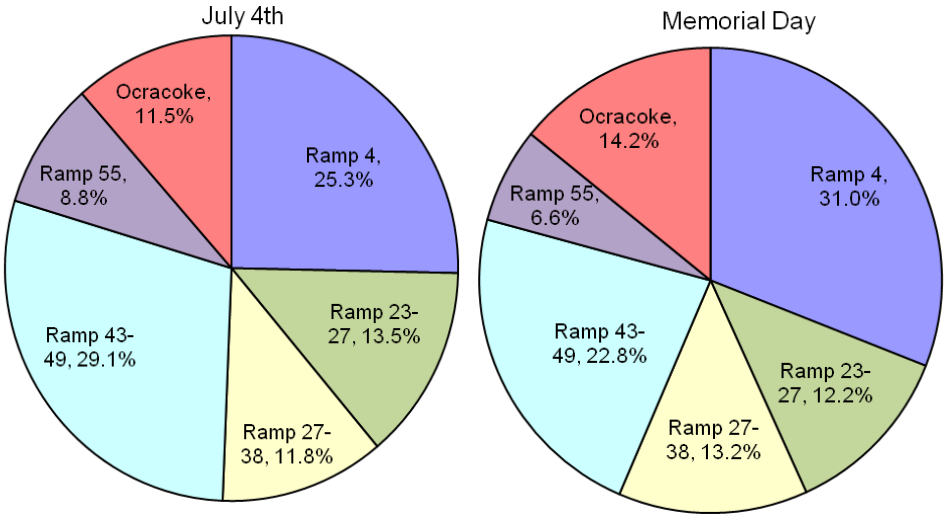


FIGURE 24. ORV DISTRIBUTION BASED ON AERIAL COUNTS, FOURTH OF JULY AND MEMORIAL DAY 2008

Closures. A number of areas throughout the Seashore have been closed to ORV travel for many years, either due to safety issues or for resource protection purposes. Temporary closures to ORVs also occur along the beaches to protect sea turtles and bird species such as piping plovers, American oystercatchers, and colonial waterbirds. The Seashore contains approximately 68 miles of shoreline that are available for public use, when not closed for resource or safety concerns. The 13 miles of beach that comprise Pea Island National Wildlife Refuge are within the Seashore boundary and are managed separately and under a different regulatory framework by the USFWS; ORVs are not permitted on Pea Island.

Currently, all the Seashore beaches are potentially open to ORV use during the winter, except a section near the Cape Hatteras Lighthouse (which is closed year-round), and those beaches under a safety closure. Some beaches are also closed to ORV use if they become too narrow. During the summer months, the amount of Seashore beach open can vary depending on resource closures, as detailed in "Chapter 2: Alternatives." On the soundside, 18 access points are publicly available to ORVs. However, vehicular access is limited on the soundside because the Seashore prohibits ORV use on vegetated areas, and most of the soundside areas have vegetation. Closures vary from year to year depending on a range of management considerations.

Following Hurricane Isabel, ORV-use areas (restrictions) were put in place in March 2004 to protect sensitive habitat that opened up as a result of dune destruction and to provide for more consistent management of breeding and nesting bird closures. These closures did not decrease the sum total of shoreline miles open to ORV access and public recreation nor did it impact the number of ramps open to

allow ORV access to Seashore beaches. White posts were placed 150 feet landward from the average, normal high-tide line, or, if existing, at the vegetation or remnant dune line. Beach areas landward of the post line, although not open to ORV use, are open to pedestrian use (NPS 2004b).

Temporary wildlife closures take place throughout the Seashore, including within areas of ORV and pedestrian use, to comply with protection measures afforded nesting sea turtles and protected shorebirds, particularly the piping plover. These closures are implemented at crucial periods during the life of these species. During these closures, the NPS routes ORV beach traffic around the temporary wildlife closure when possible. When full beach closures occur, ORV traffic may be temporarily rerouted around the landward side of the closure area to provide ORV access to open sections of beach. Temporary wildlife closures apply to both ORV and pedestrian use although occasionally pedestrian access will be allowed in pedestrian corridors.

Bird Closures. The open sand flats near the three inlets in the Seashore (Oregon, Hatteras, and Ocracoke) are used by protected bird species and are also favorite fishing areas that visitors access in ORVs. Piping plover, American oystercatcher, and colonial waterbird breeding activity has been documented on and near the ocean beach in all of these locations.

In 2005, a 0.1-mile "pass-through only" section of the ORV corridor was enforced at Bodie Island Spit, to reduce disturbance to plovers foraging at ephemeral pools close to the original corridor boundary. Pedestrians were not allowed in the pass-through zone. At Cape Point, a resource closure was created around a complex of ephemeral pools to protect an oystercatcher brood (the closure extended to approximately 50 feet from the edge of the pools). This closure was later used by a plover brood that hatched to the west. Cape Point was closed to ORVs after the plover brood moved to the ephemeral pool area. At South Ocracoke, the ORV corridor was narrowed in one place to protect a section of ocean intertidal zone where a pair of adult plovers was observed foraging on several occasions. ORVs were permitted to drive past the protected area in the backshore but were restricted from the shore of the sound (Cohen 2005a).

In 2005, at Hatteras Inlet Spit, ORV traffic was temporarily permitted only in the ORV corridor once per hour in convoys escorted by bird observers to reduce the risk of mortality to an oystercatcher brood and to reduce disturbance to an incubating plover nest. ORVs were permitted to park at the tip of the spit, west of the escort corridor. "Gatekeepers" were posted at each end of the escort route to assure that no unescorted ORVs entered the restricted area (NPS 2005b). The spit was closed to recreation at night. Once the plover eggs hatched, Hatteras Spit was closed to ORV traffic until the chicks fledged. The ORV escort program operated in the Hatteras Spit area south of the Pole Road from 7 a.m. until 8 p.m. daily

beginning on May 21, 2005, and ending on June 16, 2005 (27 days) (NPS 2006e). Pedestrian access through the escort area was also prohibited.

In 2005, temporary closures also occurred at multiple other beach locations to protect piping plovers, American oystercatchers, terns, and colonial waterbirds from ORV and pedestrian use. These closures occurred on all three islands but were most concentrated on Hatteras Island, followed by Ocracoke. The Interim Protected Species Management Strategy (Interim Strategy) was published in January 2006 and finalized by a FONSI in July 2007 (NPS 2007). The Interim Strategy presented a multifaceted approach that included including the establishment of pre-nesting closures, species protection buffers, wintering habitat protection, and temporary resource closures. The Interim Strategy did not include an escort system, but instead relied on alternate routes and bypasses to access points and spits while avoiding resource closures. Although the Interim Strategy established specific distances for species buffers, it allowed for the reduction or expansion of these areas based on professional judgment of the resource management staff. Species and recreational vehicle management under the Interim Strategy resulted in beach closures similar to those that occurred in previous years. However, management and closures would be altered by a lawsuit and subsequent consent decree in 2008.

In February 2008, Defenders of Wildlife and the National Audubon Society filed a lawsuit against the NPS alleging inadequacies in management of protected species at the Seashore under the Interim Strategy and failure of the Seashore to comply with the requirements of the ORV executive order and NPS regulations regarding ORV use. However, a consent decree was filed on April 16, 2008, in U.S. District Court (signed on April 30, 2008), whereby the parties involved in the lawsuit agreed to a settlement of the case. The most immediate effect of the consent decree was that it established a prohibition on night driving on beaches between the hours of 10 p.m. and 6 a.m. from May 1 through November 15. The consent decree also resulted in larger buffers than those prescribed in the Interim Strategy being established during portions of the spring and summer around bird breeding and nesting areas; this included creating a 1,000-meter (3,280-foot) vehicle perimeter and a 300-meter (984-foot) pedestrian perimeter around piping plover chicks until they have fledged. From May 15 through August 21, 2008, an average of 10 miles of oceanfront beach at the Seashore was closed to both pedestrians and ORVs. The largest amount of beach closures was reported on May 29, 2008, when 12.8 miles of beach were closed to all users to protect birds exhibiting breeding, nesting, and/or foraging behavior. (Insert photo of typical closures for birds and turtles)

Comment [bdm48]: Should we be consistent with the terminology in the consent decree and call it a buffer?

Sea Turtle Closures. Temporary closures to ORVs and pedestrians are implemented during nesting and hatching activities for all three sea turtle species that are known to nest at the Seashore. In May 2008, approximately 10.6 miles of the 66.4 miles at the Seashore were under resource closures, mostly for bird

nesting. Generally, ORVs and pedestrians can negotiate around these posted closures. However, when the turtle eggs are ready to hatch, the NPS implements a beach closure with fencing from the nest to the water's edge. If sufficient room exists, ORVs and pedestrians can go around the landward side of the fence. In some cases, a full beach closure must be implemented because of the location of a nest relative to a dune or vegetation preventing ORV and pedestrian access through the area. Of the 39 temporary closures established in 2005, full beach closures were required at 20 locations (NPS 2005d). As mentioned previously, the consent decree signed in April 2008 included a prohibition on night driving to protect nesting sea turtles. The consent decree also contains provisions for full beach closures in the fall to allow existing turtle nests to hatch safely.

Safety Closures. Areas normally open to ORVs may close for safety reasons. Adverse weather conditions can result in narrow beach areas or flooded conditions, among other hazards, necessitating closures to vehicles. In November 2005, safety closures included 1.6 miles on Bodie Island, 22.8 miles on Hatteras Island, and 6.5 miles on Ocracoke Island (P. Stevens, pers. comm., November 2005). However, from May 15 through August 21, 2008, safety closures throughout the season consistently included a total of 11.1 miles of beach (NPS 2008). Under current management, village beaches are closed in the summer to protect visitors during the busy summer season in areas such as Rodanthe, Waves, Salvo, Avon, Frisco, and Hatteras.

CROWDING, VISITOR ENCOUNTERS, AND VISITOR SAFETY

A University of Idaho study indicated that one of the reasons people visited the Seashore was to escape crowds and seek solitude. When asked about crowding, 27% of visitors said they felt "crowded" to "extremely crowded," while 43% of visitors felt "somewhat crowded." Thirty percent of visitors surveyed indicated that they felt "not at all crowded." Many visitor groups (49%) reported that crowding "detracted from" their park experience (University of Idaho 2003).

As part of the visitor experience, visitor safety is also considered. Public comment on this plan/EIS indicated that some visitors felt that there was a potential for conflicts between visitors on foot and visitors using ORVs. Park staff indicated that in the past 10 years, there are no known incidents of conflicts or incidents between visitors using ORVs and visitors not using ORVs; however, public comment indicated that the speed of ORVs on the beach and how close they drive to other park users is a concern.

There were also approximately three incidents on the beach where sand ledges had collapsed under a vehicle. These accidents did not result in park users being injured. In addition, there are approximately two submerged vehicles at the Seashore per year.

VISITOR SATISFACTION

To assist the NPS in complying with the Government Performance and Results Act (GPRA), a visitor survey was conducted by the University of Idaho Park Studies Unit for units of the NPS in FY08. The survey was developed to measure each park unit's performance related to NPS GPRA Goals IIa1 (visitor satisfaction) and IIb1 (visitor understanding and appreciation). Survey cards were distributed at the Seashore to a random sample of visitors from July 1 to July 31, 2008. The report included three categories of data: park facilities (which included visitor centers, exhibits, restrooms, walkways/trails/roads, and campgrounds/picnic areas), visitor services (assistance from park employees, park maps/brochures, ranger programs, and commercial services), and recreational opportunities (nature/history/cultural learning and outdoor recreation). Overall, the percentage of Seashore visitors satisfied with the facilities, services, and recreational opportunities was 95%. Individually, 93% of visitors were satisfied with park facilities, 85% of visitors were satisfied with visitor services, and 89% were satisfied with recreational opportunities (University of Idaho 2008).

In the 2002 University of Idaho study, the researchers solicited visitor opinions about selected factors that affect visitor experience. As would be expected, vehicles on the beach were perceived very differently by different visitors, but most stated that the use of vehicles on the beach did not detract from their visitor experience. The factors receiving the highest proportion of "no effect" ratings were airplane overflights (50% of those surveyed), dogs off leash (35%), vehicles on the beach (34%), and visitors drinking alcohol (33%). Factors receiving the highest proportion of "added to my experience" ratings included vehicles on the beach (20%) and fires on the beach (16%), while those receiving the highest "detracted from my experience" ratings were litter (40%) and vehicles on the beach (18%). About 29% of those surveyed did not experience vehicles on the beach (University of Idaho 2003).

Night Skies

The NPS defines a natural lightscape as "a place or environment characterized by the natural rhythm of the sun and moon cycles, clean air, and of dark nights unperturbed by artificial light. Natural lightscapes, including dark night skies, are not only a resource unto themselves, but are an integral component of countless park experiences" (NPS 2007b). The NPS created the Night Sky Team in 1999 to address increasing alarm over the loss of night sky quality throughout the network of national parks. The Night Sky Team functions as a center of expertise that provides advice, guidance, and technical support in characterizing and preserving park lightscapes (NPS 2007b). According to the Night Sky Team, the Seashore is one of only a handful of sites in the eastern United States with a nearly natural regimen of light and dark, where light patterns are made up primarily of the dark sky, moon, and stars (NPS 2008e).

In November 2007, the NPS Night Sky Team visited the Seashore to record preliminary measurements of night sky quality from three sites: the Bodie Island Maintenance Facility (Bodie Island); Boardwalk 27 (Hatteras Island); and the boardwalk south of Frisco (Hatteras Island) (NPS 2008e). During this visit, the team concluded that the Seashore has better night sky quality as compared to most other NPS units east of the Mississippi River. Furthermore, measurements showed that light pollution sources beyond the Seashore boundary illustrated the need to be aware of the easily impacted night skies (NPS 2008e).

Measurements of the night sky at the Seashore were taken with a CCD (charge-coupled device) camera (a scientific-grade digital camera) that captures the known magnitude (a measure of stellar brightness) of known stars as an index to determine the ambient brightness of the nighttime sky. These measurements are influenced by atmospheric conditions, which affect how light travels through the sky. To account for these changes, multiple measurements are taken over a period of time. The initial measurements at the Seashore occurred over two nights, with more planned in the future (NPS 2008e).

Results from the November 2007 measurements found that sky brightness ranged from approaching a natural level of darkness to significantly light polluted, with the potential to threaten the ecological health of the coastal environment in some areas (NPS 2008e). To address those areas where there are high levels of light pollution, the Night Sky Team recommended retrofitting or swapping existing light fixtures in favor of turtle-friendly and night-sky-friendly fixtures, as well as working with park neighbors to enact night sky measures such as lighting ordinances (NPS 2008e).

SOCIOECONOMIC RESOURCES

This section describes the social and economic environment that potentially would be affected by the proposed alternatives. The social and economic environment of a region is characterized by its demographic composition, the structure and size of its economy, and the types and levels of public services available to its citizens.

The socioeconomic environment evaluated for this EIS encompasses the Outer Banks portion of two counties in North Carolina – Dare and Hyde. Hatteras and Bodie Islands are part of Dare County while Ocracoke Island is within Hyde County. This area contains thirteen zip codes, eighteen of the nineteen block groups in Dare County, and one of the four block groups in Hyde County. (Sidebar: definition of block groups)

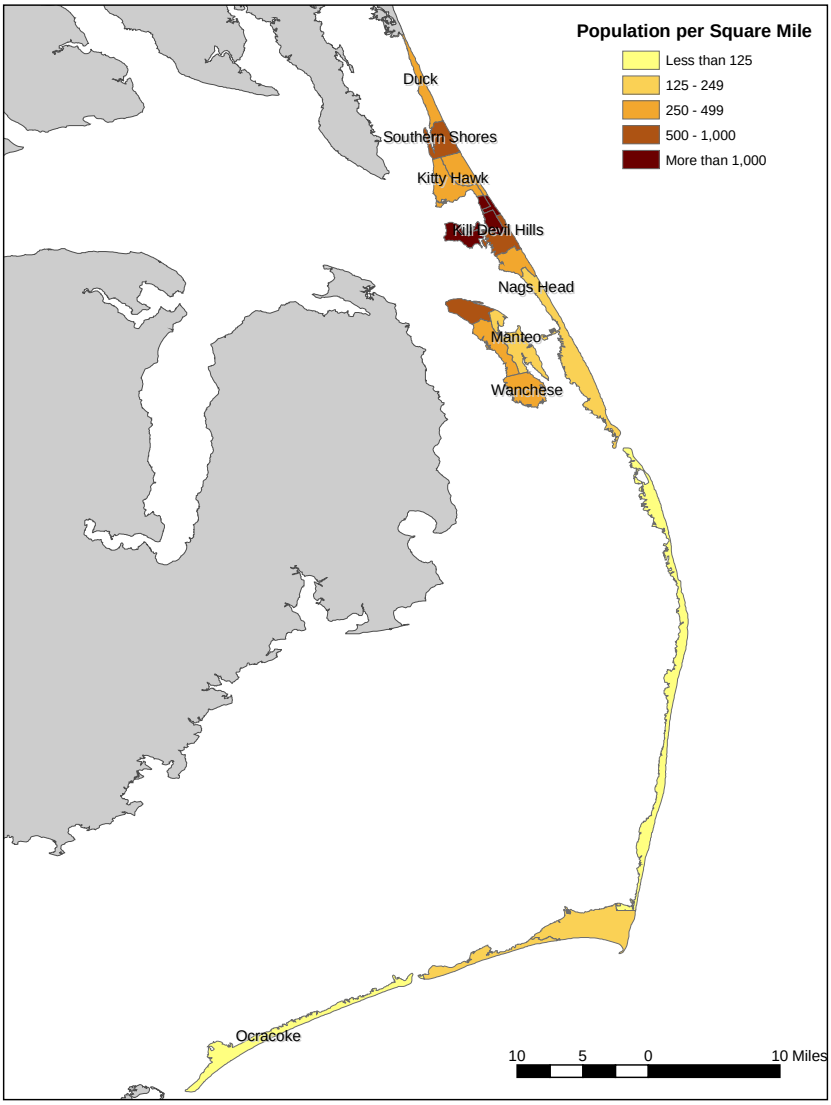
The Outer Banks portion of Dare and Hyde counties forms the economic region of influence (ROI) and defines the geographic area in which the predominant social and economic impacts from the proposed alternatives are likely to take place. The towns Ocracoke, Hatteras, Frisco, Avon, Buxton, Salvo, Waves, and Rodanthe will be most affected by the proposed actions because they are located within the Seashore.

The largest towns within the ROI include Nags Head, Kill Devil Hills, and Kitty Hawk, which are located on Bodie Island north of the Seashore. Data not available at the block group or zip code level will be reported at the county level.

DEMOGRAPHICS

The economic ROI is primarily rural in character, although portions of Dare County, especially in the north, are developed with large tracts of vacation homes and small businesses that support the area's robust tourism industry. Much of Dare County's permanent population also resides in this area, the most densely populated portion of the ROI (figure 25). Note that data presented are often taken from the U.S. Census Bureau. The census places people according to "usual residence" guidelines, so people are counted where they live most of the year.

In recent years, population trends have differed substantially for Dare and Hyde counties. Table 24 provides population statistics for the state of North Carolina, Dare and Hyde counties and the Dare and Hyde County block groups located on the Outer Banks. Between 2000 and 2008, Dare County's population grew 12%, from 29,967 to 33,584. This is a slightly lower percentage change in population as the state of North Carolina as a whole. However, the portion of the state population occupying Dare County remained 0.4%. During this same time period, the population of Hyde County decreased by 11%, from 5,826 to 5,181 (U.S. Census Bureau 2008c), lowering the portion of the state population occupying Hyde County from 0.07% to 0.06%. The Dare County block groups within the ROI account for 96% of Dare County's population, while Hyde County block group represents only 13% of Hyde County's population (U.S. Census Bureau 2000a).



Source: Environmental Systems Research Institute, Inc. 2002. "2000 Census Block Groups: NC." [CD-ROM]. ESRI Data & Maps 2002.

FIGURE 25. 2000 POPULATION DENSITY BY BLOCK GROUP

TABLE 24. POPULATION STATISTICS

Geographic Area	2000[1]	2007[2]	2015[3]	2029[3]	Percent Change, 2000–2007	Percent Change, 2000–2029
North Carolina	8,049,313	9,222,414	10,429,282	12,769,797	15%	59%
Dare County	29,967	33,584	31,225	26,053	12%	-13%
Dare County BGs[4]	28,798	—	—	—	—	—
Hyde County	5,826	5,181	5,256	4,717	-11%	-19%
Hyde County BG[5]	730	—	—	—	—	—

Sources:

[1]U.S. Census Bureau 2000a; generated by RTI International; using American FactFinder; "Census 2000 Summary File 3 (SF3) – Sample Data" <http://factfinder.census.gov>; (December 5, 2008).

[2]Population Division, U.S. Census Bureau 2009. "Annual Estimates of Resident Population Change for Counties of North Carolina and County Rankings: April 1, 2000 to July 1, 2008 (CO-EST2008-POPCHG2000_2008-37)." Release Date: March 19, 2009. <http://www.census.gov/popest/estimates.php>.

[3]Office of State Budget and Management, North Carolina 2009. "Projected Annual County Population Totals."<http://www.osbm.state.nc.us/ncosbm/facts_and_figures/socioeconomic_data/population_estimates.shtm >; (September 1, 2009).

[4]The 18 Dare County BGs in the ROI.

[5]The one Hyde County BG in the ROI.

According to population projections published by the North Carolina Office of State Budget and Management's State Demographics unit, the state and Hyde County population trends are expected to continue into the foreseeable future, while Dare County is projected to lose residents. By 2029, population in Dare County is projected to decrease to 26,053, a 13% reduction relative to 2000. The population of Hyde County is expected to fall further to 4,717, a 19% decrease relative to 2000 (Office of State Budget and Management North Carolina 2009).

Demographic and economic trends during the last three decades have contributed to growing differences in the population characteristics and income levels in the different areas of the ROI. The rate of change is especially rapid in northern Dare County, where a smaller percentage of residents were born in North Carolina, shown in figure 26.

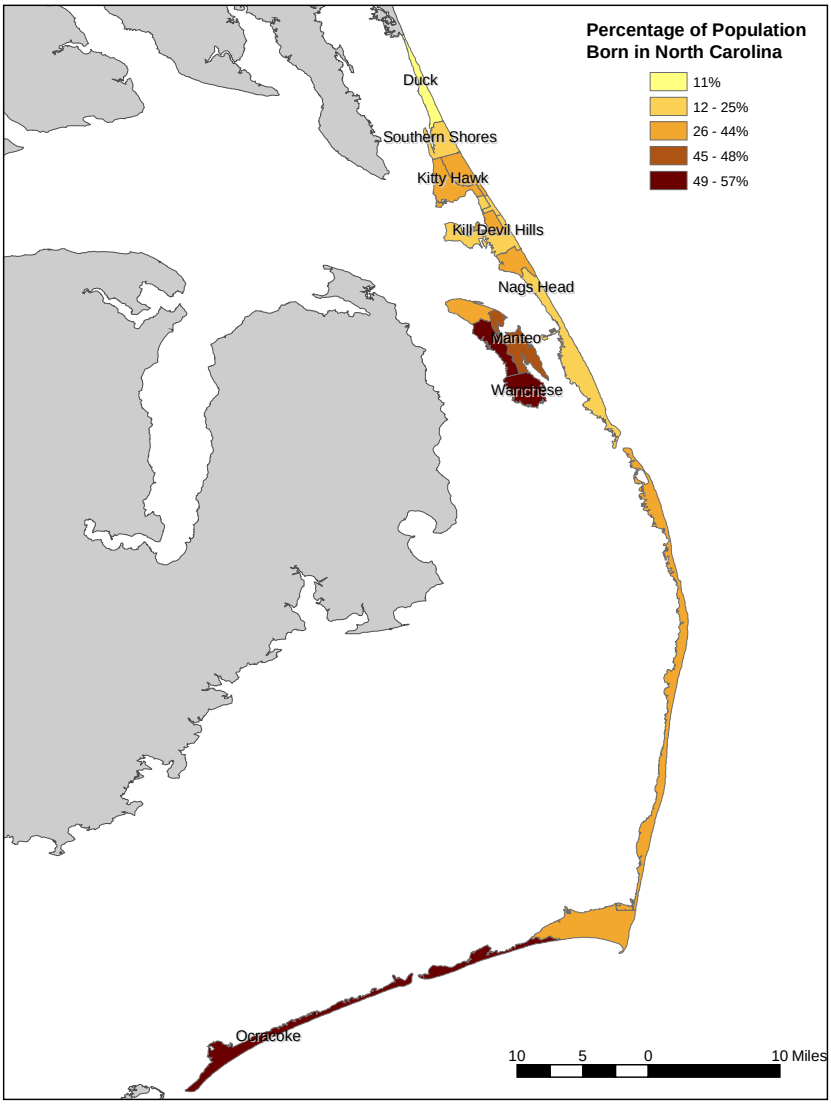
In 1999, the areas within the ROI had a 13% greater per capita income than North Carolina as a whole, and 6% greater than the country as a whole (table 25). This distribution varies across the ROI. Ocracoke, southern Dare County, and portions of Roanoke Island all had a lower per capita income than the more densely populated block groups in the northern part of the ROI (figure 27).

TABLE 25. EMPLOYMENT BY SECTOR, 2000

	Number of Employees	Percentage			Difference	
Industry	ROI	ROI	NC	US	ROI-NC	ROI-US
Construction	2,102	14%	8%	7%	5%	7%
Accommodation and food services	1,857	12%	6%	6%	6%	6%
Real estate, rental and leasing	1,078	7%	2%	2%	5%	5%
Retail trade	2,296	15%	12%	12%	3%	3%
Agriculture; forestry; fishing and hunting	491	3%	1%	1%	2%	2%
Public administration	992	6%	4%	5%	2%	2%
Arts; entertainment; and recreation	453	3%	1%	2%	2%	1%
Utilities	162	1%	1%	1%	0%	0%
Management of companies and enterprises	0	0%	0%	0%	0%	0%
Other services (except public administration)	714	5%	5%	5%	0%	0%
Mining	4	0%	0%	0%	0%	0%
Administrative and support and waste management services	432	3%	3%	3%	0%	-1%
Information	379	2%	2%	3%	0%	-1%
Wholesale trade	414	3%	3%	4%	-1%	-1%
Professional; scientific; and technical services	688	4%	5%	6%	0%	-1%
Transportation and warehousing	365	2%	4%	4%	-1%	-2%
Educational services	986	6%	8%	9%	-2%	-2%
Finance and insurance	365	2%	4%	5%	-2%	-3%
Health care and social assistance	890	6%	11%	11%	-5%	-5%
Manufacturing	764	5%	20%	14%	-15%	-9%

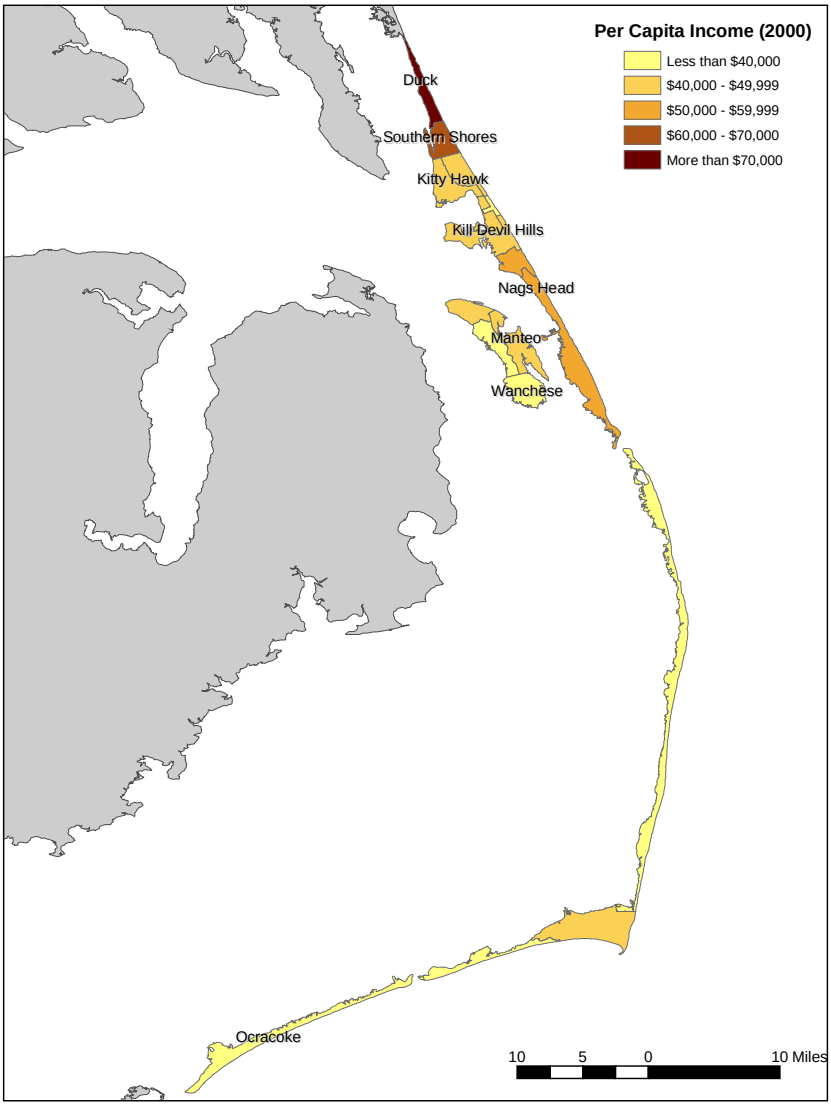
Source: U.S. Census Bureau 2000a; generated by RTI International; using American FactFinder; "Census 2000 Summary File 3 (SF3) – Sample Data" <http://factfinder.census.gov>; (December 5, 2008).

1



Source: U.S. Census Bureau 2000a; generated by RTI International; using American FactFinder; "Census 2000 Summary File 3 (SF3) – Sample Data" <http://factfinder.census.gov>; (December 5, 2008).

FIGURE 26. PERCENTAGE OF RESIDENTS BORN IN NORTH CAROLINA BY BLOCK GROUP, 2000



Source: U.S. Census Bureau 2000a; generated by RTI International; using American FactFinder; "Census 2000 Summary File 3 (SF3) – Sample Data" <http://factfinder.census.gov>; (December 5, 2008).

FIGURE 27. 1999 PER CAPITA INCOME BY BLOCK GROUP

In 2000, the ROI had a minority population of only 6% of the total (Table 26). This is less than in North Carolina and the U.S. as a whole, which had 30% and 31% minority populations respectively. The ROI also had a lower percentage of individuals below the poverty level and a lower percentage of individuals without high school diplomas. The distribution of poverty rates by block groups is shown in Figure 28.

TABLE 26. ENVIRONMENTAL JUSTICE STATISTICS, 2000

Geographic Area	Per Capita Income	Percent of Population		
		Minority	Below the Poverty Level	Without High School Diploma
United States	$41,994	31%	12%	20%
North Carolina	$39,184	30%	12%	22%
ROI	$44,462	6%	8%	11%

Source: U.S. Census Bureau 2000a; generated by RTI International; using American FactFinder; "Census 2000 Summary File 3 (SF3) – Sample Data" <http://factfinder.census.gov>; (December 5, 2008).

EMPLOYMENT

As noted above, with the exception of the northern portion of Dare County, the ROI is primarily rural. There are no military bases, major federal facilities, state prisons, commercial airports, or four-year colleges in the ROI.

Within the ROI, much of the employment caters to tourists visiting the area. The sectors of construction; accommodation and food services; real estate, rental and leasing; and the retail trade accounted for 47.52% of the total employment within the ROI and 49.98% within the Hatteras BGs in 2000. These sectors only account for 26.50% of employment in the United States as a whole (table 25).

The majority of businesses within the ROI are located in the northern three zip codes in Dare County, encompassing the towns of Duck, Southern Shores, Kill Devil Hills and Nags Head. This area accounts for 64.8% of establishments and 69.6% of employment within the ROI in 2007 and has seen robust employment growth since 2000. Other areas of the ROI have experienced smaller gains or reductions in employment (figure 19). In 2007, Hatteras and Ocracoke Islands contained 13.1% of the employees within the ROI. Small businesses are especially important within the ROI, with 1,713 of 2,104 establishments (81.42%) in the ROI operating with fewer than 10 employees in 2007, compared to 73.37% nationwide (U.S. Census Bureau 2009b).

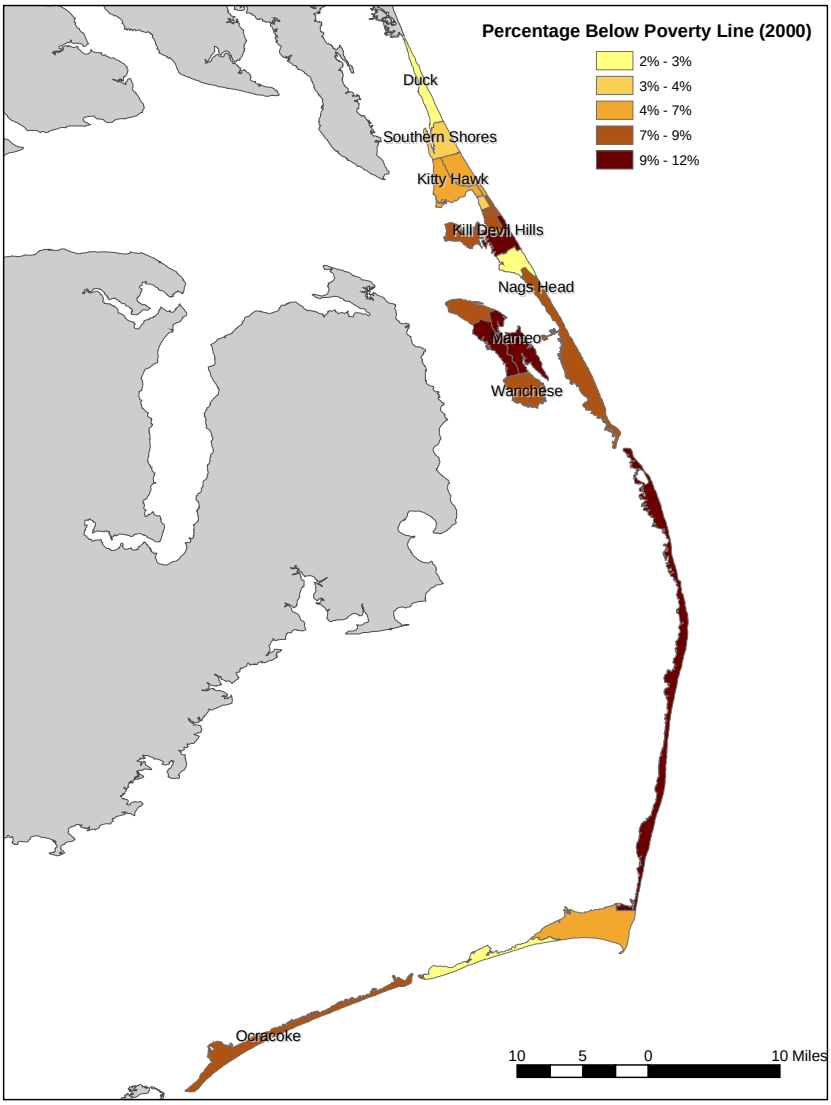
In addition to these employees, Dare and Hyde Counties had 5,764 of self-employed individuals in 2007. The construction, real estate and rental and leasing, and agriculture, forestry, fishing and hunting (of

which 61% are commercial fishermen) industries comprise 49% of all nonemployers[1] in the two counties (table 27).

TABLE 27. NONEMPLOYERS BY INDUSTRY, 2007

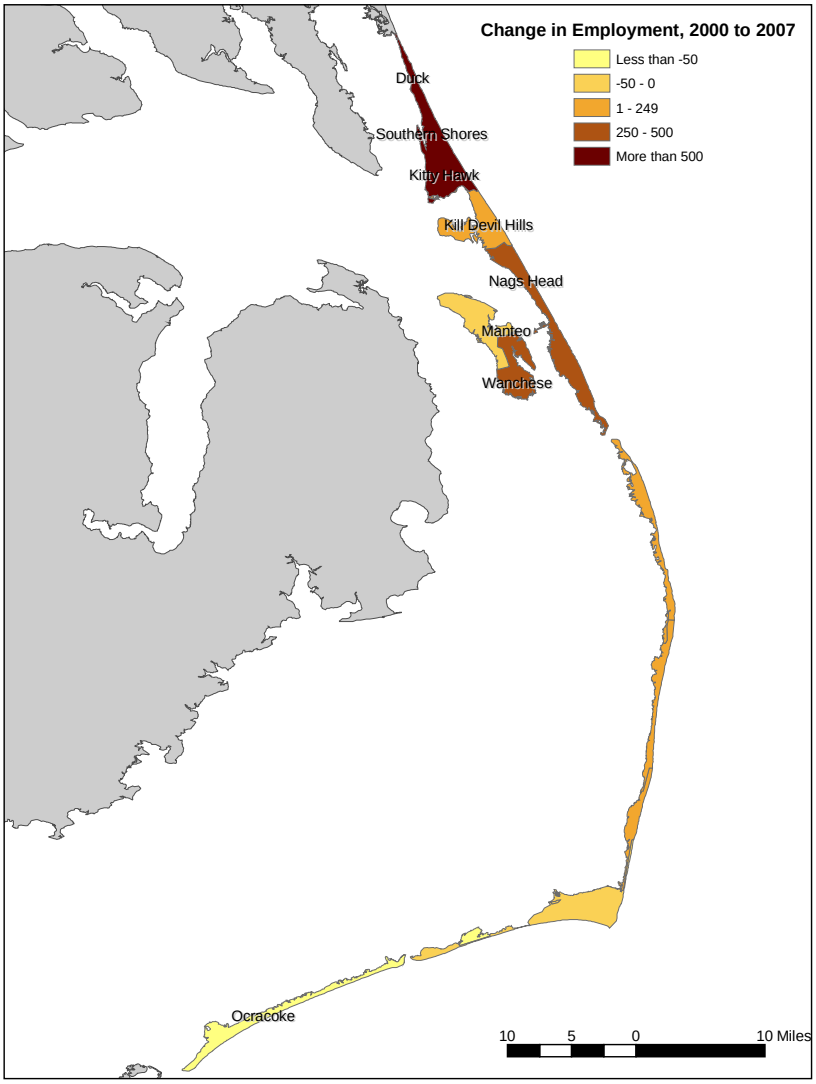
	Number of Nonemployers	Percentage			Difference	
Industry	Dare & Hyde Counties	Dare & Hyde Counties	NC	US	Counties - NC	Counties - US
Agriculture, forestry, fishing and hunting	667	12%	1%	1%	10%	10%
Construction	1,262	22%	16%	12%	6%	10%
Real estate and rental and leasing	912	16%	11%	11%	5%	5%
Administrative and Support and Waste Mang and Remediation Srvs	529	9%	10%	8%	-1%	1%
Accommodation and food services	109	2%	1%	1%	1%	0%
Utilities	3	0%	0%	0%	0%	0%
Manufacturing	>67	1%	2%	2%	0%	0%
Mining, quarrying, and oil and gas extraction	0	0%	0%	0%	0%	0%
Wholesale trade	72	1%	2%	2%	0%	-1%
Information	>37	1%	1%	1%	-1%	-1%
Educational services	80	1%	2%	2%	-1%	-1%
Arts, entertainment, and recreation	234	4%	4%	5%	0%	-1%
Finance and insurance	>99	2%	3%	4%	-1%	-2%
Other services (except public administration)	611	11%	15%	14%	-5%	-3%
Transportation and warehousing	>86	1%	4%	5%	-3%	-3%
Retail trade	309	5%	9%	9%	-4%	-4%
Health care and social assistance	195	3%	6%	8%	-3%	-5%
Professional, scientific, and technical services	461	8%	12%	14%	-4%	-6%
Total for all sectors	5,764	100%	100%	100%		

[1] From http://www.census.gov/econ/nonemployer/intro.htm : "Nonemployers are typically self-employed individuals operating very small businesses, which may or may not be the owner's principal source of income…Data are primarily comprised of sole proprietorship businesses filing IRS Form 1040, Schedule C, although some of the data is derived from filers of partnership and corporation tax returns that report no paid employees."



Source: U.S. Census Bureau 2000a; generated by RTI International; using American FactFinder; "Census 2000 Summary File 3 (SF3) – Sample Data" <http://factfinder.census.gov>; (December 5, 2008).

FIGURE 28. PERCENTAGE OF POPULATION BELOW THE POVERTY LINE BY BLOCK GROUP, 2000



Sources: U.S. Census Bureau, 2002. "County Business Patterns: 2000, Zip Code Totals File." <http://www.census.gov/econ/cbp/download/00_data/index.htm>.

U.S. Census Bureau, 2009a. "County Business Patterns: 2007, Zip Code Totals File." <http://www.census.gov/econ/cbp/download/07_data/index.htm>.

FIGURE 29. CHANGE IN EMPLOYMENT BY ZIP CODE

UNEMPLOYMENT

In 2008, an average of 6.5% of the civilian labor force in Dare County was unemployed (1,437 individuals) and 7.1% in Hyde County (187 individuals) (table 27). The unemployment rates for Dare and Hyde counties were higher than the unemployment rates in North Carolina as a whole in 2008. For June 2009, the North Carolina (seasonally unadjusted) unemployment rate has risen to 11.1%, higher than Dare and Hyde counties (6.7% and 5.5% respectively).

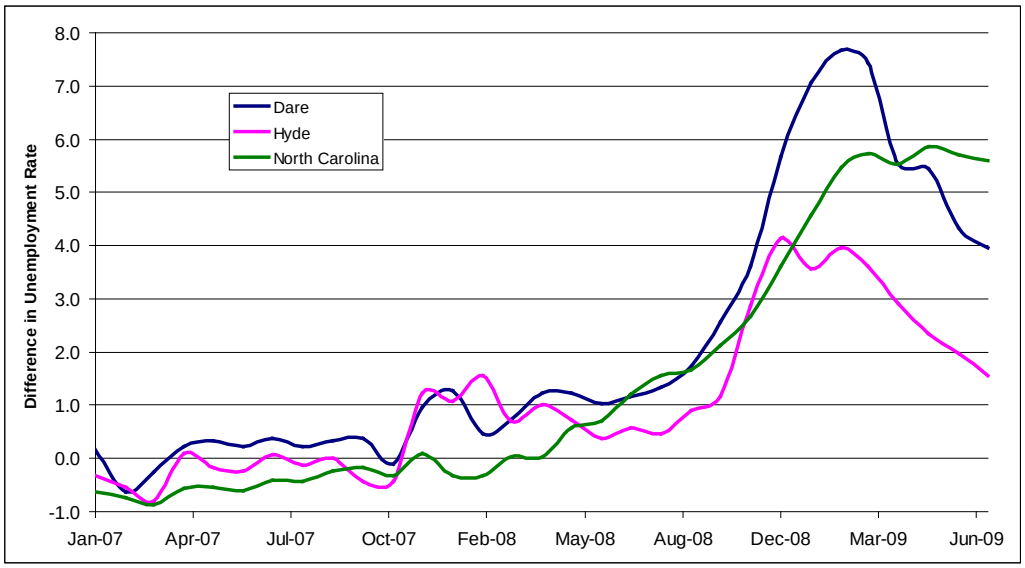
Within Dare County, establishments in construction, manufacturing and retail trade industries accounted for the majority of private job losses from 2007 to 2008. Within retail trade, job losses in furniture & home furnishings stores; building material & garden equipment & supplies dealers; food & beverage stores; and health & personal care stores were partially offset by employment gains in clothing & clothing accessories stores; gasoline stations; and sporting goods, hobby, & musical instrument stores.

Unemployment rates in North Carolina, Dare, and Hyde Counties remain elevated relative to their 2004-2006 average in the summer of 2009. Dare and Hyde Counties have recovered slightly since the winter of 2008/2009 (figure 30).

TABLE 27. EMPLOYMENT CHARACTERISTICS, 2008

	North Carolina	Dare County	Hyde County
Labor Force	4,543,754	22,087	2,644
Employment	4,256,815	20,650	2,457
Unemployment	286,939	1,437	187
Unemployment Rate	6.3%	6.5%	7.1%

Source: Bureau of Labor Statistics, 2009. "Local Area Unemployment Statistics." <http://www.bls.gov/lau>; (September 2, 2009).



Source: Bureau of Labor Statistics, 2009. "Local Area Unemployment Statistics." <http://www.bls.gov/lau>; (September 2, 2009).

FIGURE 30. DIFFERENCE IN UNEMPLOYMENT RATE FROM 2004-2006 MONTHLY AVERAGE

TOURISM CONTRIBUTIONS TO THE ECONOMY

The economy of the ROI is largely driven by the region's tourist draw, mainly during the summer months. As estimated by the North Carolina Department of Commerce, travel expenditures in Dare County have increased faster than those for the state as a whole (table 28); however travel expenditures in Hyde County have decreased since 2000. In 2008, Department of Commerce estimates that tourism is responsible for 11,250 jobs in Dare County and 370 jobs in Hyde County (Department of Commerce 2009).

TABLE 28. ESTIMATED DOMESTIC TRAVEL EXPENDITURES ($2008 MILLIONS)

Geographic Area	1991	2000	2008	2000 to 2008 CAGR
North Carolina	$11,092.58	$15,089.89	$16,864.60	1.6%
Dare County	$377.40	$624.14	$777.41	3.2%
Hyde County	$17.93	$29.58	$28.11	-0.7%

Source: North Carolina Department of Commerce, 2009. "Economic Impact of Travel in North Carolina Based on Visitor Spending." <http://www.nccommerce.com/en/TourismServices/PromoteTravelAndTourismIndustry/TourismResearch/visitorspending.htm>. (September 2, 2009).

Housing

In 2000, the ROI had a total of 26,891 housing units, with 97% of these located in the Dare County block groups. The ROI's housing is roughly 54% urban and 46% rural, with 100% of the urban housing units being located in Dare County block groups. Over 50% of the housing units in the ROI are for seasonal, recreational, or occasional use (table 29). The distribution of vacant housing units for seasonal, recreational, or occasional use is shown in Figure 21. This is further evidence of the importance of tourism's contributions to the region's economy.

Since 2000, Dare County has experienced a 21% increase in the number of housing units, relative to a 14% change state wide (table 30). However, in October of 2008, Dare County had the fifth highest foreclosure rate of any county in North Carolina, with one in every 679 housing units in foreclosure (RealtyTrac.com 2008).

TABLE 29. HOUSING UNIT STATISTICS, 2000

	United States	North Carolina	ROI
Total	115,904,641	3,523,944	26,891
Urban	89,966,555	2,080,729	14,578
% of Total	78%	59%	54%
Occupied	105,480,101	3,132,013	12,588
Vacant	10,424,540	391,931	14,303
For seasonal, recreational, or occasional use	3,872,468	147,087	13,771
% of Total	3%	4%	51%

Source: U.S. Census Bureau, 2000a; generated by RTI International; using American FactFinder; "Census 2000 Summary File 3 (SF3) – Sample Data" <http://factfinder.census.gov>; (December 5, 2008).

TABLE 30. CHANGE IN HOUSING UNITS

Geographic Area	2000	2008	Percent Change 2000–2008
United States	115,904,641	129,065,264	11%
North Carolina	3,523,944	4,201,378	19%
Dare County	26,671	32,749	21%
Hyde County	3,302	3,495	5%

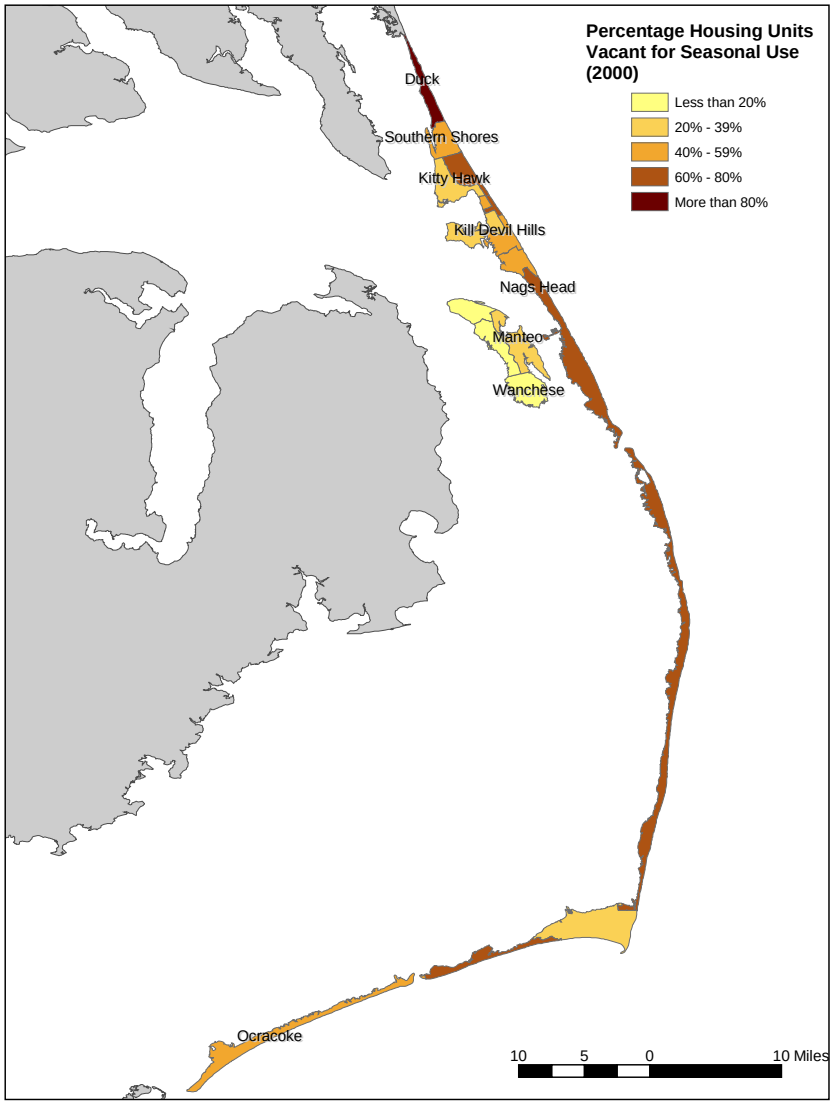
Sources: Population Division, U.S. Census Bureau, 2009a. "HU-EST2008: State Housing Unit Estimates: April 1, 2000 to July 1, 2008." Release Date: August 6, 2009. < http://www.census.gov/popest/housing/files/HU-EST2008.CSV>.

Population Division, U.S. Census Bureau, 2009b. "HU-EST2008-37: Housing Unit Estimates for Counties of North Carolina April 1/2000 to July 1/2008." Release Date: August 6, 2009. <http://www.census.gov/popest/housing/files/HU-EST2008-37.CSV>.

Quality of Life

Quality of life encompasses those attributes of resources (man-made or naturally occurring) of a region that contribute to the well-being of its residents. The relative importance of these attributes to a person's well-being is subjective (e.g., some individuals consider outdoor recreational opportunities essential to their well-being, others require access to cultural institutions essential to their quality of life, and still others may hold public safety as their primary quality-of-life concern). Quality-of-life analyses typically address issues relating to potential impacts of the proposed action on the availability of public services and leisure activities that contribute to the quality of life of an affected ROI's inhabitants. For the purpose of this study, the quality-of-life affected environment includes the natural environment, public schools, law enforcement, medical facilities, and fire protection services.

The natural environment, including beaches and wildlife, provide the primary basis for quality of life on the Outer Banks. As discussed above, beach-related tourism drives the economy of the area. Local residents also receive significant recreational benefits from the area's natural assets. In addition to the Seashore, the ROI includes Jockey's Ridge State Park, and Pea Island National Wildlife Refuge (Outer Banks Chamber of Commerce 2008). There are also public and private beaches, marinas, piers and other recreational outlets. Two categories of outdoor recreation pertinent to the assessment of alternative management plans, recreational fishing and bird watching, are discussed further below using data from the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR).



Source: U.S. Census Bureau, 2000a; generated by RTI International; using American FactFinder; "Census 2000 Summary File 3 (SF3) – Sample Data" <http://factfinder.census.gov>; (December 5, 2008).

FIGURE 31. PERCENTAGE OF HOUSING UNITS VACANT FOR SEASONAL, RECREATIONAL, OR OCCASIONAL USE BY BLOCK GROUP, 2000

North Carolina is the sixth most popular state for fishing, with an estimated 1,263,000 residents and nonresidents participating in 2006 (U.S. Department of the Interior et. al. 2008). Recreational fishing is a significant part of North Carolina's economy, attracting spending from both local and out-of-state anglers. Approximately 519,000 anglers in North Carolina engaged in saltwater fishing in 2006 (table 31). Expenditures from fishing trips totaled an estimated $692,977,000 in 2006, with $450,313,000 coming from saltwater anglers. While only 40% of anglers report participating in saltwater fishing, nearly 65% of all trip-related expenditures go toward this activity.

Nonresident angler expenditures are important to regional economic impacts, as they represent an addition to area wealth rather than a change in the mix of spending by residents. Nonresidents make up only 31% of all anglers in North Carolina but comprise 51% of saltwater anglers. Nonresidents, who often must pay greater lodging and transportation fees, spend an average of 65% more than residents for trip-related expenditures over all types of fishing.

Separate expenditure data for residents and nonresidents on saltwater fishing was not available. However, trip-related expenditures (including food, lodging, transportation, ice, bait, guide and usage fees, rental equipment, and other items, but excluding the cost of purchased equipment) are much higher for saltwater anglers than for all anglers combined, averaging $754 per person for both residents and nonresidents, compared to $549 per person for all fishing. Saltwater fishermen spend more per angler on food and lodging, transportation, and other trip costs, but spend proportionally less on transportation and slightly more on food, lodging and other costs. Overall, saltwater fishing such as that on Cape Hatteras attracted a greater percentage of out-of-state residents and averaged 56% greater trip-related expenditures than all types of fishing combined.

Dare and Hyde counties sold 40% of coastal recreational fishing licenses sold within the eight coastal counties in North Carolina and 18% of all coastal recreational fishing licenses sold in 2008. Dare County ranks first among all North Carolina counties in coastal recreational fishing license sales (table 32).

TABLE 31: RECREATIONAL FISHING IN NORTH CAROLINA, BY RESIDENTS AND NONRESIDENTS

Source: U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2008.

	Resident	Nonresident	Total
Total participants	868,000	395,000	1,263,000
% Total Participants	69%	31%	100%
# Saltwater	253,000	266,000	519,000
% Saltwater	49%	51%	100%
Total trip-related expenditures	$395,296,000	$297,681,000	$692,977,000
Average trip-related expenditures per participant	$456	$753	$549

"2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation."
<http://www.census.gov/prod/www/abs/fishing.html>

TABLE 32. NUMBER OF COASTAL RECREATIONAL FISHING LICENSES SOLD BY NORTH CAROLINA COUNTY OF SALE (LOCATION WHERE LICENSE SALES AGENT RESIDES), EXCLUDING BLANKET COASTAL RECREATIONAL FISHING LICENSES, BY CALENDAR YEAR.

County	2007	2008
Dare	93,225	82,635
Hyde	6,322	5,358
Brunswick	38,721	33,303
Carteret	46,813	38,456
Currituck	2,660	2,435
New Hanover	34,556	28,558
Onslow	16,098	15,185
Pender	17,462	14,733
Total	469,521	411,886

Source: North Carolina Marine Fisheries, North Carolina Wildlife Resources Commission, 2009.
"Coastal Recreational Fishing License Sales Update." Release Date: May 31, 2009.
<http://www.ncfisheries.net/CRFL/downloads/CRFLSalesReportMay_31_2009.pdf>

Among all states, North Carolina ranks nineteenth for number of wildlife watchers, with 2,641,000 participants in 2006. Wildlife watching is classified as activities for which wildlife watching is the primary purpose, and does not include trips zoos or museums or accidental observation of wildlife. Wildlife watchers may be feeding, photographing or observing wildlife. Approximately 15% of wildlife watchers in North Carolina were nonresidents in 2006.

Away-from-home wildlife watching is defined as wildlife observation occurring at least one mile away from home. Table 33 presents information about away-from-home wildlife watching in North Carolina. Among away-from-home wildlife watchers in North Carolina, approximately 56% are nonresidents.

Away-from-home bird watchers made up 620,000 or 90% of all away-from-home wildlife watchers. Of these, 50% reported watching "other water birds." This category includes shorebirds, cranes, herons and all other water birds not classified as waterfowl and serves as the best representation of birds on Cape Hatteras. Among wildlife watchers observing "other water birds", nonresidents made up 69% of participants. Thus, wildlife watching for birds like those on Cape Hatteras is far more likely to be participated in by nonresidents than other wildlife watching.

Wildlife watchers in North Carolina spent a total of $246,906,000 in trip-related costs in 2006. This number includes food, lodging, transportation, rented equipment, and guide or permit fees, but not expenditures on purchased equipment. Away-from-home resident wildlife watchers spent an average of $281 per person per trip, while nonresident participants spent $421. Although separate expenditure data for other water bird watchers was not available, other water birds such as shorebirds are more likely to attract out-of-state wildlife watchers, who then spend on average 50% more than resident wildlife watchers.

TABLE 33: AWAY-FROM-HOME WILDLIFE WATCHING IN NORTH CAROLINA, BY RESIDENT AND NONRESIDENT

	Resident	Nonresident	Total
Total away-from- home participants	300,000	386,000	686,000
Percent of total participants	44%	56%	100%
Total away-from -home birders	284,000	336,000	620,000
Total birders	46%	54%	100%
Away-from-home "other water bird" observers	95,000	215,000	310,000
Percent of "other water bird" observers	31%	69%	100%
Total trip-related expenditures	$84,245,000	$162,662,000	$246,906,000
Average trip-related expenditure per participant	$281	$421	$360

Source: U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2008. "2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation." http://www.census.gov/prod/www/abs/fishing.html

Preservation and Nonuse Values

Preservation or nonuse impacts represent a category of values held by people independent of their use of the resources that also includes existence value and bequest value. The main assumption underlying the concept of nonuse values is that individuals' welfare can be enhanced simply by the *knowledge* that specific ecosystems are being protected or improved. As the name implies, individuals receive these types of services without any specific use of or interaction with the ecosystems. For example, nonuse values from preserving a natural area may come from the knowledge that future generations are more likely to experience and enjoy the area (i.e., "bequest values").

Economic theory recognizes that individuals can hold value for the Cape Hatteras National Seashore and the ecosystems contained within its boundaries because they want future generations to enjoy the area, because they value the protected species supported by the area or because they feel the natural communities contained within the National Seashore have intrinsic value separate from the value they provide to visitors.

Measuring values for these "nonuse" services is more difficult and involves more uncertainty than for recreational and aesthetic services. Nevertheless, a variety of studies demonstrate that nonuse values exist and may be quite large depending on the resource in question. Loomis and White (1996) synthesize key results from 20 threatened and endangered species valuation studies using meta-analysis methods. They are able to identify variables that explain the observed variation in estimated willingness-to-pay (WTP) values for threatened and endangered species and examine how per-household benefit estimates compare with cost estimates for protection. In their meta-analysis, Loomis and White review 20 contingent value studies coming from both the published and gray literature. They find that annual WTP estimates range from a low of $8 for the Striped Shiner fish to a high of $124 for the Northern Spotted Owl. Using these 20 studies, they apply regression based methods to combine valuation findings and to identify statistically significant determinants of estimated values for TES. Some of their key findings include statistically significant effects on WTP of (1) the size of the change in a species population, (2) whether those expressing values for the species are users of the affected resource, and (3) whether the species is a marine mammal or bird. Loomis and White also use the meta-analysis results to conduct a rough benefit-cost analysis. They note that even in supposedly 'high cost' cases, such as the Northern Spotted Owl, costs per household are relatively low and are well below the benefits found in WTP studies.

SEASHORE MANAGEMENT AND OPERATIONS

Seashore management and operations activities related to ORV management fall within the various operational divisions of the Seashore, which include Administration, Resource Management, Law Enforcement, Interpretation, and Maintenance. The baseline for park operations and management will be discussed both in terms of pre-consent decree (under the Interim Strategy) (before 2008) and post-consent decree (2008).

Administration. Administrative staff members at the Seashore have a variety of responsibilities related to ORV management, including compiling and sending out weekly access and resource updates, managing payroll for the Seashore, fielding questions from visitors regarding OHV management, fulfilling human resources functions and supervisory roles, and providing IT and other technical support, in addition to the superintendent's role in ORV management. Administrative costs address the need to provide technical assistance to the approximately 25 field and administrative staff members associated with ORV management. Administrative support related to ORV management required approximately 3.15 FTE ($225,500) under the Interim Strategy. This number increased to 3.55 ($252,350) plus approximately $3,000 of direct materials costs (total cost $255,350) in 2008 with the implementation of measures under the consent decree. The increased level of effort for administration is primarily related to the increased need for IT support as the use of technology was increased to inform the public about areas open for ORV use or closed for species protection.

Law Enforcement. Law enforcement officers at the Seashore are responsible for enforcing all applicable regulations, including those related to ORV and species management. In relation to ORV management, duties of law enforcement include patrolling the Seashore, as well as providing on–the-spot interpretation to visitors as to the reason for certain ORV regulations and species management efforts. Other duties include responding to violations and conducting investigations. Support (or materials) costs for these Seashore staff members include vehicles, fuel, training, travel, field supplies, and radio support. Law enforcement support related to ORV management required approximately 13 FTE ($1,047,500) and $100,000 in support costs (total cost approximately $1,147,500) under the Interim Strategy. This number increased to 16.5 FTE ($1,321,500) and $160,000 in support costs (total cost approximately $1,481,000) in 2008 with the implementation of measures under the consent decree. This increased level of effort for law enforcement is primarily related to the increased amount of time patrol rangers are devoting to ORV management, such as addressing the night-driving restrictions under the consent decree.

Resource Management. Resource management staff members at the Seashore are responsible for all monitoring and surveying of species at the Seashore, as well as establishing and changing the required

resource closures once state- or federally listed species are found at the Seashore. This staff includes supervisory roles as well as full- and part-time field staff to implement species management measures. Support (or materials) costs for these Seashore staff members include vehicles (such as ATV), fuel, training, field supplies (such as signs), monitoring supplies, and travel. Resource management efforts at the Seashore required approximately 9.5 FTE ($423,500) and $85,000 in support costs (total cost approximately $508,500) under the Interim Strategy. This number increased to 15 FTE ($778,000) and $35,000 in support costs (total cost approximately $813,000) in 2008 with the implementation of measures under the consent decree. This increased level of effort for resource management staff is primarily related to the need for additional field staff and GIS staff to address the closure requirements and to be able to provide weekly mapping of the closures to keep the public informed of their activities.

Interpretation. Interpretation staff members at the Seashore are responsible for providing information programs to park visitors, specifically on the subject of species management. Support (or materials) costs for these Seashore staff include printing newsletters and brochures, and obtaining materials for visitor programs. Interpretation efforts at the Seashore required approximately 1.5 FTE ($58,500) and $10,000 in support costs (total cost approximately $68,500) under the Interim Strategy. This number increased to 3 FTE ($181,500) and $12,000 in support costs (total cost approximately $193,000) in 2008 with the implementation of measures under the consent decree. This increased level of effort for interpretation staff is primarily related to the increased level of programs and information provided to the public regarding areas available for ORV use, as well as providing information about why certain ORV and species management measures are being implemented at the Seashore. With the increase in programs, the number of staff members devoted to ORV management issues has also increased.

Facility Management. Facility management staff members at the Seashore are responsible for providing maintenance and repairs for beach ramps and parking lots, as well as installation of informational signs along the beach. This division of the Seashore is also responsible for maintaining and repairing the vehicles used by all other divisions of the Seashore, including those used for law enforcement and resource management patrols. Support (or materials) costs for these Seashore staff members include ramp fill material, vehicle parts, and vehicle maintenance supplies. Facility management efforts required approximately 0.6 FTE ($46,500) and $10,000 in support costs (total cost approximately 56,500) under the Interim Strategy. This number increased to 3.6 FTE ($158,600) and $20,000 in support costs (total cost approximately $178,600) in 2008 under the implementation of the consent decree. This increased level of effort for facility management staff is primarily related to the need to increase the number of maintenance workers and laborers. The increase in both law enforcement and resource management staff

results in an increased number of vehicles that need to be maintained. The additional signage and educational requirements require more staff and effort to install, and an increased level of effort.