2011 progress report: Using a Network of Sites to Evaluate How Climate-mediated Changes in the Arctic Ecosystem are Affecting Shorebird Distribution, Ecology and Demography

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Abstract

To obtain a better understanding of how shorebirds will respond to climate-mediated changes in the Arctic's morphology and ecology, we have established a network of sites, known as the Arctic Shorebird Demographics Network (ASDN), wherein we collected information on a suite of predictor variables thought to be responsive to climate change, with a future goal of correlating these variables with measures of shorebird distribution, ecology, and demography. Starting in 2010, we established nine field sites across the Arctic, from Nome, Alaska to Hudson Bay, Nunavut. The number of sites was expanded from 9 to 11 sites in 2011. Protocols were adopted/modified from prior studies in the Arctic to create a standardized protocol that has been updated prior to each field season. We have compiled all of the data from the various sites during the first two years of the ASDN operation, and results from our first two field seasons conducted in 2010 and 2011 are presented here.

A total of 2,526 nests belonging to 24 species were located in 2010 and 2011 combined. The largest number of nests belonged to the five ASDN focal species: Dunlin, Semipalmated Sandpipers, Red and Red-necked Phalaropes, and Pectoral Sandpipers. Nest initiation dates varied tremendously across sites for the focal shorebird species investigated during this study. Apparent nest success rates also varied between years and sites, with the lowest nest success recorded at East Bay in 2010 (22%) and the highest at Mackenzie Delta in 2010 (100%). A total of 2,488 adults belonging to 19 species were banded in 2010 and 2011 combined. The number of adults banded per species ranged from 4 to 334 in 2010 and from 1 to 387 in 2011. ASDN focal species were again captured the most frequently. The highest returns of color-marked adults were observed in Dunlin, Red-necked Phalarope, Semipalmated Sandpiper, Western Sandpiper, and Whimbrel. Besides the shorebird data, field personnel kept daily species lists, and established sampling stations to document aquatic and terrestrial invertebrate diversity, phenology, and abundance. In addition, data were collected on predators, small mammals and other alternative prey for predators of shorebirds, snow and surface water, and general climatic variables.

ASDN principal investigators and other partners are collaborating on 17 projects that use the geographically vast and taxonomically rich ASDN data. ASDN studies include investigations of the potential for an ecological mismatch between invertebrate emergence and shorebird hatching, variation in shorebird nest predation across the Arctic, assessment of predator diversity and abundance in relation to human development, and factors affecting shorebird settlement patterns. Avian health issues being investigated include avian influenza, avian malaria, gut microbiota, and mercury exposure. Migratory connectivity studies include projects using light-level geolocators to document migratory pathways and wintering areas of American Golden-Plover, Dunlin, and Semipalmated Sandpipers. An additional study is using stable isotope signatures to document connections between breeding, migration and wintering areas of Semipalmated Sandpipers. Other studies are focusing on the effects of spring phenology on timing of breeding in shorebirds, invertebrate phenology in relation to habitat and weather, long-distance dispersion of moss by shorebirds, and the distribution of Arctic invertebrates.

Although this report summarizes information collected in 2010 and 2011, we have also collected data in 2012 (3rd field season), and are in the process of revising protocols and preparing for the fourth of five proposed field seasons. A report summarizing the third field season will be available in December 2013.

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Other principal investigators and graduate students running field camps within the Arctic Shorebird Demographic Network are listed in Appendix 2. The data and accomplishments for this report are a product of all of these people.

No information contained within this report should be used without written consent by the report's authors and the principal investigators responsible for the data.

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Background

The Arctic has experienced the most pronounced warming of the entire world (ACIA 2004). Within the circumpolar Arctic, terrestrial areas in northern Alaska, western Canada, and central Russia have experienced the most rapid warming (Martin et al. 2009). For example, the Arctic Coastal Plain of Alaska is projected to have a 1.6 ° Celsius increase in temperature and a 12% increase in precipitation by 2051 to 2060. Further, the overall length of the frost-free season is expected to increase by 18 days by mid-century, with most of this occurring in the fall (Martin et al. 2009). The higher summer temperatures and longer summer season may increase the amount of water lost to evapotranspiration, resulting in a drier landscape, although enhanced cloud cover, which reduces evapotranspiration, and possible increases in precipitation may counteract this drying trend to some degree. The warmer air temperatures are predicted to accelerate ice wedge degradation and accompanying thermokarst pond development, a pattern already observed that has led to an increase in the proportion of land covered with surface water (Shur et al. 2003).

These climate-mediated habitat changes are likely to have a profound effect on the animals using the Arctic regions of Alaska and Canada, particularly for the millions of shorebirds that breed and raise their young between June and September (Johnson and Herter 1989). Predicting how long-term changes will affect shorebirds, however, is difficult, and it seems likely that there will be both positive and negative effects on any given species. Beyond direct effects on habitat conditions, earlier snowmelt may decouple the apparent synchrony between shorebird breeding chronology and food availability (MacLean 1980). The timing and availability of surface-active insects is critical to shorebirds for egg production (Klaassen et al. 2001), chick growth (Schekkerman et al. 2003), and pre-migratory fattening before southward departure (Connors et al. 1979, 1981; Connors 1984; Andres 1994). Decoupling of phenological events could negatively affect shorebird productivity and survival. In contrast, warmer summers and delayed freeze-up may improve shorebird reproductive success through prolonged availability of invertebrates, since cold weather conditions have been shown to slow chick growth and reduce chick survival (Soloviev et al. 2006). Climate warming may also affect shorebirds indirectly by altering the availability of alternate prey (i.e., Brown Lemming (*Lemmus sibiricus*) and Collared Lemming (*Dicrostonyx groenlandicus*) to shorebird predators (Ims and Fuglei 2005, Kausrud et al. 2008).

Beyond anticipated climate changes and their impacts on shorebirds, humans are causing more direct impacts on the landscape and the bird communities. New and expanding Native villages, along with a recently legalized spring and summer subsistence harvest of shorebirds in Alaska (Alaska Migratory Bird Co-Management Council 2003), may negatively affect shorebirds through habitat alteration and direct mortality. Mineral, oil, and natural gas production in the Arctic has expanded in recent years (Gilders and Cronin 2000, National Research Council 2003), and areas previously closed to oil and gas exploration and development have been leased within Alaska (U.S. Bureau of Land Management 2006). Potential effects of oil and gas development on wildlife include the loss of habitat through the building of roads, pads, pipelines, dumps, gravel pits, and other infrastructure. Roads and pads also increase levels of dust, alter hydrology, thaw permafrost, and increase roadside snow accumulation (Auerbach et al. 1997; National Research Council 2003). Anthropogenic impacts may decrease habitat quantity and quality for nesting shorebirds (Meehan 1986; Troy Ecological Research Associates 1993a; Auerbach et al. 1997). Furthermore, oil field infrastructure may enhance predator numbers by providing denning and nesting habitat and supplemental food (through human

garbage) during winter months. An increase in predators may result in lower adult shorebird and nest survival (Eberhardt et al. 1983; Day 1998; National Research Council 2003, but see Liebezeit et al. 2009). Lower adult survival and nesting success may create population sinks in the vicinity of human developments (National Research Council 2003), especially for species with high site fidelity. Therefore, expanding oil development could have cumulative negative effects on breeding shorebirds using the Arctic region of Alaska and Canada.

Goals and Objectives

To obtain a better understanding of how shorebirds will respond to climate-mediated changes in the structure and function of the arctic ecosystem, we established a network of sites in 2010 known as the Arctic Shorebird Demographics Network (ASDN). Biologists at these sites collected information on a suite of predictor variables thought to be responsive to climate change, as well as information on shorebird ecology and demography. Special emphasis was placed on obtaining data on the abundance and distribution of surface water, which affects the distribution and abundance of invertebrates and indirectly the distribution of some shorebird species (e.g., Red and Red-necked Phalaropes). We also collected data to investigate how summer temperatures and growing season length affect insect emergence and abundance, and how the timing of invertebrate emergence relates to adult shorebird breeding phenology, body condition, and survival.

These data were collected within a larger framework of objectives that the ASDN has developed to ascertain why many arctic-breeding shorebird populations are declining. Objectives included:

1) Collecting demographic data (nest survival, adult survival, mate and site fidelity, age at first breeding) on a select group of Arctic-breeding shorebirds that will allow us to assess potential factors limiting population growth.

2) Documenting contemporary patterns of species presence and abundance (i.e. breeding densities) of shorebirds, and when possible assessing how species assemblages and abundance have changed historically.

3) Documenting seasonal patterns of nest initiation, habitat use, and presence of species.

4) Collecting environmental information, including avian and mammalian predators of shorebirds, alternative prey availability, and weather.

5) Correlating data from objectives 1) through 4) to assess impacts of climate change on shorebird breeding ecology.

6) Participate in projects that take advantage of the ASDN's large geographic footprint, multi-year study, and diversity of shorebird species, toinvestigate shorebird health, migratory connectivity, and ecotoxicology.

Methods

The methods used in this study rely on the knowledge gained by partners through decades of collective work at shorebird breeding areas in Alaska and Canada. Protocols have been

adopted/modified from prior projects such as the Tundra Predator study (Liebezeit et al. 2009), the Arctic Wildlife Observatories Linking Vulnerable Ecosystems (WOLVES) project (http://www.cen.ulaval.ca/arcticwolves/en_project_descrip_CAN_method.htm), and the US Fish and Wildlife Service study protocols from the Barrow Shorebird Breeding Ecology Study (Liebezeit et al. 2007, Naves et al. 2008) and the Arctic National Wildlife Refuge. Version 2 of this protocol was completed in May 2011, and included new protocols on aging shorebirds, pond hydrology, geolocator retrieval, revised aquatic invertebrate sampling, disease assessment (avian malaria and gut microbiota), and revised predator and prey monitoring. Collectively these changes resulted in the protocol expanding from 97 to 116 pages. A version 3 of the protocol was completed in May 2012; both version 2 and 3 can be found at ftp://ftp.manomet.org/ShorebirdResearch/ASDN.

Results and Discussion

Network Sites Established in 2010 and 2011

Nine ASDN sites were established in 2010, ranging from Nome in the western part of Alaska to East Bay in northeastern Canada (Fig. 1). The full suite of activities was not implemented at Cape Krusenstern until 2011. Two new sites, Bylot Island and the Colville River, joined in 2011, and one site, Prudhoe Bay, was down scaled so as to not include marking birds and nest searching in 2011. Sponsoring organizations and names of the principal investigators at each site are listed in Appendix 1.

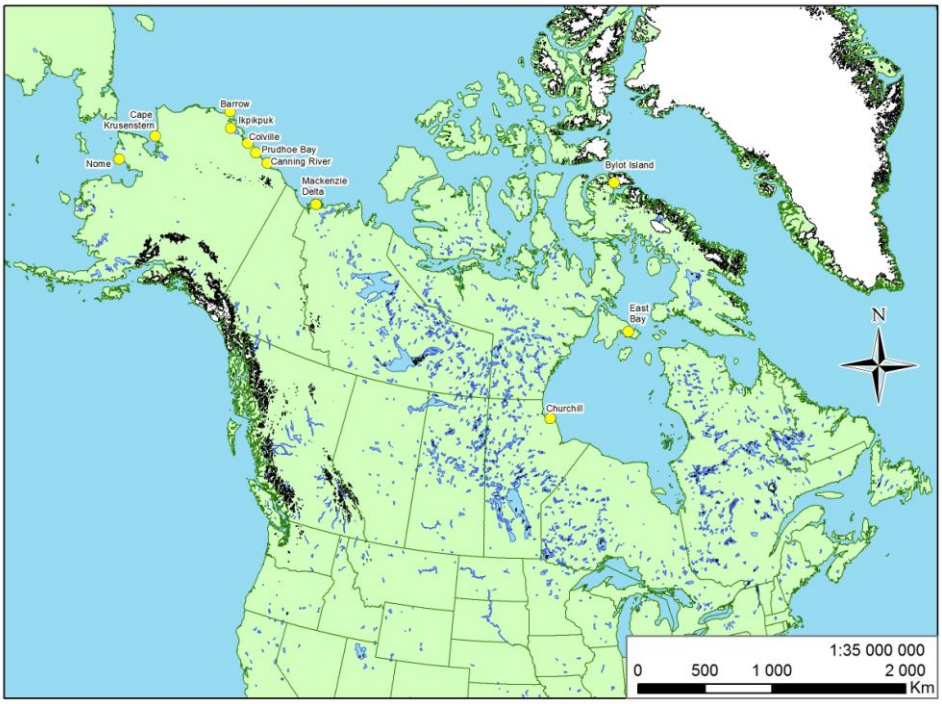

Figure 1. Location of the eleven ASDN sites established in 2010 or 2011.

Database Development and Population

Excel files have been established for the data described below. Most data have GPS locations that will allow georeferencing, and will be incorporated into a geodatabase that is web-accessible. A list of all data collected at each ASDN site in 2011 is presented in Table 1.

- Field camp Metadata: field personnel, plot and sampling locations
- Adult and chick banding records
- Band resighting records
- Nest records
- Snow and surface cover
- Pond water level monitoring
- Lemmings: winter nest counts, incidental observations, intensive trapping
- Predator point counts and area surveys
- Food resources: terrestrial and aquatic invertebrates
- Weather: automated hourly measurements: manual rainfall and snow
- Daily species list
- Daily camp journal

Shorebird Data

Prior to the start of the field season, principal investigators agreed to focus their studies on key species of arctic-breeding shorebirds (‘focal species’ hereafter) that 1) exhibited high site fidelity and were therefore good candidates for estimating annual survival; 2) were present at two or more ASDN field sites, thereby providing comparative data under different environmental conditions; 3) were sufficiently common to allow reliable estimates of nest success; and 4) were likely to be influenced by climate change, based on a range of reasonable scenarios. Based on these four criteria, we chose our five focal species to be Dunlin, Semipalmated Sandpiper, Pectoral Sandpiper, Red Phalarope, and Red-necked Phalarope. Additional species were monitored at various ASDN camps where they were common or because they were the subject of other studies. A full list of species, with genus and species names, is provided in Appendix 2.

<u>Number and Diversity of Shorebird Nests</u>

A total of 2,526 nests belonging to 24 species were located in 2010 and 2011 combined (Table 2). More nests were located in 2011 relative to 2010 (1,544 vs. 982), due to initiation of field work at the Colville River and Bylot Island in 2011, but also higher numbers of nests at most other locations. Number of nests per species ranged from 1 to 252 in 2010, and from 1 to 365 in 2011, with the largest number of nests belonging to the ASDN focal species (i.e., Dunlin, Semipalmated Sandpipers, Red and Red-necked Phalaropes, and Pectoral Sandpipers). Four species were only observed in one year of the study,

Table 1. Site activity and data collected by ASDN site in 2011.[a] See subsequent tables for when surveys were conducted and level of effort expended.

	Nome	Cape Krusenstern	Barrow	Ikpikpuk	Colville	Prudhoe Bay	Canning River	Mackenzie Delta	Bylot Island	East Bay	Churchill
Dates site active	17 May – 23 July	27 May - 4 July	27 May – 1 August	5 June – 17 July	18 May – 3 Aug.	3 Jun – 18 July	2 June – 14 July	4 June – 12 July	5 June – 5 August	11 June – 25 July	24 May – 2 Aug
# of personnel	5	4	6 - 9	8	2	2 - 3	8	4 - 6	5	4	4
Site latitude	N64.4	N67.1	N71.2	N70.5	N70.4	N70.2	N70.1	N69.3	N73.2	N63.9	N58.7
Site longitude	W164.9	W163.5	W156.6	W154.7	W150.7	W148.5	W145.8	W134.9	W80.1	W81.7	W93.8
Data collected											
Geo metadata	x	x	x	x	x	x	x	x	x	x	x
Nest record	x	x	x	x	x	x	x	x	x	x	x
Egg mm	x	x	x	x	x	x	no	x	x	no	x
Adult banding	x	x	x	x	x	no	x	x	x	x	x
Adult Resight	x	x	x	x	x	x	x	x	x	x	x
Chick banding	x (few)	no	x	no	no	no	no	x	x	no	x
Weather-hourly	x	x	x	x	yes	x	x	x	x	no	x
Weather-manual rain fall and snow	x	x	no	x	yes	?	x	x	x	x	no
Invert collection	x	x	x	x	x	no	x	x	x	x	x
Lemming-live and winter nest counts	None observed	None observed	x	x	None observed	x	None observed	x	x	no	None observed
Predator	x	x	x	x	x	x	x	x	x	no	x
Snow surveys	x	x	x	x	x	x	x	x	x	no	x
1st occurrence	x	x	x	x	x	x	x	x	x	x	x
Daily species list	x	x	x	x	x	x	x	x	x	x	x
Pond hydrology	x	x	x	x	x	no	x	x	x	no	x

[a] x = collected data, no = no data.

Table 2. Number of nests found at each ASDN site by species in 2010 and 2011.

	Nome		Cape Krusenstern		Barrow		Ikpikpuk		Canning River		Colville	Prudhoe Bay	Mackenzie Delta		East Bay		Churchill		Bylot Island	Total
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2011	2010	2010	2011	2010	2011	2010	2011	2011	
amgp	--	--	--	--	15	11	--	--	1	2	1	--	--	1	--	2	3	4	78	118
barg	--	--	--	--	--	--	3	--	--	--	1	--	--	--	--	--	--	--	--	4
basa	--	--	--	--	1	--	--	--	1	--	--	--	--	--	--	--	--	--	25	27
bbpl	--	--	--	--	--	--	1	--	2	1	3	--	--	--	12	10	--	--	8	37
bbsa	--	--	--	--	--	--	--	--	--	3	--	--	--	--	--	--	--	--	--	3
crpl	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	2
dunl	--	3	21	14	63	69	20	13	12	15	14	--	--	--	3	3	26	35	--	310
hugo	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	1
lesa	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	8	11	--	21
lbdo	--	--	--	--	17	35	2	4	--	1	1	--	--	--	--	--	--	--	--	60
pesa	--	1	--	--	38	108	11	3	46	78	5	10	--	2	--	--	--	--	1	303
rekn	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1
reph	--	--	--	--	72	158	10	13	17	26	13	2	--	--	25	13	--	--	5	351
rnph	24	50	7	12	6	12	7	9	29	34	18	3	1	7	--	--	15	11	--	245
rutu	--	--	--	--	--	1	--	--	2	1	7	2	--	--	28	12	--	--	--	53
sand	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1
sbdo	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12	18	--	30
sepl	--	--	--	--	--	--	--	--	--	--	1	--	4	4	7	11	--	--	--	27
sesa	30	68	17	36	43	42	62	62	70	80	73	29	1	4	--	--	--	--	--	617
stsa	--	--	--	--	--	--	--	--	3	5	--	--	--	2	--	--	2	2	--	14
wesa	44	90	10	10	8	10	--	--	--	--	--	--	--	--	--	--	--	--	--	172
whim	--	--	--	--	--	--	--	--	--	--	--	--	6	5	--	--	20	15	--	46
wrsa	--	--	--	--	1	1	--	--	--	--	--	--	--	--	33	23	--	--	10	64
Grand Total	98	212	55	72	264	447	116	104	183	246	137	46	12	28	110	73	86	78	129	2526

including Buff-breasted Sandpiper, Common Ringed Plover, Hudsonian Godwit, Red Knot, and Sanderling. The number of nests found per ASDN site ranged from 12 to 264 in 2010, and from 28 to 447 in 2011 (Table 2). Several researchers are exploring species distribution and nest density patterns in greater detail as part of either core or side-project investigations. *Sarah Saalfeld and Richard Lanctot are investigating environmental and social factors that may explain the annual variation in settlement patterns of shorebird species found at the ASDN sites across the Arctic. Megan Boldenow, a new PhD student working with Abby Powell at the University of Alaska Fairbanks, is considering investigating why shorebird nesting density is so much higher near the Beringia region of the Circumpolar Arctic (not a formal side project yet).*

Nest Initiation Dates

Nest initiation dates varied tremendously across sites for the focal shorebird species investigated during this study (Figs. 2, 3). Timing of egg-laying appeared to vary less within sites across years than among sites although no formal analysis has been conducted to date. A number of investigators are exploring initiation date variation in greater detail as part of either core or side project investigations. *Eunbi Kwon and Brett Sandercock are investigating how nest initiation (and consequently egg hatching) relates to timing of insect emergence. Kirsty Gurney and David Ward are investigating how nest initiation relates to satellite-derived measures of NDVI (i.e., tundra green-up) and soil temperature.*

Nest Success and Survival

Most nests (78% across both years) were monitored every 3-5 days for survival. Apparent nest success rates (no. of nests with at least one young hatching) varied among years and sites, with the lowest nest success recorded at East Bay in 2010 (22%) and the highest at Mackenzie Delta in 2010 (100%, Table 3). Corrections to estimates will be available as we continue to proof the data and correct assignments in how field technicians assigned nest fate. We will use the nest survival model in Program Mark to estimate nest daily survival rates (DSR) in the future. *Paul Smith and Joe Liebezeit are analyzing how shorebird nest DSR varies across a large geographic area, and how environmental covariates such as predators, lemmings, weather and invertebrates affect survival rates.*

Adult and Chicks Captured

A total of 2,488 adults belonging to 19 species were banded in 2010 and 2011 combined (Table 4). More adults were banded in 2011 than in 2010 (1343 versus 1145). This increase resulted from the addition of the Colville River and Bylot Island sites in 2011, but also higher numbers of adults banded at Nome, Cape Krusenstern, and Barrow. Other sites had lower numbers of adults banded due to decreases in nest density or lower capture effort. Number of adults banded per species ranged from 4 to 334 in 2010, and from 1 to 387 in 2011, with the largest number of adults banded belonging to the ASDN focal species (i.e., Dunlin, Semipalmated Sandpipers, Red and Red-necked phalaropes, and Pectoral Sandpipers). Four species were only observed in one year of the study (BBPL, BBSA, HUGO, and WISN), and five species were only captured at one location (BBPL, East Bay; BBSA, Prudhoe Bay, HUGO, Mackenzie Delta; STSA, Mackenzie Delta; and WISN, Nome). *From most of these individuals, additional data were collected including biometric measurements, molt scores, body condition, and a variety of samples (e.g., blood, feathers, feces) were collected for use in side projects (see below).* Blood and feather samples have been archived either at the U.S. Fish and Wildlife Service Office in Anchorage or with the site investigators.

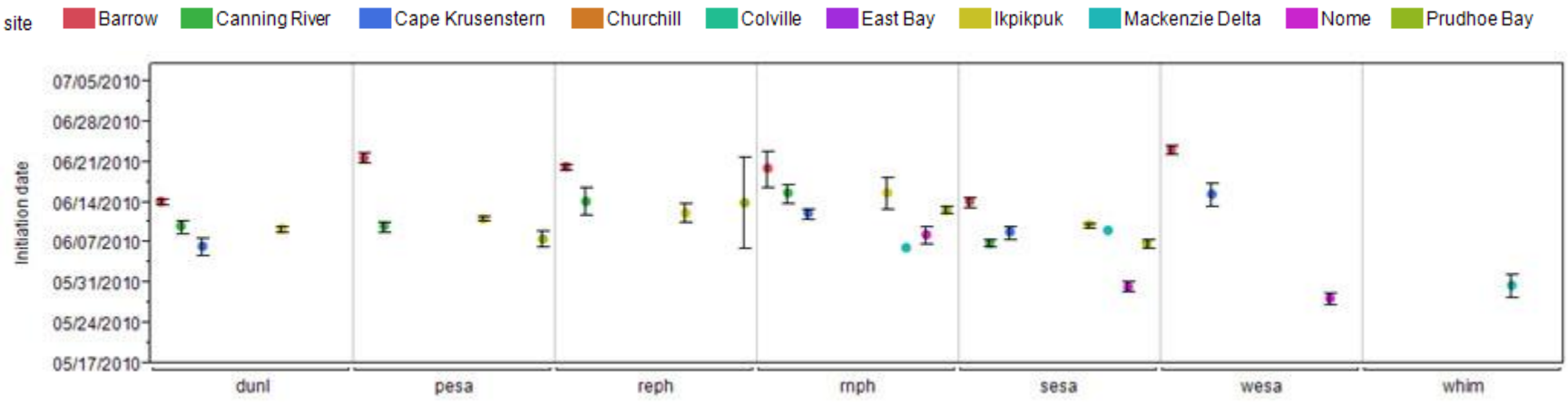

Figure 2. Nest initiation dates of common shorebird taxa found at ASDN sites in 2010.

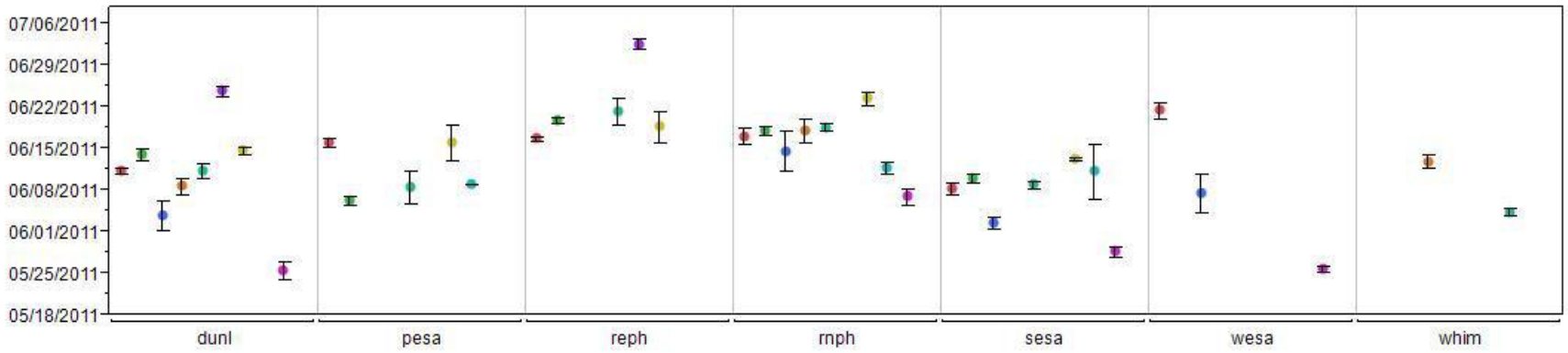

Figure 3. Nest initiation dates of common shorebird taxa found at ASDN sites in 2011.

Table 3. Apparent nest success [% hatch, (n)] of shorebirds breeding at ASDN sites in 2010 and 2011. Churchill (2010) data were not available at time of preparing this document. Species not breeding at each site denoted with "--."

	Nome		Cape Krusenstern		Barrow		Ikpikpuk		Colville	Prudhoe Bay	Canning River		Mackenzie Delta		East Bay		Churchill	Bylot Island
	2010	2011	2010	2011	2010	2011	2010	2011	2011	2010	2010	2011	2010	2011	2010	2011	2011	2011
amgp	--	--	--	--	28 (14)	91 (11)	--	--	--	--	0 (1)	0 (1)	--	100 (1)	--	0 (2)	--	63 (24)
barg	--	--	--	--	--	--	33 (3)	--	100 (1)	--	--	--	--	--	--	--	--	
basa	--	--	--	--	100 (1)	--	--	--	--	--	0 (1)	--	--	--	--	--	--	90 (20)
bbpl	--	--	--	--	--	--	--	--	33 (3)	--	100 (1)	--	--	--	45 (11)	38 (8)	--	33 (3)
bbsa	--	--	--	--	--	--	--	--	--	--	--	0 (1)	--	--	--	--	--	
dunl	--	--	71 (14)	100 (12)	56 (62)	91 (56)	50 (2)	85 (13)	72 (11)	--	82 (11)	0 (10)	--	--	0 (3)	0 (2)	100 (15)	
hugo	--	--	--	--	--	--	--	--	--	--	--	--	--	100 (1)	--	--	--	
lesa	--	--	--	--	--	--	--	--	--	--	--	--	--	100 (2)	--	--	--	
lbdo	--	--	--	--	12 (17)	62 (34)	0 (2)	100 (2)	0 (1)	--	--	--	--	--	--	--	--	
pesa	--	--	--	--	50 (36)	79 (106)	33 (3)	100 (2)	67 (3)	14 (7)	76 (33)	45 (67)	--	100 (2)	--	--	--	
rekn	--	--	--	--	--	--	--	--	--	--	--	--	--	--	100 (1)	--	--	
reph	--	--	--	--	66 (67)	85 (155)	50 (2)	89 (9)	67 (12)	0 (1)	70 (10)	68 (19)	--	--	43 (23)	0 (8)	--	100 (1)
rnph	54 (13)	60 (30)	0 (5)	86 (7)	100 (1)	91 (11)	33 (3)	50 (4)	72 (18)	--	75 (24)	56 (27)	100 (1)	86 (7)	--	--	100 (2)	
rutu	--	--	--	--	--	100 (1)	--	--	67 (6)	100 (2)	100 (1)	100 (1)	--	--	21 (19)	50 (12)	--	
sand	--	--	--	--	--	--	--	--	--	--	--	--	--	--	100 (1)	--	--	
sepl	--	--	--	--	--	--	--	--	100 (1)	--	--	--	100 (4)	100 (4)	20 (5)	45 (11)	--	
sesa	67 (20)	44 (30)	43 (7)	86 (35)	67 (42)	98 (42)	56 (9)	86 (59)	71 (69)	67 (18)	90 (63)	78 (67)	100 (1)	100 (4)	--	--	--	
stsa	--	--	--	--	--	--	--	--	--	--	0 (2)	100 (4)	--	100 (2)	--	--	--	
wesa	50 (22)	47 (42)	33 (3)	86 (7)	50 (8)	50 (10)	--	--	--	--	--	--	--	--	--	--	--	
whim	--	--	--	--	--	--	--	--	--	--	--	--	100 (6)	100 (5)	--	--	20 (15)	
wrsa	--	--	--	--	0 (1)	100 (1)	--	--	--	--	--	--	--	--	25 (32)	21 (14)	--	0 (2)
Total	56 (55)	49 (102)	48 (29)	89 (61)	56 (254)	83 (427)	41 (24)	85 (89)	70 (125)	52 (31)	80 (147)	58 (197)	100 (12)	96 (28)	22 (95)	29 (57)	63 (32)	70 (50)

Table 4. Number of adult birds banded at each ASDN site by species in 2010 and 2011. Numbers include those banded in prior years but recaptured in 2010 and 2011.

	Nome		Cape Krusenstern		Barrow		Ikpikpuk		Canning River		Colville River	Prudhoe Bay	Mackenzie Delta		East Bay		Churchill		Bylot Island	Total
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2011	2010	2010	2011	2010	2011	2010	2011	2011	
amgp	--	--	--	--	19	15	--	--	--	--	--	--	--	1	--	--	--	--	43	78
barg	--	--	--	--	--	--	6	1	--	--	--	--	--	--	--	--	--	--	--	7
basa	--	--	--	--	2	--	--	--	2	--	--	--	--	--	--	--	--	--	3	7
bbpl	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12	--	--	--	12
bbsa	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--	--	--	--	--	5
dunl	--	2	30	26	105	147	35	31	23	19	6	6	--	--	1	--	46	50	--	527
hugo	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	1
lbdo	--	--	--	--	15	48	8	--	--	--	--	1	--	--	--	--	--	--	--	72
pesa	--	2	--	--	26	50	30	--	39	38	3	20	--	8	--	--	--	--	--	216
reph	--	--	--	--	61	44	18	9	11	7	4	5	--	--	36	--	--	--	--	195
rnph	16	55	2	12	8	9	13	10	19	10	2	5	6	13	--	--	6	3	--	189
rutu	--	--	--	--	--	2	--	--	5	--	8	3	--	--	21	12	--	--	--	51
sepl	--	--	--	--	--	--	--	--	--	--	--	--	8	6	8	--	--	--	--	22
sesa	35	104	18	58	85	61	50	68	102	51	31	35	9	14	--	--	--	--	--	721
stsa	--	--	--	--	--	--	--	--	--	--	--	--	4	4	--	--	--	--	--	8
wesa	51	184	11	19	15	10	--	--	--	--	--	--	--	--	--	--	--	--	--	290
whim	--	--	--	--	--	--	--	--	--	--	--	--	6	7	--	--	39	12	--	64
wisn	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
wrsa	--	--	--	--	--	1	--	--	--	--	--	--	--	--	20	--	--	--	--	21
Total	102	350	61	115	336	387	160	119	201	125	54	80	33	54	86	24	91	65	46	2488

Chicks were also captured and banded at Barrow (2010 and 2011) and Nome, Mackenzie Delta, Bylot Island and Churchill (all in 2011). We do not summarize the numbers here but they exceeded 1500.

Adult Return Rate

The percentage of color-marked adults that were initially marked in 2010 and returned in 2011 varied among our five focal species (Table 5). The highest returns were observed in Dunlin, Red-necked Phalarope, Semipalmated Sandpiper, Western Sandpiper, and Whimbrel. The percentage returning varied substantially among sites within each species, especially Red-necked Phalarope and Western Sandpiper. Additional years of information on return rates are needed before adult survival analysis can be conducted using Program Mark (3 to 4 years of returns are required). Our preliminary data, however, suggest that sufficient numbers of birds return for each of these species to obtain reliable adult survival estimates. Much lower return rates were observed in Red Phalarope and Pectoral Sandpiper, making adult survival estimates impossible to calculate. Other species, such as American Golden-Plover, Baird's Sandpiper, Long-billed Dowitcher, Ruddy Turnstone, and White-rumped Sandpiper, had sizeable numbers of birds banded at one or two sites; adult survival estimates may be possible for some of these but will be based on a much smaller geographic scale. For most of the species not listed in Table 5, adult return rates are not meaningful because the number of birds marked was too small at any given site. Funding is being sought for a post-doctoral research associate to evaluate adult survival rates among shorebirds at the ASDN sites. The postdoc would be trained and supervised by Brett Sandercock for the demographic analyses.

Table 5. Estimates of the percentage of color-marked individuals returning to ASDN sites in 2011. A "-" means no individuals of that species were banded at that ASDN site and available to be resighted.

	Nome	Cape Krusenstern	Barrow	Ikpikpuk	Canning River	Mackenzie Delta	Churchill
Dunlin	-	43%	27%	30%	27%	-	39%
Pectoral Sandpiper	-	-	0%	0%	8%	-	-
Red Phalarope	-	-	3%	11%	0%	-	-
Red-necked Phalarope	25%	50%	26%	8%	26%	0%	0%
Semipalmated Sandpiper	66%	11%	22%	48%	40%	22%	-
Western Sandpiper	69%	9%	13%	-	-	-	-
Whimbrel	-	-	-	-	-	33%	13%

Daily Species List

All ASDN sites recorded a daily species list in 2010 and 2011; in most cases this list included not only presence and absence of birds and mammals but also a rough count of the number of animals as well as a measure of effort made to detect these animals (e.g., number of people involved in the count). For 2012, we continued to collect these data as they provide a good measure of relative abundance, especially for species that fluctuate dramatically in number from year-to-year. Good examples of such "irruptive" species include Snowy Owls (*Bubo scandiacus)*, Pomarine Jaegers (*Stercorarius pomarinus*) and lemmings, which can vary tremendously in population numbers among years. Many of the ASDN sites have also contributed their bird observation data to eBird, which is a real-time, online checklist program that collects bird observations made by recreational and professional bird watchers (http://ebird.org/content/ebird/about).

Food Resources

ASDN sites established sampling stations to document aquatic and terrestrial invertebrate diversity, phenology, and abundance. Each ASDN site established five replicate samples in the following three habitats: aquatic, mesic terrestrial, and dry terrestrial. Data collection dates and sample acquisition for 2010 and 2011 are listed in Table 6. To date, all of the 2010 samples and most of the 2011 samples have been processed by Bob Wisseman of Aquatic Biology Associates, Inc. Three sites have opted to process their own invertebrate data, including Bylot Island, Nome, and Churchill.

An example of the invertebrate information obtained from this sorting process is presented in Figure 4 for the Barrow site. Because these data are so voluminous, we do not report them here. Food resource data are being used in several core and side-project investigations that include many of the ASDN sites. *Dan Rinella is using this information along with pond hydrology and weather data to predict dates of invertebrate emergence (see below). Eunbi Kwon and Brett Sandercock are exploring how patterns of invertebrate emergence relate to nest hatching (i.e., the mismatch hypothesis; e.g. see Figure 5). Other researchers are using invertebrate data as covariates to explain density of shorebirds and nest success. Finally, the invertebrate biologist community has taken an interest in the invertebrate species themselves (see below).*

Predator and Alternative Prey Surveys

Avian and mammalian predators were surveyed by conducting point counts weekly throughout the summer at each ASDN site in 2010 (Table 7). During the fall of 2010, ASDN collaborators requested a protocol change to address the low encounter rates for predators at some arctic sites. Accordingly, an index approach was developed to cover a wider geographic area within each study area and allow predator abundances to be recorded throughout the day. Some ASDN sites continued point count surveys in 2011 to ensure long-term continuity in data collection. As part of this change, observers were also instructed to count Brown and Collared lemmings during these surveys (see version 2 protocol). Lemmings and other small mammals are also inventoried by conducting daily opportunistic counts and a single nest count transect shortly after snow melt. The opportunistic data are recorded on daily species lists. *Joe Liebezeit and the Wildlife Conservation Society have expressed an interest in assessing predator diversity and abundance across the North Slope of Alaska and McKenzie River Delta site. They will apply the findings of the nest survival study mentioned above to evaluate whether sites with human development represent an anomaly in terms of predator abundance or nest survival. Specifically, they will determine whether the abundance or influence of subsidized predators is greater at sites closer to human development.*

Table 6. Range and number of food resource data collection events at ASDN sites in 2010 and 2011. Number of collection events is noted in parentheses. Each collection event represents 3 to 5 samples, except for where both bottle traps and sweep net samples were employed for aquatic sampling (East Bay in 2010, and Nome and Canning River in 2011). Twice as many samples were collected at the latter three sites. -- : samples not collected.

Site	Terrestrial		Aquatic
	Dry	Mesic	
2010			
Nome	4 June – 10 July (13)	4 June – 10 July (13)	4 June – 10 July (13)
Cape Krusenstern	--	--	--
Barrow	14 June – 29 July (16)	20 June – 29 July (14)	23 June – 29 July (13)
Ikpikpuk	13 June – 13 July (11)	13 June – 10 July (10)	14 June – 13 July (11)
Prudhoe Bay	12 June – 11 July (10)	12 June – 11 July (10)	12 June – 11 July (10)
Canning River	13 June – 7 July (9)	13 June – 7 July (9)	13 June – 7 July (9)
Mackenzie Delta	15 June – 7 July (8)	15 June – 7 July (8)	15 June – 7 July (8)
East Bay	23 June – 25 July (11)	23 June – 25 July (11)	23 June – 25 July (11)
Churchill	2 June – 1 Aug (21)	2 June – 1 Aug (21)	2 June – 1 Aug (21)
2011			
Nome	25 May - 21 July (20)	31 May – 21 July (18)	7 June – 21 July (20)
Cape Krusenstern	3 June – 3 July (11)	3 June – 3 July (11)	3 June – 3 July (11)
Barrow	4 June – 28 July (19)	4 June – 28 July (19)	4 June – 28 July (19)
Ikpikpuk	8 June – 14 July (13)	8 June – 14 July (13)	8 June – 14 July (13)
Prudhoe Bay	--	--	--
Canning River	8 June – 8 July (11)	8 June – 8 July (11)	8 June – 8 July (11)
Colville	28 May – 13 July (16)	3 June – 13 July (14)	31 May – 13 July (15)
Mackenzie Delta	8 June – 11 July (12)	8 June – 11 July (12)	8 June – 11 July (14)
East Bay	19 June – 24 July (13)	19 June – 24 July (10)	--
Churchill	9 June – 30 July (18)	9 June – 30 July (18)	9 June – 30 July (18)
Bylot	12 June – 17 Aug (34)	14 June – 17 Aug (32)	14 June – 1 Aug (23)

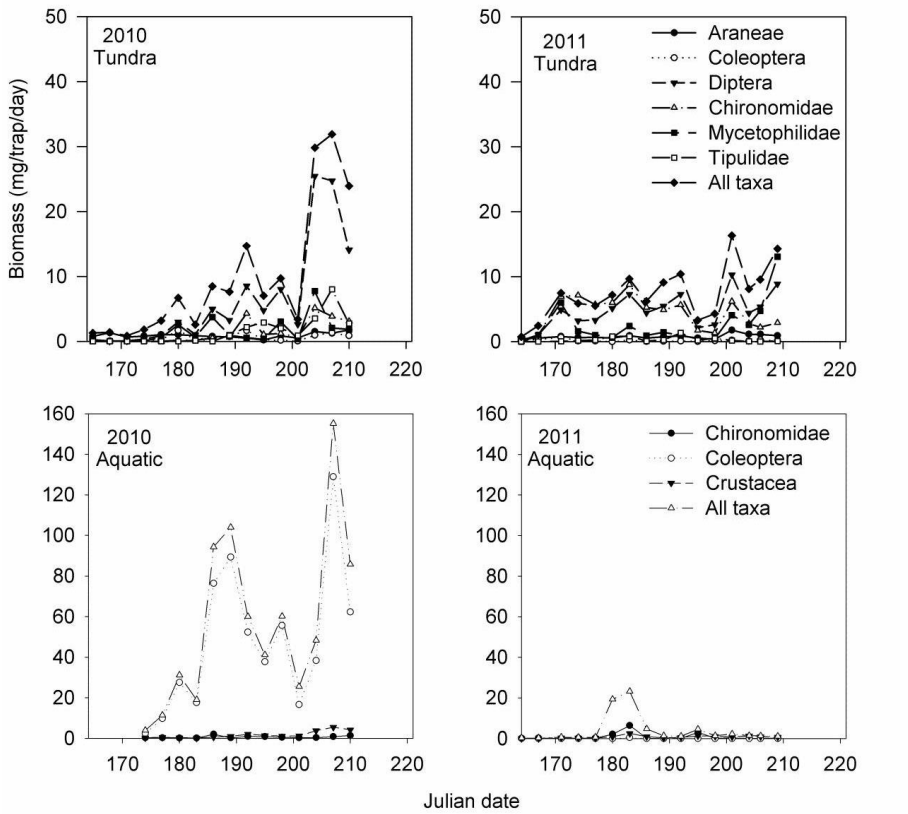

Figure 4. Seasonal variation in invertebrate biomass from mesic/xeric tundra samples and aquatic samples near Barrow, Alaska from 2010 - 2011.

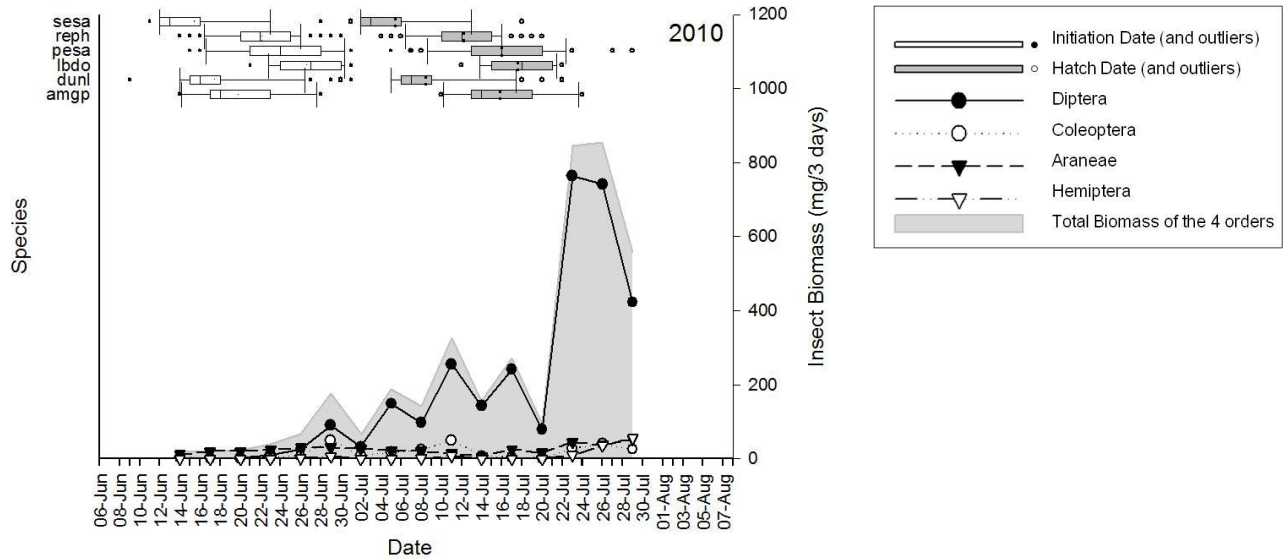

Figure 5. Phenology of shorebird egg-laying, hatch, and invertebrate emergence at Barrow, Alaska, in 2010. Biomass abundance is listed for four dominant invertebrate orders (all families combined) separately and together (gray shaded area). Box plots illustrate 25% and 75% quartiles, median (solid line), mean (dashed line), and outliers (dots outside of bars).

Snow and Surface Water

Snow cover was measured at the beginning of each field season to estimate the date of 50% snow melt and to obtain information on the rates of snow melt for comparison among years and among sites. Surface water was measured less intensively, with the goal to obtain general rates of water loss from the tundra through time. The approach to measure snow and surface water changed between 2010 and 2011 (Table 8). In 2010, personnel collected visual measures of snow cover at a minimum of 10 fixed locations (e.g., at 50 m square quadrats) every other day until 90% of the snow had melted. Surface water, in contrast, was measured independently of snow by locating three unique sites within each of four habitat types: the troughs of high-centered polygons, the centers of low-centered polygons, small ponds or waterbodies, and non-polygonized areas. At each of these locations, water depth was recorded once a week throughout the field season. Not all sites had each of these habitat types and not all sites recorded these data. In 2011, snow and surface water measurements were combined. To do this, we expanded the measurements done at the snow sites in 2010 to include all surface cover features (e.g., snow, water, and land). To accomplish both snow and surface water objectives, surface cover was recorded every other day during the beginning of the season when the snow melts quickly, and then weekly to the end of the field season to gauge changes in surface water. In 2011, no water depths were recorded but rather the percentage of each quadrat that had water was recorded. Snow and surface water measurements will continue unchanged from the approach used in 2011 for the remaining field seasons. *Snow melt dates are being used as covariates in nest initiation and nest survival core studies within the ASDN (see above).*

Climatic conditions

Climate data were collected at a federally maintained weather facility in a nearby community (fixed) or with remote weather stations (remote) at all ASDN sites (Figure 6, Table 9). Data were collected for air temperature, relative humidity, as well as wind speed and direction at all sites. In addition, field crews measured precipitation (snow, rain) manually using rain/snow gauges. Similar data from the fixed weather stations have been downloaded from internet sites. All of the climate data for 2010 have submitted for inclusion in the hydroclimate data archive (Imiq) compiled by the Arctic LCC and North Slope Science Initiative.

Shorebird Ecological and Environmental Variables

Preliminary analysis correlating the predictor variables thought to be responsive to climate change and measures of shorebird distribution, ecology, and demography are on-going because data are still being collected. We have italicized areas above where ASDN core or side-projects are on-going.

Table 7: Range and number of predator surveys and small mammal inventory at ASDN sites in 2010 and 2011. Number of collection events is noted in parentheses. no = no data were collected.

Site	Predator Point-Counts	Predator / Lemming Index	Lemming Nest Count	Trapping of Lemmings	Small Mammal Daily Species List
2010					
Nome	2 Jun (1)	no	no	yes[1]	18 May – 12 Jul
Cape Krusenstern	no	no	no	no	--
Barrow	1 Jun – 29 Jul (8)	no	yes	yes[2]	25 May – 30 Jul
Ikpikpuk	17 Jun – 7 Jul (3)	no	yes	no	9 Jun – 13 Jul
Prudhoe Bay	17 Jun – 14 Jul (3)	no	yes	no	7 Jun – 17 Jul
Canning River	6 – 30 June (4)	no	yes	no	5 Jun – 10 Jul
Mackenzie Delta	14 Jun – 2 Jul (3)	no	no	no	10 Jun – 5 Jul
East Bay	20 Jun – 22 Jul (3)	no	yes	no	2 Jun – 25 Jul
Churchill	20 July (1)	no	yes	no	25 May – 2 Aug
2011					
Nome	no	18 May – 21 Jul (60)	yes	yes[1]	18 May – 8 Jul
Cape Krusenstern	no	4 – 28 Jun (9)	yes	no	28 May – 3 Jul
Barrow	2 Jun – 26 Jul (9)	2 Jun – 26 Jul (9)	yes	yes[2]	27 May – 1 Aug
Ikpikpuk	no	5 Jun – 16 Jul (39)	yes	no	4 Jun – 16 Jul
Colville	no	30 May – 13 Jul (45)	yes	no	18 May – 31 Jul
Prudhoe Bay	no	no	no	no	4 Jun – 18 Jul
Canning River	7 Jun (1)	7 Jun – 10 Jul (12)	yes	no	3 Jun – 12 Jul
Mackenzie Delta	no	7 Jun – 7 Jul (17)	no	no	5 Jun – 10 Jul
East Bay	no	no	no	no	11 Jun – 25 Jul
Churchill	no	9 Jun – 20 Jul (24)	yes	no	26 May – 3 Aug
Bylot Island	no	7 Jun – 16 Aug	yes	yes[3]	5 Jun – 5 Aug

[1] Live trapping conducted by ASDN staff.

[2] Trapping of lemmings is being conducted independently of the ASDN by Kaithryn Ott (live-traps; USFWS, Ecological Services) and Denver Holt (snap traps; Owl Research Institute).

[3] Live and snap trapping of lemmings are being conducted independently of the ASDN by Gilles Gauthier's field personnel located at Université Laval, Quebec City, Canada.

Table 8. Sampling period, frequency and method for estimating snow and surface water measurements at each ASDN site in 2010 and 2011.

	ASDN site										
	Nome	Cape Krusenstern	Barrow	Ikpikpuk	Colville River	Prudhoe Bay	Canning River	Mackenzie Delta	East Bay	Churchill	Bylot Island
2010: snow											
Sampling Period	no	no	30 May – 19 Jun	9 – 29 Jun	n/a	4 – 19 Jun	5 – 30 Jun	No snow present	2 Jun – 25 Jul	no	n/a
Frequency†	no	no	2d	3-5d	n/a	3-5d	5d	n/a	1d	no	n/a
Method	no	no	50 m^2	50 m^2	n/a	50 m^2	50 m^2	n/a	Area	no	n/a
Date 50% loss	no	no	12 Jun	Unk[2]	n/a	Unk[3]	15 Jun	n/a	9 Jun	no	n/a
2010: surface water											
Sampling Period	4 Jun – 10 Jul	no	22 Jun – 24 Jul	12 Jun – 3 Jul	n/a	15 Jun – 13 Jul	10 Jun – 7 Jul	no	2 Jun – 25 Jul	no	n/a
High Center polygons	no	no	6	4	n/a	5	10	no	no	no	n/a
Low centered polygons	no	no	6	4	n/a	5	10	no	no	no	n/a
Non-polygonized	no	no	6	4	n/a	5	no	no	no	no	n/a
Pond	8	no	6	4	n/a	5	10	no	no	no	n/a
Tidal inlet	8	no	no	no	n/a	no	no	no	no	no	n/a
General Study area	no	no	no	no	n/a	no	no	no	1	no	n/a
2011: snow and surface water combined											
Sampling Period	20 May – 20 Jul	7 – 20 Jun	29 May – 26 Jul	9 – 29 Jun	20 May – 13 July	3 Jun – 16 Jul	6 Jun – 9 Jul	6 Jun – 6 Jul	no	24 May – 28 Jul	30 May
Frequency†	2d, then 7d	7d	2d, then 7d	3-5d	2d, then 7d	2-4d	5d	1d, then 5d	no	3d, then 7d	2-3d
Method	Area	Area	50 m^2	50 m^2	Area	50 m^2	50 m^2	Area	no	Area	Area
Date 50% loss	20 May	Unk‡	14 Jun	Unk‡	30 May	Unk‡	11 Jun	Unk‡	no	Unk‡	9 Jun

No = no sampling done; n/a = not applicable since ASDN site was not established

† d = day; #d, then #d indicates interval snow was measured and then surface water was measured.

‡ Unk = Unknown, snow was <50% when field camp was established

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Figure 6. Example of a remote weather station deployed at ASDN sites.

Table 9. Dates where weather information was collected at ASDN sites in 2010 and 2011.

	ASDN site										
	Nome	Cape Krusenstern	Barrow	Ikpikpuk	Colville River	Prudhoe Bay	Canning River	Mackenzie Delta	East Bay	Churchill	Bylot Island
2010											
Sampling Period	16 May – 12 Jul	no	25 May – 31 Jul	10 Jun – 13 Jul	no	4 Jun – 18 Jul	4 Jun – 11 Jul	9 Jun – 7 Jul	3 Jun – 27 Jul	25 May – 2 Aug	no
Method	Remote	no	Fixed	Remote	no	Fixed	Remote	Remote	Remote	Fixed	no
Interval	1 hr	no	1 hr	1 hr	no	1 hr	1 hr	1 hr	daily	4 hr	no
2011											
Sampling Period	16 May – 21 Jul	2 Jun – 4 Jul	1 May – 31 Aug	5 Jun – 16 Jul	10 Jun – 9 Aug	1 Jun – 30 Jul	5 Jun – 13 Jul	7 Jun – 11 Jul	17 Jun – 22 Jul	1 May – 15 Aug	5 Jun – 5 Aug
Method	Remote	Remote	Fixed	Remote	Remote	Fixed	Remote	Remote	Remote	Fixed	remote
Interval	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr	Daily	4 hr	1 hr

Projects Using ASDN Data

The Network has taken an active role in encouraging projects related to the ecology and conservation of shorebirds that can take advantage of the taxonomic diversity and geographic dispersion of our ASDN sites. Below we provide the project title, lead coordinators, and brief description of each project. For many of these projects, there will be many other ASDN principal investigators involved. Full project proposals are available for all of these studies.

1) Avian Influenza – U.S. Fish and Wildlife Service, Migratory Bird Management

   To evaluate the presence of H5N1 highly pathogenic avian influenza in shorebirds, four sites in Arctic Alaska collected cloacal swabs from birds in 2010. The four sample sites included Barrow, Ikpikpuk River, Prudhoe Bay and the Canning River. No positive cases of H5N1 influenza were detected from any shorebird. An annual report describing samples obtained was submitted to the US Fish and Wildlife Service in the spring of 2011.

2) Migratory connectivity of Dunlin using geolocators – Stephen Yezerinac, Mount Allison University

   To determine the spatial relationships among important wintering, migration, and breeding areas of Dunlin, a total of 268 light level geolocators were placed on Dunlin at five of the ASDN sites (Cape Krusenstern, Barrow, Ikpikpuk, Canning River, Churchill) and two additional sites outside of the ASDN network (Cold Bay and Yukon Delta, Alaska) in June of 2010. A total of 96 of these devices were retrieved from birds in June 2011. Preliminary analysis of the track lines of these birds has been completed and a manuscript describing the migratory connectivity of the three North American subspecies of Dunlin is in preparation.

3) Migratory connectivity of Semipalmated Sandpiper using stable isotopes – David Mizrahi, New Jersey Audubon

   To determine the spatial relationships among important wintering, migration, and breeding areas of Semipalmated Sandpipers, the 6th primary covert feathers were collected from birds captured at ASDN sites in 2011. Stable isotope values obtained from these feathers will be used to determine if birds breeding in eastern and western Arctic regions use different wintering areas. Stable isotope data obtained from birds in Suriname and French Guiana has provided an effective way to distinguish adult birds caught in these two countries. A better understanding of migratory connectivity is badly needed given the recent population declines observed in eastern Canada. Preparation and assays of samples collected by ASDN collaborators during the 2011 and 2012 field season will be completed by April 2013. Reports to funding agencies are due September 2013 and a manuscript will be ready for submission shortly thereafter.

4) Avian malaria of shorebirds – Claudia Ganser (PhD candidate) and Samantha Wisely – Florida State University

   To further understand the role of Arctic-breeding shorebirds in the global transmission cycle of avian malaria, this study's objectives were to 1) estimate avian malaria pathogen prevalence of Arctic-breeding shorebirds, 2) identify haematozoa lineages (strains) to describe the pathogen community in shorebirds, and 3) determine the biogeography of haematozoa to identify hotspots along migratory routes and infer cross-species transmission events across the globe. In 2011, a total of 419 red blood samples were collected from 11 shorebird species sampled at six locations in Alaska. Of these samples, 2.39% (10) of these were found to have evidence of haematozoa;

prevalence was variable across shorebird species (Ruddy Turnstone=0%, Dunlin=1.03%, White-rumped Sandpiper=0%, Western Sandpiper=4.17%, Pectoral Sandpiper=4.17%, Semipalmated Sandpiper=2.00%, Long-billed Dowitcher=4.76%, Red Phalarope=0%, American Golden Plover=0%, Wilson's Snipe=0%). Infections by parasites from the genera *Plasmodium* and *Haemoproteus* were detected, but evidence of *Leucocytozoon* infections was not found. Two *Plasmodium* lineages in two shorebird samples and a new *Haemoproteus* lineage in two shorebird samples were detected. Additional samples are planned for collection in 2012 and 2013.

5) Gut microbiota of shorebirds – Kirsten Grond (PhD student) and Brett Sandercock – Kansas State University

To better understand the relationship between health of migratory birds and their gut microbial communities, this study sought to determine if the diversity and prevalence of microbiota in Arctic-breeding shorebirds varies with migration route, habitats used, and general wintering region of the world. In 2011, 630 fecal samples belonging to 12 species at 11 ASDN sites were gathered. Of these, DNA was successfully extracted from 587 samples belonging to 10 shorebird species. All samples have been scanned for two major bacterial groups, *Bacteroidetes* and *Enterococcus*, using different quantitative PCR assays. Fecal indicator bacteria (FIB) such as *Enterococcus* spp. and *Bacteroidetes* were detected in all shorebird species tested in this study with the exception of the White-rumped Sandpiper. A greater abundance of *Bacteroidetes* compared to *Enterococcus* spp. was observed in most shorebird species; an exception was the Red Phalarope and Red-necked Phalarope that showed the reverse pattern. Due to large variation in microbiota values between species, qPCR results showed no clear distinction in prevalence of *Enterococcus* between shorebird species based on similarity in flyway and migration route. The pelagic species of phalaropes showed a lower average prevalence of *Bacteroidetes* than the upland and coastal species. Additional laboratory analyses using high throughput sequencing via the Illumina platform have recently commenced and results will be made available to K. Grond for analyses as soon as possible. Additional samples are planned for collection in 2012 and 2013.

6) Mercury exposure in shorebirds – David Evers and Iain Stenhouse, Biodiversity Research Institute

To evaluate the risk of mercury exposure across a diversity of shorebird species over a large geographic range, a project was funded in 2011 to sample and test shorebirds for exposure in 2012. Shorebirds are predicted to be exposed to mercury through the local food web in concentrations that may impair health and, ultimately, have adverse effects at the population level. Contaminant exposure has already been identified as one of five leading factors that may be limiting shorebird populations (Butler et al. 2004), but the degree to which mercury contamination may be contributing to reduced reproductive success and population declines has not been well studied. In 2012 and 2013, feather and blood samples will be collected from a variety of shorebird species at field sites across the ASDN network.

7) Effects of spring phenology on timing of breeding in shorebirds – Kirsty Gurney, University of Alaska Fairbanks; and David Ward and Michael Budde, U.S. Geological Survey

To assess spatial and annual variation in arctic shorebird breeding phenology and to understand how spring phenology affects these patterns, satellite-derived information on spring thaw (i.e., soil temperature) and greening of vegetation (i.e., NDVI) was gathered for

participating ASDN sites and related to nest initiation data. This project was proposed in spring 2012, and is currently collating nest initiation data from ASDN sites. Satellite-derived data will be available in spring 2013 and data analysis and paper preparation will take place in the fall 2013.

8) Invertebrate phenology in relation to habitat features and weather - Daniel Rinnella, University of Alaska Anchorage

To better understand invertebrate phenology and abundance, statistical models will be developed that relate the timing and duration of (1) aquatic insect emergence and (2) terrestrial insect activity to a suite of climatic and weather predictors. Models will be used to forecast changes in the timing of invertebrate prey availability for arctic-breeding shorebirds and other consumers based on scenarios of future climate change. The investigations of phenology for this project rely on invertebrate, weather, and snow melt data collected at ASDN sites in 2010-2011, as well as project-specific data on pond habitat (e.g., bathymetry) and water temperature data collected in 2011. Over 1500 invertebrate samples were collected in each of 2010 and 2011, and pond habitat and temperature data were collected from 35 ponds in 2011. Additional data were collected in 2012. Funds for this study were provided independently from the Arctic LCC in 2011.

9) Test of the Phenological Mismatch Hypothesis in Arctic-breeding Shorebirds – Eunbi Kwon (PhD Candidate) and Brett Sandercock, Kansas State University

Climate change is predicted to change the date of peak emergence of invertebrates in Arctic regions, whereas the peak hatch of migratory shorebirds in these same areas is predicted to be less flexible due to factors regulating the timing of migration. To test for the potential of an ecological mismatch, this project will evaluate the presence and the degree of phenological mismatch among different breeding populations and shorebird species within the ASDN network. Invertebrate samples and nest initiation data have been collected at ASDN sites in 2010, 2011, and 2012, and data analysis are being conducted.

10) Migratory connectivity of American Golden-Plovers – Jean-François Lamarre (PhD Candidate) and Joël Bêty, Université du Québec à Rimouski

To determine the spatial relationships among important wintering, migration and breeding areas of American Golden-plovers, light-level geolocators were placed on plovers in Nome and Barrow in 2009 and 2010. Seven of these devices were retrieved in 2010 and 2011, providing some of the first migratory track lines of plovers to date. In 2011, 24 geolocators were placed on plovers on Bylot Island. Some devices were recovered in 2012, and additional 52 geolocators were deployed at ASDN sites (Nome, Barrow, Churchill, and Bylot Island) and other locations (Caw Ridge, Alberta) in 2012. Geolocator devices will be recovered in 2013, and collectively track lines from all birds will be used to prepare a paper describing the migratory connectivity of this species.

11) Migratory connectivity of Semipalmated Sandpipers – Stephen Yezerinac, Mount Allison University; Stephen Brown, Manomet Center for Conservation Sciences; David Mizrahi, New Jersey Audubon; and Richard Lanctot, US Fish and Wildlife Service

To determine the spatial relationships among important wintering, migration, and breeding areas of Semipalmated Sandpipers, 190 light level geolocators will be placed on birds at five ASDN sites in the Arctic during the 2013 field season. An additional 30 geolocators will also be

placed on birds at one site in Brazil in 2013. Geolocators will be retrieved in 2014, and light level data will be used to construct migration pathways, and to elucidate important wintering and breeding areas.

12) Do migratory shorebirds disperse Moss (Bryophyta) diaspores? – Lily Lewis (PhD Candidate) and Chris Elphick, University of Connecticut

To test the hypothesis that long-distance dispersal of moss is occurring by transport on migratory shorebirds, personnel are collecting breast feather samples from shorebirds captured throughout the ASDN network. This project was proposed in the fall of 2012 and feather samples will occur in the summer of 2013.

13) Variation in shorebird nest predation across the North American Arctic – Paul Smith, Smith and Associates Ecological Research Ltd., and Joe Liebezeit, Wildlife Conservation Society

To better understand geographic patterns in shorebird nest survival, variation in nest survival will be related to shorebird nest density, predator abundance, lemming abundance, and other environmental variables (such as timing of snow melt or mean June temperature). This study will use data from the first four years of the ASDN operation (2010-2013 field seasons), with plans for analysis in the fall of 2013 and submission of a manuscript to a peer-reviewed journal by February 2014.

14) Assessment of predator diversity and abundance in relation to human development – Joe Liebezeit, Wildlife Conservation Society

Using information generated from the shorebird nest predation study (project13), this study proposes to integrate the assessment of predator abundance and shorebird nest survival into a predator management plan for the North Slope of Alaska. Increasing human activity in the Arctic, particularly through energy extraction, has subsidized native generalist species like common ravens, arctic fox, and Glaucous Gulls. These generalist species take advantage of human food subsidies and use man-made structures for denning and nesting. This project will generate the empirical data needed to better understand the degree to which subsidized predators are impacting shorebirds' reproductive success, and what conservation benefits might be anticipated through better practices. Data on predation and shorebird nest survival from ASDN sites on the North Slope of Alaska between 2010 and 2014 will be used for this study.

15) Arctic shorebird settlement patterns – Sarah Saalfeld and Richard Lanctot, U.S. Fish and Wildlife Service

Shorebirds appear to use conservative and opportunistic settlement strategies to exploit the unpredictable Arctic environment. However, no study has used long-term data from intensively marked populations of shorebirds from multiple sites to systematically assess whether these two settlement strategies exist and if species consistently follow one strategy or another through time. Furthermore, no study has evaluated the environmental and social factors influencing how individual birds settle. This study, proposed in spring 2013, will use data collected at ASDN sites over the five year study period to investigate how shorebird nest density relates to invertebrate amount and dependability, abundance of predators and alternative prey, timing of snow melt and vegetation green-up, prior reproductive success of shorebirds in an area, and social cues.

16) Distribution of Arctic invertebrates – Bob Wisseman, Aquatic Biology Associates, Inc. and partners in systematic zoology who are invertebrate specialists.

A request was made to summarize and publish information collected from ASDN sites on the distribution and abundance of species within the Trichoptera (caddisflies), Plecoptera (stoneflies), Ephemeroptera (mayflies or shadflies), and Diptera (true flies) orders. These publications would involve researchers from a number of different universities across the United States.

17) Feather and blood collection for stable isotope and genetic investigations

We have collected feather and blood samples from captured individuals for future studies on migratory connectivity (via stable isotopes) and population genetics and phylogeography in 2010 and 2011. To date, feathers have been or are planned to be used from Dunlin and Semipalmated Sandpipers, and we anticipate future use of these tissues as funds become available and new principal investigators become interested.

Other Accomplishments

Principal investigators met in person or by teleconference to discuss data collection and protocols related to conducting field work during the Alaska Bird Conference in November 2010, the Western Hemisphere Shorebird Group meeting in August 2011, and the North American Ornithological Congress in August 2012. We have also held regular teleconference calls outside of these meetings to discuss protocols and data collection techniques so as to ensure standardization and consistency in quality data collection. We also learned of issues faced by individual ASDN site leaders that prohibited them from conducting various field tasks during these meetings. This "face time" was critical for obtaining buy-in from all site leads and allowing us to make progress towards our goals. Based on discussions at this meeting, we established a comprehensive Memorandum of Understanding (MOU) among all of the organizational partners sponsoring a field site. The MOU was signed by all parties in March 2011. This document will guide the interactions of the partners, and ensure that collaborative data analysis and publication proceed smoothly following completion of the project. We have also developed a standardized side-project MOU that discusses the roles and responsibilities of side project principal investigators and ASDN network leaders.

As of this writing, we have generated the following publications, reports, popular articles, and presentations from work associated with data collected at all or particular sites within the Arctic Shorebird Demographics Network between 2010 and now. Items are listed chronologically within each topic.

Peer-reviewed Publications

Clark, N. A., C. D. T. Minton, J. W. Fox, K. Gosbell, R. B. Lanctot, R. R. Porter, and S. Yezerinac. 2010. The use of light-level geolocators to study wader movements. *Wader Study Group Bull.* 117: 173–178.

Franks, S., D.R. Norris, T.K. Kyser, G. Fernández, B. Schwarz, R. Carmona, M.A. Colwell, J. Correa Sandoval, A. Dondua, H.R. Gates, B. Haase, D.J. Hodkinson, A. Jiménez, R.B. Lanctot, B. Ortego, B.K. Sandercock, F. Sanders, J.Y. Takekawa, N. Warnock, R.C. Ydenberg, and D.B. Lank. 2012. Range-wide patterns of migratory connectivity in the Western Sandpiper *Calidris mauri. Journal of Avian Biology* 43:1-13.

Governali, F.C., H.R. Gates, R. B. Lanctot, and R.T. Holmes. 2012. Egg volume can be accurately and efficiently estimated from linear dimensions of eggs for arctic-breeding shorebirds. *Wader Study Group Bulletin* 119:46-51.

Smith, P.A., C. L. Gratto-Trevor, B.T. Collins, S. D. Fellows, R.B. Lanctot, J. Liebezeit, B. McCaffery, D. Tracy, J. Rausch, S. Kendall, S. Zack and H. R Gates. 2012. Trends in abundance of Semipalmated Sandpipers: Evidence from the Arctic. *Waterbirds 35:106-119.*

McKinnon, L., Juillet, C. and E. Nol. (in revisions). Arctic-nesting birds find physiological relief in the face of trophic contraints. *Nature Scientific Reports.*

Saalfeld, S.T., B.K. Hill, and R.B. Lanctot. (in review). Shorebird responses to construction and operation of a landfill on the Arctic Coastal Plain. *Condor*.

Reports:

Gates, H.R., R.B. Lanctot, J. Liebezeit, and P. Smith. 2010. Arctic Shorebird Demographics Network Breeding Camp Protocol, version 1, May 2010. Unpubl. paper by U.S. Fish and Wildlife Service, Anchorage, Alaska.

Gates, H.R., R.B. Lanctot, J.R. Leibezeit, and P. Smith. 2010. Arctic Shorebird Demographic Network breeding season protocol. Unpubl. Report by U.S. Fish and Wildlife Service, Anchorage, Alaska.

Lanctot, R.B. 2010. Avian influenza sampling of shorebirds at Barrow and Cape Krusenstern, Alaska -2010. Unpubl. report for U.S. Fish and Wildlife Service, Anchorage, Alaska.

Lanctot, R.B., and H. R. Gates. 2010. Cape Krusenstern Shorebird Breeding Ecology Study. Investigator's Annual Report. National Park Service.

Liebezeit, J.R. and S. Zack. 2010. Nesting success and nest predators of tundra-nesting birds on the Ikpikpuk River, NE planning area National Petroleum Reserve - Alaska – 2010 annual report. A report prepared by the Wildlife Conservation Society for the Bureau of Land Management, Alaska Department of Fish and Game and other interested parties. Available for download at http://www.wcsnorthamerica.org/tabid/3645/Default.aspx.

Liebezeit, J.R. and S. Zack. 2010. Nesting success and nest predators of tundra-nesting birds in the Prudhoe Bay Oilfield, Long-term Monitoring – 2010 annual report. A report prepared by the Wildlife Conservation Society for the Bureau of Land Management, Alaska Department of Fish and Game, BP Exporation, Alaska, Inc., and other interested parties. Available for download at http://www.wcsnorthamerica.org/tabid/3645/Default.aspx.

Arctic Shorebird Demographics Network Protocol Subcommittee. 2011. Arctic Shorebird Demographics Network Breeding Camp Protocol, version 2, May 2011. Unpubl. paper by U.S. Fish and Wildlife Service and Manomet Center for Conservation Sciences.

Lamarre, J.-F., Bolduc, E., Bêty, J. and Gauthier, G. 2011. Reproductive and migratory ecology of insectivores (Shorebirds and Songbirds) and the effect of climate change on insectivore-insect interactions on Bylot Island. Sirmilik National Park,, Park's Canada Summary Report. 7p.

Wisely, S.M., Ganser, C. 2011. Avian malaria surveillance in Arctic breeding Shorebirds. Ongoing or new studies of Alaska shorebirds annual summary compilation, Alaskan Shorebird Group. U.S. Fish and Wildlife Service.

Gates, H.R., R.B. Lanctot, and S. Yezerinac. 2012. Migratory connectivity of Dunlin breeding at Cape Krusenstern National Monument. Murie Science and Learning Center Fellowship Report to the National Park Service.

Gates, H. R., R. B. Lanctot, J. R. Liebezeit, P. A. Smith, and B. L. Hill 2012. Arctic Shorebird Demographics Network Breeding Camp Protocol, Version 3, April 2012. Unpubl. paper by U.S. Fish and Wildlife Service and Manomet Center for Conservation Sciences.

Wisely, S.M, Ganser, C. 2012. Avian malaria surveillance in Arctic breeding Shorebirds. Annual Summary, Alaskan Shorebird Group. U.S. Fish and Wildlife Service.

Lanctot, R.B., K. Grond, J.W. Santo Domingo, and B.K. Sandercock. 2013. Phylogenetic analysis of microbiota inhabiting the gut of shorebirds using high throughput genetic sequencing techniques.

Unpubl. report to the national U.S. Fish and Wildlife Service's Avian Health and Disease Program.

Wisely, S.M, Ganser, C. 2013. Biogeography of Transmission Dynamics for a Vector-borne pathogen recently found in Arctic-breeding Shorebirds. Avian Health and Disease Progress Report, Alaskan Shorebird Group. U.S. Fish and Wildlife Service.

Popular Articles:

Sandercock, B.K. 2010. There's no place like Nome for professor researching migrant shorebirds. News release, Kansas State University.

Lanctot, R.B. 2012. Dunlin gives (almost) all for shorebird research and conservation. Tattler 24:10-11.

Presentations at Meetings

Brown, S., R.B. Lanctot, and B. Sandercock. 2009. Arctic shorebird demographics network. 15th Annual Alaska Shorebird Group Meeting, Anchorage, Alaska.

Brown, S., R.B. Lanctot, and B. Sandercock. 2010. Arctic Shorebird Demographics Network: overview and current status. 13th Alaska Bird Conference, Anchorage, Alaska.

Lanctot, R.B., S. Brown and B.K. Sandercock. 2010. Arctic Shorebird Demographic Network: understanding the mechanisms behind shorebird declines. 25th International Ornithological Congress. Campos do Jordão, SP, Brazil.

Lanctot, R.B.,S. Brown and B.K. Sandercock. 2010. Arctic shorebird demographic network: understanding the mechanisms behind shorebird declines. Joint Meeting of the American Ornithologists' Union (128th), Cooper Ornithological Society (80th), and the Society of Canadian Ornithologists (30th). San Diego, California.

Brown, S., R.B. Lanctot, H.R. Gates, and B. Sandercock. 2011. Arctic Shorebird Demographics Network. 17th Annual Alaska Shorebird Group Meeting, Anchorage, Alaska.

Brown, S., R.B. Lanctot, and B. Sandercock. 2011. The Arctic Shorebird Demographics Network: Understanding the mechanisms behind shorebird declines. 4th Western Hemisphere Shorebird Group, Vancouver, British Columbia.

Doll, A., M. Wunder, R.B. Lanctot, and C. Stricker. 2011. Estimating arrival times of Arctic-breeding Dunlin using stable isotopes. 4th Western Hemisphere Shorebird Group, Vancouver, British Columbia.

Kwon, E., and Sandercock, B.K. 2011. Population dynamics of arctic-breeding shorebirds under environmental change. Invited talk. Ewha Women's University, Seoul, Korea. December 22, 2011.

Kwon, E., and Sandercock, B.K. 2011. Age-specific demography and population dynamics of the Western Sandpiper (Calidris mauri). 4th Western Hemisphere Shorebird Group Meeting. Vancouver, Canada. August 11-15, 2011.

Kwon, E., and Sandercock, B.K. 2011. Changes in breeding phenology of arctic-breeding shorebirds: comparative study over two decades. KOS 2011 Fall Meeting. Great Bend, KS. USA. September 30-October 2, 2011.

Kwon, E., and Sandercock, B.K. 2011. Age-specific Demography and Population Dynamics of the Western Sandpiper (Calidris mauri). Division of Biology, BioForum. Manhattan, KS. March 5, 2011.

Kwon, E., and Sandercock, B.K. 2011. Age-specific Demography and Population Dynamics of the Western Sandpiper (Calidris mauri). AFO/COS/WOS 2011 Meeting. Kearney, NE. March 9-13, 2011. (poster)

Wunder, W., R.B. Lanctot, C. Stricker, L. Wassenaar, B. Casler, A. Dey, P. Doherty, A. Dondua, S. Drovetski, D. Edwards, R. Gates, B. Hill, O. Lane, J. Liebezeit, D. Poppe, B. Schwarz, P. Tomkovich, D. Tracy, O. Valchuk, and S. Zack. 2011. Using stable isotopes in primary feathers to classify Dunlin subspecies. 4th Western Hemisphere Shorebird Group, Vancouver, British Columbia.

Cunningham, J., D. Kesler, and R.B. Lanctot. 2012. Effects of experience on male and female breeding habitat selection in Arctic-breeding shorebirds. 5th North American Ornithological Conference, Vancouver, British Columbia.

Doll, A., M. Wunder, R.B. Lanctot, and C. Stricker. 2012. Estimating temporal movements of a migratory species using stable carbon isotopes. 8th International Conference on Applications of Stable Isotope

Techniques to Ecological Studies, Brest, France.
Gates, H,R., S. Brown, R.B. Lanctot, and B. Sandercock. 2012. The Arctic Shorebird Demographics Network: Understanding causes of shorebird declines. 14th Alaska Bird Conference, Anchorage, Alaska.
Gates, H.R., S. Brown, R.B. Lanctot, and B. Sandercock. 2012. The Arctic Shorebird Demographics Network: Understanding causes of shorebird declines. 5th North American Ornithological Conference, Vancouver, British Columbia.
Kwon, E., and Sandercock, B.K. 2012. Age-specific demography and population dynamics of the Western Sandpiper (Calidris mauri). Kansas Ornithological Society 2012 Fall Meeting. Winfield, Kansas. September 28-30, 2012.
Kwon, E., and Sandercock, B.K. 2012. Changes in breeding phenology of arctic-breeding shorebirds: comparative study over two decades. 5th North American Ornithological Conference. Vancouver, BC, Canada. August 14-18, 2012.
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Lanctot, R.B. 2012. What happens when you remove a top predator (Arctic Fox) from an Arctic ecosystem? Findings from a 9-year shorebird study at Barrow, Alaska. 20th Kachemak Bay Shorebird Festival, Homer, Alaska.
Lanctot, R.B., S. Saalfeld, B. Hill, R. Gates, A. Taylor, J. Cunningham, A. Doll, and M. Budde. 2012. What happens when you remove an Arctic Fox from a tundra ecosystem? 14th Alaska Bird Conference, Anchorage, Alaska.
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McKinnon, L., Jehl, J., Picotin, M., Juillet, C., Bolduc, E. Bêty, J and E. Nol. 2012. Assessing the sensitivity of arctic-nesting shorebirds to climate induced changes in insect phenology. From Action to Knowledge, International Polar Year (IPY) 2012, Montréal, QC.
McKinnon, L. and E. Nol. 2012. Optimizing shorebird breeding phenology in a changing arctic environment. North American Ornithological Conference, Vancouver, BC.
Saalfeld, S., R.B. Lanctot, S. Brown, and B. Hill. 2012. Shorebird response to construction and operation of the North Slope Borough Landfill in Barrow, Alaska. 14th Alaska Bird Conference, Anchorage, Alaska.
Yezerinac, S., R.B. Lanctot, S. Brown, B. Casler, D. Fifield, R. Gates, B. Hill, S. Kendall, J. Liebezeit, L. McKinnon, and E. Nol. 2012. Connecting Dunlin breeding sites with migratory stopover and wintering locations using light-level geolocation.5th North American Ornithological Conference, Vancouver, British Columbia.
Kwon, E., Lank, D., and Sandercock, B.K. 2013. Changes in breeding phenology and reproductive success of long-distance migratory shorebirds. Division of Biology BioForum. Manhattan, KS. March 2, 2013.
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Relevance to Arctic LCC conservation goals:

The Arctic Shorebird Demographics Network (the Network) is a geographically broad, multi-partner strategy that on-going support from the U.S. Fish and Wildlife Service, U.S. Geological Survey, the Canadian Wildlife Service, Environment Canada, academic partners, and many non-governmental conservation organizations (including Manomet, Inc.). Our study meets several stated objectives within the Arctic Landscape Conservation Cooperative Development and Operations Plan (draft plan December 2009). Specifically, it:

1) has a broad geographic scope that is focused on the Arctic;

2) currently includes a host of partners, including State and Federal Agencies and NGOs, as well as universities;
3) focuses on measuring habitat availability and quality; as well as priority migratory shorebirds that occupy a predominant role in the Arctic environment;
4) will improve our fundamental understanding of ecological changes by providing an inventory of surface water, insects, climate conditions, predators, alternative prey, and shorebird ecology;
5) will build science capacity, by leveraging funds acquired elsewhere to operate the ASDN, and by doing so, complement the priority science needs identified by the WildREACH workshop; and

Fund Expenditures

Funding from the Arctic LCC allowed the ASDN to become a reality in 2010. These funds were critical for successful completion of protocols and data collection, and provided a small boost to many sites that allowed them to start-up in 2010 and continue in 2011. Funds were used to equip sites with necessary equipment (e.g., weather stations, nest traps, invertebrate sampling materials), to hire and supervise field technicians collecting data to meet Arctic LCC specific-objectives at field sites, to pay for invertebrate analysis, and to hire a logistical coordinator that has developed protocols and collated the data from 2010 and 2011. A follow-up grant from the Arctic LCC in 2012 provided funds to cover analyses of invertebrates samples collected in 2012.

The ASDN steering committee continues to seek funds from many locations to pay for general ASDN costs. Seed funding from the Arctic LLC was vital in allowing us to prepare competitive grants proposals that were successfully funded by a series of different sponsors, including NFWF (successful in 2010, 2011, and 2012), Neotropical Migratory Bird Conservation Program of the U.S. Fish and Wildlife Service (successful in 2010, 2011, 2012), and the Alaska Department of Fish and Game (successful in 2010, failed in 2011). We also submitted a proposal to the National Science Foundation's Research Coordination Network grant program in October 2011 that was declined. During July 2012, a proposal was submitted to the U.S. Fish and Wildlife Service's Survey, Monitoring, and Assessment program to hire a 3-year post-doctoral research associate to help with data analyses. Our project was ranked number one in the nation, but federal budget cutbacks due to sequestration prevented our project from being funded. Principal investigators from each site (Appendix 1) fund most of the costs of their sites and collectively acquire funds from many funding agencies, both public and private (see list below). Overall, the seed funding provided by the Arctic LCC has been leveraged by at least 10:1.

The Future

The ASDN expanded from 9 to 11 sites in 2011. We raised new funds to expand field efforts at the Cape Krusenstern site, and new investigators at Bylot Island (Joël Bêty) and the Colville River (David Ward) joined the ASDN in 2011. Due to budget reductions and delays in funding within many federal programs we were unable to raise sufficient funds to continue operating the Prudhoe Bay site at full capacity in 2011. The ASDN network has continued to grow in 2012. Two new sites were added in Russia (Chaun River Delta and Lower Khatanga River) and one site was added in Canada (Burnt Point). Last, two new sites will join the ASDN in 2013; including Igloolik and Coats Island in Nunavut, Canada.

One of our most impressive achievements is the number of network projects that have developed due to the collection of data over many species over a large geographic area. The 17

projects listed above will surely increase as people think of new and creative ways to use the data being collected and the samples being archived.

Acknowledgements

Our progress report summarizes field work conducted by many individuals from many different organizations. Appendix 1 lists the principal investigators and students working at each ASDN site. Within each of these sites, there were a number of additional field technicians whose names are not mentioned. We thank them all for being willing to work in a collaborative nature to address very large scale questions. Besides the Arctic LCC funding, which necessitated this report, field crews were supported by the U.S. Fish and Wildlife Service (including the Arctic National Wildlife Refuge, Selawek National Wildlife Refuge, Migratory Bird Management, and Avian Influenza programs); Manomet Center for Conservation Sciences; the National Fish and Wildlife Foundation; the Neotropical Migratory Bird Conservation Act; U.S. Geological Survey, Alaska Science Center's Changing Arctic Ecosystem Initiative; National Park Service, Cape Krusenstern National Monument and a Murie Science and Learning Center grant to River Gates; Bureau of Land Management; ArcticNet; Department of Indian Affairs and Northern Development Canada, Cumulative Impacts Monitoring Program and Arctic Research Infrastructure Fund; Environment Canada, Canadian Wildlife Service & Science and Technology Branch; Natural Resources Canada, Polar Continental Shelf Program; Natural Sciences and Engineering Research Council of Canada (Discovery Grant, Northern Supplement, International Polar Year, graduate student scholarships), EnviroNorth Program (Canada); National Science Foundation (Office of Polar Programs, and Doctoral Dissertation Improvement Grant to Nathan Senner); the Alaska Department of Fish and Game; FQRNT (Quebec); University of Alaska Fairbanks; Université du Québec à Rimouski, Cornell University Graduate School Mellon Grant (Nathan Senner); Churchill Northern Studies Centre; American Ornithologists' Union; Liz Claiborne / Art Ortenberg Foundation; Faucett Family Foundation; and Athena Foundation.

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Appendix 1. Sponsoring organization(s), names of principal investigators, and graduate students for ASDN sites established in 2010 – 2012, and proposed for 2013.

ASDN Site	Institution	Principal Investigator	Graduate Students
Active sites in 2010			
Nome, Alaska, USA	Simon Fraser University, Kansas State University	David Lank, Brett Sandercock	Eunbi Kwon, Willow English
Cape Krusenstern, Alaska, USA	U.S. Fish and Wildlife Service, Migratory Bird Management	River Gates, Richard Lanctot	Megan Boldenow
Barrow, Alaska, USA	U.S. Fish and Wildlife Service, Migratory Bird Management	Richard Lanctot	Andy Doll, Jenny Cunningham, Kirsten Grond
Ikpikpuk River, Alaska, USA	Wildlife Conservation Society	Joe Liebezeit, Steve Zack	
Prudhoe Bay, Alaska, USA	Wildlife Conservation Society	Joe Liebezeit, Steve Zack	
Canning River, Alaska, USA	U.S. Fish and Wildlife Service, Arctic NWR; Manomet Center for Conservation Sciences;	Steve Kendall, David Payer, Stephen Brown,	
Mackenzie Delta, Northwest Territories, Canada	Environment Canada	Jennie Rausch, Lisa Pirie	
East Bay, Nunavut, Canada	Environment Canada, Smith and Associates Ecological Research Ltd	Grant Gilchrist, Paul Smith	
Churchill, Manitoba, Canada	Trent University, Cornell University	Erica Nol, Laura McKinnon, Nathan Senner	Nathan Senner
New in 2011			
Bylot Island, Nunavut, Canada	University of Quebec at Rimouski	Joël Bêty	Jean-François Lamarre
Colville River Delta, Alaska, USA	U.S. Geological Survey, Alaska Science Center	David Ward	
Reduced in 2011			
Prudhoe Bay, Alaska, USA	Wildlife Conservation Society	Joe Liebezeit, Steve Zack	
New in 2012			
Burntpoint, Ontario	Ontario Ministry of Natural Resources	Rod Brook, Ken Abraham	
Chaun River Delta, Russia	Ornithology Institute of Biological Problems of the North, Wildlife Conservation Society	Diana Solovyeva, Martin Robards, Joe Liebezeit	
Lower Khatanga River, Taimyr, Russia	Lomonosov Moscow State University	Mikhail Soloviev	

Appendix 1 cont.

New in 2013			
Coats Island, Nunavut, Canada	Environment Canada, Smith and Associates Ecological Research Ltd	Grant Gilchrist, Paul Smith	
Igloolik, Nunavut, Canada	Department of Environment, Government of Nunavut	Nicolas Lecomte	

Appendix 2. Species whose nests were located or were banded at ASDN sites in 2010 and 2011. Listed alphabetically by common name to match other tables.

Common Name	Genus Species	4-letter acronym
American Golden-Plover	*Pluvialis dominica*	AMGP
Bar-tailed Godwit	*Limosa lapponica*	BTGO
Baird's Sandpiper	*Calidris bairdii*	BASA
Black-bellied Plover	*Pluvialis squatarola*	BBPL
Buff-breasted Sandpiper	*Trygnites subruficollis*	BBSA
Common-ringed Plover	*Charadrius hiaticula*	CRPL
Dunlin	*Calidris alpina*	DUNL
Hudsonian Godwit	*Limosa hudsonica*	HUGO
Least Sandpiper	*Calidris minutilla*	LESA
Long-billed Dowitcher	*Limnodromus scolopaceus*	LBDO
Pectoral Sandpiper	*Calidris melanotos*	PESA
Red Knot	*Calidris canutus*	REKN
Red Phalarope	*Phalaropus fulicaria*	REPH
Red-necked Phalarope	*Phalaropus lobatus*	RNPH
Ruddy Turnstone	*Arenaria interpres*	RUTU
Sanderling	*Calidris alba*	SAND
Semipalmated Plover	*Charadrius semipalmatus*	SEPL
Semipalmated Sandpiper	*Calidris pusilla*	SESA
Short-billed Dowitcher	*Limnodromus griseus*	SBDO
Stilt Sandpiper	*Calidris himantopus*	STSA
Western Sandpiper	*Calidris mauri*	WESA
Whimbrel	*Numenius phaeopus*	WHIM
White-rumped Sandpiper	*Calidris fuscicollis*	WRSA
Wilson's Snipe	*Gallinago delicata*	WISN