MONITORING OF INDUSTRIAL SOUNDS, SEALS, AND BOWHEAD WHALES NEAR BP'S NORTHSTAR OIL DEVELOPMENT, ALASKAN BEAUFORT SEA, 2007: ANNUAL SUMMARY REPORT

by

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Greeneridge Sciences Inc. & Applied Sociocultural Research

for

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*Cover Photograph***:** DASARs on the M/V *Gwydyr Bay*, with Northstar Island in the background. Photo: Lisanne Aerts, Aug 2007.

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TABLE OF CONTENTS

CHAPTER 1:
INTRODUCTION, DESCRIPTION OF BP'S ACTIVITIES, AND RECORD OF SEAL SIGHTINGS, 2007[1]

by

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INTRODUCTION

BP Exploration (Alaska) Inc. began constructing offshore oil-production facilities in the Prudhoe Bay area, Alaskan Beaufort Sea, during early 2000, and began producing crude oil from Northstar Island during late 2001. Northstar is the first offshore oil production island in the Beaufort Sea. The Northstar Development includes a gravel island for the main facilities and two pipelines connecting the island to the existing infrastructure in Prudhoe Bay. One pipeline transports crude oil to shore, and the other transports natural gas to the island for power generation and field injection. In winter and early spring, the island is connected to the shore by an ice road from West Dock. The facilities on the island include prefabricated modules for living quarters, utilities, and warehouse/shop. Also present are a drilling rig (now used infrequently) and facilities for waste grind and injection and for oil production and gas injection. The production facilities include gas turbine engines to operate power generators and gas compressors. Northstar Island is approximately 9.5 km (6 mi) offshore from Point Storkersen, northwest of the Prudhoe Bay industrial complex, and 5 km (3 mi) seaward of the closest barrier island. Northstar is 87 km (54 mi) northeast of Nuiqsut, the closest Native Alaskan (Inupiat) community, and approximately 27 km (16.5 mi) west of Cross Island where Nuiqsut residents hunt for bowhead whales during autumn (Fig. 1.1). Northstar Island is, to date, the only offshore oil production facility in the Beaufort Sea north of the barrier islands.

Since Aug 1998 BP has submitted various requests to the National Marine Fisheries Service (NMFS) to authorize incidental "taking" of small numbers of marine mammals that may result from BP's activities at Northstar. An overview of these requests is provided in Table 1.1. The current Northstar LoA is valid from 7 Jul 2007 through 6 Jul 2008. The LoAs issued under the previous and current

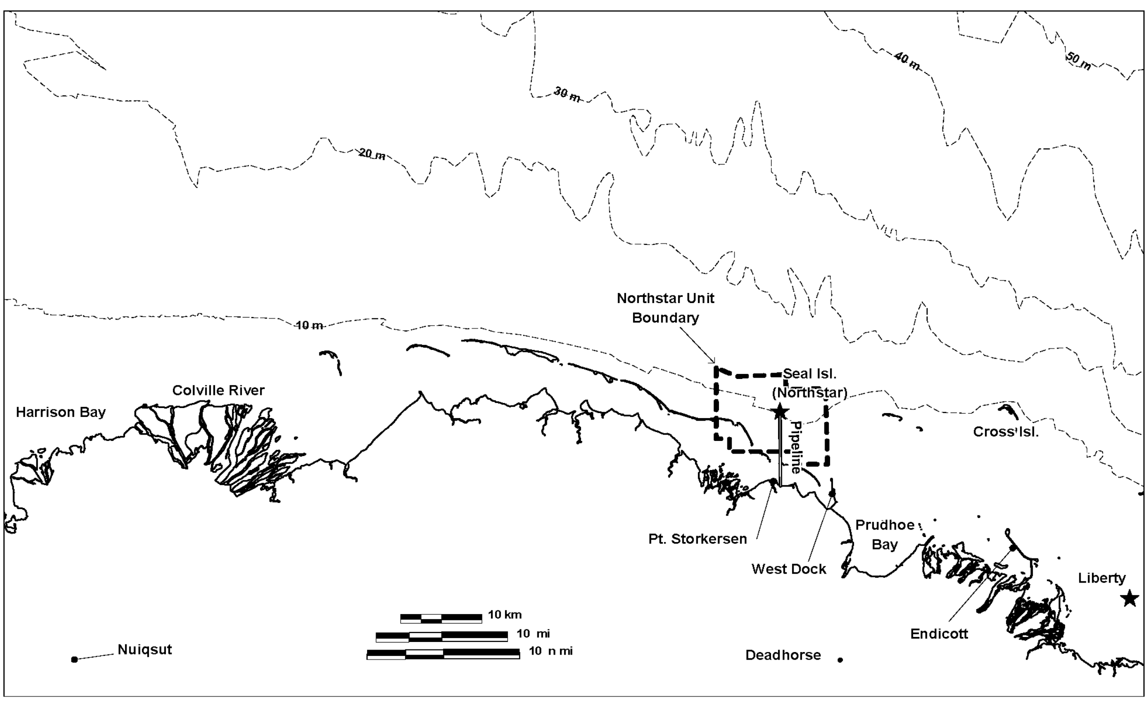

FIGURE 1.1. Location of the Northstar Development at Seal Island in the central Alaskan Beaufort Sea. Seal Island was an artificial gravel island constructed for exploration drilling in the 1980s. Northstar facilities were built on the eroded remnants of Seal Island in 2000.

TABLE 1.1. Overview of BP requests to NMFS and issuance of IHAs, Regulations and LoAs allowing "taking" of small numbers of marine mammals that may result from BP's activities at Northstar.

Date	**BP Request or Regulatory Activity**
Aug 1998	BP applied for an IHA from NMFS
Nov 1998	BP requested NMFS to promulgate regulations allowing for issuance of LoAs
25 May 2000	NMFS issued Regulations, effective from 25 May 2000 to 2005
18 Sep 2000	First LoA issued to BP for Northstar construction, effective until expired 30 Nov 2001
14 Dec 2001	Second LoA issued to BP, effective until 30 Nov 2002
9 Dec 2002	Third LoA issued to BP, effective until 30 Nov 2003
4 Dec 2003	Fourth LoA issued to BP, effective until 3 Dec 2004
30 Aug 2004	BP requested renewal of the Regulations and LoA
6 Dec 2004	Fifth LoA issued to BP, effective until 25 May 2005
7 Mar 2006	NMFS renewed the Regulations, effective from 6 Apr 2006 to 2011
7 Jul 2006	NMFS issued initial LoA under the new Regulations, effective until 6 Jul 2007
7 Jul 2007	Second LoA issued to BP under the new Regulations, effective until 6 Jul 2008

Northstar regulations have required marine mammal and acoustic monitoring studies. These studies started in 1997 and are ongoing (Richardson and Williams [eds.] 2005, Richardson [ed.] 2006b, 2007, 2008).

The marine mammal and acoustic monitoring results from 1999 to 2004 were reviewed by the Science Advisory Committee (SAC) of the North Slope Borough, which met in Anchorage on 7 Mar 2005. These monitoring results were also reviewed during the annual Beaufort Sea open-water meetings convened by NMFS to review all existing and planned monitoring studies in the Beaufort Sea. The reviews concluded that the bowhead whale monitoring program could be modified starting in 2005, with the possibility of conducting additional whale monitoring during future years. This additional monitoring effort is planned for 2008. Consistent with the recommendations of the SAC and the Beaufort Sea open-water meeting participants, during 2007 personnel at Northstar counted seals near the island in a standardized way, underwater sounds near Northstar were monitored during the September whale migration season, and calling bowhead whales were monitored offshore of Northstar. The acoustic and bowhead call data for 2007 were collected and analyzed in ways consistent with prior years to allow comparison of the 2007 results with those from 2001 to 2006.

This report describes BP's activities during the period 1 Nov 2006 through 31 Oct 2007, and it describes the results of the monitoring studies conducted during that year. This report follows the format of the preceding annual reports for 2005 and 2006 (Richardson [ed.] 2006b, 2007). Descriptions of BP's activities and the seal counts are included in this chapter and Chapter 2 provides the results of the acoustic measurements and the counts of calling bowhead whales. Since 2005, observations by subsistence whale hunters at Cross Island have been integrated into the Northstar monitoring study, following a recommendation from the NSB's SAC. They noted that 'Such observations might include general offshore distribution of whales, feeding behavior, "skittish" behavior, number of vessels and reaction to them'. Chapter 3 of this report summarizes the results of the 2007 whaling season at Cross Island, consistent with the descriptions provided in the annual reports of 2005 and 2006 (Galginaitis 2006, 2007).

This report satisfies annual reporting provisions of the current Letter of Authorization issued by the NMFS for incidental "taking" of whales and seals by Northstar activities. This report also addresses BP's company goal of implementing studies intended to understand and minimize the environmental effects of BP operations.

In addition to the annual summary reports, the SAC and participants of the annual Beaufort Sea open-water meetings recommended that various additional analyses of previous monitoring results be conducted. These analyses are included in the latest version of the updated comprehensive report (UCR). This comprehensive report is a combined presentation of the monitoring results up to 2004, along with analyses of the combined data. Various versions of the comprehensive report were circulated in Dec 2004, Apr 2006, and Apr 2007, and a further revision dated Feb 2008 (Richardson [ed.] 2008) has recently been circulated.

Based on the Northstar monitoring studies, a total of 12 peer-reviewed papers have been published in scientific journals since 2001. Of these, one was published in 2007 and another appeared in early 2008 (Table 1.2).

TABLE 1.2. Authors and titles of publications and manuscripts resulting from the Northstar marine mammal and acoustic studies program, 1999–2008. UCR is Updated Comprehensive Report (Richardson [ed.] 2008).

Authors	**Title**	**Status**
Harris, R.E., G.W. Miller and W.J. Richardson. 2001.	Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea.	***Mar. Mamm. Sci.*** 17(4):795-812.
Moulton, V.D., W.J. Richardson, T.L. McDonald, R.E. Elliott and M.T. Williams. 2002.	Factors influencing local abundance and haulout behaviour of ringed seals (*Phoca hispida*) on landfast ice of the Alaskan Beaufort Sea.	***Can. J. Zool.*** 80(11):1900-1917.
Moulton, V.D., W.J. Richardson, M.T. Williams and S.B. Blackwell. 2003.	Ringed seal densities and noise near an icebound artificial island with construction and drilling.	***Acoust. Res. Let. Online*** 4(4):112-117, plus sound files. Available at http://scitation.aip.org/arlo/
Blackwell, S.B., C.R. Greene Jr. and W.J. Richardson. 2004.	Drilling and operational sounds from an oil production island in the ice-covered Beaufort Sea.	***J. Acoust. Soc. Am.*** 116(5):3199-3211.
Blackwell, S.B., J.W. Lawson and M.T. Williams. 2004.	Tolerance by ringed seals (*Phoca hispida*) to impact pipe-driving and construction sounds at an oil production island.	***J. Acoust. Soc. Am.*** 115(5):2346-2357.
Greene, C.R., Jr., M.W. McLennan, R.G. Norman, T.L. McDonald, R.S. Jakubczak and W.J. Richardson. 2004.	Directional Frequency and Recording (DIFAR) sensors in seafloor recorders to locate calling bowhead whales during their fall migration.	***J. Acoust. Soc. Am.*** 116(2):799-813.
Blackwell, S.B. and C.R. Greene Jr. 2005.	Underwater and in-air sounds from a small hovercraft.	***J. Acoust. Soc. Am.*** 118(6):3646-3652.
Moulton, V.D., W.J. Richardson, R.E. Elliott, T.L. McDonald, C. Nations and M.T. Williams. 2005.	Effects of an offshore oil development on local abundance and distribution of ringed seals (*Phoca hispida*) of the Alaskan Beaufort Sea.	***Mar. Mamm. Sci.*** 21(2):217-242.
Blackwell, S.B. and C.R. Greene Jr. 2006.	Sounds from an oil production island in the Beaufort Sea in summer: characteristics and contribution of vessels.	***J. Acoust. Soc. Am.*** 119(1):182-196.
Williams, M.T., C.S. Nations, T.G. Smith, V.D. Moulton and C.J. Perham. 2006.	Ringed seal (*Phoca hispida*) use of subnivean structures in the Alaskan Beaufort Sea during development of an oil production facility.	***Aquatic Mamm.*** 32(3):311-324.

TABLE 1.2. Continued.

Authors	Title	Status
Blackwell, S.B., W.J. Richardson, C.R. Greene Jr. and B.J. Streever. 2007	Bowhead whale (*Balaena mysticetus*) migration and calling behaviour in the Alaskan Beaufort Sea, autumn 2001-2004: an acoustic localization study.	***Arctic***. 60(3): 255-270.
Greene, C.R. Jr., S.B. Blackwell and M.W. McLennan. 2008.	Sounds and vibrations in the frozen Beaufort Sea during gravel island construction.	***J. Acoust. Soc. Am.*** 123(2): 687-695.
Moulton, V.D., M.T. Williams, S.B. Blackwell, W.J. Richardson, R.E. Elliott and B. Streever. In prep.	Zone of displacement for ringed seals (*Pusa hispida*) wintering around offshore oil-industry operations in the Alaskan Beaufort Sea.	***Submitted***
Streever, B., R.A. Angliss, R. Suydam and others. In press.	Progress through collaboration: a case study examining effects of industrial sounds on bowhead whales.	***Bioacoustics*** (in press).
	In Preparation (titles and author lists are tentative)	
McDonald, T.L. and others	Detecting changes in distribution of calling whales exposed to fluctuating underwater sounds.	From UCR Chapter 9
Richardson, W.J. and others.	Distribution of calling bowhead whales near an oil production island at low and higher-noise times.	From UCR Chapter 10
Blackwell, S.B. and others	Effects of an oil production island on bowhead whale calling behavior.	From UCR Chapter 12

OVERVIEW OF BP ACTIVITIES, NOVEMBER 2006 – OCTOBER 2007

This section discusses BP's activities during the period from 1 Nov 2006 through 31 Oct 2007 as required by the 2006/07 LoA issued by NMFS. The ice-covered season is defined by the period 1 Nov 2006 until 15 Jun 2007, followed by the open-water season from 16 Jun through 31 Oct 2007.

Transportation To and From Northstar Island

Transportation of personnel and equipment to and from Northstar Island during both the ice-covered and the open-water season occurred by two Bell 212 helicopters and the Griffon 2000TD hovercraft. In addition to these two forms of transport, Hägglunds tracked vehicles and standard vehicles traveling over an ice road between West Dock and Northstar were used during the ice-covered season. During the open-water season additional transportation was provided by tugs, barges and ACS (Alaska Clean Seas) *Bay*-class boats. More details about transportation are provided below.

Bell 212 Helicopters

Bell 212 helicopters are medium-sized helicopters each with two turboshaft engines, a 2-bladed main rotor, and a 2-bladed tail rotor (Fig. 1.2).

FIGURE 1.2. Bell 212 helicopter used for transportation to and from Northstar.

Helicopters were used to transport crew and materials to and from Northstar during the entire year. As in previous years, they were mainly used during transition periods (freeze-up and break-up), and intermittently at other times when ice and water conditions do not permit use of land-based vehicles or boat traffic. During the present reporting period, a total of ~135 helicopter round trips were made to Northstar during the 2006/07 ice-covered season of which the majority occurred in November and December 2006. During the 2007 open-water season helicopters made ~190 round trips to Northstar, most frequently in Sep and Oct (Table 1.3). During the ice-covered season, more helicopter traffic to and from Northstar Island occurred during the early production period (2002/03) than in later years. This difference was not apparent for the open-water season. In general, the number of helicopter round trips in 2007 was within the range of the numbers recorded in previous production years (Table 1.4).

During regular helicopter operations, recommended flight corridors and altitude restrictions were maintained, as in previous seasons. For visual flight rule (VFR) conditions, standard flight altitude was 460 m (1500 ft), weather permitting. One-way flight time to Northstar was ~15 min from West Dock Base of Operations (WDBO) and 30 min from the Deadhorse airport.

The helicopter routes were negotiated among the U.S. Fish and Wildlife Service (USFWS), NMFS, and BP, at an early stage in the planning of the Northstar operations, to minimize impacts to waterfowl and marine mammals. The LoA issued by NMFS stated that helicopter flights to support Northstar operations must be limited to a corridor from Northstar Island to the mainland and, except when taking off, landing or limited by weather, must maintain a minimum altitude of 305 m (1000 ft). During poor weather or emergency conditions, pilots followed Federal Aviation Administration (FAA) altitude regulations and BP safety policy.

TABLE 1.3. Number of helicopter and hovercraft round trips to Northstar Island for each month during the ice-covered and open-water season of 2006/07. The open-water season includes the break-up period.

Month	**Helicopter**	**Hovercraft**	**Month**	**Helicopter**	**Hovercraft**
	Ice-covered season			*Open-water season*	
November 2006	189	75	June 16-30, 2007	16	96
December 2006	116	326	July 2007	17	97
January 2007	6	3	August 2007	3	100
February 2007	0	0	September 2007	42	36
March 2007	4	0	October 2007	112	18
April 2007	0	0			
May 2007	9	61			
June 1-15, 2007	11	109			

TABLE 1.4. Total number of helicopter and hovercraft round trips to Northstar Island for each year since 2003 during the ice-covered and open-water season. The open-water season includes the break-up period. The hovercraft was first tested and used in spring 2003. na = not applicable.

Year	**Helicopter**	**Hovercraft**	**Helicopter**	**Hovercraft**
	Ice-covered season		*Open-water season*	
2002/03	1122	na	277	202
2003/04	253	141	189	302
2004/05	118	180	103	188
2005/06	465	249	271	560
2006/07	335	574	190	347

Griffon 2000 TD Hovercraft

A hovercraft was also used to transport personnel during both the ice-covered and the open-water period (Fig. 1.3). The hovercraft was powered by a 355 hp air-cooled Deutz diesel engine and was 11.9 m (39 ft) in length (Blackwell 2004; Blackwell and Greene 2005). The hovercraft was capable of carrying a payload of 2268 kg (5000 lbs). During the ice-covered season, most hovercraft activity occurred in November and December 2006 and May and Jun 2007. Little hovercraft activity occurred from Jan through Apr 2007, when mainly pick-ups, SUVs, and buses were used to transport personnel. During the 2006/07 ice-covered season, the hovercraft made ~574 round trips to Northstar (Table 1.3). Hovercraft use continued into the subsequent open-water season, during which ~347 round trips occurred from West Dock to Northstar (Table 1.3). Hovercraft activity was greatest during Jun through Aug and was reduced in Sep and Oct 2007. In spring 2003, the hovercraft made its first test trips and was used for transport of personnel and supplies since then. Hovercraft traffic during the ice-covered season has increased since 2004. During the open-water season hovercraft use has been more variable over the years and ranged from 188 to 560 round trips (Table 1.4).

FIGURE 1.3. Hovercraft (Griffon 2000 TD) at the landing area on Northstar Island.

Ice Road Transportation

One offshore ice road was built during the 2006/07 ice-covered season. As during previous years, this ice road was built to transport personnel, equipment, materials, and supplies between the Prudhoe Bay facilities and Northstar Island. The ~12 km (7.4 mi) offshore ice road was built between West Dock and Northstar. Ice-road construction began on 1 Dec 2006 and was completed on 28 Jan 2007. The ice road was open to light duty traffic on 7 Jan and was officially closed on 25 May 2007.

Hägglunds tracked vehicles (model 206 SUSV; Fig. 1.4) with personnel carriers were used to transport personnel and materials between West Dock and Northstar Island during periods when the ice road did not permit standard vehicle and van traffic. These situations occurred mainly in the months just prior to completion of the ice road and during break-up when meltwater accumulating on the ice road prevented standard vehicles from safely transiting to and from the island. Average transport speeds were typically 8–16 kilometers per hour (5–10 miles per hour). The maximum allowable payloads were 380 kg (838 lbs) for the 4-person front car and 1250 kg (2756 lbs) for the 8-person personnel carrier. The Hägglunds made 37 round trips between West Dock and Northstar Island during the 2006/07 ice-covered season, of which 23 occurred in Dec 2006 and the remaining 14 in the period from Jan to May 2007. A Tucker tracked vehicle and a Mattrak also made occasional round trips to Northstar Island. The use of Hägglunds in 2006/07 was much lower than in 2005/06 (70 round trips) and higher than in 2004/05 (25 round trips). No detailed records of round trips are available for the construction and early production years (2001-2003), other than that Hägglunds were used on average 14 times a day, mainly prior to the completion of the ice-road.

Standard vehicles, including vans, pick-up trucks, and buses, were the main method of transportation for Northstar personnel from 7 Jan to 25 May 2007. A total of 2513 trips were made in this period.

FIGURE 1.4. Hägglunds tracked vehicle and personnel carrier. Power is from a turbocharged diesel engine capable of 143 hp at 4600 rpm; total weight of the two cars is ~4536 kg (10,000 lbs).

Tugs and Barges

Tug and barge activity to supply Northstar during the 2007 open-water season occurred from Jul to Oct. A total of ~40 tug and barge trips were made to Northstar during this period. Most barge activity occurred in Aug (Table 1.5A). The total number of barge trips in 2007 was lower than in 2003 and 2006, but higher than in 2004 and 2005 (Table 1.5B).

Crew Boats

Alaska Clean Seas (ACS) *Bay*-class boats (Fig. 1.5) were used by Northstar to transport personnel when weather conditions prevented the use of the hovercraft. A total of ~137 round trips to and from Northstar were recorded during the 2007 open-water season, with the highest numbers during Aug and Sep (Table 1.5A). There were 3 additional trips by *Bay*-class boats in association with acoustic monitoring of the bowhead whale migration (see "Sound Measurements and Acoustic Monitoring", below).

Records of crew boat trips for 2003 include only the round trips of the crew boat that was used in 2002 and earlier years. After the hovercraft became available in spring 2003, the crew boat was not used anymore and the trip records for 2004 to 2007 include therefore only the ACS boats. In 2004 and 2005 no round trip records were obtained for Jul and most of Aug, the numbers mentioned in Table 1.5B cover a ~32-day period from late Aug to early Oct. The number of round trips in 2007 is slightly higher compared to 2006 (Table 1.5B).

TABLE 1.5. Number of round trips to Northstar Island by tugs and barges and crew boats during the 2007 open-water season for each month (A) and for each year since 2003 (B). The open-water season includes the break-up period. The trip records of the ACS vessels in 2004 and 2005 cover only a ~32-day period from late Aug to early Oct.

(A)

Month	**Tugs/Barges**	***Crew* boats**
	Open-water season	
June 16-30, 2007	0	-
July 2007	3	22
August 2007	32	41
September 2007	4	71
October 2007	1	3

(B)

Year	**Tugs/Barges**	***Crew* boats**
	Open-water season	
2003	82	392
2004	24	22
2005	21	14
2006	64	106
2007	40	137

FIGURE 1.5. *Bay*-class boat at West Dock. Photo from Greeneridge Sciences.

Activities At and Near Northstar Island

Production Facilities

Oil production at Northstar began on 31 Oct 2001 and has occurred almost continuously from that date through the present reporting period. Power generation and compressor equipment on the island was unchanged from previous reporting periods. Solar® gas turbines powered generators that provided the main power to the island. Emergency diesel generators were also used intermittently during the reporting period, as back-up to the gas-turbine generators. Three gas-turbine-powered high-pressure compressors (model GE LM-2500) were also on the island. Two of the gas-turbine generators were in use at any one time for gas injection into the formations.

Drilling and Support

Drilling activities were conducted at two well sites from 17 Nov 2006 to 1 May 2007. Drilling at well site NS-34 started on 17 Nov and occurred until 3 Dec 2006. After some standby time to wait for ice thickness to increase, drilling resumed at the same well site on 25 Dec and lasted until 14 Jan 2007. Well site NS-33 was drilled from 28 Jan until 1 May 2007. No vibratory or impact pile driving activities took place during the present reporting period.

Training Activities

During the ice-covered season, oil spill exercises were conducted on floating ice on 8 Jan 2007. During the open-water season, offshore oil spill response training activities occurred on 12 days from 10 Jul to 25 Sep 2006. Two 7.32 m (24 ft) aluminum boats were used for this exercise.

Training sessions for the Spill Response Team were given every Monday evening. The Fire Brigade underwent weekly training on Saturday evenings. This training included classroom instruction and field activities. The field activities involved simulation of a fire scenario by activation of fire fighting equipment including deployment and charging of hoses.

Two articulated ARKTOS evacuation craft are available as the island emergency escape vehicles (Fig. 1.6). Testing and training activities with the ARKTOS evacuation craft were conducted on floating ice on 7 May 2007.

Oil Spill Inspections

Each month, four to seven aerial surveys were conducted to inspect the pipeline for leaks or spills. These surveys were done from a twin-engine fixed-wing aircraft, either a Twin Otter (DHC-6) or a CASA 212 backup aircraft. LEOS technology (Leck Erkennung und Ortangs System, also known as Leak and Location System), forward-looking infrared (FLIR) devices, and other measurement-based leak detection technologies are used for these inspections. No reportable conditions were recorded during those surveys.

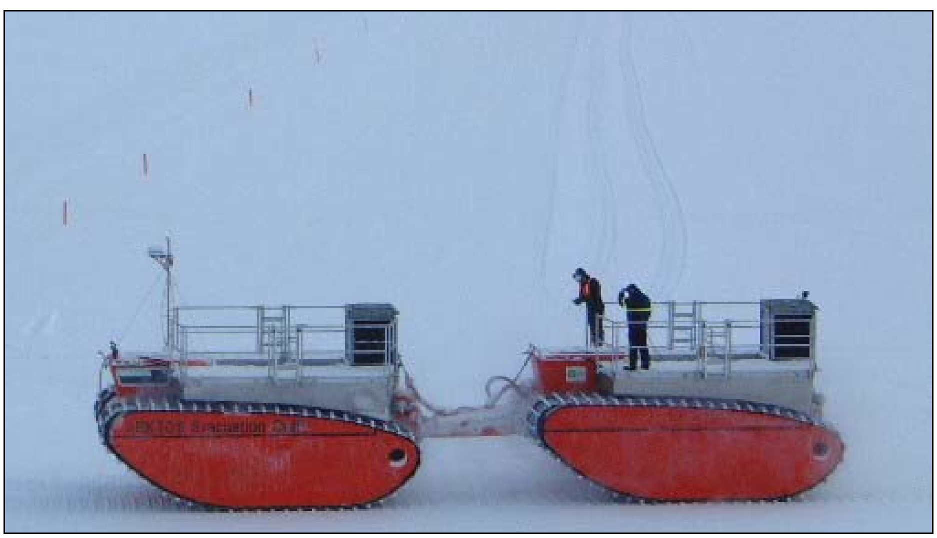

FIGURE 1.6. Articulated ARKTOS evacuation craft, used as an island emergency escape vehicle.

Reportable Spills

None of the reportable Northstar-related spills during the ice-covered season and open-water season reached Beaufort Sea water. All spilled material was contained and cleaned up. Contaminated snow, ice and gravel were removed with various types of equipment, hand tools, and absorbents (Table 1.6), thereby avoiding even minor contamination to reach the Beaufort Sea. Material spilled included drilling mud, corrosion inhibitor, sewage, methanol, motor oil, diesel, hydraulic fluid, lube oil, and propylene glycol. No clean-up activity was necessary after Northstar flare events during the reporting period.

TABLE 1.6. Record of material spilled at Northstar Island during the period from 1 Nov 2006 to 31 Oct 2007. Spilled materials out of containment were cleaned up before they could reach the Beaufort Sea.

Date	Location	Material	Quantity Released	Clean Up Action
		Ice-covered season (1 Nov '06 – 15 Jun '07)		
18 Nov	Northstar Pad	Drilling Mud	3.79	Material was scraped and placed in cuttings bin.
19 Nov	Northstar Process 33 m (109 ft) level	Corrosion Inhibitor	0.95	Absorbed and placed in oily waste bags.
9 Dec	Drilling rig roof and ground north of rig	Drilling Mud	317.97	Scraped area and put into storage bin for future onsite disposal.
27 Dec	Between process module and overhead pipe rack	Sewage	18.93	Shovels were used to scrape frozen treated effluent and material was taken to the Northstar G & I (Grind & Inject) facility.
18 Jan	Northstar well row	Corrosion Inhibitor	1.89	Sorbents were used to clean piping and gravel under the well house grating.
21 Jan	Well row in front of NS-14	Methanol	0.95	All material captured in containment.
1 Feb	NS-16 well house	Corrosion Inhibitor	0.12	Contaminated gravel cleaned up.
5 Feb	Ice road 9.1 m (30 ft) east of Northstar	Motor Oil	3.79	Most captured in 5-gal bucket; pads used to absorb ~0.47 l (1 pt) of remaining fluid.
5 Feb	Ice road 30.5 m (100 ft) west of Northstar	Diesel	3.79	Diesel-contaminated ice removed to bin and sent to G & I facility.
17 Feb	Pit #3, service module rig N33E, Well NS-33	Drilling Mud	1022.06	Free liquids sucked and transferred to G & I facility. Mops and sorbents used to wipe remaining drilling mud from the rig floors and walls.
14 Mar	Pad between warehouse and process building	Sewage	7.57	Shovels and chipping bars used to remove affected snow and ice. Material stored for later processing in G & I facility.
22 Mar	22.9 m (75 ft) east of southeast access ramp to island	Hydraulic Fluid	<0.00	Shovel used to scrape contaminated snow. Sorbents used to wipe backhoe.
11 Apr	Southeast access ramp to island	Lube oil	2.84	Loader with bucket used to scrape affected ice; shovels used to place contaminated materials into bins for processing.
20 Apr	Sea ice at southeast side of island	Hydraulic Fluid	7.57	Loader and bobcat used to scrape contaminated snow and ice for transfer to G & I facility.

TABLE 1.6. Continued.

Date	Location	Material	Quantity Released	Clean Up Action
22 Apr	Sea ice at southeast corner of island	Propylene Glycol	1.89	Sorbents, bobcat, and small hand tools used to clean and scrape affected area.
25 Apr	NS-18 well head corrosion inhibitor system	Corrosion Inhibitor	0.23	Absorbents and small hand tools used to scrape contaminated gravel.
4 May	Sea ice 18.3-22.9 m (20-25 yd) northeast of Northstar	Hydraulic Fluid	0.95	Removed ~0.76 m^3 (1 yd^3) of contaminated snow.
18 May	Sea ice ~61 m (200 ft) southeast of island	Hydraulic fluid	0.95	Shovels used to scrape contaminated snow and ice. Sorbents used to soak materials on surface of water.
20 May	On pad northwest of warehouse and adjacent sea ice	Diesel	0.38	Shovels used to scrape contaminated snow, ice, and gravel.
20 May	Sea ice ~22.9 m (75 ft) west of bench.	Hydraulic Fluid	0.04	Sorbents used to soak sheen and shovels used to scrape contaminated snow and ice.
1 Jun	Sea ice at east side of island	Hydraulic fluid	0.47	Shovels used to scrape contaminated snow.
		Open-Water Season (16 Jun – 31 Oct '07)		
9 Aug	NS-05	Hydrochloric Acid	0.11	Acid was neutralized then soaked up with sorbents.
10 Aug	NS-11 well head	Corrosion Inhibitor	1.89	Sorbents used to soak up material.
12 Aug	NS-29 well cellar	Diesel	37.85 1589.87	Liquids recovered using air actuated drum vacuum. Remaining fluids soaked up with sorbents.
17 Oct	Process module	Corrosion Inhibitor	0.95	Sorbents and oily waste bags.

Construction and Maintenance Activities

In recent years maintenance activities to repair the block system and fabric barrier around Northstar Island have been necessary. The 2007 repair activities commenced in early May with the melting of the snow and ice on the northeast bench. Excavation of the sea ice from the intended work areas on the north and east sides of the island was undertaken in early- to mid-May, with dive operations initiated on May 15th. The diving work involved 3 dive crews operating 24 hours per day. Repair activities on the northeast and northwest corners of the island continued for another month, through Jun 22nd. The 2007 repair activities consisted of removing the concrete blocks in areas that had sustained erosion and/or block damage, installing a new layer of filter fabric, installing gravel bags of various sizes to build up and stabilize the subgrade (Fig. 1.7), installing another layer of filter fabric and an overlying layer of geogrid to reduce the susceptibility of the fabric to abrasion, and installing the concrete block armor. Equipment used included a Manitowoc 888 crane, Volvo 150D loader, John Deere 650H excavator, Ingersoll-Rand zoom-boom, air compressors, Chinook 800 and Tioga heaters, and generators. A hot oil unit composed of 2 pumps and 3 holding tanks with a total capacity of 135 gallons was used to heat fluids.

FIGURE 1.7. Gravel bags used to build up elevation of Northwest corner.

Sound Measurements and Acoustic Monitoring

Boat-based work in support of acoustic monitoring of the bowhead whale migration was conducted by Greeneridge Sciences, with field assistance by LGL, on three days from late Aug to early Oct 2007. On 28 Aug a *Bay*-class boat was used to deploy a total of seven Directional Autonomous Seafloor Acoustic Recorders (DASARs) offshore of Northstar Island. Two recorders were located close to the island, 410 m (1345 ft) and 480 m (1574 ft) north of Northstar's north shore. The remaining five DASARs were deployed farther offshore, 11.4–21.4 km (7.1–13.3 mi) NNE of Northstar Island (Chapter 2). The clocks and orientations of the DASARs were calibrated during the 28 Aug deployment trip, and again and on 30 Sep. On 3 Oct, all seven DASARs were retrieved. Chapter 2 describes the acoustic methods and results.

Non-Northstar Related Activities

The Minerals Management Service conducted its usual Bowhead Whale Aerial Survey Program (BWASP) during the bowhead migration season. Other aerial surveys in support of another oil company’s offshore seismic activities in the Beaufort Sea between Harrison Bay and Kaktovik were flown or attempted on ~22 days from 22 Aug through 8 Oct. These surveys occurred near Northstar on 22 Aug and 2 and 3 Sep. Acoustical studies involving vessel-based activities occurred in the same area from late Aug to mid-Oct 2007 and were within ~9 to 12 km (5.5 to 7.4 mi) west of Northstar on 24 Aug, 20 Sep, and 11 Oct (Funk et al. [eds] 2008).

Shallow hazard and site clearance surveys were conducted in the Beaufort Sea (also by another operator) on 23 days from 30 Aug through 2 Oct. The surveys were conducted from Thetis Island to Kaktovik. Although the survey vessel was occasionally within sight of Northstar Island, no survey activity was conducted in the general area of Northstar (Funk et al. [eds] 2008).

OBSERVED SEALS

This section summarizes Northstar seal sightings during the last part of the ice-covered season and the start of the open-water season for 2005 through 2007. These observations were conducted by Northstar Environmental Specialists on behalf of BP. The protocol of the systematic seal count that has been used since 2005 includes the following:

- Count the number of basking seals from 15 May to 15 Jul once each day between 11:00 and 19:00 for at least five days per week, when practicable. No counts are made if the cloud ceiling is less than 91 m (300 ft).
- Make seal counts from the roof of the process module on Northstar Island along a strip of ~950 m (3116 ft) around the entire perimeter of the island. Scan a 360° field of view, thus covering an area of ~281 ha (695 ac).
- Scan with the naked eye, using binoculars to confirm suspected seal sightings. Use an inclinometer to estimate the distance to the seal. If the inclinometer shows that the line of sight to the seal is 2 degrees or more below the horizon, then keep it in the count. If the distance cannot be determined with the inclinometer, then the seal is too far away and is not counted.

Seal observations in 2007 began on 15 May and were conducted almost daily through 31 Jul. Over the standard reporting period from 15 May through 15 Jul, a total of 3 seals were counted during 57 days. This was much less than the total number of observations in 2005 and 2006 over the same period (Fig. 1.8). As in 2005 and 2006, no seals were observed after 15 Jul, when some monitoring continued.

Over the 3-year period, most of the seals observed in May and June were basking on the ice, and the number of observations decreased towards the end of June. In all years, seals were observed in small numbers (1 to 4 animals) from Northstar Island. Only in 2005, large groups of seals were seen on floating ice from 8 to 11 Jul. In 2007, seals were recorded singly on 3 occasions. Although it remains difficult to make definite conclusions about the trends in seal abundance around Northstar with only three years of data of this type, the number of seal observations from Northstar Island in the period 15 May to 15 Jul of 2007 was unusually low. However, communications with Northstar staff revealed that they observed normal numbers of seals on some days before or after conducting the daily seal count. This suggests that seal surveys may not have been representative of overall conditions.

Reports from Northstar Island do not provide evidence, or reason to suspect, that any seals were killed or injured by Northstar-related activities.

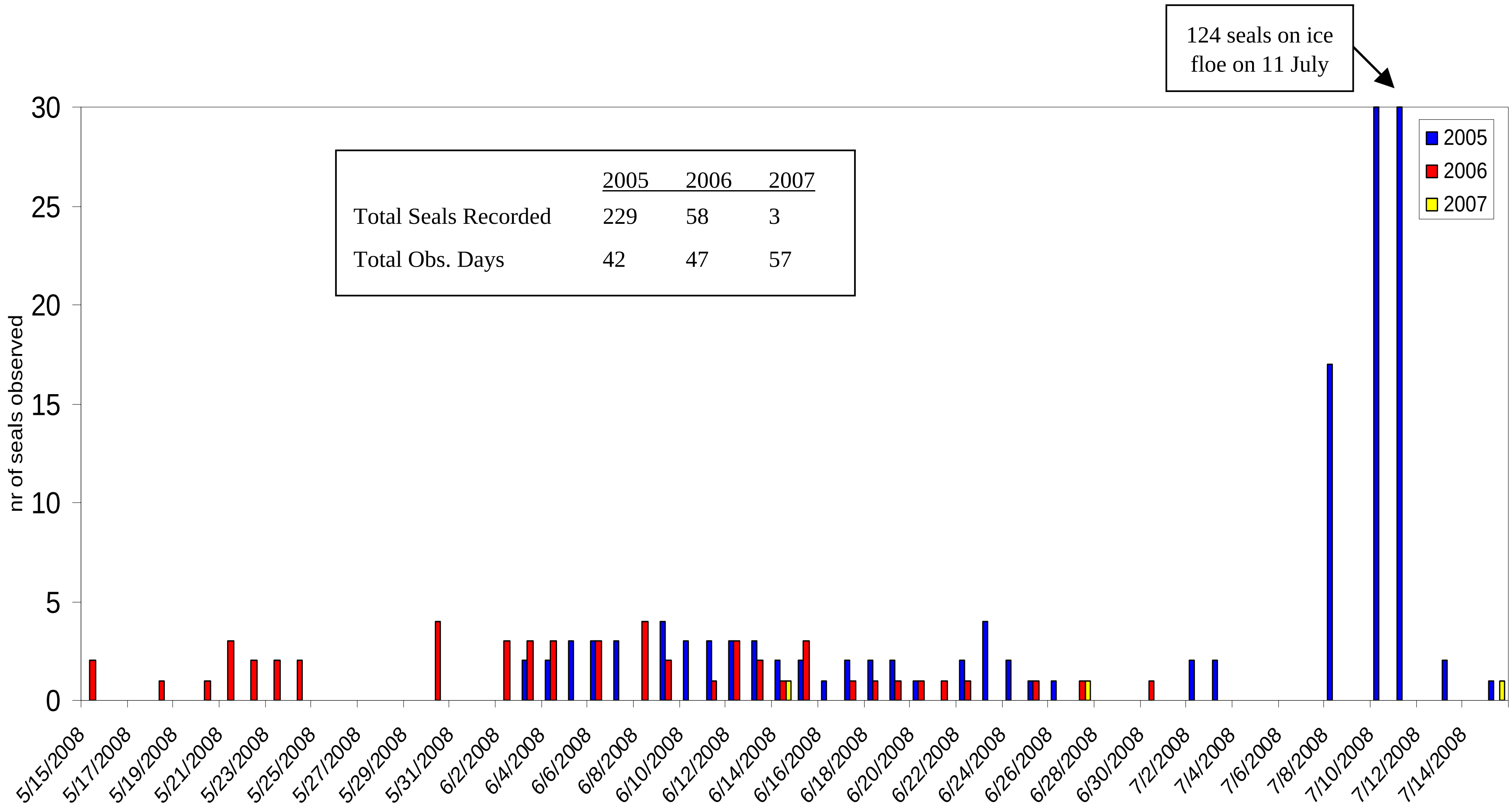

FIGURE 1.8. Number of observed ringed seals recorded from Northstar Island from 15 May to 15 Jul during 2005 through 2007. In 2005 observations started 1 Jun and no observations were made on 8 Jun. In 2006 no observations were made on 25-29 May, 1, 5 and 7 Jun and 1-4 Jul. In 2007 no observations were conducted from 25-29 May.

ACKNOWLEDGEMENTS

We thank Dr. Bill Streever, Wilson Cullor, and Dayne Haskell of the BP Environmental Studies Group for their support. Mike Williams designed the seal observation program while working with LGL and OASIS Environmental, and seal observations were made by the Northstar Environmental Specialists Hunter Ervin and Joe Serra. They were also very helpful in providing information on some of the Northstar activities. Dr. Bill Streever (BP) reviewed and commented on a draft of this report.

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CHAPTER 2:

ACOUSTIC MONITORING OF BOWHEAD WHALE MIGRATION, AUTUMN 2007 [1]

by

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ABSTRACT

During the bowhead whale migration in Sep 2007, Greeneridge Sciences (on behalf of BP) implemented an acoustic monitoring program north-northeast of BP's Northstar oil development. Monitoring objectives in 2007 were identical to those in 2005 and 2006, but modified relative to those in earlier years. Results based on data collected in 2001–2004 had suggested that the bowhead migration corridor offshore of Northstar likely was not strongly affected by varying activities at Northstar, although the southern edge of the distribution of calling whales tended to be somewhat farther offshore at higher-noise times. In addition, the North Slope Borough's Science Advisory Committee (SAC) concurred that priority be put on additional analyses of the 2001–2004 data over additional intensive data collection in 2005–2007. The primary objectives in 2007 were two-fold: (1) Monitor sounds produced by Northstar and its associated vessels, and compare the levels and frequencies to those in previous years (2001–2006). (2) Count whale calls at DASAR (Directional Autonomous Seafloor Acoustic Recorder) locations that have been used in previous years, and then compare with counts at the same locations in previous years. In addition to these primary objectives, bearings to calling whales, call locations (if available) and call types were to be analyzed and compared with previous years. The 2007 monitoring program was designed to detect significant changes, relative to prior years, in sounds produced by Northstar or in number of whales (as indicated by their calls) migrating along the southern part of the bowhead migration corridor.

On 28 Aug 2007, five DASARs were deployed at locations 11.4–21.4 km (6.2–11.6 nmi or 7.1–13.3 mi) NNE of Northstar Island. These instruments recorded sounds continuously in the 10–450 Hz frequency band for ~36 days, until 3 Oct 2007. Simultaneously, near-island recordings were obtained from two DASARs placed 410 and 480 m (1345 and 1575 ft) from Northstar over the same period. The sounds received in 2007 by one of the near-island DASARs were analyzed as broadband signals (10–450 Hz) and as one-third octave and narrowband levels. Vessel traffic to and from Northstar by ACS boats increased in 2007 compared to 2004–2006, but overall vessel traffic was still below 2001–2003 values. Median broadband levels as recorded by the near-island recorders were higher than in all previous years except 2005 (median broadband levels are generally related to wind speed). The most relevant wind speed data available for 2007 were from a different weather station (Endicott) than in previous years (Northstar Island). Nevertheless, the autumn of 2007 was an unusually windy season, which contributed to raising ambient sound levels. Overall, industrial sounds from Northstar in 2007 were about the same as in 2004–2006, except for the increased frequency of transient high-level sounds associated with boats.

In total, 11,780 bowhead whale calls were recorded in ~36 days at DASAR locations EB (2 recorders), CC, and CA. A total of 10,146 calls, or 282 calls/day, were detected by DASARs EB and CC combined. The 282 calls/day figure for 2007 compares to 110 calls/day in 2001, 208 calls/day in 2002, 895 calls/day in 2003, 1182 calls/day in 2004, 35 calls/day in 2005, and 38 calls/day in 2006, based on data from the same two sites each year. The maximum call detection rate in any hour during 2007 was 228 calls per hour. Bearings from DASAR EB to call locations were, in 2007, distributed similarly to those in previous low-ice years such as 2002, 2003, and 2004. The much higher call counts in 2007 compared to the two previous years are probably related to the absence of nearshore pack ice during the 2007 season. That is, there were probably more whales close to shore because of the absence of ice near shore.

INTRODUCTION

This chapter is a report on acoustic monitoring of bowhead whale migration near the Northstar development during the early autumn of 2007. Since 2000, the autumn migration of the bowhead whale has been monitored acoustically north of Northstar Island for a nominal 30 days per year during September. Every year since 2001, continuous underwater recordings were obtained close to Northstar Island to determine the levels and frequency composition of sounds produced by the island and associated vessels. In 2000 to 2004, whale calls were monitored continuously by an array of Directional Autonomous Seafloor Acoustic Recorders (DASARs), deployed 6.5–21.5 km (4–13.4 mi) NNE of Northstar. After retrieval of the instruments, whale calls recorded by the DASARs were localized by triangulation. The key objective of the monitoring in 2001–2004 was to assess the relationship between Northstar sounds and the location of calling whales in the southern edge of the migration corridor. We used quantile regression to examine offshore distances of the closest whale calls as a function of industrial sound levels near Northstar, measured over 15–120 min periods prior to detection of each call (see McDonald et al. 2008, Richardson et al. 2008). Overall, the offshore distance of the apparent southern (proximal) "edge" of the migration corridor was significantly (P<0.01) associated with industrial sound output each year. The best estimates of the offshore shift in the distances of the closest calling whales at times with higher levels of Northstar sound ranged from a low of 0.76 km (0.5 mi) in 2003 to a high of 2.35 km (1.5 mi) in 2002.

Based on the results achieved in 2001–2004[2], BP, the Science Advisory Committee (SAC) appointed by the North Slope Borough to review the work, and the team of scientists conducting the study concluded that monitoring as carried out in 2001–2004 did not need to be repeated every year. The 2007 effort described in this report is similar to those carried out in 2005 and 2006, and is a modified effort compared to those in 2001–2004. Results from 2001–2004 are summarized in Greene et al. (2002, 2003a) and Blackwell et al. (2006a,b, 2007b). Results from 2005 and 2006 are summarized in Blackwell et al. (2006c, 2007a). The DASAR methodology is described in Greene et al. (2004).

BP's business rationale for the overall monitoring project, and for the specific bowhead monitoring task, was driven both by corporate policies and by regulatory requirements. BP corporate policies support studies that objectively assess environmental effects that may result from BP operations. In addition, monitoring the autumn migration of bowhead whales past Northstar was required, during the open-water season of 2007, to satisfy (a) provisions of the North Slope Borough zoning ordinance for Northstar, and (b) the monitoring requirements of a Letter of Authorization (LoA) issued by NMFS to BP on 6 Jul 2007. That LoA was issued under regulations that became effective on 6 Apr 2006 (NMFS 2006).

The specific objectives in 2007 were as follows:

(*1*) *to measure near-island sounds about 450 m (1476 ft) north of Northstar using DASARs and to compare the amplitude and frequency composition of the sounds with similar data collected in previous years; and*

(2) to install a small array of DASARs in four of the locations used in previous years (see below), obtain whale call counts from one DASAR, and compare the counts with those obtained at the same location in 2001–2006.

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[2] Due to technical difficulties with the DASARs in 2000, the 2000 data set was incomplete and could not be used for a full-scale analysis of the effects of Northstar on the bowhead whale migration.

Objective (1) provides an impartial record of the underwater sounds near the Northstar operation, which can be compared to equivalent records from previous years. For example, these data allow us to detect changes in the frequency composition or received level of sounds produced by Northstar, compared to previous years. Objective (2) provides a means of identifying any unusual trends in the 2007 bowhead whale migration as compared to the previous six years. The project design and objectives for 2007 were approved by the peer review group convened by NMFS in April 2007.

As in 2006, it was decided at the end of the season to analyze whale calls from DASARs at all four locations in the offshore array. The additional analyses, whose results are included in this Chapter, allowed comparisons of call counts at more DASAR locations and added two more objectives:

(3) obtain bearings to whale calls and localization of calls, if possible. A comparison of the bearings or locations obtained in 2007 with those obtained in previous years should provide information on the distribution of the calling whales, i.e., the proportion of calls originating offshore vs. inshore of the locations of the DASARs deployed in 2007; and

(4) compare the types of calls recorded at DASAR locations used in 2007 with the call types recorded at the same locations in previous years.

METHODS

Summary of Methodology in 2001–2006

Directional sensors from DIFAR (Directional Frequency and Recording) sonobuoys were used, along with digital recording equipment and batteries, to construct Directional Autonomous Seafloor Acoustic Recorders (DASARs). For a complete description, see Greene et al. (2004). The DIFAR sensor includes a compass, two horizontal orthogonal directional sensors, and an omnidirectional pressure sensor to sense an acoustic field. DASARs record at a sampling rate of 1 kHz onto a 25.4-GB disk drive. This allows for continuous sampling for up to 45 days and spans an acoustic range up to nearly 500 Hz, adequate for bowhead vocalizations.

In ***2001–2004***, DASARs were deployed at 10 locations 6.5–21.5 km (4–13.4 mi) NNE of Northstar (see Fig. 2.1, filled triangles, open diamonds, and open square, and Table 2.1). In ***2005*** and ***2006***, DASARs were deployed at three of the locations used in 2001–2004: WB, CC (2 DASARs), and EB in 2005, and CC, EB (2 DASARs), and CA in 2006 (Table 2.1). The DASARs recorded continuously for the entire field season, usually late Aug/early Sep until late Sep/early Oct (range 24 to 35 days). Whale calls were tallied on all DASAR records. When a whale call was recorded by two or more DASARs in 2001–2004 and 2006, a position for the calling whale was obtained by triangulation, using the DASAR bearing information. In 2005 bearings were only obtained for EB, because the other DASARs moved on the seafloor during their deployment; thus no whale call positions were calculated for 2005.

A continuous record of sounds from Northstar Island and its attending vessels was obtained by deploying several redundant recorders (either cabled hydrophones, ASARs[3] or DASARs) ~450 m (1476 ft) from the island's north shore (see Fig. 2.1, open triangle). One minute of data was used every 4.37 min (or

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[3] ASAR = Autonomous Seafloor Acoustic Recorder. This type of recorder was described in Greene et al. (1997) and Blackwell and Greene (2002). It includes an omnidirectional hydrophone and does not have the directional capabilities of a DASAR.

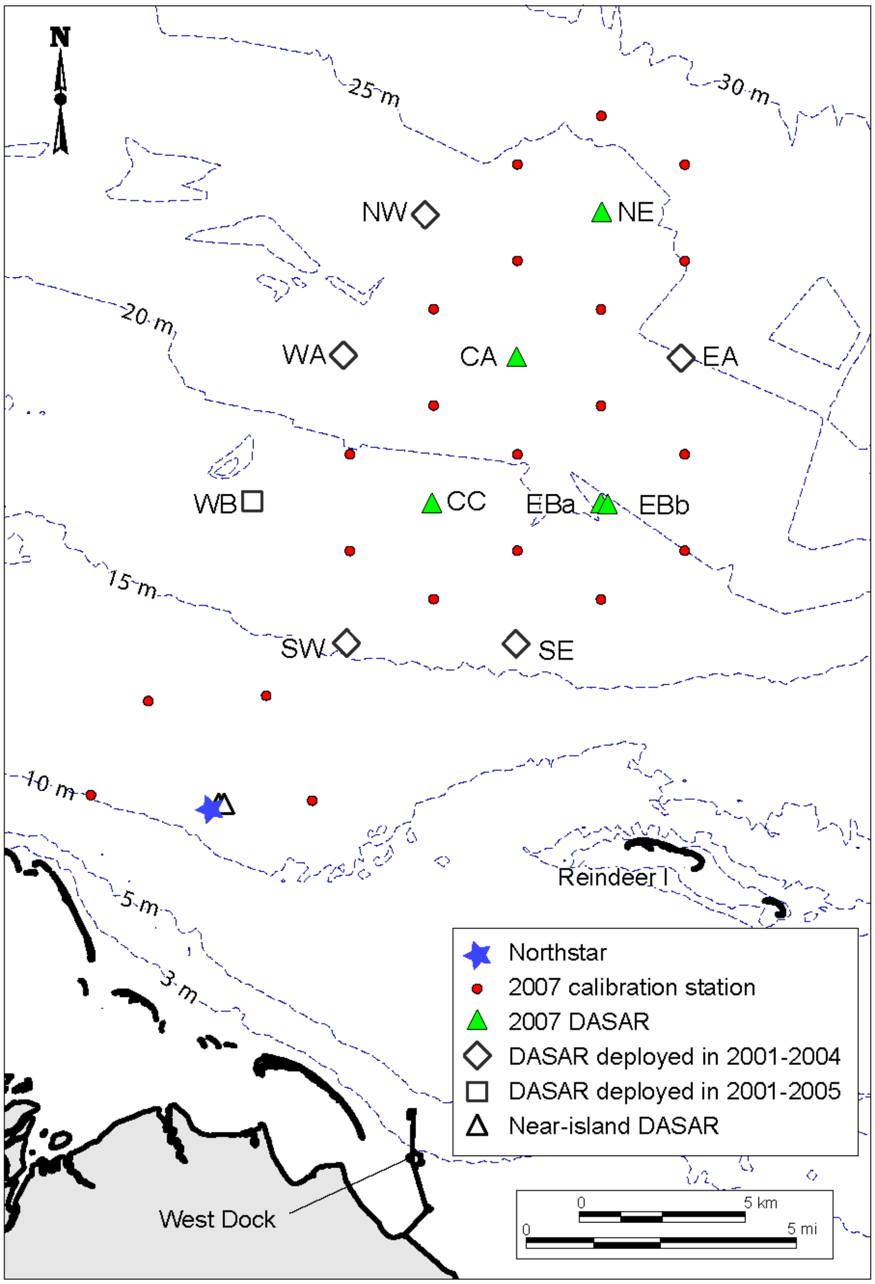

FIGURE 2.1. Locations of five array DASARs, 21 calibration stations, and two near-island DASARs (see Fig. 2.2) with respect to Northstar Island, Sep 2007. DASAR locations used in 2007 are shown with green triangles. All DASAR locations were used in 2001–2004; locations used in 2005 and 2006 are shown in Table 2.1. Calibrations were performed at all calibration locations after deployments on 28 Aug, and on 30 Sep 2007 before retrievals.

~330 times per 24-h day) to calculate a broadband (10–450 Hz) level as well as an Industrial Sound Index (ISI). The ISI was determined from the sum of the mean-square sound pressures in the five one-third octave bands centered at 31.5, 40, 50, 63, and 80 Hz, i.e., including frequencies from 28 to 90 Hz. These five one-third octave bands contain most of the industrial sound energy emanating from Northstar (Blackwell 2003).

TABLE 2.1. Summary of DASAR deployment locations used in 2001–2007. DASAR locations are listed from north to south and east to west. √ = complete record obtained; √ * = incomplete record because of DASAR malfunction; √ ** = DASAR deployed but no data collected because of recorder malfunction.

DASAR	2001	2002	2003	2004	2005	2006	2007
NE	√	√	√	√			√
NW	√ **	√	√	√			
EA	√ *	√	√ *	√			
CA	√ *	√	√	√		√	√
WA	√	√	√	√			
EB	√ *	√	√	√	√	√	√
CC	√ *	√	√	√	√	√	√
WB	√	√	√	√	√		
SE	√	√	√	√			
SW	√ *	√ *	√	√ *			
Northstar	√	√	√	√	√	√	√

2007 Field Deployments

On 28 Aug 2007 seven DASARs were deployed from the ACS vessel *Gwydyr Bay*. Ice conditions were very different from 2005 and 2006 when abundant pack ice delayed deployment of the DASARs by up to a week. No pack ice was seen during deployments in 2007.

The two near-island DASARs (NSb and NSc) were deployed ~410 m and 480 m (1345–1575 ft) northeast of Northstar's north shore (Fig. 2.1, Fig. 2.2). Water depth there was about 12 m (Table 2.2). NSb and NSc were 146 m (479 ft) apart (see Fig. 2.2).

The ACS vessel then headed to the offshore array and deployed DASARs in locations CC, EB (2 recorders), CA, and NE, at distances 11.4–21.4 km (6.2–11.6 nmi or 7.1–13.3 mi) NNE of Northstar Island (Fig. 2.1, Table 2.2). To obtain good positions by triangulation, a triangle-shaped layout (as in 2006 and 2007) is preferred over placing DASARs in a line (as in 2005, when ice limited the deployment geometry). The number of calls detected generally increases with distance from shore within the area covered by the array. In 2005 and 2006 few calls were detected, in large part because of the presence of pack ice. To increase the number of calls detected in 2007, a DASAR was also placed at location NE.

All seven DASARs started recording at ~12:00 local time on 28 Aug (Table 2.2). After DASAR deployments on 28 Aug, an acoustic transponder in each DASAR was interrogated to confirm that each DASAR was operating nominally. All seven DASARs recorded continuously at a 1 kHz sampling rate until they were retrieved on 3 Oct 2007.

Calibration of the DASAR Clocks

Each DASAR contains a magnetic compass and clock. However, to provide greater precision in times (and bearings if used), the DASAR clocks and orientations were calibrated by projecting test sounds at known locations (Fig. 2.1) and known times, and receiving these sounds via the DASARs. These acoustic transmissions allow us to correct for slight drift in the clock built into each DASAR (Greene et al. 2003b, 2004). It is important to characterize and correct for this drift in order to obtain the correct times of the

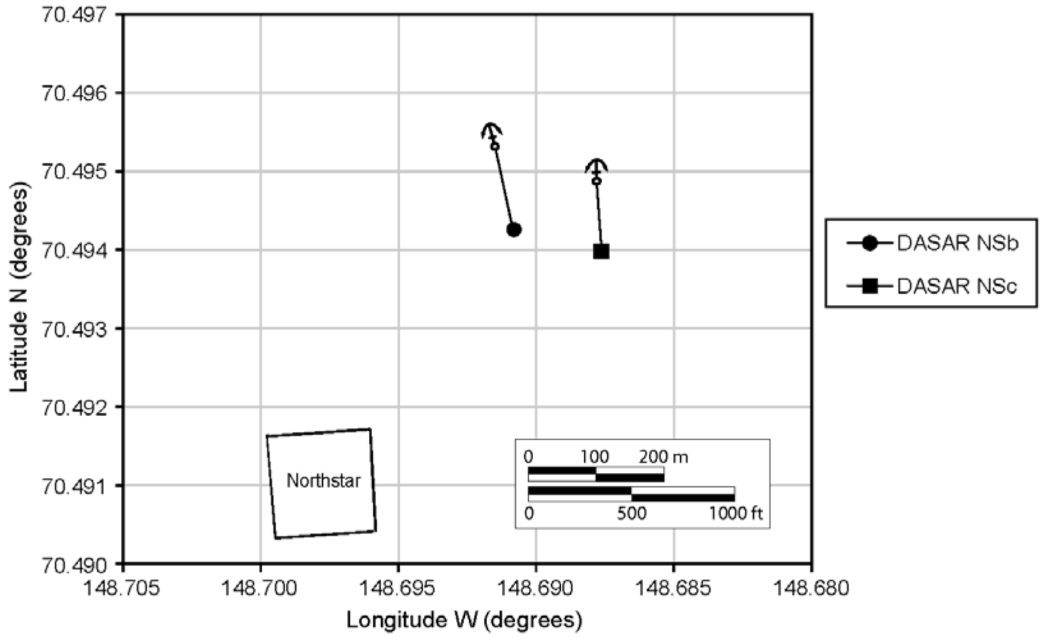

FIGURE 2.2. Deployment locations of near-island DASARs (filled symbols) and their anchors near Northstar Island in 2007. Both DASARs were deployed on 28 Aug, retrieved on 3 Oct, and functioned throughout their deployment period.

TABLE 2.2. DASAR locations in 2007, with installation date and time, start and end of data collection, position, and water depth. All times are local Alaska Daylight Saving times. DASAR units 1, 2, 6, 8, and 11 were installed offshore in the array; units 3 and 4 were deployed close to Northstar (NS).

Location	Unit #	Installed (Date; Local Time)	Data Start	Data End	Latitude (deg N)	Longitude (deg W)	Depth (m)
EBa	11	28 Aug 2007 11:22	28 Aug 2007 12:00:28	3 Oct 2007 18:03	70.577	148.391	23.2
EBb	8	28 Aug 2007 11:31	28 Aug 2007 12:00:26	3 Oct 2007 17:40	70.577	148.386	22.9
CC	2	28 Aug 2007 10:57	28 Aug 2007 12:00:18	3 Oct 2007 17:07	70.576	148.527	19.8
CA	6	28 Aug 2007 11:52	28 Aug 2007 12:00:26	3 Oct 2007 19:10	70.616	148.462	23.5
NE	1	28 Aug 2007 12:25	28 Aug 2007 12:00:25	3 Oct 2007 18:42	70.655	148.396	23.8
NSb	4	28 Aug 2007 10:10	28 Aug 2007 12:00:22	3 Oct 2007 16:00	70.494	148.691	12.5
NSc	3	28 Aug 2007 10:22	28 Aug 2007 12:00:22	3 Oct 2007 15:38	70.494	148.688	12.5

whale calls, and to synchronize the data from various DASARs when triangulating calls. Calibrations were performed on two days during the 2007 field season:

- 28 Aug, all 21 calibration stations (see Fig. 2.1). These calibrations were performed directly following deployment of the DASARs;
- 30 Sep, all 21 calibration stations. These calibrations were performed before retrieval of all the instrumentation on 3 Oct.

In 2007 the same model of J-9 sound projector, amplifier, sound source, GPS timing, and projected waveform were used as in 2003–2006. The projected waveform consisted of a 2-s tone at 400 Hz, a 2-s linear sweep from 400 to 200 Hz, a 2-s linear sweep from 200 to 400 Hz, and a 2-s linear sweep from 400 to 200 Hz. Figure 7.3 in Blackwell et al. (2006a) shows a spectrogram of this waveform. The source level of the projected sounds was ~150 dB re 1 μPa-m. An entire ping transmission required 8 s, and there were 7 s between two consecutive pings, which initiated every 15 s.

Signal Analysis

Near-island DASARs

After equalization (see ***Equalization Process*** in Blackwell et al. 2006c), data collected by the near-island DASARs were used to determine the sound spectrum (1-Hz intervals) for a one-minute period every 4.37 min (262 s). This provided ~330 spectral measurements per 24-hr day per DASAR. To derive each of these 1-min spectra, a series of 119 one-second-long data segments, overlapped by 50% and thus spanning 1 min, were analyzed. For each minute analyzed, the 119 resulting 1-Hz spectra were averaged to derive a single averaged spectrum for the 1-min period.

Those narrowband results were used to determine the corresponding broadband (10–450 Hz) and one-third octave band levels averaged over 1 min. This provided a measurement of the sound level in each band, averaged over a 1-min period, for each 4.37-min interval. These data provided an essentially continual record of the levels of low-frequency underwater sounds 410 and 480 m (~1345 and 1575 ft) from Northstar during the study period, 28 Aug–3 Oct 2007. The narrowband and one-third octave data were also summarized to derive “statistical spectra” showing, for each frequency or one-third octave band, the levels exceeded during various percentages of the 1-min samples. For each of the frequency cells or one-third octave bands in the spectra, the values were sorted from smallest to largest, and the minimum, 5th-percentile, 50th-percentile, 95th-percentile, and maximum values for that frequency cell were determined.

Industrial Sound Index.—For comparison with previous years (2001–2006), the near-island recordings in 2007 were used to define an “Industrial Sound Index” or ISI. The ISI was constructed by adding together the sound levels in one-third octave bands that appeared to be dominated by industrial components. A detailed rationale for the selection of particular one-third octave bands during 2001 and 2002 is presented in Blackwell (2003). The ISI for 2001–2006 was defined as the sum of the mean square pressures in the one-third octave bands centered at 31.5, 40, 50, 63, and 80 Hz, the “5-band ISI” (Blackwell 2003; McDonald et al. 2008). Total mean-square sound pressure (SPL) in the five one-third octave bands considered was computed as

$$ISI = 10 \cdot \log_{10} \cdot \left(10^{\frac{dB_{31.5}}{10}} + 10^{\frac{dB_{40}}{10}} + 10^{\frac{dB_{50}}{10}} + 10^{\frac{dB_{63}}{10}} + 10^{\frac{dB_{80}}{10}} \right),$$

where $dB_{31.5}$, dB_{40}, dB_{50}, dB_{63}, and dB_{80} are SPLs in the corresponding five one-third octaves (Richardson et al. 1995, p. 30). The result is the sound pressure in the (approx.) 28 to 90 Hz band.

Array DASARs

Whale call data from all five offshore DASARs (EBa, EBb, CC, CA, and NE) were analyzed in the same way as they have been in the past (2001–2006, see Greene et al. 2002, 2003a; Blackwell et al. 2006a,b,c). Calls recorded while the acoustic crew’s vessel was in the DASAR array were removed from the analyses. Whale calls were tallied on all offshore DASARs by examining all DASAR records simultaneously, minute by minute, to count calls and to determine call types. A spectrogram was produced of each call (or suspected call). Based on viewing the spectrogram and simultaneously listening to the call with headphones, analysts classified all calls as ***simple calls*** of various types, or as ***complex calls***. The call classification was based on descriptions by Clark and Johnson (1984) and Würsig and Clark (1993):

- ***Simple calls*** were frequency modulated (FM) tonal calls or "moans", generally in the 50–300 Hz range. We distinguished (1) ascending or up calls, "/"; (2) descending or down calls, "\"; (3) constant calls, "–"; and (4) ∪-shaped and ∩-shaped inflected calls.
- ***Complex calls*** were infinitely varied and included pulsed sounds, squeals, growls with abundant harmonic content, and combinations of two or more simple and complex segments. Subcategories of complex calls could not be discerned consistently, so all subcategories were pooled.

During the whale call classification process the bearing from each DASAR to each detected call is determined automatically. If a call is detected by at least two DASARs, the bearings to that call can be combined to determine a position by triangulation.

Two parameters were calculated based on the bearings from each DASAR to the various whale calls: the ***vector mean bearing*** and the ***mean vector length*** (Batschelet 1981). Figure 2.3 shows an example of a mean bearing calculation using the bearings to 9 different calls. The vector mean bearing for each year indicates the average direction from a given DASAR to the calls it received that year, while the mean vector length (L) is a measure of the variation of the individual bearings around the vector mean direction. For example, if all the bearings to calls were the same (say 45°), then the vector mean would be 45° and the mean vector length would be 1. If the bearings were spread evenly in all directions (say 4 bearings at 0°, 90°, 180°, and 270°), then the vector mean would be indeterminate and the mean vector length would be 0.

The proportion of calls "offshore" versus "inshore" (O/I ratio) was also calculated for DASARs EB, CC and CA, to be compared with values from previous years (Blackwell et al. 2006c, 2007a). "Offshore" and "inshore" were defined in relation to a ***baseline***, which is a line parallel to the general trend of the shoreline (108° to 288° True). ***Offshore calls*** were defined as those whose bearings from the DASAR of interest were between 288° and 107.9° True (including 360°/0°, true north), and ***inshore calls*** were defined as those with bearings between 108° and 287.9° (including 180°, south; Fig. 2.4). The definition of "offshore" and "inshore" was changed in 2007 compared to the two previous years. In 2005 and 2006 we excluded calls that fell in two 20° buffer zones, centered on the baseline[4]. However, in some years up to ~30% of the calls fell into the eastern buffer zone (bearings in the range 98°–118°) and were therefore excluded in the calculations of the O/I ratio. Since this seemed unreasonable the buffer zones were eliminated in 2007. Prior-year data were also reassessed based on the new procedure.

To provide information on ambient[5] sound levels away from Northstar, data recorded by DASAR EBa were analyzed the same way as data from the near-island DASAR (see above). Of the DASARs for which we have a continuous record since 2001 (EB and CC), EB is the most suitable because it is farthest from Northstar Island (~15 km or 9.3 mi). Note however that sound levels recorded at location EB contain some anthropogenic sounds from Northstar and possibly other operations in the Prudhoe Bay area.

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[4] These zones were, therefore, the ranges 98°–118° and 278°–298°.

[5] We define ambient sounds as the sounds other than those of interest. Generally, ambient sound levels are used as a reference level to study a new sound. For example, for the near-island recorders ambient sounds are those produced by wind and waves, and, if present, distant anthropogenic sound sources.

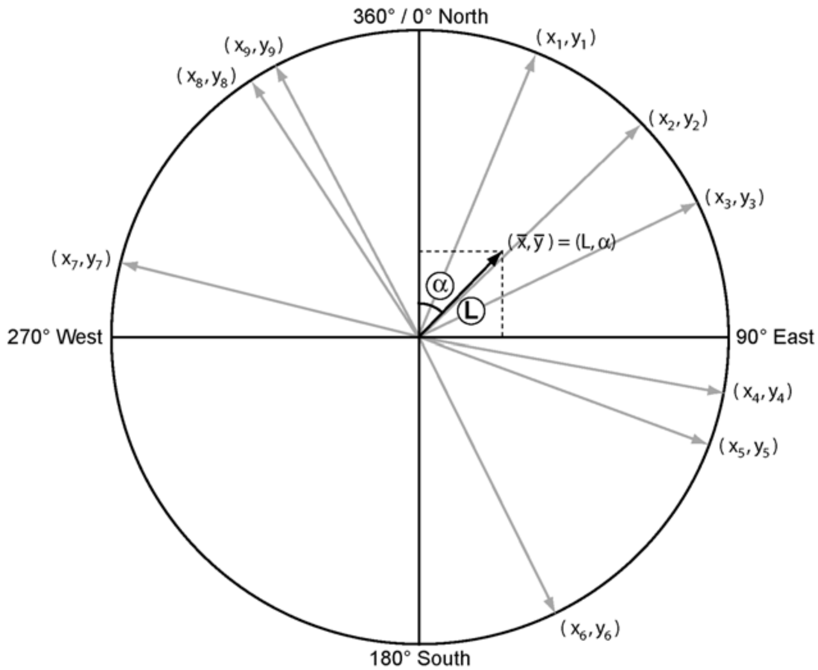

FIGURE 2.3. Average bearing calculation. The gray arrows are example bearings from a DASAR (located in the center of the circle). Mean bearing angle α = $\arctan(\bar{x}, \bar{y})$, where $\bar{x}$ and $\bar{y}$ are the average cos and sin, respectively, of all bearings obtained at one DASAR during a season. Mean vector length L = $\sqrt{\bar{x}^2 + \bar{y}^2}$, is a measure of the variation of individual bearings around the vector mean direction.

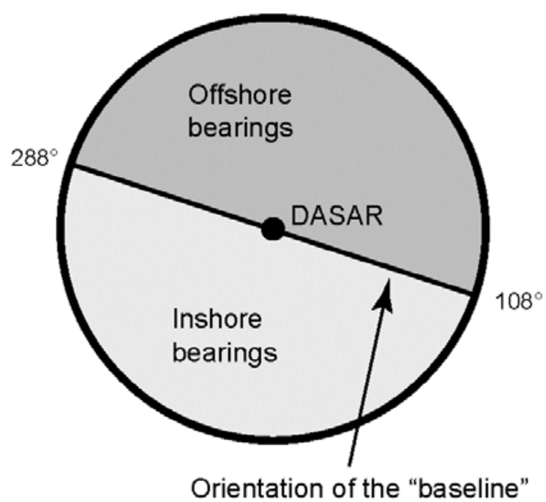

FIGURE 2.4. Definition of the “offshore” and “inshore” sectors in relation to the orientation of the baseline and DASAR location (filled circle in center). See text for details.

RESULTS

This section is organized with five main sections describing

1. DASAR operations in 2007;
2. Calibration of the DASAR clocks;
3. Underwater sounds at Northstar, including temporal variation in broadband levels and ISI levels, spectral analyses, and comparisons with previous years;
4. Underwater sounds at offshore DASAR EB, including temporal variation in broadband levels, percentile levels of broadband sound, and comparisons with previous years;
5. Whale call analyses, including (a) the number of whale calls detected at the offshore DASARs and comparisons with previous years; (b) bearings to calls, O/I ratios, and locations of calls received by at least 2 DASARs, and comparisons with previous years; (c) analysis of call types in 2007 and comparison with call types obtained at the same locations in previous years.

DASAR Operations in 2007

All DASARs functioned throughout their deployment. The magnetic compass data indicated that four out of seven DASARs rotated one or more times on their bases while sitting on the seafloor in 2007: CC, CA, NE, and NSc. This has also happened in past years, despite the addition of weights and anti-rotation tabs to the DASAR bases. Since compass bearing calibrations are performed after deployment and before retrieval, a DASAR can be moved once on the seafloor by currents or surge without any loss of information; the early- and end-season calibrations can be used for the times preceding and following the shift in position, respectively. The time of the rotation is documented via the log of magnetic compass bearings vs. time (e.g., Fig. 2.5). However, if the recorder is moved more than once, then the reference bearing will not be known precisely during the interval between the recorder's first and last shift on the seafloor. (The magnetic compass data are adequate to identify times when orientation shifts, but not sufficiently precise to characterize the actual orientation.) Repeated DASAR rotations resulted in inability to calculate accurate bearings to whale calls during ~2 days for DASAR NE, ~0.5 days for DASAR CA, and ~9 days for DASAR CC (16–24 Sep). Both EB DASARs remained stable on the seafloor during their entire deployment. Figure 2.5 shows the magnetic compass headings for DASAR CC, which moved twice during its deployment, and DASAR EBa. Wind speed in 2007 was high compared to previous years (see below) and likely contributed to the DASARs' movements on the seafloor.

Calibration of the DASAR Clocks

The results of the clock drift calibrations are presented in Table 2.3. Unlike the bearing calibrations, which improve noticeably with the number of pings used, the clock calibrations can be done using only a few pings. Therefore only the first ping from each calibration station was used for each of the two calibration days. Clock drift for the various DASARs ranged from –0.47 to –2.94 seconds per day.

Underwater Sounds at Northstar

Broadband Sounds

The sound levels recorded by the two near-island DASARs (NSb and NSc) were in close agreement, with differences that are well within the variation one might expect based on reception at slightly different

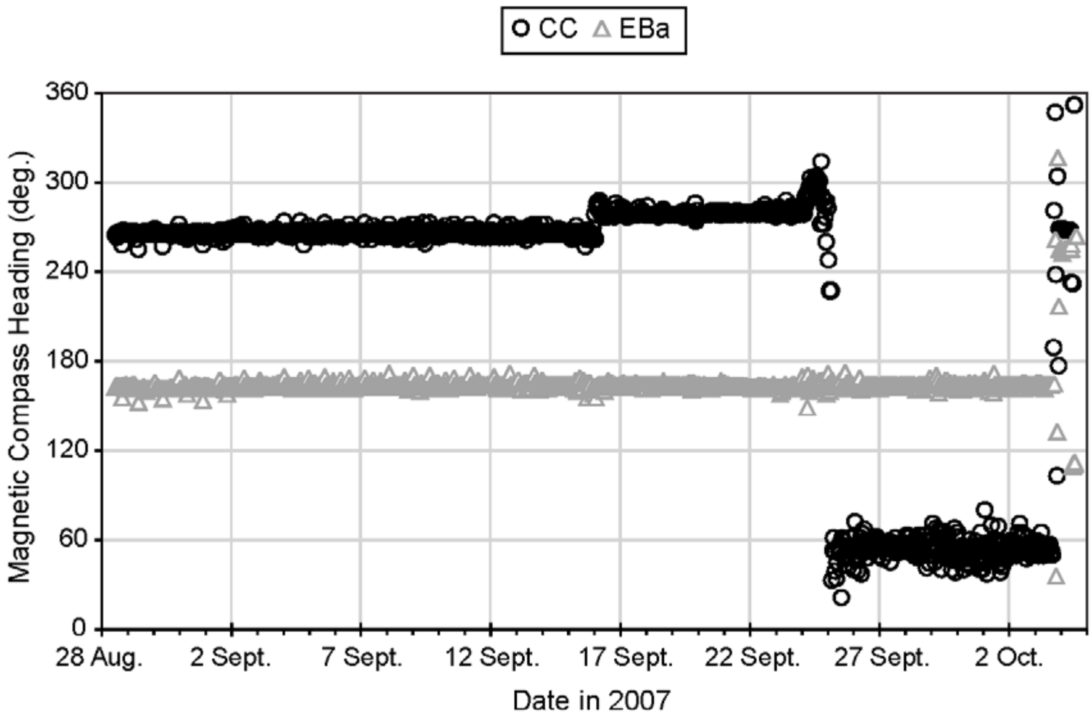

FIGURE 2.5. Magnetic compass heading vs. time for DASARs CC and EBa over their respective deployment periods in 2007. Whereas DASAR EBa remained stable on the seafloor during its deployment, the orientation of DASAR CC shifted twice, close to midnight on Sep 15/16, and on Sep 24. Both DASARs were retrieved on 3 Oct 2007, as indicated by the large shifts in compass heading then.

TABLE 2.3. DASAR clock drift rate in 2007. Clock drift is characterized by its rate or "slope", in seconds per day.

DASAR	Unit #	Slope (s/day)
EBa	11	-2.938
EBb	8	-1.897
CC	2	-1.344
CA	6	-1.136
NE	1	-0.468
NSb	4	-0.999
NSc	3	-1.716

locations. NSb had a slightly higher noise floor (by ~2 dB), which could have been due to a deployment location with more currents. We decided to use the data collected by DASAR NSb as this DASAR had the most stable compass bearings over its deployment. The signals from DASAR NSb were analyzed to determine the broadband (10–450 Hz) level of underwater sound based on a one-minute analysis every 4.37 minutes. The combined results are presented as a sound pressure time series (SPTS) in Figure 2.6B for the period 28 Aug–3 Oct 2007. The range of broadband levels obtained for DASAR NSb in 2007 was 91–133 dB re 1µPa. This is similar to values obtained in 2002, 2003, 2004, 2005, and 2006, which were 90–135, 90–137, 92–133, 88–136, and 90–131 dB re 1 µPa, respectively.

Broadband levels close to Northstar are determined by a combination of two factors: sound-generating industrial activities at and near Northstar, which are dominated by vessels when present (Blackwell and Greene 2006), and wind speed, which largely determines ambient sound levels. The MMS weather station on Northstar, which had provided us with wind speed information since 2001, was decommissioned in late 2006. Therefore, the wind speed data used for 2007 come from the Endicott weather station. Endicott is located at the end of a causeway, 4 km (2.5 mi) offshore and 36 km (22 mi) ESE of Northstar. Wind speed statistics for the five MMS stations (Badami, Cottle Island, Endicott, Milne Point, and Northstar, see MMS 2007) over the period 2001–2006 show that values for Northstar were closest to those recorded by Endicott. Mean values for the two stations over the six-year period were as follows (Northstar value first and Endicott value second in each case; higher values in **bold**):

- Mean wind speed: 5.13 m/s for Northstar versus **5.31 m/s** for Endicott
- Standard deviation: 2.96 m/s versus **3.48 m/s**
- Median wind speed: **4.66 m/s** versus 4.44 m/s
- Maximum wind speed: **24.9 m/s** versus 23.7 m/s

Mean hourly wind speed, as recorded by the Endicott weather station during the 2007 field season, is shown in Figure 2.6A. The lowest broadband levels in Figure 2.6B are indicative of the quietest times in the water near Northstar Island, and generally correspond to times with low wind speeds. Conversely, times of high wind speed (e.g., 2, 15, or 24 Sep) usually correspond to increased broadband levels in the DASAR record (Fig. 2.6B). Data from previous years have shown that short duration “spikes” in broadband levels are usually attributable to vessel activity (Blackwell and Greene 2006). Figure 2.7 summarizes mean wind speed during September in each year of the Northstar study, as recorded by the Northstar (2001–2006) or Endicott (2007) weather stations. Figure 2.7 shows that, on average, 2007 was one of the windiest field seasons over the course of this study (2001–2007).

Figure 2.8 shows broadband (10–450 Hz) levels of sound as recorded at the near-island recorders in 2001–2007. In all years baseline levels (the lower edge of an “envelope” around the plotted sound pressure time series) are mainly determined by wind.

Industrial Sound Index (ISI)

As in 2001–2006, the sum of sound components in the frequency range 28–90 Hz defined the ISI. The ISI for the 2007 study period is shown in Figure 2.6C as a function of time. Ideally, the ISI would represent only sounds generated by Northstar-related activities. However, it is not possible to completely isolate Northstar-related sounds from ambient sounds, mainly because ambient sounds (e.g., from wind and waves) are broadband in nature. As in previous years the ISI was closely related to the overall 10–450 Hz level, but the ISI is a few decibels lower as a consequence of excluding sound components at frequencies below 28 Hz and above 90 Hz. In 2007, 1-min ISI values were, on average, 6.9 dB below 10–450 Hz broadband values. This average difference is somewhat greater than in previous years: it was 4.2 dB in 2006, 5.7 dB in 2005, 5.0 dB in 2004, and 5.7 dB in 2003. However, these averages have large standard deviations and differences between years may not be significant.

Figure 2.6D shows the relationship between the minimum hourly ISI value as recorded by the near-island recorder and the mean hourly wind speed at Endicott. Based on results from prior years, we assumed that the relationship would be approximately linear, but in 2007 there was an indication of a curvilinear relationship (Fig. 2.6). Even so, minimum hourly ISI value and mean hourly wind speed were more closely correlated in 2007 ($r = 0.87$) than in 2006 ($r = 0.70$) or 2005 ($r = 0.75$), probably in part because of the high

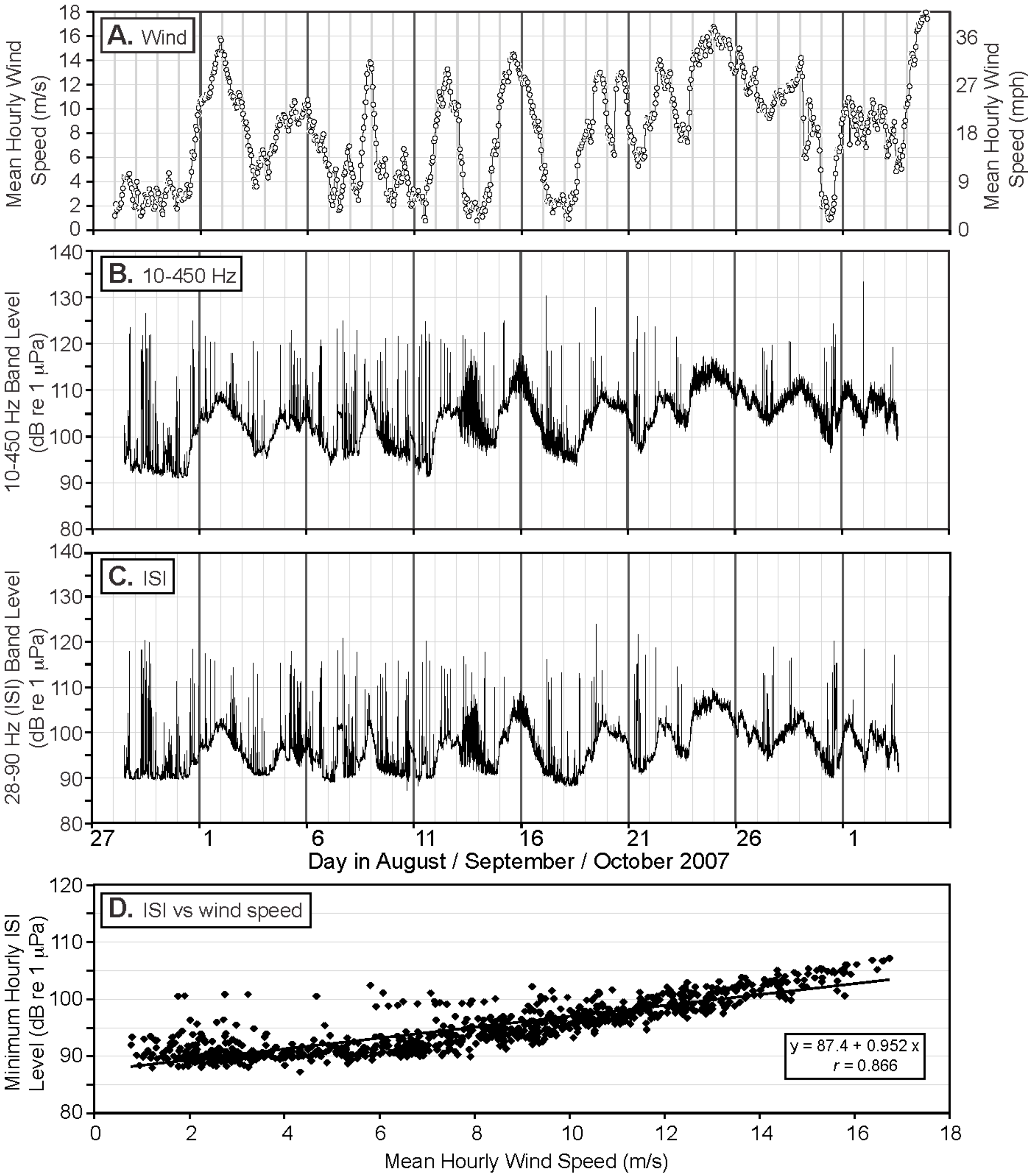

FIGURE 2.6. Variation in levels of underwater sound near Northstar in relation to date/time and wind speed, 28 Aug–3 Oct 2007. ***(A)*** Mean hourly wind speed as recorded by the Endicott weather station. ***(B)*** Broadband (10–450 Hz) levels of underwater sound near Northstar vs. time, as recorded by DASAR NSb. This recorder was deployed 410 m (1345 ft) north of Northstar. ***(C)*** Corresponding ISI band level (~28–90 Hz) from DASAR NSb. ***(D)*** Minimum hourly ISI level versus mean hourly wind speed at Endicott, for the 2007 field season.

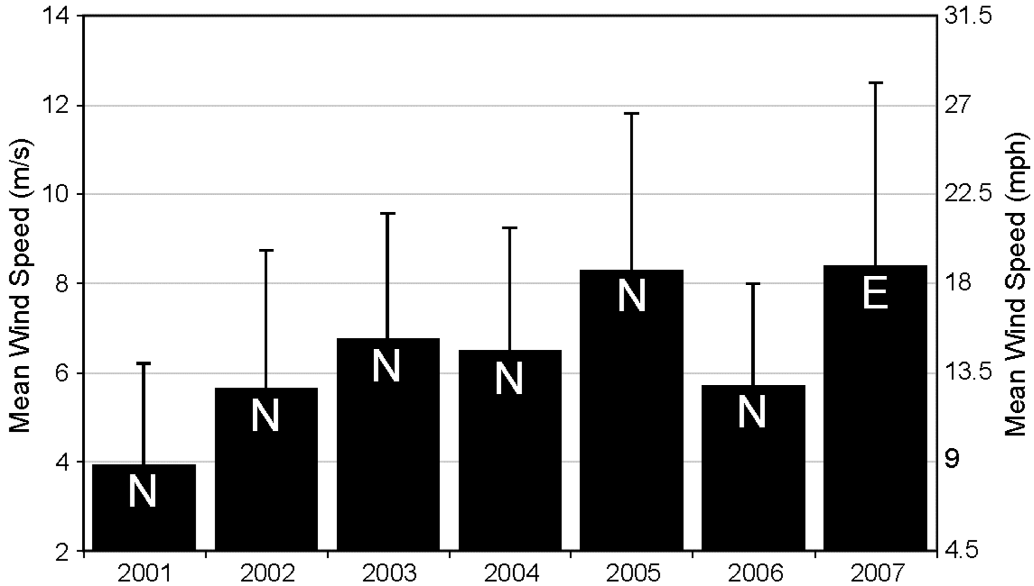

FIGURE 2.7. Mean wind speed for the period 31 Aug–30 Sep for 2001–2007, plus one standard deviation. Data for 2001–2006 were collected by the Northstar (N) weather station, and data for 2007 were obtained by the Endicott (E) weather station (see text for details).

wind speeds in 2007. In 2007 there was a weak relationship between wind speed and ISI level for mean wind speeds below 7 m/s ($r = 0.19$). In contrast, for mean wind speeds above 7 m/s the correlation coefficient increased to 0.85 and the slope of a linear regression increased five-fold from 0.24 to 1.28.

Statistical Spectra of Island Sounds

To characterize the sounds near Northstar during the study period in 2007, percentile distributions of one-third octave band levels and spectral density levels were calculated for DASAR NSb and are shown in Figure 2.9. Overall, these spectra are similar to those from previous years (2006: see Fig. 2.7 in Blackwell et al. 2007a; 2005: Fig. 2.8 in Blackwell et al. 2006c; 2004: Fig. 8.9 in Blackwell et al. 2006b; 2003: Fig. 7.16 in Blackwell et al. 2006a; 2002: Fig. 6.19 in Blackwell 2003; 2001: Fig. 7.19 in Blackwell and Greene 2002; 2001: Fig. 7.31 in Blackwell and Greene 2001), with some variations. As in previous years, peaks were present at 30 and 60 Hz – these peaks have been present every year of monitoring. There was also a peak at 87 Hz, which has been present every year since 2003. However, a peak at ~24 Hz, present in 2002, 2004, and 2006, was not present in 2007. Percentile levels of broadband sound as recorded by the near-island recorders in 2001–2007 are compared in Table 2.4 and Figure 2.10. In 2007 percentile levels of broadband sound at various frequencies were well within the corresponding ranges of values from previous years (Fig. 2.10).

Specific Island Sound Sources

Vessels.—As has been the case during open-water seasons since 2004, personnel and goods were transported to the island with the hovercraft and, when weather conditions precluded its use, with helicopters. In addition, ACS vessels made runs to the island during Sep 2007. The daily number of round trips by the hovercraft, tugs (usually accompanied by a barge), and ACS vessels are shown in Figure 2.11. These records were compiled by Crowley Marine, ACS, and the Northstar scheduler. All references to

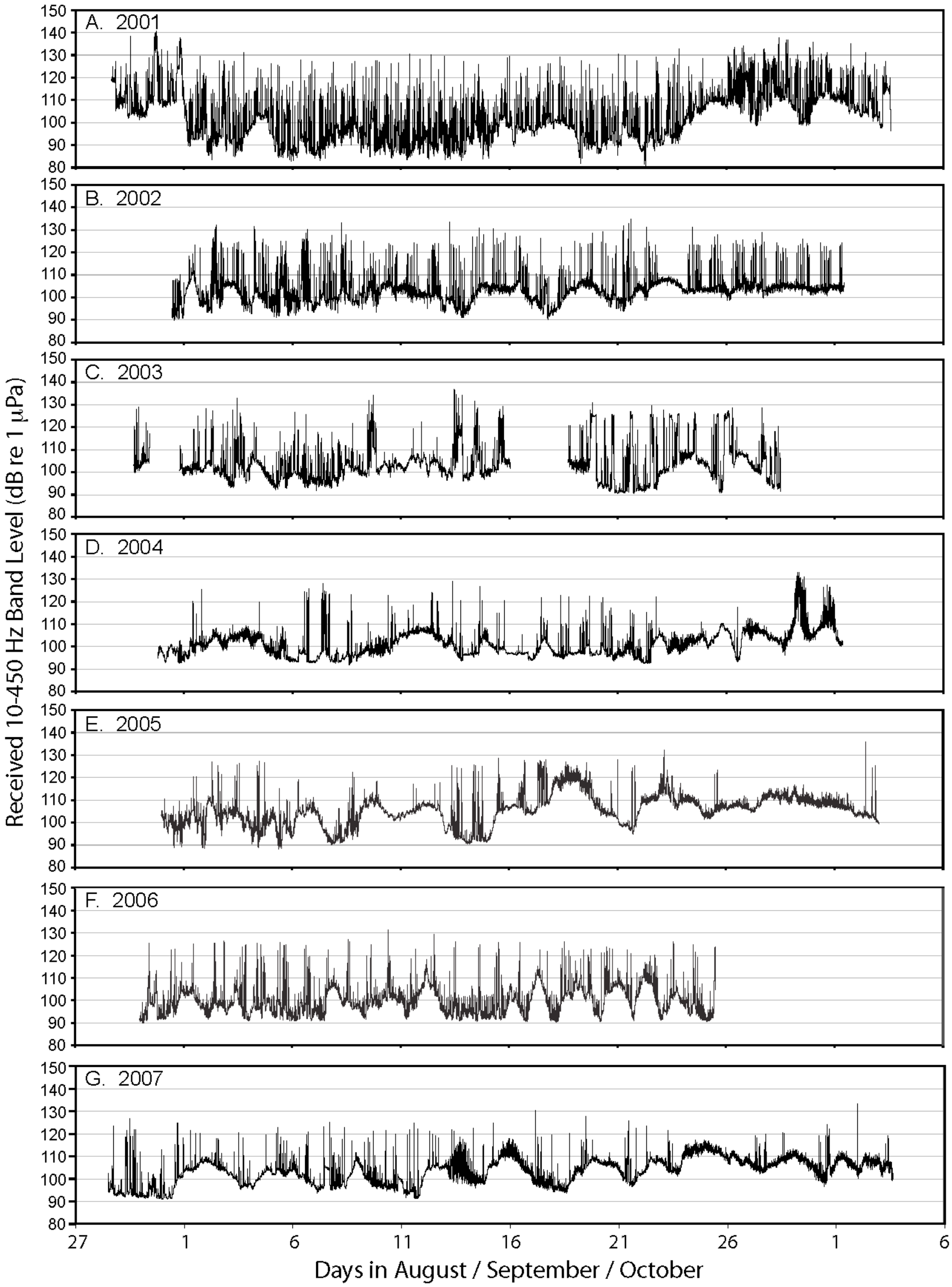

FIGURE 2.8. Sound pressure time series (10–450 Hz band level) for the 2001–2007 seasons, as recorded by the near-island recorders—a cabled hydrophone in 2001, 2002, and the first part of 2003, and a DASAR for the second part of 2003, and all of 2004, 2005, 2006, and 2007.

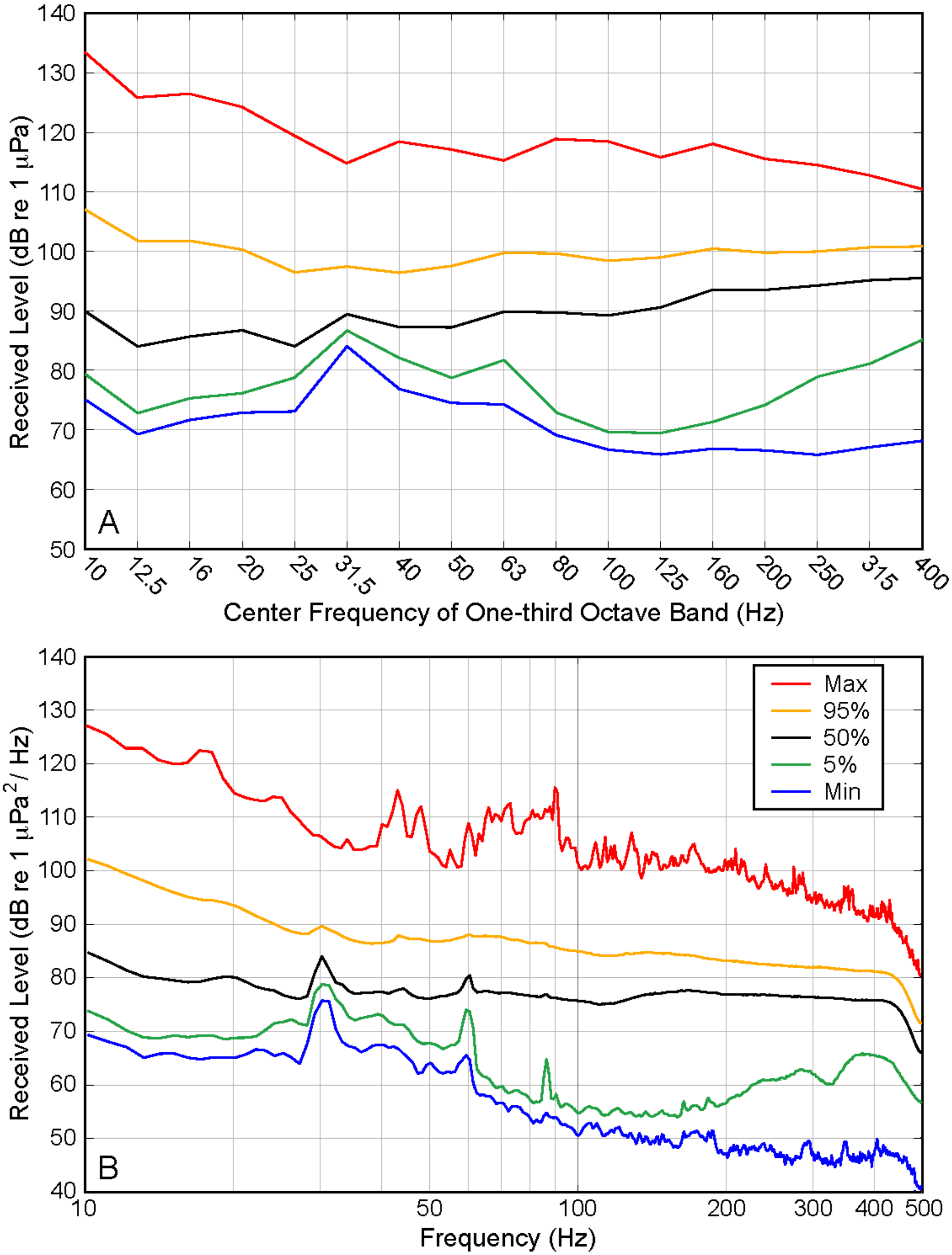

FIGURE 2.9. Statistical spectra for sounds recorded by DASAR NSb during the period 28 Aug–3 Oct 2007. ***(A)*** One-third octave band levels. ***(B)*** Sound spectral density levels. In both plots the five curves show, for each frequency, the minimum, the 5th, 50th, 95th percentiles, and the maximum. For both plots the number of 1-min measurements used was 11,906. The rapidly dropping values at frequencies close to 500 Hz are an effect of the anti-aliasing filter applied to the DASAR data.

TABLE 2.4. Percentile levels, in dB re 1 μPa, of broadband (10–450 Hz) underwater sound recorded near Northstar Island in 2001–2007. In 2001 (1–21 Sep) and 2002 (31 Aug–23 Sep), data were collected by cabled hydrophone (CH) #2. In 2003, data were recorded both by CH #2 (29 Aug–16 Sep) and DASAR NS (18–28 Sep). In 2004, 2005, and 2006, data were recorded by DASAR NSa (30 Aug–1 Oct), DASAR NSb (1 Sep–2 Oct), and DASAR NSc (30 Aug–25 Sep), respectively. In 2007, data were recorded by DASAR NSb (28 Aug–3 Oct). "Range" is the difference between maximum and minimum. All hydrophones were at similar distances (410–550 m or 1345–1804 ft) north of Northstar.

	2001[a]	2002[a]	2003[a]		2004[a]	2005	2006	2007
	CH #2	CH #2	CH #2	DASAR NS	DASAR NSa	DASAR NSb	DASAR NSc	DASAR NSb
Min	80.8	89.7	91.8	90.4	92.0	88.0	89.8	90.9
5^{th} %ile	87.3	94.8	95.2	91.7	93.7	92.4	91.7	93.4
50^{th} %ile	101.8	103.5	101.8	103.4	100.5	105.5	98.7	104.0
95^{th} %ile	122.7	117.3	116.7	125.1	110.1	118.2	111.4	112.5
Max	140.5	135.0	136.8	131.1	133.1	135.8	131.4	133.3
Range	59.7	45.3	45.0	40.7	41.1	47.8	41.6	42.8

[a] For 2001–2004, values presented here differ very slightly from those presented in reports from 2005 and earlier for two reasons: (1) a new equalizing filter (Blackwell et al. 2006c) was applied retroactively to all DASAR data; and (2) broadband levels are presented for the 10–450 Hz range instead of 10–500 Hz.

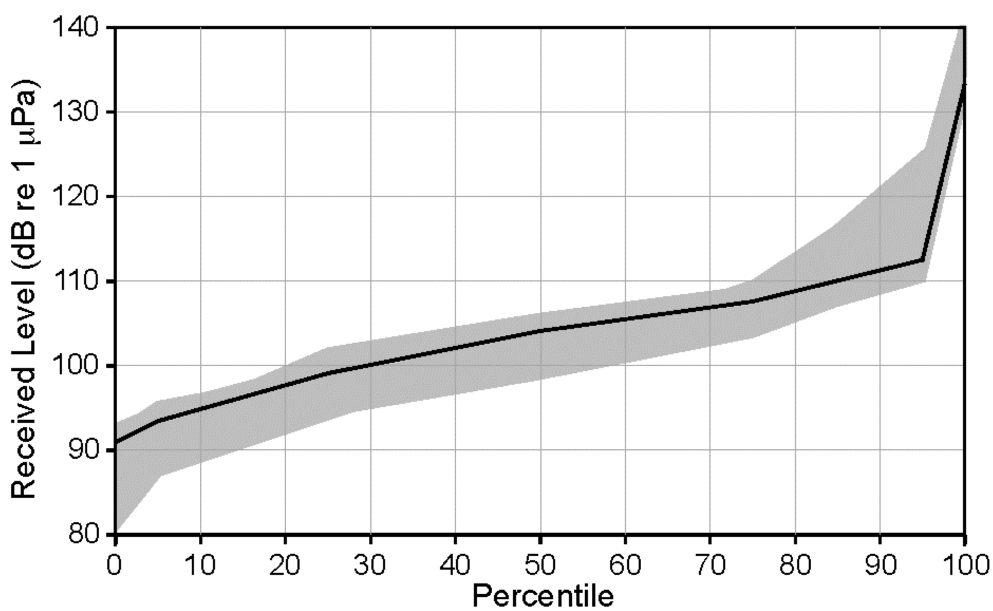

FIGURE 2.10. Minimum, 5^{th}, 25^{th}, 50^{th}, 75^{th}, and 95^{th} percentiles, and maximum received levels of broadband (10–450 Hz) sound at DASAR NSb for 2007 (black line), as compared to the "envelope" of values obtained in 2001–2006 from near-island recorders (cabled hydrophones or DASARs, see Table 2.4). The number of 1-min measurements used in 2007 was 11,906.

"trips" in this subsection refer to round trips. Averages (# trips/day) were calculated over the period of deployment of the near-island recorders, which varied slightly from year to year.

- The *hovercraft* made a total of 41 trips to Northstar during the period 28 Aug–3 Oct 2007, or on average 1.1 trip/day. This is lower than in 2006 (4.4 trips/day) and 2005 (1.6 trips/day), but higher than in 2004 (0.6 trips/day). The hovercraft did not suffer any mechanical problems during the 28 Aug–3 Oct period in 2007, but as usual was only able to operate in fairly good weather conditions (see below).

- *Tugs*[6] *and barges* made 13 trips to Northstar in 37 days, i.e., 0.35 trips/day. This is lower than in 2006 (1 trip/day) and 2003 (1.6 trips/day), and about the same as in 2005 (0.5 trips/day) and 2004 (0.4 trips/day).

- *ACS vessels*[7] (excluding the trips by the acoustics crew) made 76 round trips to Northstar in 37 days, an average of 2.1 trips/day. This is more than the number of daily trips in 2006 (~1 trip/day), 2005 (0.33 trips/day) and 2004 (0.7 trips/day). According to Royce O'Brien at ACS, "Bay" boats did occasional freight runs to the island, but they were mainly used for personnel transfer when ice, wind, sea state, or fog conditions precluded the use of the hovercraft or helicopters. In addition, the acoustics crew used an ACS "Bay" boat on a total of 3 days during the 2007 field season to deploy, calibrate and retrieve the DASARs in the offshore array and close to Northstar (see gray shading in Fig. 2.11). The number of boat-days by the acoustic crew each year has been as follows: 12, 8, 8, 9, 5, 5, and 3 in 2001–2007, respectively.

Round trips to the island by tugs and ACS vessels combined (including trips for the acoustic work) accounted for ~75% of all the large vertical "spikes" in DASAR NSb's sound pressure time series (Fig. 2.6B). This estimate was obtained the same way as in 2005 and 2006 (see Blackwell et al. 2006c, 2007a). We matched spikes (or tight groups of spikes) in the sound pressure time series with the times of arrival and departure of the vessels of interest. Our estimate is a minimum estimate, since the arrival and departure spikes were taken into account, but not sound spikes created for example by maneuvering at the island. For 2007, the number of reported round trips by tugs and ACS vessels whose arrival and / or departure at Northstar could be matched to a spike in the SPTS was ~96%.

Underwater Sounds Offshore at DASAR EB

Figure 2.12 shows broadband (10–450 Hz) levels of sound as recorded offshore at DASAR location EB in 2001–2007 (the record of DASAR EBa is shown for 2007). DASAR EB was located ~15 km (9.3 mi) northeast of Northstar (Fig. 2.1). During calibrations on 30 Sep 2007 no health checks were performed, so the vessel never got closer than ~2 km (1.2 mi) from location EB, which explains the small size of the spike (Fig. 2.12). Baseline levels of sound at any DASAR are mainly a function of sea state, and therefore wind speed. Despite the higher mean wind speeds in 2007 compared to 2006 (Fig. 2.7), sound levels at EB in 2007 were similar to those in the same period in 2006 (Fig. 2.12). Figure 2.13 shows percentile levels of underwater sound at location EB, calculated each year over the entire season. Percentile

[6] These were the *Kavik River* (made >75% of trips) and *Sag River.*

[7] These were all trips by "*Bay*" boats, which are 12.8 m (42 ft) long aluminum-hulled OSRVs (oil spill response vessels).

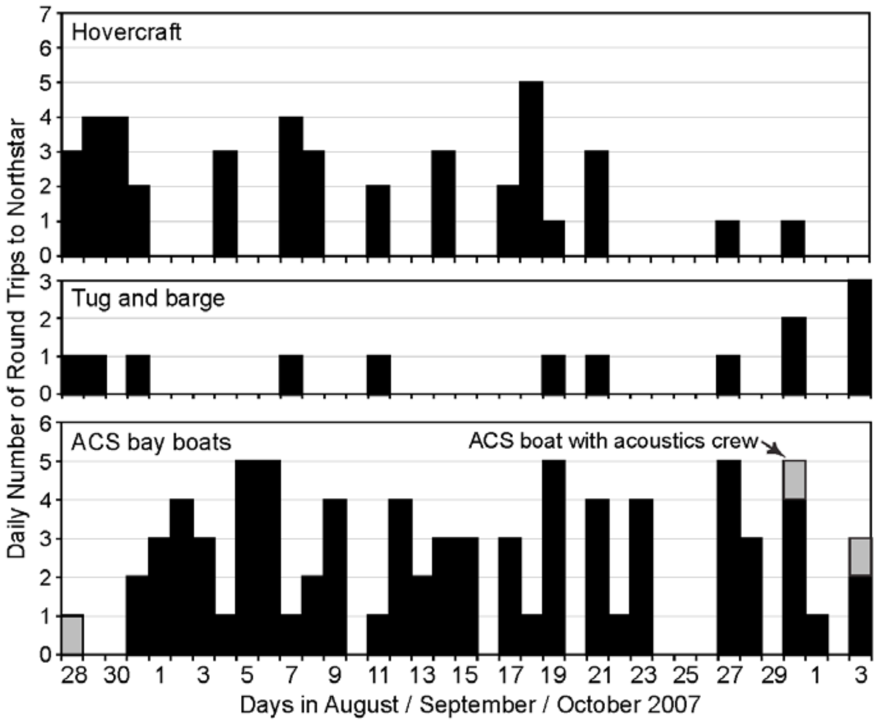

FIGURE 2.11. Daily number of round trips to Northstar Island by the hovercraft, tugs and barges, and ACS vessels (black shading = Northstar related, gray shading = acoustics crew) during the 2007 field season.

levels in 2007 were generally within the ranges recorded in the years 2001–2006, and for the low percentiles (minimum and 5th percentile), 2007 levels were amongst the lowest.

Figure 2.14 compares received levels of broadband sound at the near-island recorder and EB. Received levels at EB were on average ~6 dB lower than at the near-island DASAR. When a vessel was present at the island, this difference could reach 41 dB. In contrast, the presence of spike-causing activities (presumably a vessel) at EB could lead to received levels that were up to 23 dB higher than concurrent levels at the island. However, at 94% of the 2007 sampling times, the broadband level near the island exceeded that at EB.

Whale Call Analyses

Number of Whale Calls Detected

A total of 12,835 calls were detected on the records of DASARs CC, EBa, EBb, CA, and NE combined during the 28 Aug–3 Oct period in 2007. Unless specified otherwise, a call that is detected at several DASARs is counted as a single call. Excluding NE, which was not deployed in 2006 or 2005, the total number of calls was 11,646 in 2007 compared to 1509 in 2006 (from four DASARs at the same locations) and 1613 in 2005 (DASARs CCa, CCb, EB, and WB). However the lengths of the field seasons were different, with 2007 (~36 days) being about twice as long as 2006 (~18 days). Table 2.5 compares call counts in the different years at DASAR locations EB and CC, the two locations that have been monitored every year since 2001. In years when duplicate DASARs were deployed (EB in 2006 and 2007, CC in 2005), we have only included counts from one of the duplicate DASARs. The mean number

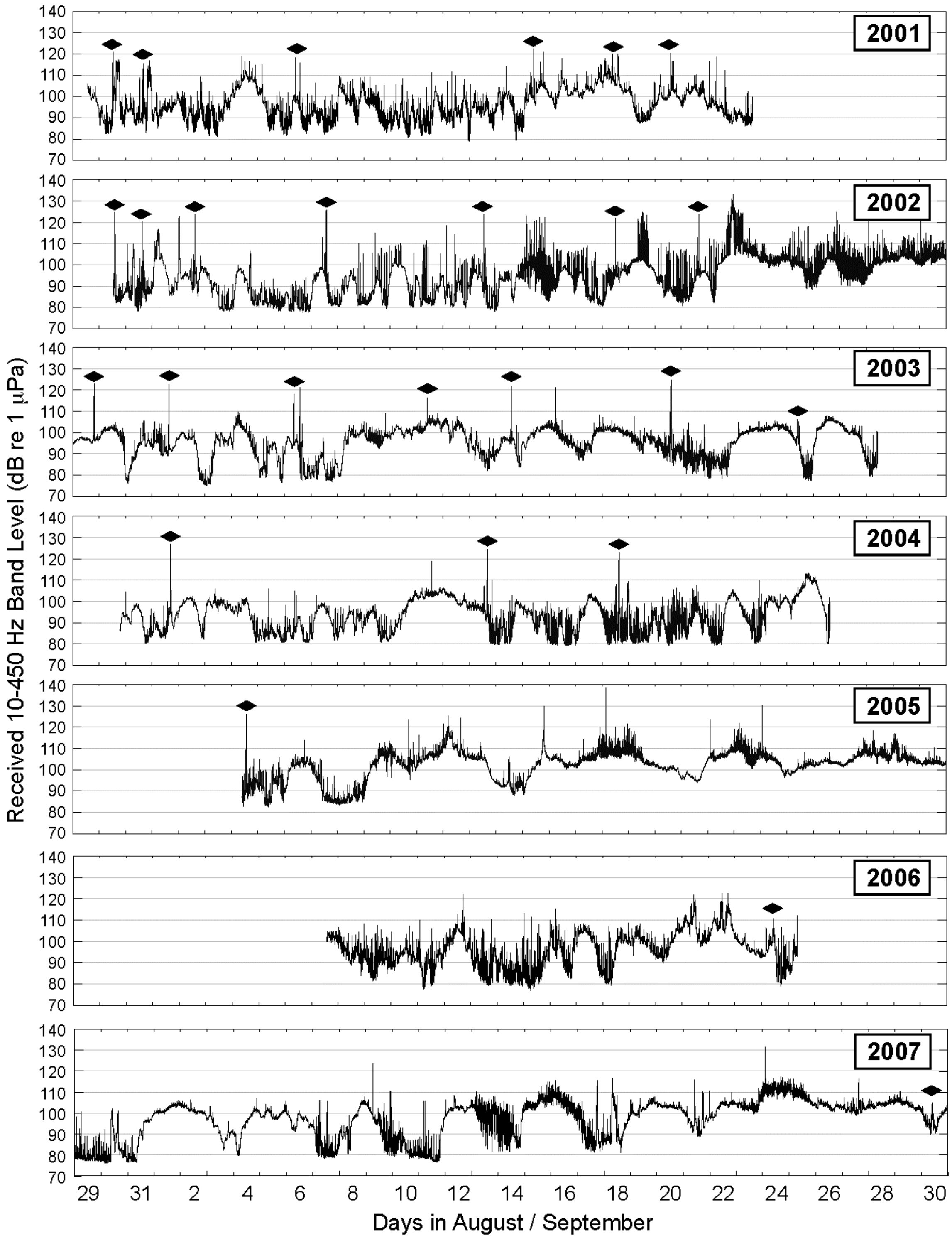

FIGURE 2.12. Broadband (10–450 Hz) sound pressure levels (SPLs) vs. time as recorded by DASAR EB in 2001–2007. Diamonds indicate spikes (brief periods of higher-level sound) created by the acoustic crew's vessel during servicing of the DASAR array.

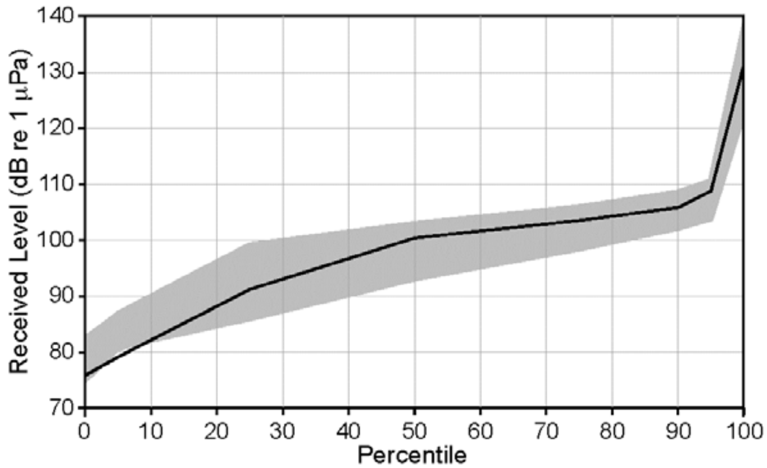

FIGURE 2.13. Minimum, 5th, 25th, 50th, 75th, 90th and 95th percentiles, and maximum received levels of broadband (10–450 Hz) sound at DASAR EB for 2007 (black line), as compared to the “envelope” of values obtained in 2001–2006. The number of 1-min measurements used in 2007 was 11,906.

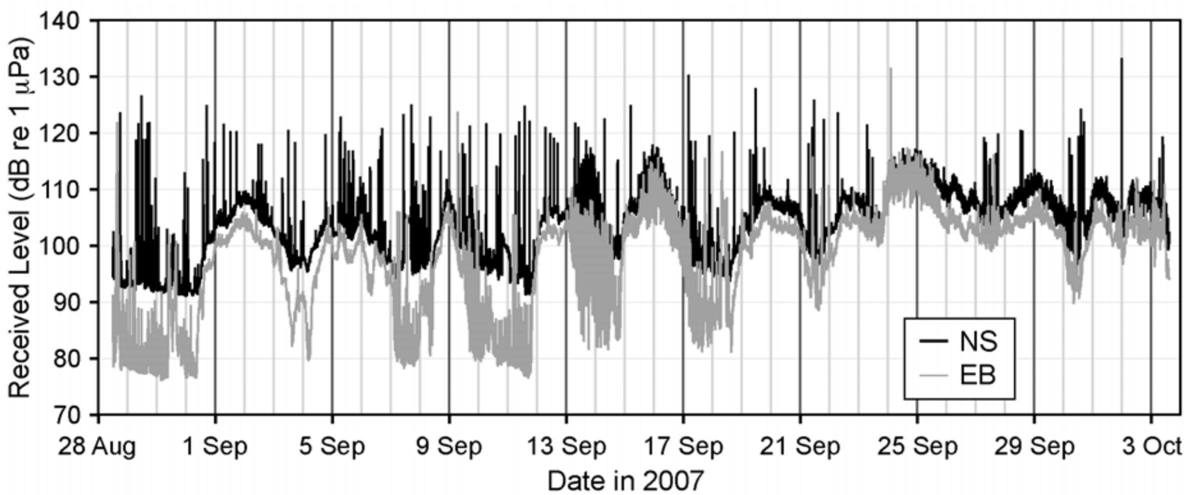

FIGURE 2.14. Received broadband (10–450 Hz) levels of sound at the near-island (NS) DASAR (black line) and concurrently at DASAR EB (gray line) for the entire 2007 field season. In 2005–2007 sounds at DASAR EB were used as ambient reference levels. Large spikes on DASAR EB’s record are likely produced by non-Northstar vessels transiting through the area.

of calls detected per day was calculated using only days when both EB and CC were functioning normally (2001: 14 out of 35 days; 2002: 23 out of 24 days; 2003: 30 out of 30 days; 2004: 27 out of 33 days; 2005: 29 out of 29 days; 2006: 18 out of 18 days; 2007: 27 out of 36 days). The percentages of calls detected at CC and EB add up to more than 100% because some calls were heard by both DASARs. When expressed as a number of calls per day the 2007 number (271 calls/day) was the third highest behind 2004 (1182 calls/day) and 2003 (895 call/day, see Table 2.5).

In 2007 there were a total of 38,198 separate call detections at the five offshore DASARs. If we omit days with indeterminate bearing references for any of the DASARs (16–25 Sep) then there were 28,922 separate call detections and they were detected by the five DASARs in the following percentages: 23% at

TABLE 2.5. Comparison of bowhead whale call counts via DASARs EB (EBa in 2006 and 2007) and CC (CCa in 2005) combined in 2001–2007. (There was a functioning DASAR at both EB and CC in each of those 7 years.) Also shown for each year are mean number of calls detected per day (considering only days when both DASARs were operating), and percentages of those calls detected at each of the two DASAR locations. See text for details.[a,b]

			Percentages of calls detected	
Year	Total calls detected at EB and/or CC	Mean # calls per day [a, b]	EB	CC
2001	1542	110	97.2	9.3
2002	4775	208	90.2	43.0
2003	26,401	895	82.3	62.6
2004	31,903	1182	83.1	72.8
2005	1020	35	62.5	56.5
2006	677	38	49.0	57.0
2007	7312	271	91.0	67.9

[a] Mean number of calls per day for individual DASARs EB and CC were as follows: **2001**, 107 and 10, respectively; **2002**: 187 and 90; **2003**: 737 and 560; **2004**: 982 and 915; **2005**: 22 and 20; **2006**: 18 and 21; **2007**: 246 and 184. For each year, these values consider days when both of these DASARs were operating.

[b] In **2000**, the DASAR array was 1 nmi (1.1 mi) farther north than in 2001–2006, with no functional DASAR near EB. The recorders closest to DASAR CC were SW1 located 1850 m (1.1 mi) north of CC, and SW2 ~4650 m (2.9 mi) southwest of CC (Greene et al. 2001). SW1 recorded 1177 calls over 11.7 days, or 100 calls per day; SW2 recorded 1012 calls over 5.7 days, or 177 calls per day.

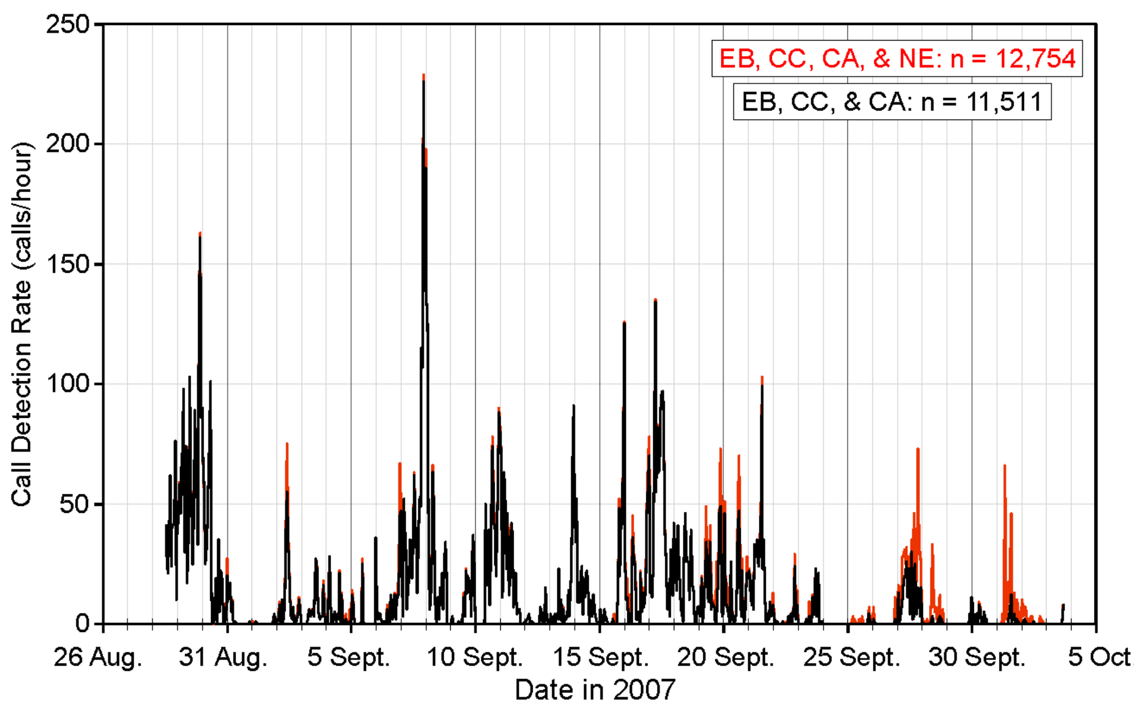

FIGURE 2.15. Hourly detection rate of whale calls as a function of time in late Aug to early Oct 2007. Calls detected via DASARs EBa, CC, CA, and NE are shown in red font and calls detected via DASARs EBa, CC, and CA are shown in black font. Total numbers of calls considered in this diagram were 12,754 and 11,511, respectively. Tick-marks on X-axis represent midnight. The highest call detection rates were 229 and 226 calls/hour, respectively, on 7 Sep between 22:00 and 23:00.

EBa (6652 calls), 23% at EBb (6717 calls), 19% at CA (5583 calls), 17% at CC (4968 calls), and 17% at NE (5002 calls). For this same subset of the data the percentages of calls detected by 1, 2, 3, 4, and 5 DASARs were 13%, 21%, 20%, 21%, and 25%, respectively. The percentage of calls detected by a single DASAR was much higher in 2005 and 2006 (65% and 86%, respectively) than in other years. In 2004, for example, 22% of calls were detected by only one DASAR (Blackwell et al. 2006b). We have no good explanation for this observation.

Figure 2.15 shows the call detection rate for the entire 2007 season, considering calls from (1) DASARs EBa, CC, CA, and NE combined, and (2) DASARs EBa, CC, and CA combined. The highest rates of call detection for these DASAR combinations were 229 and 226 calls/hour, respectively, on 7 Sep 2007, shortly before midnight. This was about twice the maximum in 2005 (112 calls/hour) and 3.4× the maximum in 2006 (67 calls/hour). In all three years, the maximum hourly call detection rate occurred during the second week of Sep: 13 Sep in 2005, 11 Sep in 2006, and 7 Sep in 2007. In 2007 there were three peaks in call detections: two early in the season (29–30 Aug and 7 Sep) and one later in our field season (~15–21 Sep), which corresponds to the middle of the fall migration season for bowheads. (Migration continues well into October, after the end of our annual monitoring period.)

Figure 2.16 compares daily number of calls detected by DASARs EB and CC combined in 2007 and in previous years. In 2007, as in 2001, mean daily call detection rates were higher in the first part of the season, before 15 Sep, whereas in 2002, 2003 and 2004 mean daily call detection rates were higher after 15 Sep. The two years with the largest call counts (2003 and 2004) showed three peaks (Fig. 2.16): a small peak in early Sep, a second peak in mid-Sep, and a third (and largest) peak on 21 Sep. In 2007 the timing of the first peak (close to 6 Sep) and its size (in the range of 1000–1500 daily calls) were similar to those in 2003 and 2004. However, the much larger increase in call detection rates later in the month (15–21 Sep) that occurred in 2003 and 2004 did not take place in 2007 (Fig. 2.16). Whether there were (in at least some years) additional peaks in calling during the latter part of the bowhead migration season, in October, is unknown. The recording equipment had to be retrieved in late Sep or early Oct, before weather and ice conditions made retrieval via a small vessel impractical.

Figure 2.17 shows the number of whale calls detected by DASAR EB per hour as a function of mean hourly wind speed, considering each hour of available data from 2002, 2003, 2005, 2006, and 2007. (Years shown are representative of the range of daily call counts, from high in 2003 to low in 2006.) Hours during which the acoustics vessel was in the DASAR array were not included. This Figure was included to help us gauge the effect of wind speed on whale call counts, since strong winds raise ambient noise and decrease the detectability of calls. In 2007 call detection rate decreased with increasing wind speed, as expected. Note that 2007 had the highest percentage of hourly samples with wind speed over 12.1 m/s (39.7 ft/s) of any of the years shown in Figure 2.17. In contrast, 2006 had unusually low wind speeds (see also Fig. 2.7), but even so the call detection rates in 2006 were low.

The analysis of all the records from DASARs placed offshore in 2001–2007 supports the general conclusion that 2007 was an intermediate year in terms of whale call counts. In 2007 whale call counts overall and per day were higher than in 2001, 2002, and the low call count years 2005 and 2006, but lower than in 2003 and 2004 (Table 2.5). In 2007 the number of whale calls detected per day by the combined DASARs EB and CC was ~2.5×, 1.3×, 0.3×, 0.2×, 7.7×, and 7.1× the numbers detected by the same two DASARs in 2001 through 2006, respectively.

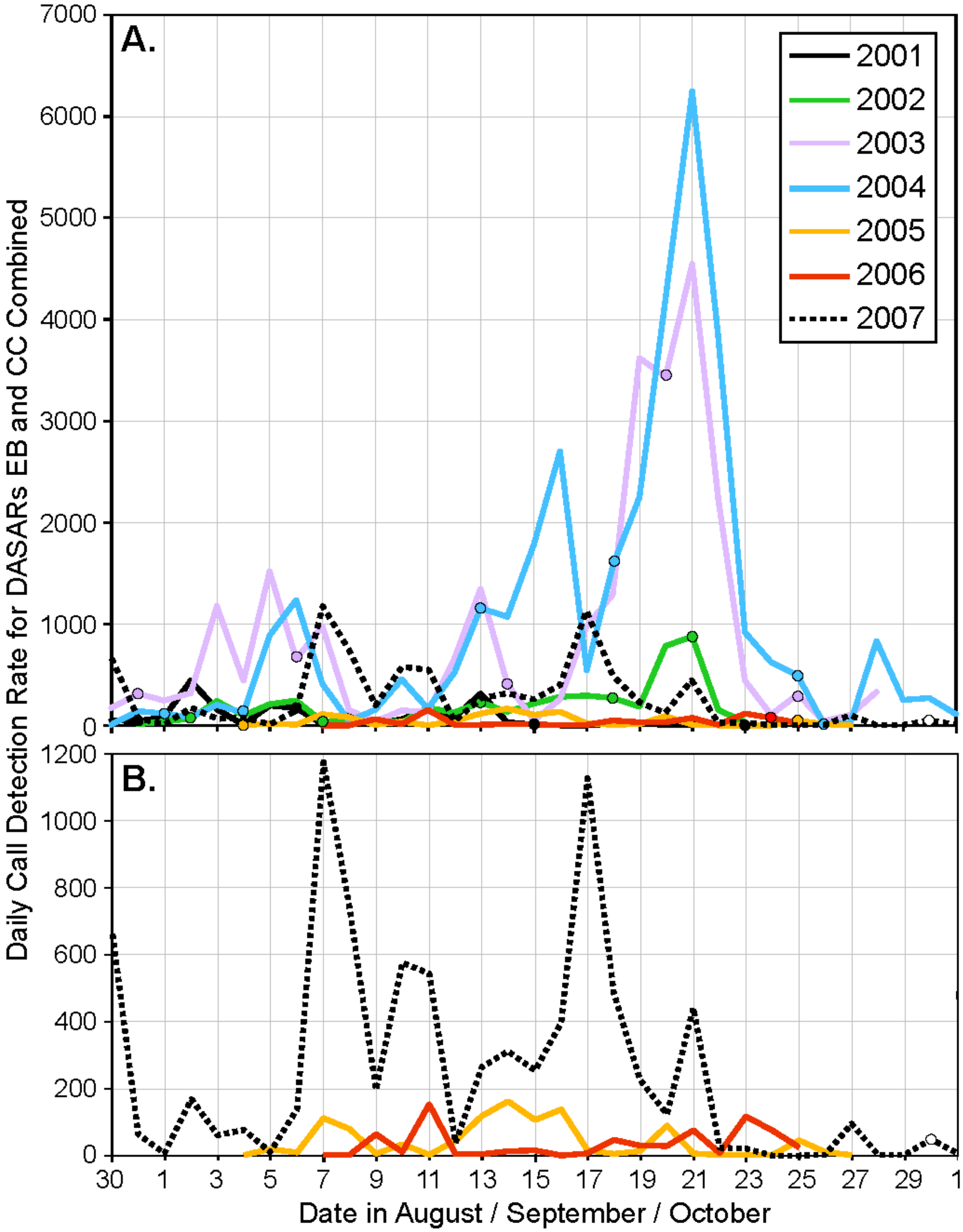

FIGURE 2.16. Daily number of bowhead calls detected by DASARs EB and CC combined for the entire 2001–2007 seasons. ***(A)*** 2001–2007, and ***(B)*** 2005, 2006, and 2007, on an enlarged scale. Daily counts marked with a dot indicate days when the acoustic vessel went into the area of the DASAR array to service the DASARs. In 2002–2007 the calls detected at those times are not included and those days are therefore “incomplete”. In 2001 all calls were counted, regardless of the presence or absence of the acoustic vessel.

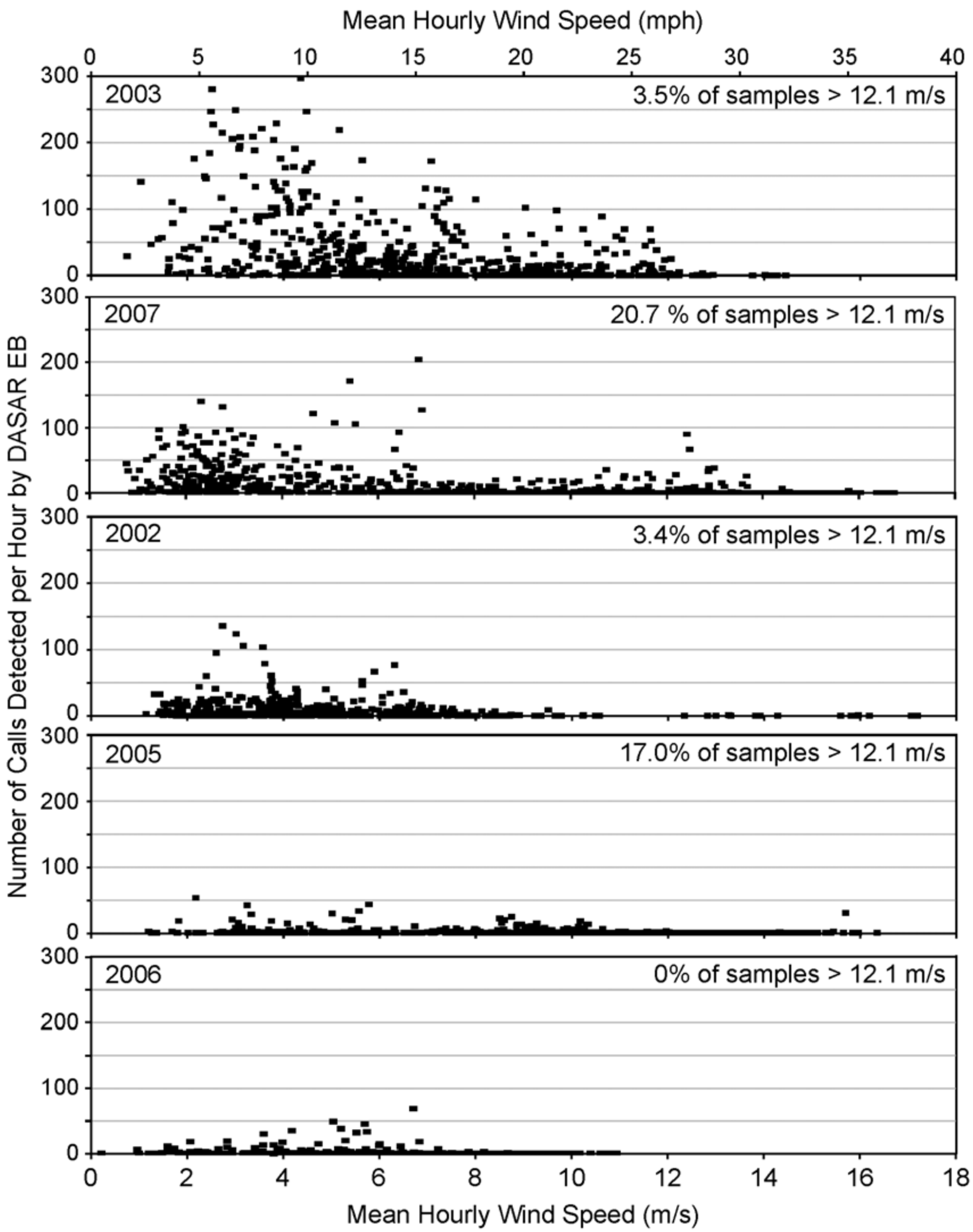

FIGURE 2.17. Hourly number of bowhead calls detected by DASAR EB as a function of mean hourly wind speed for 2002, 2003, 2005, 2006, and 2007. The different years are shown in order of decreasing numbers of calls. Wind speed data are from the Northstar weather station for all years except 2007, when data from Endicott were used (see text).

Bearing Analyses and Call Locations

In 2007, 84.5% of the 12,835 detected whale calls were recorded by two or more DASARs. Figure 2.18 shows the estimated locations of these 10,845 calls in relation to Northstar and the five-DASAR array. It should be noted that estimation of whale locations was not the primary objective of this year's program,

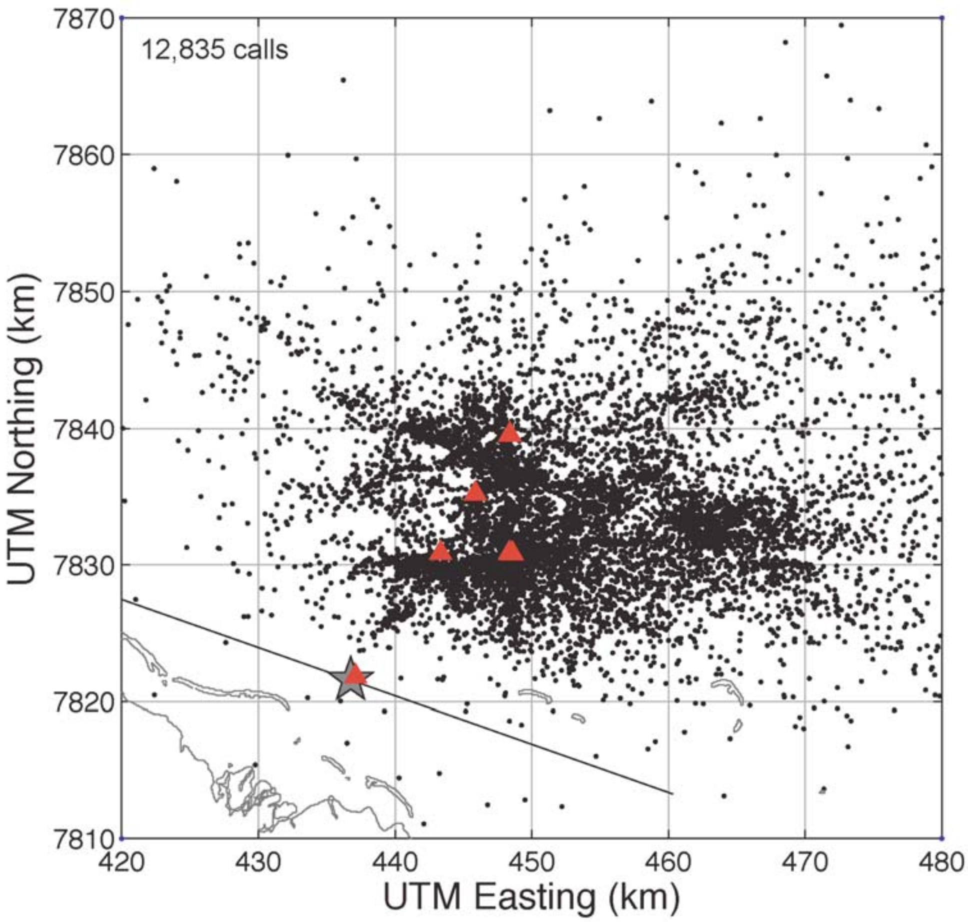

FIGURE 2.18. Estimated locations of all whale calls that were detected by two or more offshore DASARs in 2007. Northstar is shown as a gray star and the DASAR locations as red triangles. Calls recorded by the near-island DASARs were not used in the location estimations. Location accuracy increases with the number of DASARs used for each position calculation and decreases with distance from the array.

and the average accuracy of the localizations was probably lower than in 2001–2004 when more DASARs were used. Accuracy of the position estimates generally increases when a call is heard by more DASARs. In addition, confidence in the position estimates decreases with increasing distance from the DASARs. Table 2.6 summarizes some of the main results of the bearing analyses. EB is the only DASAR location for which seven consecutive years of bearing data exist. In 2005, bearings from CC could not be relied upon because that DASAR was moved by currents between successive calibrations of its orientation, and CA was not deployed due to ice. Considering all seven seasons (2001–2007), vector mean bearings to the whale calls detected by these DASARs were most often (in 18 of 19 cases) in the offshore range, i.e., 288° through 360° (N) to 98°. For all DASARs, 2002 was the year with the longest mean vector lengths (L), i.e., the strongest tendency for calls to be toward one particular direction (in this case NE–ENE) from the DASARs. Predictably, 2002 was also the year with the highest O/I ratios, i.e., the highest number of offshore calls in relation to the number of inshore calls.

In 2007 the definitions of “inshore” and “offshore” were changed compared to previous years, as explained in the *Methods*. For comparison, O/I ratio values are given in Table 2.6 for both the old (gray

TABLE 2.6. Results of the bearing analyses for DASARs EB (EBa in 2007), CC, and CA in 2001–2007. α is the vector mean bearing in degrees True, and L is the length of the mean vector (see Fig. 2.3). O/I is the ratio of number of offshore versus inshore calls. O/I ratios are shown for all years using both the old definitions of *inshore* and *offshore* (gray font) and the new ones (black font). See *Methods* and Figure 2.4 for more information on O/I ratios, and Figure 2.1 for a map of DASAR locations.

	EB				**CC**				**CA**			
	α (°)	**L**	*O/I*	**O/I**	α (°)	**L**	*O/I*	**O/I**	α (°)	**L**	*O/I*	**O/I**
2001	44	0.65	*6.5*	5.7	61	0.39	*2.0*	2.0	72	0.36	*1.7*	0.9
2002	64	0.74	*21.4*	13.6	51	0.66	*42.4*	28.2	42	0.55	*10.7*	5.2
2003	78	0.55	*2.9*	2.5	66	0.54	*6.4*	5.3	104	0.39	*1.0*	1.1
2004	69	0.42	*2.9*	2.4	67	0.52	*6.2*	4.4	109	0.32	*1.0*	1.1
2005	348	0.14	*1.3*	1.3	-	-	*-*	-	-	-	*-*	-
2006	33	0.46	*4.0*	4.0	308	0.04	*1.2*	1.4	38	0.45	*4.2*	3.7
2007	75	0.45	*2.9*	2.9	79	0.56	*3.7*	3.3	92	0.43	*1.7*	1.7
Mean O/I ratio:				4.62				7.37				2.30

font) and new (black font) definitions. However, any references to O/I ratios in the text, here and in the *Discussion*, relate to the new definition, i.e., the rightmost column for each DASAR shown in Table 2.6. In 2007 the O/I ratio for DASARs EB, CC, and CA was in the range 1.7–3.3, i.e., there were 1.7× to 3.3× more calls offshore than calls inshore. These numbers are generally in the range of previous years, except for 2002 which had distinctly higher O/I ratios (5.2–28.2, see Table 2.6). In 2007 a DASAR was deployed at location NE, for which α = 109° (i.e., ESE) and O/I ratio = 0.9, meaning *more calls were detected inshore than offshore* relative to that most northerly DASAR. (Note that the O/I ratio has only once been below 1.0 for the DASARs and years shown in Table 2.6.) These results tend to indicate that the majority of the detected whale calls in 2007 were south of the northern limit of the DASAR array, as also shown in Figure 2.18.

Figure 2.19 shows the percentage distribution of all bearings obtained via DASAR EB in each year from 2001 to 2007. (Bearings for DASAR EBb in 2007, which are not reported in Table 2.6, were nearly identical to those of DASAR EBa.) The bearings for each year were grouped into thirty-six 10° bins centered on multiples of 10° (i.e., 355°–4.99°, 5°–14.99°, etc.). The number of bearings in each bin is expressed as a percentage of the total number of call bearings determined via DASAR EB for that season. These plots emphasize the preponderance or rarity of bearings in certain directional sectors. For example, the 2002 plot shows that bearings in the range 140°–310° (inshore and to the west) were very rare that season, whereas bearings in the range 85°–105° were most common. Bearing distribution in 2007 was most similar to other low-ice years such as 2002, 2003, and 2004.

Data shown in Figure 2.19 are consistent with the hypothesis that bowhead whale calls may be directional, with higher received levels in front of the animal compared to behind it. Some indication of this is presented in a preliminary directionality analysis (Blackwell et al. 2008). There is also some equally indirect evidence of call directionality for bowheads migrating in spring (Clark et al. 1986). An alternative hypothesis, that there are some differences in whale offshore distances and/or calling behavior to the west vs. east of the DASARs, either of which could affect number of calls detected to the west vs. east, has recently received some support (Blackwell et al. 2008; Richardson et al. 2008). Based on an analysis of bowhead calls in 2001–2004, Blackwell et al. (2008) showed that significantly more calls were detected to the east of Northstar than to the west. The boundary between “east” and “west” was a line going from Northstar through the center of the

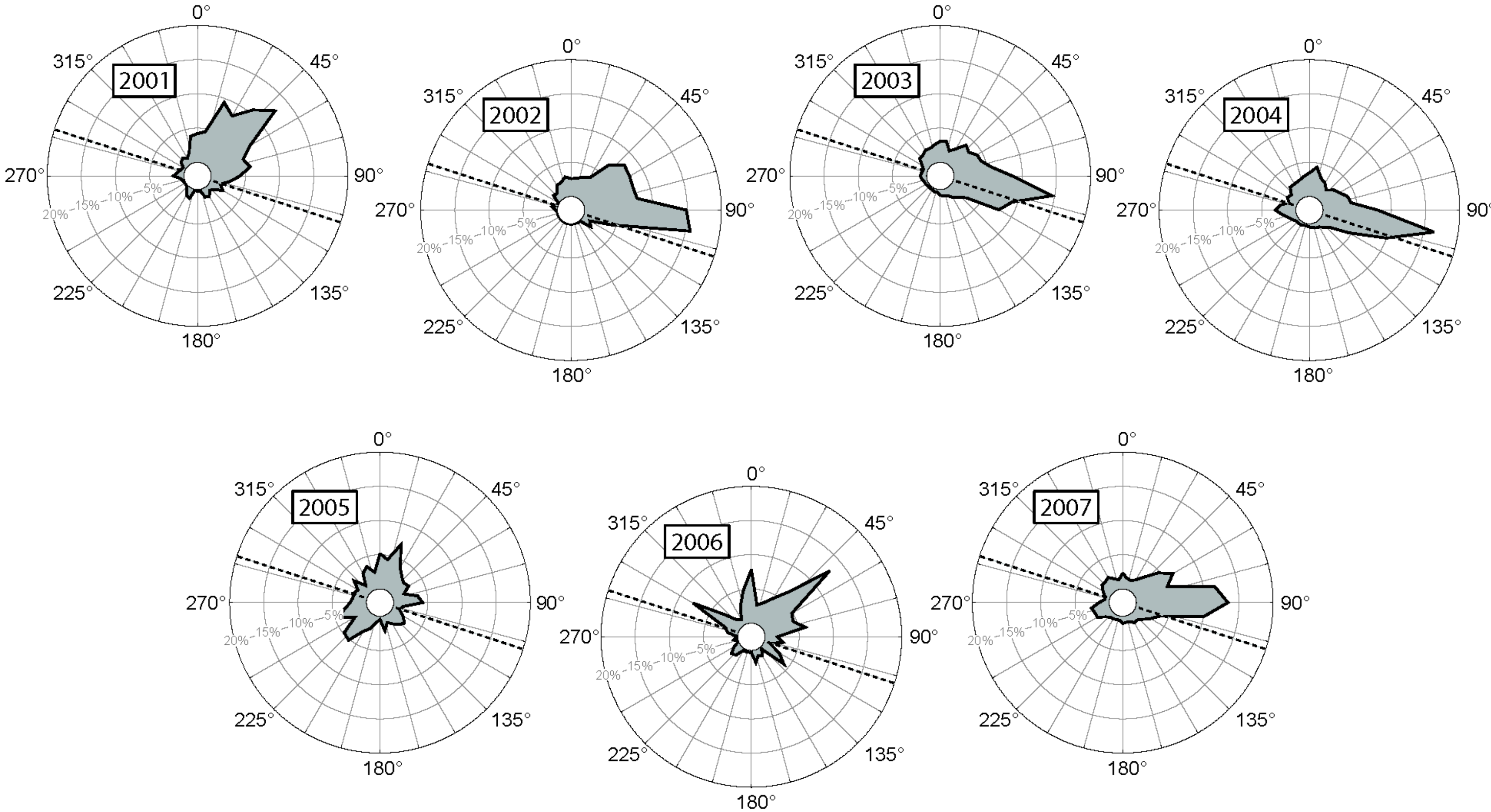

FIGURE 2.19. Directional distribution of bearings to bowhead whale calls detected via DASAR EB in 2001–2007. Results for each 10° sector are expressed as a percentage of all bearings obtained via DASAR EB that year. The orientation of the baseline (see text) is shown as a dashed line through each DASAR. Sample sizes vary widely, from ~330 in 2006 to ~26,500 in 2004, and can be obtained from Table 2.5 by applying the "percentage detected by EB" to the "total detected by EB and/or CC".

DASAR array as deployed in those years, i.e. through DASARs SW, CC, CA, and NE (see Fig. 2.1). This finding could support both hypotheses presented above, i.e. that calls are directional or that calling behavior of whales changes as they migrate by the Prudhoe Bay oilfield. A third hypothesis is that the DASARs could have a bias towards picking up signals from the east if the calls are equally strong "ahead of" and "behind" the predominantly westbound whales, but this has yet to be shown.

Call Types

Figure 2.20 shows a percentage breakdown of all bowhead whale calls detected by DASARs EB and CC by call type for 2001–2007. Calls are broken down into two main categories: simple calls and complex calls. Simple calls are further broken down into five sub-categories: upsweep, downsweep, constant call, and two types of undulation calls. The percentage of calls that were "simple" (i.e., 100% – % complex calls) varied from 81 to 87% in 2001–2003. In 2004 it dropped to 69%, in 2005 it increased to 73%, and in 2006 it was 82%, i.e., back to the 2001–2003 levels. In 2007 the percentage simple calls was 81%, i.e., about the same as the 2006 value. In 2007 relative proportions of all call types but one were within the ranges of values obtained in previous years. The exception was ∪-shaped undulations, which constituted nearly 17% of all calls in 2007, a somewhat higher value than in previous years (Fig. 2.20).

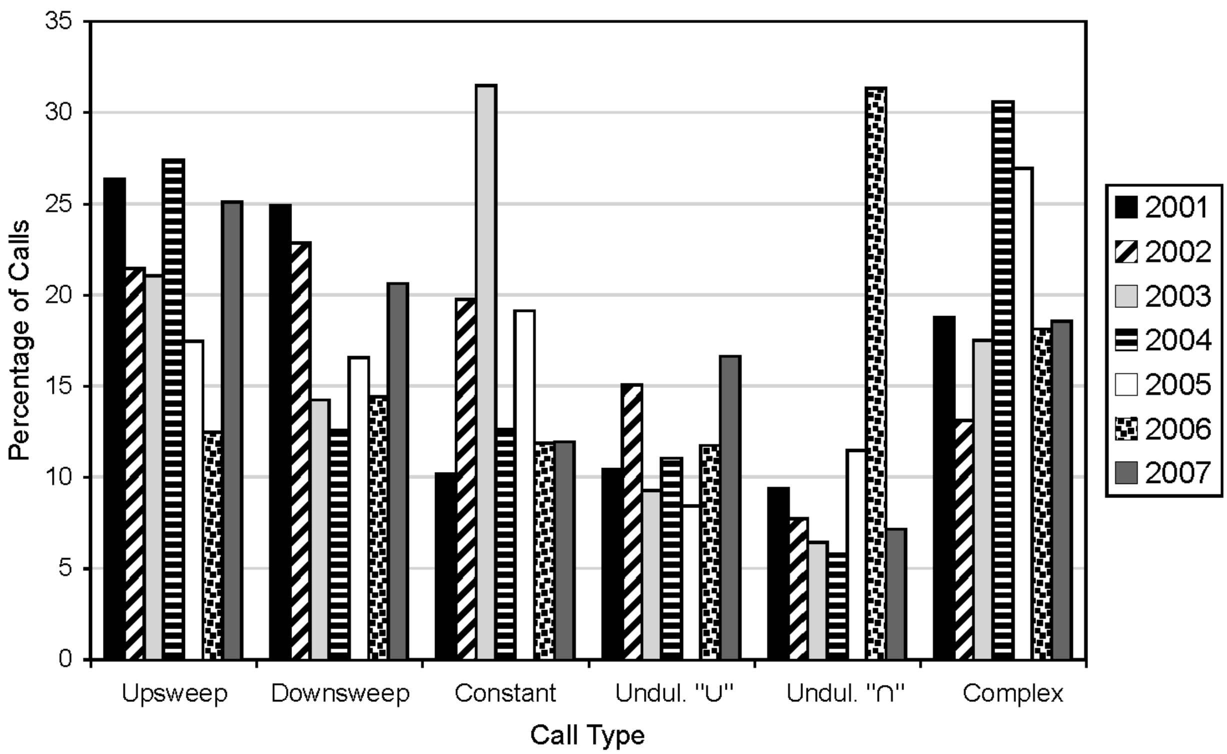

FIGURE 2.20. Percentage breakdown by call type in 2001–2007 for calls detected by one or more of DASARs EB and CC. Simple calls include upsweeps, downsweeps, constant calls, "∪" undulations, and "∩" undulations. Call sequences, which were detected only in 2004, were not included in these percentages.

DISCUSSION

Underwater Sounds at Northstar

Tugs and ACS vessels have been the main types of vessels around Northstar in recent years. The number of daily round trips to the island by tugs and barges was lower in 2007 than in any preceding year for which we have this information (since 2003). In contrast, the number of daily round trips by ACS "*Bay*" boats was the highest since 2004, when we started keeping track of ACS vessel trips. This increase in the use of ACS boats raised the overall amount of boat traffic compared to 2006: during the period 30 Aug to 30 Sep the mean daily number of round trips to Northstar by vessels that produce obvious "spikes" of underwater noise rose from about 1.9/day in 2006 to about 2.5/day in 2007. Nevertheless, visual comparison of boat spike density in Figure 2.8 shows that boat traffic in 2006 was still well below that in 2001, 2002, or 2003. Hovercraft use was within the range of previous years, but only 25% of the use in 2006. The hovercraft cannot be used in windy or rough conditions. Even though our wind speed data in 2007 came from a different location compared to previous years, 2007 seemed to be an unusually windy year, which could explain the decrease in hovercraft usage between 2006 and 2007. The hovercraft produces little underwater noise as compared with more conventional vessels (Blackwell and Greene 2005).

The statistical spectra shown in Figure 2.9 are similar to those obtained in previous years. To compare sounds from Northstar itself during different years, it is most appropriate to compare the lower percentile spectra (i.e., minimum and 5th percentile). Those represent underwater sound near Northstar when ambient sounds are low (little or no wind and waves), boats are absent, and when the sounds produced by Northstar itself are prevalent. These spectra confirm that, since Northstar went into production mode with no construction and little drilling, sounds emanating from the island itself differ little from year to year. Instead, changes between years in the broadband levels (Table 2.4) are more a function of the amount of vessel traffic and the weather (wind and sea state) over the entire field season.

In 2007, broadband (10–450 Hz) sound levels recorded 15 km (9.3 mi) from Northstar at the DASAR EBa location (Fig. 2.12) were unremarkable. In 2001–2004 and in 2006 fluctuations in minimum sound levels due to sea state generally had a periodicity of ~1–5 days. In contrast, in 2005 high sea states kept minimum ambient levels higher-than-normal for extended periods, up to two weeks. In 2007 the latter part of the season (after ~18 Sep) was much like 2005. This caused delay in DASAR retrievals, which were planned starting on 25 Sep but could not be carried out until 3 Oct. The comparison of the sound pressure time series (SPTS) from DASARs NS and EB (Fig. 2.14) shows a similar overall pattern near and away from Northstar. The two main differences between these two locations are that (1) the baseline sound level at DASAR EB is generally 3–12 dB lower than that near Northstar, and (2) the island SPTS is characterized by a greater number of boat spikes.

Whale Calls and Locations

The fall migration of bowhead whales has been monitored acoustically offshore of Northstar Island since 2000. In each of the years 2001–2004 the procedure was roughly the same. In 2005 it was changed on the basis of the results obtained during 2001–2004, and the 2007 season was the third year of the modified effort. The modified effort was designed to allow comparisons with data collected in previous years. The first two years with a modified monitoring effort (2005–2006) were years with ice conditions very different from those experienced in 2001–2004, rendering comparisons difficult. In contrast, ice conditions in 2007 were similar to those experienced in 2002–2004.

The bowhead migration past Northstar during autumn 2007 appeared to be relatively close to shore. During September 2007 there was open water along the entire Alaskan Beaufort Sea coastline and the ice edge was a minimum of 150 km (93 mi) offshore. Several studies (Moore 2000; Treacy et al. 2006) have shown a relationship between ice coverage and the typical distances of bowhead whales from shore during the migration, with whales tending to be farther from shore in heavy ice years. Based on this, an increase in the number of bowhead whale calls recorded in 2007, compared to the heavier ice years 2005 and 2006, was not unexpected. Since 1982, systematic aerial surveys have been done by or for the Minerals Management Service off the north coast of Alaska during the autumn migration period of bowhead whales. Their data provide information, on a much larger spatial scale, concerning the relative numbers of whales at various distances from shore each year. For example, 2004 was the year when the most calls were detected in or near the DASAR array (see Table 2.5), and bowhead whale sightings during MMS surveys in 2004 were on average closer to shore than in previous years (1982–2001; Monnett and Treacy 2005). MMS aerial survey data for 2005 and 2006 have not yet been published but when available, they will be useful in documenting the overall position and width of the migration corridor compared to earlier years. Preliminary data for aerial surveys during the 2007 season[8] seem to show that bowhead sightings were close to shore, but this will need to be confirmed in the final analyses. Nuiqsut whalers also observed the whales closer to shore during the 2007 fall hunt compared to previous years (see Chapter 3).

The distribution of bearings to whale calls from DASAR EB in 2007, as shown in Table 2.6 and in Figure 2.19, was most similar to the distributions in 2002–2004, three other years when the migration path offshore of Prudhoe Bay was unimpeded by ice. In these years the majority of bearings were in the 75°–105° range, i.e., roughly from the east. In contrast, in 2005 bearings were spread out in various directions, as shown by the small value of the mean vector length (L = 0.14, Table 2.6). Data from 2006 showed similarities to both 2005 and 2001. It is therefore possible that the presence of ice has an effect on the path taken by bowhead whales during their migration.

The distribution of call locations in 2007, shown in Figure 2.18, bears similarities to the distributions seen in 2003 and 2004, with an overall large number of calls and a high density of calls were detected within the bounds of the complete DASAR array (as deployed in 2001–2004, see Fig. 2.1). In addition, calls were spread both east and west of the DASAR array, as they were in 2002, 2003, and 2004 (see Fig. 10.4 for 2002, Fig. 9.3 for 2003, and Fig. 8.18 or 10.5 for 2004, all in Richardson [ed.] 2008), but not in 2006 (Fig. 2.18 in Blackwell et al. 2007a). If we assume that the presence of ice can influence the whales' migration path, then this could in part explain the similar distribution of calls west of the DASAR array in the low-ice years 2002, 2003, 2004, and 2007. In 2005 call locations were not obtained but in 2006, a year with abundant ice close to shore, there were very few calls west of Northstar. This could in part be due to whales tending to migrate farther offshore in heavy ice years.

The call type analysis (Fig. 2.20) showed that the relative use of the various standard call types in 2007 was within the range of previous years, except for a modest increase in the use of ∪-shaped undulations. Because little is known about the behavioral significance of bowhead call types, these changes are difficult to interpret. Call type percentages are not uniform across DASARs in the array, neither in space nor time, which seems to indicate that external stimuli affect the choice of call type by a migrating whale. Recent analyses of correlations between sounds from Northstar and bowhead whale calls recorded in 2001–2004 have revealed that, as bowheads approached Northstar from the east in those years, their use of constant-frequency calls increased as a function of the levels of tones recorded by near-island recorders

[8] At http://www.mms.gov/alaska/ess/bwasp/bwasp/bwasp.htm

(Blackwell et al. 2008). In addition, their relative use of complex calls increased as they traveled westward past Northstar, irrespective of sound levels as recorded by the near-island recorder.

The acoustic monitoring effort in 2007 was a modified version of the project as implemented in 2001–2004, but was similar to the implementation in 2005 and 2006. It provided the data needed to characterize sounds from Northstar Island during much of the 2007 bowhead migration period, including a comparison of their levels and frequencies with previous years. Counting whale calls at four DASAR locations in 2007 provided data that were directly comparable with previous years. The 2007 season was similar to the 2003 and 2004 seasons in several ways: (1) open water conditions with no or very little ice; (2) whale call counts in the thousands, although 2007 counts were not nearly as high as in 2003 and 2004; (3) a majority of the detected calls near the DASAR array (as opposed to offshore as in 2001, 2002, and to some extent 2006); (4) call locations spread both east and west of DASAR array (as opposed to 2001 or 2006 when very few calls were detected west of the array); (5) spread of bearings at DASAR EB (Fig. 2.19), with most calls coming from the E or ESE.

Based on boat traffic records, sound emissions associated with Northstar activities in 2007 were probably somewhat higher than in 2006, but lower than in 2001–2003. However, the weather was also considerably windier than in 2006, which increases baseline sound levels. We have no evidence that the island *per se* was producing sounds that were different in amplitude or frequency characteristics compared to previous years.

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CHAPTER 3:
SUMMARY OF THE 2007 SUBSISTENCE WHALING SEASON, AT CROSS ISLAND[1,2]

by

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[2] All conclusions and opinions expressed in this report are those of the author and do not necessarily represent those of either BP or the Nuiqsut whalers.

ABSTRACT

The North Slope Borough's Science Advisory Committee has recommended that local and traditional knowledge of Nuiqsut whalers be incorporated into reports concerning BP's Northstar marine mammal and acoustic monitoring program. This chapter does so in large part by summarizing data acquired during the 2007 phase of the Minerals Management Service project "Annual assessment of subsistence bowhead whaling near Cross Island". Those data were supplemented by additional analysis and interviews with the whalers focusing on specific aspects of the 2007 season relevant to BP's Northstar monitoring program. The interviews concentrated on whalers' encounters or concerns with non-whaling vessels in 2007, the whalers' observations of the general offshore distribution of whales, whale feeding behavior (if any), and "skittish" behavior.

In 2007, the first whaling crew went to Cross Island on 30 Aug, the second whaling crew on 31 Aug, and the last three crews on 3 Sep. Despite marginal weather and sea conditions, whales were observed on four of the five days when the whaling crews were actively scouting and they used their full quota of four strikes in a period of eight days. The entire season consisted of 13 days, including travel, butchering, and other tasks on Cross Island. The first crew landed a whale 31 Aug. Poor weather during the next two days precluded any scouting activity and travel from Nuiqsut to Cross Island. The second crew struck and lost a whale 3 Sep, when the last three crews were traveling to Cross Island. Weather prevented most crews from scouting during the next three days, and the boats that did go out saw only a few whales. Two whales were landed on 7 Sep. Since the three landed whales totaled 36.6 m (120 ft) in length, the captains decided not to request a fifth strike. The next three days were spent butchering and packing. All five crews left Cross Island 11 Sep.

In summary, the 2007 Cross Island hunt was quite successful, although the full quota of whales was not landed. Weather and sea conditions prevented any scouting activity on three days, and resulted in limited scouting on two other days. Two days were used for travel to and from Cross Island only, and three days were used for butchering and packing. There were only three days with reasonably favorable scouting conditions, and it was on those three days that Nuiqsut whalers used their four strikes and landed three whales. Weather and sea conditions were marginal overall, but the proximity of whales to Cross Island in 2007 enabled the whalers to use their full quota on the few days when scouting conditions were good. The absence of ice increased the adverse effect of wind, and even on relatively calm days large swells made scouting somewhat difficult. As in previous years, the whalers had a season-long concern with non-whaling vessel traffic, but did not report any specific conflict incidents. Some whales were reported to be more "spooky" than others, but no general pattern of "spookiness" was reported. No whale feeding behavior was reported.

INTRODUCTION

During the autumn migration period of bowhead whales, subsistence hunters from Nuiqsut travel to Cross Island, 28 km (17.5 mi) east of Northstar Island, in order to hunt bowhead whales. In recent years, a quota of four whales has been allotted to the Nuiqsut hunters. Cross Island is relatively close to the Prudhoe Bay area and its associated industrial activities. There is considerable concern among the Nuiqsut hunters about the potential for vessel and aircraft traffic, and other industrial activities, to interfere with the hunt.

The North Slope Borough's Science Advisory Committee (SAC) reviewed the results of BP's Northstar marine mammal and acoustic monitoring program during early 2005. Among their recommendations was a recommendation to use Traditional Knowledge (TK) in future monitoring. Specifically the SAC recommended that the observations of subsistence whale hunters at Cross Island should be integrated into the Northstar monitoring study. The SAC noted that "Such observations might include general offshore distribution of whales, feeding behavior, "skittish" behavior, number of vessels and reaction to them. We recommend that TK observations be summarized in a section of the Northstar annual report."

Since 2001, the Minerals Management Service has sponsored a detailed study of the whaling activities at Cross Island (Galginaitis and Funk 2004, 2005; Galginaitis 2006a,b, 2007a,b). Each year since 2001, Galginaitis has spent much or all of the autumn whaling season at Cross Island with the Nuiqsut whalers, documenting their activities and interpretations of events. As part of this work, GPS (Global Positioning System) dataloggers have been placed on whaling vessels to document the tracks of the whalers as they scout for whales. Systematic observations and interviews with the whalers supplement the GPS data. The whalers have been very cooperative in supporting this work, and in providing detailed information.

It was apparent that the ongoing MMS study provided a good starting point for the compilation of the types of traditional knowledge that the NSB's SAC had recommended be incorporated into BP's Northstar monitoring program. Consequently, BP has augmented the ongoing MMS-supported program during 2005–07, to compile the specific types of information mentioned by the SAC (Galginaitis 2006c).

This chapter of BP's 2007 Annual Summary Report describes information provided by the Nuiqsut subsistence whalers on selected aspects of the 2007 whaling season. This included the general offshore distribution of whales in 2007, any observations of feeding behavior of whales, observed "skittish" behavior of whales, the number of vessels (aside from whaling vessels) encountered at sea, and observed whale reactions to those vessels. To provide broader context, this chapter begins with a discussion of the methods used for gathering the information in this chapter, a very general description of the equipment and methods used for fall subsistence whaling, and a brief summary of the 2007 subsistence whaling season at Cross Island. That introductory summary mentions some factors that may limit the conclusions that can be drawn, e.g., lack or scarcity of observations, indeterminate causes, or possible multiple cause-effect linkages. This chapter deals almost entirely with the 2007 season, which sets definite limits on the conclusions that can be drawn. Some comparative information from previous years is mentioned briefly. More details for prior years can be found in earlier reports prepared for MMS (Galginaitis and Funk 2004, 2005; Galginaitis 2006a,b, 2007a) and for BP (Galginaitis 2006c, 2007b).

METHODS

The objective of the MMS Cross Island project is to describe Cross Island whaling using measures that document year-to-year variability in whaling and, when sufficient time series data are available, will allow tests of hypotheses on the causes of this variability. Concern about potential effects of oil and gas development on whaling is the prime motivation for the MMS project, but it is recognized that other factors can strongly affect Cross Island whaling and thus need to be considered as well. These other factors include weather and ice conditions, equipment problems, whalers' decisions, and non-industrial human activities. During the MMS-sponsored project, information is collected on level of hunting effort, including how many boats go out each day, crew size, how much time is spent on the water, lengths of trips in miles, and furthest point away from Cross Island during each trip. Information is also collected on the abundance and distribution of whales, including the number and location of whales observed and/or struck by the whalers.

Information on the level of hunting effort was collected by systematic observations by MSG, who was on Cross Island for most of the whaling season in each of 2001–2007. This information was supplemented by conversations with all of the boat crews. Further information on the hunting effort, and on the abundance and distribution of whales, was obtained by issuing Garmin handheld GPS (Global Positioning System) units to all boats operating from Cross Island. The whalers were given instructions on how to record the GPS coordinates (track) of the boat's trip, and how to mark waypoints of significance, including whale sightings and strikes, sightings of vessels other than whaling vessels, and other pertinent observations. This information was then mapped, and that is the basis for the Figures included in this report. It should be noted that whaling crews mark relatively few points when on the water, and the points they do mark represent the boat's positions at times when a whale or group of whales was seen. These whales may be quite close or miles away (depending on the conditions of the day).

The information collected with the GPS units was supplemented by subsequent conversations (in English) and reviews of the mapped GPS information with each boat crew. During this review of boat tracks shortly after the hunters' return, crew members would often remember and identify locations where they saw whales, and these points were added to the recorded GPS information. Some of these points were boat positions, and some were estimated positions of whales (and thus not located on a boat track). Other points were reference coordinates and may represent past whale sightings, so they also may not be located on boat tracks. Galginaitis did not accompany the whalers in their boats while they were hunting, since it is not permissible for any non-Native to participate actively in hunting marine mammals.

Supplemental systematic interviews that focused on those topics of particular concern to BP were conducted both on Cross Island and in Nuiqsut after the whaling season. These interviews were primarily with whaling captains or senior crew members who had encountered non-whaling vessels while scouting for bowheads. These interviews were guided by an informal protocol developed to document each such encounter within the context of that day's scouting/whaling activities. Thus there were no "sampling" issues *per se*—information was collected from all crews that had such encounters. A more detailed description of the methodology can be found in Galginaitis and Funk (2004, 2005) and Galginaitis (2006a).

SUBSISTENCE WHALING EQUIPMENT, METHODS, AND CONSTRAINTS

A basic understanding as to how subsistence whaling is conducted by Nuiqsut whalers is important in interpreting how those activities might be affected by industry activities. The following is intended to provide only enough detail to ensure that the subsequent material is understandable. For a broader review, see Stoker and Krupnik (1993) or Rexford (1997).

The community of Nuiqsut is located about 25.7 km (16 mi) inland ("as the crow flies") on the Colville River. Nuiqsut crews harvest whales only in the fall. Their whaling location is Cross Island, about 73 "direct" miles or 92 to 109 "water" miles from Nuiqsut. Cross Island is located about 16.1 km (10 mi) north of Endicott, 24.1 km (15 mi) NW of West Dock, and 27.4 km (17 mi) east of Northstar (see Fig. 1.1 in Chapter 1). There are currently six active whaling crews in Nuiqsut. Five of these whaled in 2007. There are also some additional identified crews that have not whaled since at least 2000. Whether a crew goes out during any specific season depends upon the captain's personal and economic circumstances. Some crews use more than one whaling boat. Whaling boats are generally 5.5 to 7.3 m (18 to 24 ft) long, with aluminum or fiberglass hulls, and single outboard motors of 70 to 250 horsepower. The bylaws of the Alaska Eskimo Whaling Commission (AEWC) specify the equipment to be used for the whale hunt, and the general manner in which it is to be conducted.

Nuiqsut whalers will generally go scouting for whales on any day when the weather is suitable for finding and striking whales unless a whale was taken the prior day, in which case butchering usually has priority. However, this pattern may be changing. In 2006, Nuiqsut crews landed single whales on three successive days, apparently because the whales were relatively small and the hunters wanted to take advantage of a period of good weather for scouting (Galginaitis 2007a,b). Whalers invariably use the term "scouting" rather than "hunting" to describe looking for whales to strike. Good whaling weather is determined more by wind speed and sea conditions than anything else. Whalers prefer days with no wind, but winds up to 8–16 kilometers per hour (5–10 miles per hour), or even higher, can be acceptable. Sea conditions generally correspond with wind speed, but scouting can occur even with higher winds, depending on the circumstances. Ice cover generally moderates the effect of wind by dampening wave height. Boats typically scout for whales with a complement of three or four people, although some boat crews ranged in size from 2 to 7. Although solitary boats do take whales on occasion (for example the first two strikes used by Nuiqsut whalers in 2007 were conducted by such boats), it is not encouraged. Nuiqsut boats almost always scout for whales with at least one other boat, in case of mechanical break down or other emergencies. Whaling crews with two or three boats are willing to whale without the support of other crews. It is still commonly agreed that five to seven boats is a preferable number to have available for scouting for whales on a given day. The availability of fewer boats decreases the efficiency, safety, and overall chance for success of the hunt.

Once Nuiqsut whalers spot a whale and determine that it is a proper whale to take (generally 7.6 to 10.7 m [25 to 35 ft] long, and not a mother with a calf), they will approach it at high speed so that it dives. They will then estimate where it will reappear (usually in 5 to 10 minutes, but sometimes longer) and once they reach that area will wait and search at low speed until the whale surfaces and is spotted. They will then repeat the process. The objective is to tire the whale so that it must stay on the surface for longer periods of time, until one of the boats can get close enough to strike the whale on its left side with the darting gun.

The whale is killed by the delivery of whale "bombs", which are in essence very large bullets with timed fuses (generally 4 to 8 seconds) that explode inside the whale. Inupiat whalers adopted this technology from the commercial Yankee whalers. The whale bombs are delivered to the whale via two methods: a darting gun attached to a harpoon, or a shoulder gun.

During fall whaling, the first bomb is delivered via a darting gun, which at the same time deploys a harpoon with an attached float. The harpoon and darting gun are both attached to a long wooden handle. This is thrown from the boat at the whale, usually at a distance of no greater than 3.0–4.6 m (10 or 15 ft), and ideally closer. Once the whale is struck, the harpoon separates from the handle. A trigger rod fires the darting gun and shoots the bomb into the whale. An internal hammer ignites the bomb's fuse once it hits and penetrates the whale's skin and the bomb explodes 4 to 8 seconds later (depending on how long a fuse was used). The darting gun remains on the handle and thus floats in the water until it can be recovered. It must be dried and cleaned before being used again. In extreme cases this can be done on the water, but it is usually done on shore. Thus, most darting guns are effectively one-shot weapons. Each whaling boat has at least one, and sometimes two, darting guns on board. The second weapon used to deliver whale bombs is the shoulder gun—a very heavy, short barreled, high caliber “rifle” used to shoot the same sort of black-powder bomb as is used in the darting gun, only with fletches or fins to help stabilize its flight in the air. In the fall, the shoulder gun can only be used after a float has been attached to a whale with a darting gun. The first bomb kills some whales. However, when multiple bombs are required, the shoulder gun is useful because it can be used to fire more than one shot.

Until recently, all Nuiqsut whalers used the “traditional” black powder bombs – technology adopted from the commercial Yankee whalers. All captains, or a trusted member of a captain’s crew, loaded and assembled these bombs each year, often only after reaching Cross Island, due to the hazards involved. As discussed above, the darting gun and shoulder gun black powder projectiles are essentially the same. The more recently developed “super bomb” can only be used on a darting gun, with a specially modified barrel. It is manufactured in Norway, uses penthrite instead of black powder, and is designed to kill whales faster than a black powder bomb. It is a product of the interest in developing more efficient weapons for subsistence whaling, but development has been somewhat delayed due to the relatively small demand and its somewhat complicated operation compared to the black powder bomb (Øen 1995, Sadler and Grønvik 2003, AEWC 2006).

The darting gun is always thrown from the right side of the boat, since it is attached to a line and the float, and this line is always rigged on the right side of the boat. If the darting gun were thrown to the left of the boat, the float line would then stream across the boat at high speed, endangering the crew and the structural integrity of the boat. Thus the whale must be approached on the whale’s left side, since the boat normally “catches up” to the whale from behind it to achieve a striking position.

Once the whale is dead, all available boats assist in towing it back to Cross Island to be butchered. It is hauled up on the beach with mechanical assistance. All cutting is done with an assortment of knives with long handles. The initial butchering and division into crew shares is done on Cross Island, but further division among crew members is done after the crew and whale products are in Nuiqsut.

The harvest of bowhead whales by crews from Nuiqsut is displayed in Table 3.1. Because Nuiqsut was resettled in 1973, years before 1973 are not included in this table.

TABLE 3.1. Recent harvest of Bowhead Whales Near Cross Island.

Year	Whales			Notes
	Quota	Landed	Struck & Lost	
1973	NA	1	0	
1982	1	1	0	
1986		1	0	
1987		1	0	
1989		2	2	Oil industry vessel disturbance noted by whalers
1990		0	1	Oil industry disturbance noted, also rough seas
1991	3	1	2	Poor weather, adverse ice conditions
1992	3	2	1	
1993	3	3	0	Very favorable whaling conditions
1995	4	4	0	
1996	4	2	0	
1997	4	3	1	
1998	4	4	1	
1999	4	3	0	
2000	4	4	0	Very favorable whaling conditions
2001	4	3	0	Whalers report whales tended to be “skittish”
2002	4	4	1	
2003	4	4	0	Poor weather
2004	4	3	0	Poor weather
2005	4	1	0	Very poor weather, adverse ice conditions, disruption
2006	4	4	0	Adverse ice conditions first half of season
2007	4	3	1	Overall poor weather, little ice, whales close

Notes: Years of no harvest and no “struck and lost” are not listed. This does not imply that no whaling effort was made in those years. “Quota” was not applicable prior to 1978. It is not clear from the records (or informants) when the quota for Nuiqsut increased to 2 whales and then to 3 whales.

Sources: Compiled from AEWC records, personal communications with Nuiqsut whalers, and field notes from the 2001–2007 whaling seasons. Blank spaces indicate that for these years no definitive documentation of the annual quota for Nuiqsut exists – or rather, may exist but has not been found.

THE 2007 WHALING SEASON

This section contains a general or overview summary of the 2007 Cross Island whaling season. Annex 3.1 contains more detail on a day-by-day basis for both whaling activity and other vessel traffic noted in the Cross Island area.

Five crews whaled from Cross Island in 2007. One of these was a newly formed crew with a captain who had whaled for many years as the co-captain of an existing crew. Three crews whaled with only one boat and two of these crews used a second boat for support tasks (e.g., to haul supplies). The other two crews each used two boats for whaling. As in previous years, the start of the Cross Island whaling season depended primarily on weather conditions, reports of whale sightings near Cross Island, and the condition of the boats. The first crew left for Cross Island on 30 Aug and reported good scouting weather and presence of whales. This prompted the second crew to leave for Cross Island on 31 Aug. The other three crews were finalizing their preparations and were further delayed by two days of bad weather (1–2 Sep) before they could leave for Cross Island on 3 Sep. The researcher traveled with this last group of three crews and was therefore not present at Cross Island on the days that the first whale was landed (31 Aug) and a whale was struck and lost (3 Sep). Three of the five crews scouted for whales on 4 Sep, but due to the marginal weather conditions they did not scout very long and reported few whales or blows. Weather prevented any crews from scouting on 5 Sep. On 6 Sep conditions were worse than on 4 Sep and the two crews that attempted scouting spent less than two hours on the water and did not report seeing any whales or blows. All crews went out scouting on 7 Sep and a whale was taken relatively quickly in the morning. Once it was towed to Cross Island, the captains agreed that — since conditions were still good for scouting — they should take advantage of the situation, as the weather might worsen over the next few days. All crews, except the crew that had taken the whale that morning, went scouting in the afternoon. Their attempt was successful and another whale was landed in the afternoon. After it was towed in, the captains again conferred and decided that three landed whales (averaging over 12.2 m [40 ft]) were enough and that they did not want to request authorization (from the AEWC) for a fifth strike. It turned out that weather conditions on 8–9 Sep were not very suitable for scouting, and 10 Sep was spent finishing butchering and packing. Conditions on 11 Sep were ideal for traveling and all crews left for Nuiqsut.

Data from the project's weather station at Cross Island provided information on the weather conditions from when it was set up on 4 Sep (4:58 PM) through 11 Sep (7.56 AM). During this period, crews went out scouting for whale on 4 Sep, 6 Sep, and 7 Sep (and earlier on 31 Aug and 3 Sep). From 4 through 6 Sep the wind speed was 24.1 to 40.2 kilometers per hour (15 to 25 miles per hour). The wind direction shifted on 6 Sep, and varied between 0 and 24.1 kilometers per hour (0 and 15 miles per hour) on 7 Sep. On 8 Sep the wind increased to 56.3 kilometers per hour (35 miles per hour), and then decreased in the next several days to a light breeze on 11 Sep. The barometric pressure showed a slow increase from low on 4 Sep to a peak on 7 Sep (a sharp increase from 6 Sep) and showed a rapid decrease on 8 Sep. After the 8^{th}, the barometric pressure steadily increased to a peak on 11 Sep. The Cross Island weather station wind readings were consistent with the wind information reported in Chapter 2.

The whaling seasons for the five crews ranged in length from 9 to 13 days, counting travel days. The seasons for the individual crews were 9, 9, 9, 12, and 13 days. Weather and sea conditions during the 2007 season were different than in previous years. Ice cover was mostly absent and winds were relatively strong, which in the absence of ice cover made scouting for whales difficult. However, whales were migrating relatively close to Cross Island so the whalers were able to find and strike whales when conditions were good for scouting. The combination of the proximity of whales to Cross Island and a few days with favorable scouting conditions resulted in a relatively short whaling season of 13 days. In comparison, there was a 21-day season in 2006 (Galginaitis 2007a) and a 27-day season in 2005 (Galginaitis 2006b).

The researcher was not on Cross Island for the entire 2007 whaling season, but was able to collect GPS tracks and whaler accounts for all scouting days, although not from all boats. There was one new boat with a hard-topped cabin that interfered with the GPS satellite reception, so GPS tracks for this boat were incomplete. Accounts for 31 Aug and 3 Sep are less detailed because the researcher had not yet arrived on Cross Island; however, they are adequate for present purposes. The number of boats scouting on any given day ranged from 2 to 7. Crews reported spotting whales on four of the five days when at least one boat went out scouting, but remarked that they observed the most whales on 7 Sep, 31 Aug, and 3 Sep. They saw only a few on 4 Sep and did not report seeing any on 6 Sep. The days with the best conditions for scouting (little wind, calmer seas) were those on which more whales were observed. It was believed that whales were present on all days, but simply more difficult to see on some days than others.

Figure 3.1 shows all documented GPS tracks for all Cross Island boats for all days in 2007, color-coded by day. This Figure clearly indicates that on the days when scouting conditions were better (31 Aug, 3 Sep, and 7 Sep) the tracks were longer and generally in the area where Nuiqsut whalers typically strike their whales (northeast of Cross Island). On days when conditions did not allow scouting to the northeast of Cross Island, trips were shorter and fewer whales were seen. Figure 3.2, comparing all GPS tracks for all boats for each season from 2001 to 2007 shows that in 2007 Nuiqsut whalers in general did not go as far from Cross Island to land their whales as they had in other recent years. The combination of overall poor (windy) weather and the presence of whales close to Cross Island likely explains this pattern.

OBSERVED WHALE FEEDING BEHAVIOR IN 2007

There were no reports of whale feeding behavior during the 2007 Cross Island whaling season. This does not necessarily mean that feeding did not occur; however, it is an indicator that whale feeding activity was not very obvious in 2007. No stomach contents from any of the whales landed in 2007 were examined, so no samples were taken. Possible explanations for the lack of observed whale feeding behavior, not mutually exclusive, are as follows:

- whale feeding is not commonly observed (or at least not reported) by Nuiqsut whalers near Cross Island (only one incident during the previous six years);
- most feeding by bowhead whales is known to occur below the surface (e.g., Würsig et al. 1989) where it would be invisible to people in small boats;
- few whales were observed by whalers on some days during the 2006 season;
- on some days when scouting was possible, swell and waves (due to wind) made spotting and observing whales difficult;
- on days when a relatively large number of whales were observed, most were seen only at a relatively large distance (as blows);
- barge and other vessel activity may have "spooked" whales (although Nuiqsut whalers did not report any specific cases where non-whaling vessels may have influenced whales or whaling activity); and
- a major part of the migration may have bypassed the area accessible to the whalers, as they stayed relatively close to Cross Island (compared to the other years of the study).

For the six years of the study previous to 2007, only one observation of whale feeding was reported and recorded. This was a spectacular sighting of a whale feeding on the surface with its mouth open, about 12.6 km (7.8 mi) from Cross Island, bearing 34° True. The captain, a very experienced whaler, remarked that this was the first time he had seen this. This does not necessarily indicate that Nuiqsut whalers observed no whale feeding behavior on other occasions in 2001–2007 when scouting for whales. It probably means that such observations were not common or that it is not easy to determine if whales are feeding. Nuiqsut whalers tend not to speculate on what an animal ***may*** be doing – if they are unsure they will usually not say anything. If other obvious feeding behavior had been observed during 2001–2007, it probably would have been reported. Nuiqsut whalers do believe that whales feed near Cross Island, especially when whales appear to be staying in the area rather than swimming directly through it. When whaling, however, they are often not in a position to make such observations due to less than ideal weather and sea conditions, or the need to concentrate on the immediate tasks of whaling.

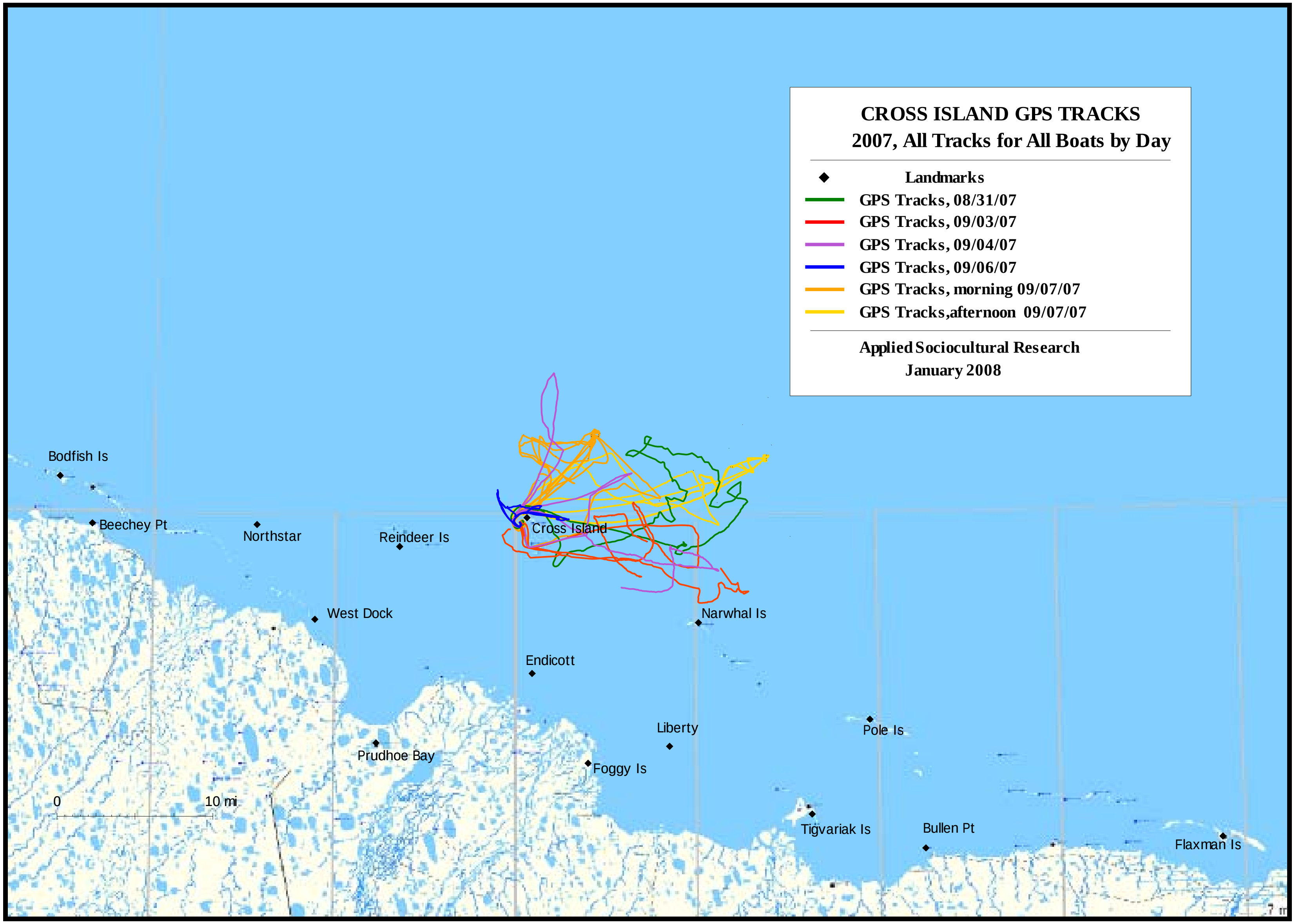

FIGURE 3.1. Cross Island GPS whaling tracks, 2007 season, all tracks color-coded by day.

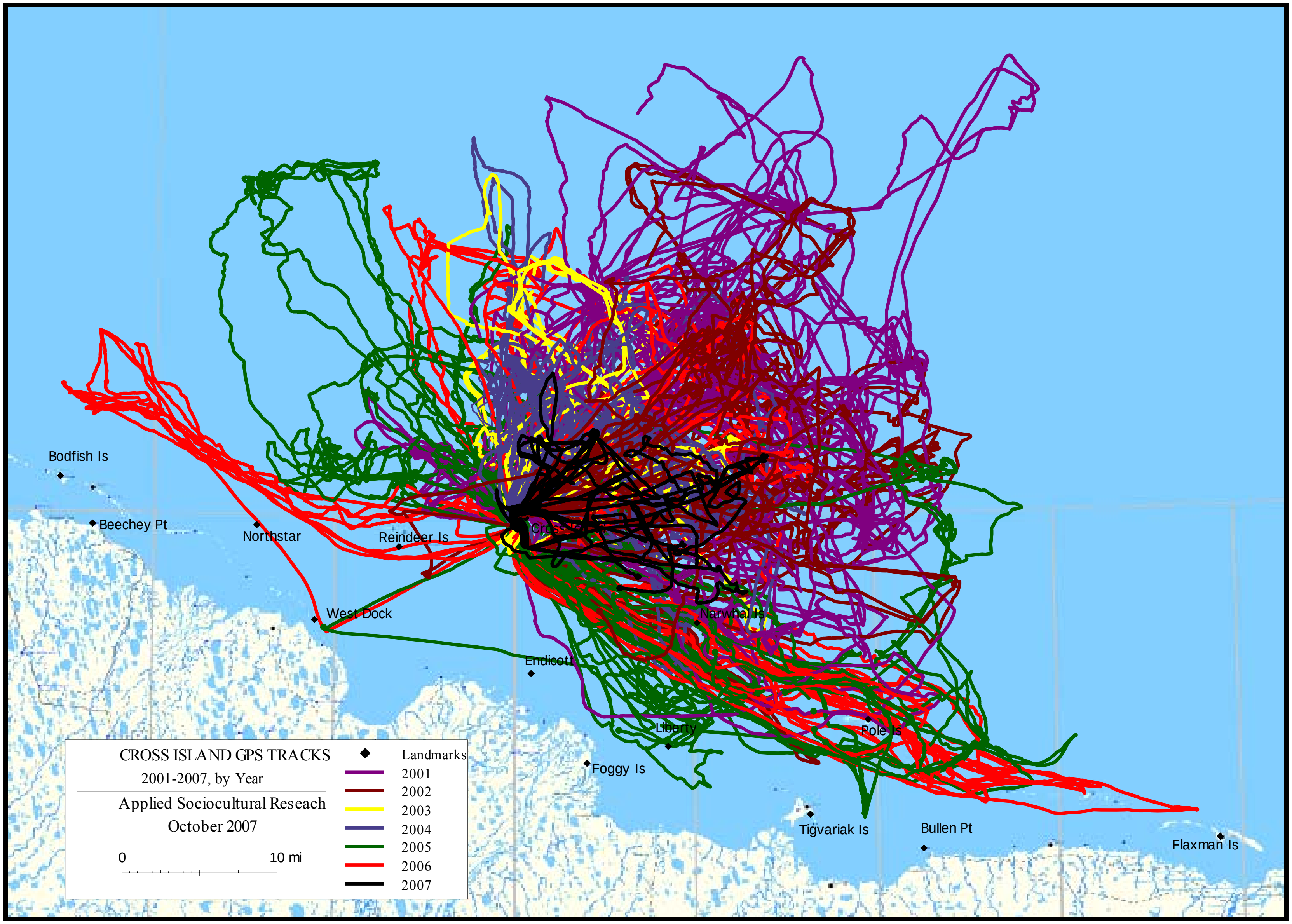

FIGURE 3.2. Cross Island GPS whaling tracks by year, 2001–2007.

Most feeding by bowhead whales is below the surface and difficult to recognize via surface observations. There have been some previous observations of bowheads feeding actively at the surface in the Canadian and Alaskan Beaufort Sea, with mouths open (Würsig et al. 1985, 1989; Richardson and Thomson [eds.] 2002). The first whale taken by a Nuiqsut crew, in 1973, was reported to have been feeding on the bottom near Flaxman Island. Some other whales landed at Cross Island have been found to have recently-consumed food in their stomachs (Lowry and Sheffield 2002; Lowry et al. 2004). One of the whales taken in 2006 was also reported to have had mud on its jaw, and one of the two stomachs that were examined was quite full (Galginaitis 2007a).

"Skittish" Whale Behavior During 2007

For the most part, Nuiqsut whalers reported that when they found whales in 2007, they were able to follow them. On days of marginal scouting conditions (4 Sep and 6 Sep especially), they saw fewer whales and they were more difficult to follow. A few whales were described as appearing to be "spooked" from the time the whalers first saw them. A "spooked" whale might be traveling faster, spending more time on the surface, and/or exhibiting a more erratic course than most migrating whales. Such a whale may also stay nearer the ice edge or floating ice (if there is any) than most migrating whales. Thus, spooked or skittish whales are more difficult to follow than other whales. Nuiqsut whalers are also wary of approaching and striking such whales, even if they can follow and catch up with them, since they are less predictable than other whales. In discussions with the whalers during the 2007 whaling season, whales were seldom described as acting in a "spooky" manner.

In 2001, a season when whalers reported that whales seemed to be much more skittish than normal, they suggested several possible explanations (Galginaitis 2006c). Although Nuiqsut whalers cited industry activities as one possible explanation or factor for this pattern, they said that other explanations were also possible. These other factors were ice conditions to the east of Cross Island, possible presence of natural predators such as killer whales, barge traffic related to the Kaktovik water and sewer project, or other air or vessel traffic to the east of Cross Island. Note that two of these, while not related to oil industry activities, are related to other human economic activities.

General Offshore Distribution of Whales, 2007

Although whaling success was good for both 2006 and 2007, there were still relatively few days on which whalers were able to scout in open water and find a good number of whales (5 of 10 scouting days in 2006, 3 of 5 scouting days in 2007). Whales were found relatively far from Cross Island in 2006, mainly because of ice conditions in the view of the whalers (Galginaitis 2007a,b). The whalers were unable to look for whales closer to Cross Island in any event because of the ice. In 2007, the whalers found whales relatively close to Cross Island and as such had no need to travel further offshore. There was little or no ice cover to contend with in 2007. Wind and sea conditions in 2007 would likely have made scouting for whales farther away from Cross Island more difficult and dangerous. The whalers could not determine, and would not hazard an opinion, as to the overall distribution of whales in 2007. They knew that the ones they were seeing were close to Cross Island, but did not know if they represented the bulk of the migration or not. On days when conditions were especially favorable for scouting (the first part of 31 Aug and most of 7 Sep), the crews that were out scouting reported seeing many whales and blows. On at least one trip between Cross Island and West Dock one crew reported spotting a whale.

NUIQSUT WHALERS' REPORTS OF VESSEL ACTIVITIES, 2007

Annex 3.1, at the end of this chapter, summarizes the specific observations made by Nuiqsut whalers, during the 2007 Cross Island whaling season, of activities by vessels other than whaling vessels, along with observations on whaling activities. (Henceforth, all references to "vessels" in this section refer to vessels other than whaling vessels.) A researcher (Galginaitis) staying with the whalers on Cross Island recorded this information, and it was checked with the Deadhorse Communication Center Call Log. Summaries are included only for those days on which vessel activity was reported, or for days on which whale scouting activity occurred. Blows of whales were also spotted from Cross Island on several days. Based on the daily information in Annex 3.1, the following summary has been compiled, attempting to draw some generalizations from the daily information.

Perhaps the most significant aspect of Annex 3.1 is the absence of any specific cases in 2007 where Nuiqsut whalers complained about the effects of vessel traffic on their subsistence whaling activities. While a great deal of vessel activity was taking place, most of it was of a regular or scheduled nature in support of operations to the west of Cross Island. As has been stated in the past and is repeated in the Deadhorse Communication Center Call Log (2007), Nuiqsut whalers do not want vessel activity to the east of Cross Island during the subsistence whaling season, but are much more tolerant of such activities west of Cross Island. In a few cases where there was some question as to whether vessel traffic could proceed or not, the conflict avoidance process worked well and prevented any potential (perceived or actual) effects on whaling activities. These cases involved requests from the *Stryker* on 4 Sep and 7 Sep, and from Bowhead Transportation on 4 Sep. It should also be noted that more vessel traffic, from a wider geographical area, was documented in the Deadhorse Communication Center Call Log for 2007 than in previous years. This is another indication that the conflict avoidance agreement procedures are becoming more familiar to all the parties involved and may be working better to avoid potential conflicts.

Nuiqsut whalers have some generalized perceptions as to how industrial activities affect their hunt, based on their experiences of such activities. The proximity of onshore development facilitates the logistical support of Cross Island whaling, and Nuiqsut whalers make frequent supply runs (weather permitting) between Cross Island and West Dock. Logistical support and emergency assistance from industry are at times requested by the whalers. However, whalers perceive offshore oil and gas activities as potentially adverse to whaling, primarily because of noise and/or potential spills and accidents.

However, insofar as Northstar in particular is concerned, whalers have not reported effects on their hunt from its development and production activities, although oil spills and noise are still of concern for the potential disruptive effects they could have. BP has made efforts to decrease the risk of spills and to reduce the effects of vessel and air traffic to Northstar as much as practicable. Northstar is to the west of Cross Island and "downstream", in terms of the westward bowhead migration, from the areas where Nuiqsut whalers normally scout for whales. Thus, the hunters do not expect Northstar to be as problematic, in terms of direct effects on whaling, as development to the north and east of Cross Island would be (Ahmaogak 2002: 5, 14). Nuiqsut whalers prefer, however, not to whale near industry facilities, if they can avoid doing so, and the mere existence of offshore oil and gas production facilities in the Beaufort Sea will probably always be a source of concern for Northern Alaskan Inupiat. This in itself imposes a burden on the local population, whether it is considered a direct or an indirect effect.

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ANNEX 3.1: DAILY ACCOUNTS

This Annex 3.1 summarizes specific observations made by Nuiqsut whalers of activities by vessels other than whaling vessels during the 2007 Cross Island whaling season, with additions from the 2007 Deadhorse Communication Center Call Log (DCCCL). Actually, as no accounts of non-whaling vessels were recorded by the researcher for the 2007 whaling season, all of the following information was abstracted from the DCCCL. The log was examined primarily for the dates of the whaling season (31 Aug–11 Sep). The overall impression is that most documented activity was of a routine nature, and that the overall conflict avoidance procedures worked well during the 2007 season. The only case where these procedures seem to have been invoked is in regard to the vessel *Stryker* and the operations of Bowhead Transport on 4 Sep. This case was handled amicably and resolved quickly to the satisfaction of the whalers. This, and the lack of reports from the whalers of encounters with non-whaling vessels, is a good sign that the Deadhorse Communication Center is indeed functioning to avoid conflicts between the whalers and others who are transiting or otherwise using the area. In the summaries that follow, the number of trips between various points on each day is generally not enumerated. That is, the summaries indicate where traffic was occurring during the 2007 whaling season, but not necessarily the magnitude or frequency of such traffic. Such estimates can be determined from the log entries, but the effort required to derive them was not deemed necessary for this report. In addition to the vessel traffic noted below, aerial surveys were flown (on behalf of groups other than BP) on all days when weather permitted – following the stipulated rules to ensure that they did not interfere with ongoing whaling activities.

The main point to be derived from these daily accounts is that there was little or no conflict during the 2007 Cross Island subsistence whaling season, and that most of the documented non-whaling vessel traffic was for regular and ongoing activities and was to the west of Cross Island. As indicated in the parts of the accounts **in bold** below, Nuiqsut whalers are sensitive to such activities to the east of Cross Island (since such activities could affect whales before they reach the whalers) but for the most part they have less concern about regular non-whaling vessel activities to the west of Cross Island.

8/29

Cross Island support/mobilization. Also traffic from Cape Simpson to Barrow, from Cape Simpson to Prudhoe Bay, between STP and Oliktok Point, and between Oliktok Point and the Oooguruk Unit (daily activity of at least 8 roundtrips by boat and 1 roundtrip by air).

8/30

Cross Island support/mobilization. One crew leaves Nuiqsut to go to Cross Island. Non-whaling vessel traffic from Prudhoe Bay to Cape Simpson, between Prudhoe Bay and Northstar, from Prudhoe Bay to Barrow, from Herschel Island to Barrow, between STP and Northstar, and the daily schedule between Oliktok Point and Oooguruk.

8/31

Cross Island support/mobilization. A second crew leaves Nuiqsut to go to Cross Island. The first crew goes scouting for whales and strikes and lands a whale. Non-whaling vessel traffic from Cape Simpson to Prudhoe Bay, Canada to Prudhoe Bay, between Prudhoe Bay and Northstar, between West Dock and Endicott, from Cape Simpson to West Dock, and the daily schedule between Oliktok Point and Oooguruk.

9/01

Winds reported at 20–25 knots at Cross Island, so there is no scouting activity. Non-whaling vessel activity includes the daily schedule between Oliktok Point and Oooguruk, Canada to Prudhoe Bay, between Prudhoe Bay and Northstar, between STP and Northstar, and between West Dock and Endicott.

9/02

Winds again reported to be 20–25 knots at Cross Island, preventing any scouting. Non-whaling vessel traffic between STP and Northstar, between West Dock and Endicott, and the daily schedule between Oliktok Point and Oooguruk.

9/03

Conditions improved at Cross Island, worse than the morning of 8/31 but better than when they were towing the whale on 8/31. One crew went out scouting and the other took its *tavsi* (community share) over to West Dock. The second crew then went to assist the second crew with a struck-and-lost whale and then to scout. The last three crews arrive on Cross Island from Nuiqsut. Non-whaling traffic between STP and Northstar and the daily schedule between Oliktok Point and Oooguruk.

9/04

Marginal scouting conditions at Cross Island, but three crews go out scouting while two remain on shore. Some whales seen, but none are struck. Non-whaling vessel traffic between STP and Northstar, the daily schedule between Oliktok Point and Oooguruk, and between Prudhoe Bay and Northstar. **There was some discussion among industry representatives, AEWC, and the Communication Center about the "action plan" for the self-propelled barge *Stryker* and Bowhead Transportion's general barging activities. It was agreed to curtail their activities when told that the *Stryker* is not welcome at Kaktovik [during whaling] and that "Nuiqsut does not want vessels on the east side while whaling is going on" (Deadhorse Communication Center Call Log 2007, page 07-3119).**

9/05

High winds at Cross Island preclude any scouting activity. Non-whaling vessel traffic confined mainly to the daily schedule between Oliktok Point and Oooguruk as most other traffic is weathered in at various sheltered locations (Thetis Island, West Dock, etc.)

9/06

Marginal scouting conditions at Cross Island, but two crews go out scouting (briefly) while three crews remain on shore. Non-whaling vessel traffic between STP and Northstar, the daily schedule between Oliktok Point and Oooguruk, between West Dock and Endicott, and a support vessel between West Dock and Cross Island. Several vessels were also at West Dock, reported to be waiting on the weather.

9/07

Excellent scouting conditions and all five crews went out scouting. A whale was struck early in the morning and towed to Cross Island around noon, and four crews went out in the afternoon and landed another whale. Non-whaling vessel traffic between West Dock and Northstar, the daily traffic between Oliktok Point and Oooguruk, STP and Northstar, West Dock and Oliktok Point, extra trips between

Oliktok Point and Oooguruk, and a support trip between STP and Cross Island. **The *Stryker* trip west was specifically allowed with the explanation that such travel "is okay Westbound – whalers concern is for eastbound traffic" (Deadhorse Communication Center Call Log 2007, page 07-3137.**

9/08

Nuiqsut whalers call a cease-fire, as they have used their quota. They butcher all day on Cross Island. Non-whaling vessel traffic between West Dock and Northstar, the daily schedule between Oliktok Point and Oooguruk, between Prudhoe Bay and Northstar, between STP and Northstar, between STP and Endicott, and extra trips between Oliktok Point and Oooguruk.

9/09

Nuiqsut whalers again butcher all day on Cross Island. Non-whaling vessel traffic between STP and Northstar, the daily schedule between Oliktok Point and Oooguruk, and extra trips between Oliktok Point and Oooguruk.

9/10

Nuiqsut whalers butcher and pack all day on Cross Island. Non-whaling vessel traffic between STP and Northstar, the daily schedule between Oliktok Point and Oooguruk, extra trips between Oliktok Point and Oooguruk, between STP and Milne Point, and from Prudhoe Bay to Barrow.

9/11

All five crews leave Cross Island for Nuiqsut. Non-whaling vessel traffic between West Dock and Northstar, the daily schedule between Oliktok Point and Oooguruk, extra trips between Oliktok Point and Oooguruk, from Prudhoe Bay to Barrow, and between STP and Oooguruk. The demobilization barge also went out to Cross Island and back to West Dock.

9/12

The wisdom of the whalers leaving Cross Island on 9/11 was reinforced as at least one (commercial, non-whaling) ship had to anchor at Cross Island for 9/12–9/16 due to weather, finally heading to West Dock on 9/17.