APPENDIX V:

MONITORING OF INDUSTRIAL SOUNDS, SEALS, AND BOWHEAD WHALES NEAR BP'S NORTHSTAR OIL DEVELOPMENT ALASKAN BEAUFORT SEA, 2006: ANNUAL SUMMARY REPORT [1,2]

edited by

W.J. Richardson (2007)

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Monitoring of Industrial Sounds, Seals, and Bowhead Whales Near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2006: Annual Summary Report

by

LGL Limited environmental research associates

and

Greeneridge Sciences, Inc.

for

BP Exploration (Alaska) Inc.

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Monitoring of Industrial Sounds, Seals, and Bowhead Whales Near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2006: Annual Summary Report

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CHAPTER 1: INTRODUCTION, DESCRIPTION OF BP'S ACTIVITIES, AND RECORD OF SEAL SIGHTINGS, 2006 [1]

by

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INTRODUCTION

BP Exploration (Alaska) Inc. (BP) is producing crude oil from the Northstar Unit in the Beaufort Sea, northwest of Prudhoe Bay (Fig. 1.1). Northstar is a gravel island connected to Prudhoe Bay facilities by two subsea pipelines and, seasonally, by an ice road constructed from West Dock Base of Operations. In August 1998, BP began a series of requests to the National Marine Fisheries Service (NMFS) for regulations and associated Incidental Harassment Authorizations (IHAs) and Letters of Authorization (LoAs) to authorize incidental "taking" of small numbers of marine mammals that may result from BP's activities at Northstar (Table 1.1). In 2000, NMFS promulgated regulations under section 101 (a) (5) of the Marine Mammal Protection Act to authorize incidental "taking" of small numbers of whales and seals as a result of Northstar activities through 25 May 2005 (NMFS 2000). In August 2004, BP requested that NMFS reissue those regulations for another 5-year period. NMFS renewed those regulations on 7 March 2006, to take effect on 6 April 2006 (NMFS 2006). The initial LoA under those new regulations was issued by NMFS to BP on 7 July 2006. The various LoAs issued under the previous and current Northstar regulations have required monitoring studies. Several types of marine mammal and acoustic monitoring had been completed through 2005 (Richardson and Williams [eds.] 2004, 2005; Richardson [ed.] 2006b).

During early 2005, those monitoring results were reviewed by the Science Advisory Committee (SAC) of the North Slope Borough, which met in Anchorage on 7 March 2005. The monitoring results through 2004 were also reviewed on 10–11 May 2005 at the meeting convened annually by NMFS to

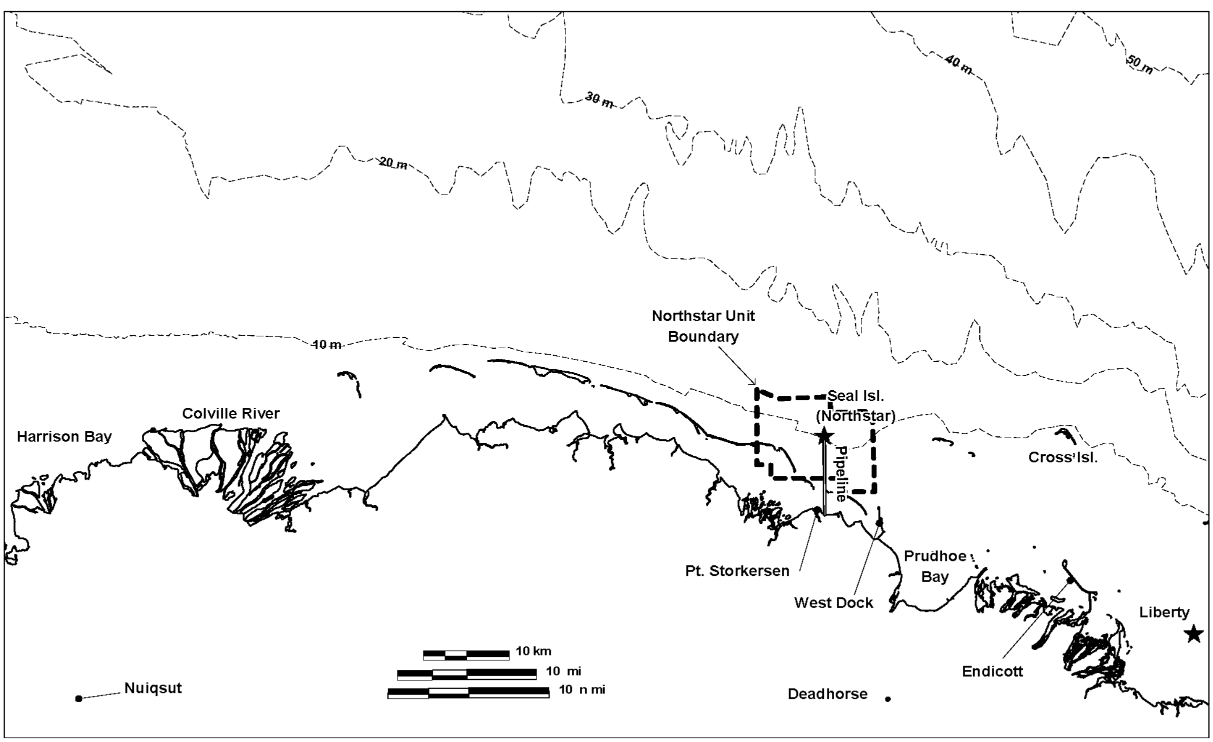

FIGURE 1.1. Location of the Northstar Development at Seal Island in the central Alaskan Beaufort Sea.

TABLE 1.1. History of small-take authorizations associated with the Northstar Development.

Date	BP Request or Regulatory Activity
Aug. 1998	*BP requested initial IHA from NMFS for Dec. 1998 to Dec. 1999 construction*
Nov. 1998	*BP requested NMFS to promulgate regulations allowing for issuance of LoAs*
15 March 1999	Interim IHA issued by NMFS to BP
25 May 2000	**NMFS issued the requested regulations (effective to 25 May 2005)**
18 Sept. 2000	First LoA issued by NMFS to BP for the construction period (expired 30 Nov. 2001)
14 Dec. 2001	Second LoA issued to BP (expired 30 Nov. 2002)
9 Dec. 2002	Third LoA issued to BP (expired 30 Nov. 2003)
4 Dec. 2003	Fourth LoA issued to BP (expired 3 Dec. 2004)
30 Aug. 2004	*BP requested renewal of the regulations and an initial LoA under new regulations*
4/6 Dec. 2004	Fifth LoA issued to BP to cover remaining term of initial regulat. (to 25 May 2005)
25 May 2005	Fifth LoA and initial regulations expire
7 Mar. 2006	**NMFS renewed the Regulations, effective 6 Apr. 2006 to 6 Apr. 2011**
7 July 2006	NMFS issued initial LoA under the new Regulations (to expire 6 July 2007)

review monitoring studies in the Beaufort Sea. Based on the results up to 2004, it was concluded that the monitoring programs for both seals and bowhead whales could be modified starting in 2005, with the possibility of conducting additional whale monitoring program in a future year if necessary. This was reconfirmed during the next year's meeting, on 18 April 2006, when results for 2005 and plans for 2006 were reviewed. Consistent with the recommendations of this group, during 2005 and 2006, 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 2006 were collected and analyzed in ways consistent with prior years to allow comparison of the 2006 results with the results from 2001–2005.

This report describes BP's activities during the November 2005 through October 2006 period, and it describes the results of the monitoring studies conducted during that year. This report follows the format of the preceding annual reports for 2004 and 2005 (Richardson and Williams [eds.] 2005; Richardson [ed.] 2006b). Descriptions of BP's activities and the seal counts are included in this chapter. Chapter 2 provides the results of the acoustic measurements and the counts of calling bowhead whales. Chapter 3 concerns the bowhead hunt at Cross Island, east of Northstar, during 2006.

The Science Advisory Committee recommended in 2005 that observations by 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." BP adopted that recommendation, and Chapter 3 of the preceding annual report for 2005 provided the first results of that type (Galginaitis 2006). Chapter 3 of this report is an updated version concerning the 2006 whaling season at Cross Island.

This report satisfies annual reporting provisions of the Letter of Authorization issued by the National Marine Fisheries Service 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.

The Science Advisory Committee and participants in the 2005 and 2006 Beaufort Sea open-water meetings also recommended that various additional analyses of previous monitoring results be done. BP and its contractors agreed to this, and undertook to incorporate the results into an updated comprehensive report (UCR). This is to be a combined presentation of the monitoring results up to 2004, along with additional analyses of the combined data. A preliminary version of the UCR was circulated in April 2006 (Richardson [ed.] 2006a). Work on the additional analyses has been ongoing since then, and a further updated comprehensive report will be completed in early 2007.

During the one year period summarized in this report, BP and its contractors also continued to work toward publication of the monitoring results in peer-reviewed journals. Eight papers based on Northstar studies had been published through 2005 and two additional papers were published in 2006 (Table 1.2). Additional manuscripts have been completed (Table 1.2) and others are in preparation.

TABLE 1.2. Authors and titles of publications resulting from the Northstar marine mammal and acoustic studies program, 1999–2006.[a]

Authors	Title	Journal or Status
Acoustical Studies		
Greene, C.R., Jr., S.B. Blackwell and M.W. McLennan (MS)	Sounds and vibrations during initial construction of an oil production island in the ice-covered Beaufort Sea	Manuscript
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., and C.R. Greene Jr. (2005)	Underwater and in-air sounds from a small hovercraft	***J. Acoust. Soc. Am.*** 118(6): 3646-3652
Blackwell, S.B., and C.R. Greene Jr. (2006)	Sounds from an oil production island in the Beaufort Sea in summer: characteristics and contributions of vessels	***J. Acoust. Soc. Am.*** 119(1): 182-196
Bowhead Whale Studies [a]		
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., W.J. Richardson, C.R. Greene Jr., and B. Streever (in press)	Bowhead whale (*Balaena mysticetus*) migration and calling behaviour in the Alaskan Beaufort Sea, autumn 2001–2004: an acoustic localisation study	***Arctic*** (in press)
McDonald, T.L., W.J. Richardson, C.R. Greene Jr., S.B. Blackwell, and B. Streever (MS)	Detecting changes in distribution of calling whales exposed to fluctuating anthropogenic sounds	Manuscript
Streever, B., R.A. Angliss, R. Suydam, and others (submitted)	Progress through collaboration: a case study examining effects of industrial sounds on bowhead whales	Submitted manuscript

TABLE 1.3. Continued.

Author	Title	Journal or Status
Seal Studies		
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(1): 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
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
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
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 Beaufort Sea during development of an oil production facility	***Aquatic Mamm.*** 32(3): 311-324
Moulton, V.D., M.T. Williams, S.B. Blackwell, W.J. Richardson, B. Streever, and R.E. Elliott (MS)	Zone of displacement for ringed seals (*Phoca hispida)* around offshore oil-industry operations in the Alaskan Beaufort Sea	Manuscript

[a] Additional papers on the "bowhead whale" portions of the work are in preparation.

BP ACTIVITIES, NOVEMBER 2005 – OCTOBER 2006

BP Activities, 2005-2006 Ice-covered Period

This section discusses BP's activities during the ice-covered period from 1 Nov. 2005 through 15 June 2006. It is followed by a section that discusses BP's activities during the open-water period from 16 June through 31 Oct. 2006.

Ice Road Construction

One offshore ice road was built during the 2005–2006 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 29 Nov. 2005 and was completed on 3 Jan. 2006. The ice road was used from 3 Jan. 2006 until it was officially closed on 21 May 2006.

Transportation To and From Northstar Island

Two Bell 212 ***helicopters*** have been used to transport personnel and equipment to and from Northstar. These are medium-sized helicopters each with two turboshaft engines, a 2-bladed main rotor, and a 2-bladed tail rotor (Fig. 1.2). More helicopter traffic to and from Northstar Island occurred during the construction and early production periods (2001–2002) than in recent years (Table 1.3).

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

TABLE 1.3. Number helicopter round trips to Northstar Island by year. For 2002 and 2006, the numbers exclude round trips in Nov. and Dec.

Year	2001	2002	2003	2004	2005	2006
Helicopter round trips	1133	2222	799	272	500	380

Bell 212 helicopters were used to transport crew and materials to and from Northstar during the early and late parts of the ice-covered season of 2005–2006. Most of the helicopter traffic during the 2005–2006 ice-covered period occurred during Nov. and Dec. 2005 (Table 1.4). Helicopter traffic was reduced during the mid-portion of the ice-covered period and resumed during May and June. Helicopters made 465 round trips to Northstar during the 2005–2006 ice-covered period (Table 1.4).

TABLE 1.4. Number of Bell 212 helicopter round trips to Northstar Island by month during the 2005–2006 ice-covered period.

Month	Helicopter Round Trips
November 2005	193
December 2005	153
January 2006	18
February 2006	0
March 2006	0
April 2006	0
May 2006	66
1-15 June 2006	35

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 1500 ft (460 m), 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 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 (=Seal) Island to the mainland and, except when taking off, landing or limited by weather, must maintain a minimum altitude of 1000 ft (305 m). During poor weather or emergency conditions, pilots followed Federal Aviation Administration (FAA) altitude regulations and BP safety policy.

Hägglunds ***tracked vehicles*** (model 206 SUSV; Fig. 1.3) with personnel carriers were used to transport personnel and materials between West Dock and Northstar Island. Average transport speeds were typically 8–16 km/h (5–10 mph). 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 70 round trips between West Dock and Northstar Island during the 2005–2006 ice-covered period. A Tucker tracked vehicle and a Mattrak also made occasional round trips to Northstar Island.

Standard vehicles, including vans, pick-up trucks, and buses, were the main method of transportation for Northstar personnel from 3 Jan. 2006 to 21 May 2006.

A ***Griffon 2000 TD Hovercraft*** (Fig. 1.4) was also used to transport personnel during the ice-covered period. 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. Most hovercraft activity occurred in Dec. 2005 and in May and June 2006 (Table 1.5). Little hovercraft activity occurred from Jan. through Apr. 2006. During the 2005–2006 ice-covered period, the hovercraft made 249 round trips to Northstar (Table 1.5). Hovercraft use continued into the subsequent open-water period.

Chronology of Island Activities

Production Facilities.—Oil production at Northstar began on 31 Oct. 2001 and has occurred almost continuously from that date throughout the present reporting period. Power generation and compressor

FIGURE 1.3. 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 lb).

FIGURE 1.4. Hovercraft (Griffon 2000 TD) at the landing area on Northstar Island.

TABLE 1.5. Number of hovercraft round trips to Northstar Island by month during the 2005–2006 ice-covered period.

Month	Hovercraft Round Trips
November 2005	0
December 2005	83
January 2006	7
February 2006	0
March 2006	0
April 2006	0
May 2006	82
1-15 June 2006	77

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 six well sites during the reporting period (Table 1.6). Some of the activity involved well maintenance or drilling above the formation. Two new wells were drilled and completed, and surface drilling was conducted at a third new well site. Activities associated with drilling included vibratory and impact pile driving using an APE 200 vibratory pile driver and a DELMAG D-100 impact pile driver. These activities were conducted on 8–9 May 2006 to drive conductor pipes at wells NS-33 and NS-36, which were located within the perimeter of Northstar Island.

TABLE 1.6. Dates and type of activities at well sites on Northstar Island during the 2005–2006 ice-covered period.

Well Site	Dates	Activity
NS-08	7–25 Dec. 2005	Well maintenance
NS-10	25 Dec. 2005–3 Jan. 2006	Well maintenance
NS-14	3 Jan.–3 Feb. 2006	Drilled well sidetrack
	12–21 May 2006	
NS-30	3 Feb.–23 Mar. 2006	Drilled and completed new well
	30 Mar.–8 Apr. 2006	
NS-34	23–30 Mar. 2006	Drilled new well, surface hole only
NS-11	8 Apr.–12 May 2006	Drilled and completed new well

Training Activities.—No oil spill exercises were conducted on floating ice during the 2005–2006 ice-covered season. 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.

Oil Spill Inspections.—Each month, six to seven aerial surveys were conducted to inspect the pipeline for leaks or spills. These surveys were done by twin-engine fixed-wing aircraft, either a Twin Otter (DHC-6) or a CASA 212 backup aircraft. No reportable conditions were recorded during those surveys.

Reportable Spills.—There were 17 reportable Northstar-related spills during the 2005–2006 ice-covered season (Table 1.7). Material spilled included corrosion inhibitor, scale inhibitor, diesel fuel, hydraulic fluid, anti-foulant, drilling mud, sulfuric acid, hydrochloric acid, and sewage. Most of this material remained in containment and was recovered. Smaller amounts of some materials including sewage, corrosion inhibitor, hydraulic oil, drilling mud, hydrochloric and sulfuric acid, and diesel fuel were spilled outside of containment. A small amount of hydraulic oil was spilled off the pad on 3 and 4 Jan. 2006 (Table 1.7). All material spilled during this ice-covered season was cleaned up. No clean-up activity was necessary after Northstar flare events during the reporting period.

Construction and Maintenance Activities.—In recent years maintenance activities to repair the block system and fabric barrier around Northstar Island have been necessary. In 2006, this work began on 26 May and continued into the subsequent open-water period until 28 June. Divers were used for underwater work throughout the duration of the procedure. The diving work was much more intensive in 2006 than in previous years and involved 3 dive crews operating 24 hr per day. Initial repair activities included melting ice using high pressure washers and a hot water sled. Blocks were removed and sandbags were positioned in areas where gravel had been washed away. A new fabric barrier was placed over the sandbags and the blocks were replaced and shackled together. 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.

Equipment Used, 2005–2006

Transportation.—Equipment used for transportation included Bell 212 helicopters, Hägglunds tracked vehicles, and a Griffon 2000TD hovercraft, as described above, along with busses, pick-up trucks, and vans.

Emergency Escape Exercises.—Two articulated ARKTOS evacuation craft (Fig. 1.5) are available as the island emergency escape vehicles. Each ARKTOS evacuation craft is 15 m (50 ft) long and 3.9 m (13 ft) high with a beam of 3.8 m (12 ft 9 in). The maximum speed is 16 km/h (10 mph) on land or ice, and 11.1 km/h (6 knots) in water. Each ARKTOS is capable of carrying 52 people, 24 in the front section and 28 in the rear section. The ARKTOS evacuation craft were not used during the present ice-covered period.

Ice Road Construction.—Bluebird rolligon-type pumpers (Fig. 1.6) were used for ice-road flooding.

Power Generation and Gas Injection.—Five gas turbines are located at Northstar Island: three Solar® generators for power generation, and two GE LM-2500 high pressure compressors for gas injection. Each Solar® generator is a 13,000 hp (9700 kW) gas turbine, rated at 10,780 rpm and operating at 9500 rpm. Each high pressure compressor is a 30,000 hp (22,370 kW) gas turbine, rated at 10,000 rpm and running between 9000 and 9400 rpm; speed varied with the gas injection rate. There is also a low-pressure compressor driven by a 5000 hp (3730 kW) electric motor running at a constant speed of 3600 rpm.

TABLE 1.7. Record of material spilled at Northstar Island during the ice-covered period, 2005–2006. Spilled materials out of containment were cleaned up.

Date	Description/Source	Material	Gallons Out of Containment	Gallons in Containment
26 Nov. 2005	Leak in pipe connection from lift station	Sewage	10.00	100.00
8 Dec. 2005	Pin hole leak in weld	Scale Inhibitor		0.25
20 Dec. 2005	O-ring failure	Anti-foulant		2.00
26 Dec. 2005	Loose ring on top of tote	Corrosion inhibitor	0.004	
3 Jan. 2006	Broken hose fitting on dozer	Hydraulic oil	0.5	
4 Jan. 2006	Broken hose fitting on dozer	Hydraulic oil	0.75	
24 Jan. 2006	Mud spilled onto floor during process drilling	Drilling mud	0.2	167.8
31 Jan. 2006	Battery fell off pallet	Sulfuric acid	0.01	
5 Feb. 2006	Valve misalignment between pits	Drilling mud		5
26 Feb. 2006	Incorrect installation of fuel line	Diesel fuel	0	180
3 Apr. 2006	Acid release during transport	Hydrochloric acid	1	
6 Apr. 2006	Cracked weld due to pump vibration	Hydrochloric acid		1
27 Apr. 2006	Mud line valve failure	Drilling mud	55	55
5 May 2006	Release during fueling operation	Diesel fuel	2	
15 May 2006	Cap not secured	Corrosion inhibitor	0.01	
15 May 2006	Leak from trencher fuel tank	Diesel fuel	0.06	
20 May 2006	Loose fitting	Hydraulic oil	0.03	

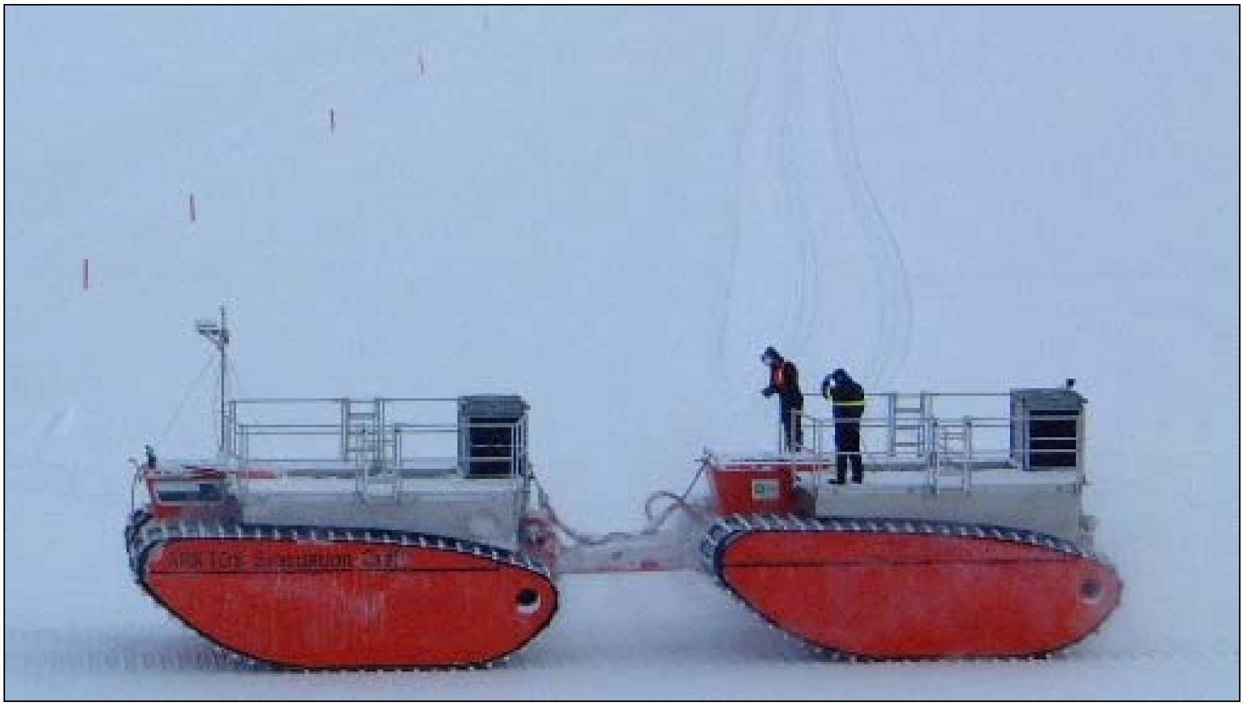

FIGURE 1.5. Articulated ARKTOS evacuation craft, used as an island emergency escape vehicle.

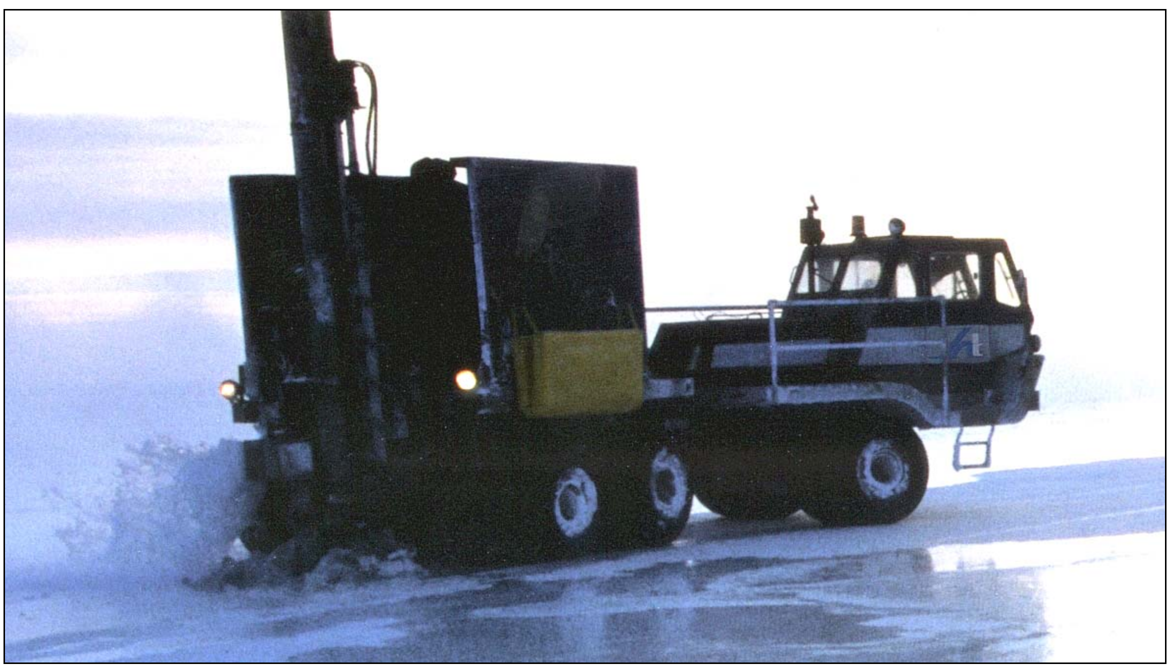

FIGURE 1.6. Blue Bird rolligon-type vehicle with 12” ice auger (stowed) and 10.2” pump auger (in use).

BP Activities, 2006 Open Water Period

Transportation To and From Northstar Island

As during previous years and during the previous ice-covered period, Bell 212 ***helicopters*** were used to transport personnel and freight to and from Northstar Island during the 2006 open-water period. Helicopters made ~261 round-trips to Northstar during the period (Table 1.8).

TABLE 1.8. Number of Bell 212 helicopter round trips to Northstar Island by month during the 2006 open-water period.

Month	Helicopter Round Trips
16-30 June 2006	34
July 2006	26
August 2006	33
September 2006	13
October 2006	155

The ***hovercraft*** used during the ice-covered period was also used to transport personnel and freight during the 2006 open-water period. The hovercraft made 560 round trips from West Dock to Northstar during the 2006 open-water period (Table 1.9).

TABLE 1.9. Number of hovercraft round trips to Northstar Island by month during the 2006 open-water period.

Month	Hovercraft Round Trips
16-30 June 2006	47
July 2006	124
August 2006	114
September 2006	162
October 2006	113

Tug and barge activity to supply Northstar during the 2006 open-water period occurred from July to Oct. A total of 64 tug and barge trips were made to Northstar during the 2006 open-water period (Table 1.10). A fuel transfer was accomplished on 29 Aug. 2006.

TABLE 1.10. Number of tug and barge round trips to Northstar Island by month during the 2006 open-water period.

Month	Tug and Barge Round Trips
16-30 June 2006	0
July 2006	10
August 2006	25
September 2006	25
October 2006	4

Alaska Clean Seas (ACS) ***Bay*-*class boats*** (Fig. 1.7) made 106 round trips to and from Northstar during the 2006 open-water period to transport personnel (Table 1.11). There were 5 additional trips by *Bay*-class boats in association with acoustic monitoring of the bowhead whale migration (see "Sound Measurements and Acoustic Monitoring", below).

TABLE 1.11. Number of *Bay*-class boat round trips to Northstar Island by month during the 2006 open-water period.

Month	***Bay*-Class Boat Round Trips**
July 2006	1
August 2006	69
September 2006	33
October 2006	3

Overall, there were more tug and barge trips to Northstar during the 2006 open water period than during the corresponding period in 2005 (64 vs. 21 round trips). Also, there was more use of *Bay*-class boats in the 2006 open-water period than in 2005 (111 vs. 19 round trips). A significant amount of vessel traffic occurred from late August through freeze-up. BP has initiated internal discussions about the desirability of reducing vessel use during that period in future years (Annex 1.1).

FIGURE 1.7. Bay-class boat at West Dock. Photo from Greeneridge Sciences.

Activities On and Near Northstar

Production Facilities.—Solar® generators, a diesel generator, high-pressure compressors, crude stabilizer pumps, and water injection pumps used during the previous ice-covered period remained in use during the open-water period.

Other On-Island Equipment.—A number of pieces of equipment were used on Northstar Island during the open-water period. A Volvo 150 front-end loader was used daily and a Manitowoc 888 crane, Caterpillar 966 loader, mechanic box truck, mobile aerial lifting platform, Caterpillar 988B forklift, and Polaris 6-wheeler were used occasionally or intermittently.

Drilling and Support.— Well maintenance work was done using cables to lower equipment into existing wells at NS-8 and NS-10, and a sidetrack was drilled at NS-14. New wells were drilled at NS-11, NS-30, and NS-34. The wells as NS-11 and NS-34 were completed, and the NS-30 well was a surface hole only.

Oil Spill Response Team Training Activities.—Two 24-ft aluminum boats were used to conduct offshore oil spill response training activities on 12 days from 10 July to 25 Sept. 2006.

Emergency Evacuation Exercises.—The ARKTOS emergency evacuation vehicle was serviced and used during training activities 10 July These activities occurred in open water south and west of Northstar Island.

Oil Spill Inspections.—Aerial surveys to inspect the pipeline for leaks or spills were continued during the 2006 open-water period. Four to seven surveys of the pipeline corridor were flown each month during the reporting period. No reportable conditions were recorded during these surveys.

Reportable Spills.—Three reportable spills occurred during the 2006 open-water period. Spilled material included scale and corrosion inhibitor, and lube oil (Table 1.12). All spilled material was cleaned up.

TABLE 1.12. Record of material spilled at Northstar Island during the open-water period, 2006.

Date	Description/Source	Material	Gallons Out of Containment	Gallons In Containment
26 June 2006	Pump failure during transfer of scale inhibitor	Scale inhibitor		0.25
29 Aug. 2006	Leak in chemical injection line at DS-11	Corrosion inhibitor		0.125
19 Sept. 2006	Oil filter on loader failed	Lube oil	3	1

Construction and Maintenance Activities.—Maintenance activities to repair the island barrier system around Northstar Island, which were conducted during the ice-covered and open-water periods of 2005, were continued during the ice-covered and open water periods in 2006. These maintenance activities were suspended on 28 June and resumed from 6 to 20 Aug. 2006. The equipment and techniques that were used to repair the island barrier system were similar to those used for this purpose during the open-water season of 2005 (see Rodrigues et al. 2006).

Sound Measurements and Acoustic Monitoring

Boat-based work in support of acoustic monitoring of bowhead whale migration was done by Greeneridge Sciences on five days from late Aug. to late Sept. 2006. A *Bay*-class boat was used to deploy three Directional Autonomous Seafloor Acoustic Recorders (DASARs) 390–520 m north of Northstar Island on 29 Aug., and the vessel then did a reconnaissance farther offshore. On 5 Sept., an attempt was made to deploy DASARs ~15 km NE of Northstar Island but the quantity of ice did not allow any deployments. On 7 Sept., after ice moved away, four DASARs were deployed 11–17 km northeast of Northstar Island (Chapter 2). The DASARs were calibrated during the 7 Sept. deployment trip, and again during a fourth vessel trip on 24 Sept. On 25 Sept., all seven DASARs were retrieved. Chapter 2 describes the acoustic methods and results.

Non-Northstar Related Research

In 2006, there were no USFWS late-fall polar bear surveys along the coast and barrier islands from Barrow to the Canadian border; such surveys had been flown during previous years. The Minerals Management Service conducted its usual Bowhead Whale Aerial Survey Program (BWASP) during the bowhead migration season (Dr. C. Monnett, MMS, pers. comm.).

MMS also funded boat-based surveys to collect water, sediment, tissue, and plankton samples for physical and chemical analyses. This work occurred at various locations from the Northstar area east to Barter Island (Hardin 2006). The surveys were conducted from 24 July to 12 Aug. 2006. Sampling in the Northstar area was conducted on six days from 31 July to 10 Aug. 2006.

Some non-BP industry operations and associated acoustical studies involving vessel-based activities occurred in the general vicinity of Northstar Island on at least 5 days during August and September 2006. Specific information about those operations has not yet been released, and BP is unable to assess the potential cumulative effects without this information.

OBSERVED SEALS

This section summarizes Northstar seal sightings during the ice-covered and open-water periods for 2005 and 2006. Observations to detect seals were made from the roof of the process module on Northstar Island on 56 and 63 days in 2005 and 2006, respectively (Table 1.13). These observations were done by Northstar Environmental Specialists on behalf of BP. The surveyed area included a 950 m strip around the entire perimeter of the island, centered on the process module. An inclinometer was used to determine the edge of the search area. Observers were able to scan a 360° field of view covering an area of ~695 acres (281 ha). Initial observations of the 950-m strip around the island were made visually without the use of binoculars. Observers then used 10 × 42 binoculars to confirm suspected seal sightings. Observation periods were ~30 min in length. Most observations were of seals on ice although some seals were also observed swimming.

Seal observations began and ended earlier in 2006 than in 2005 and there were 7 more observation days in 2006 (Table 1.13). Seals were generally recorded in small numbers (1 to 4 animals) from Northstar Island during both 2005 and 2006. However, relatively large numbers of seals were recorded on floating ice from 8 to 11 July 2005. Similar numbers were not recorded in 2006, which resulted in a greater number of total seals counted in 2005 compared to 2006. Seals were generally observed basking on the ice. Later in the season a few seals were observed in open water. No seals were observed from Northstar after 15 July during either year. No responses of seals to Northstar activities were noted other than that a seal was noted to raise its head in 2005, possibly in response to Northstar activities.

Results of seal counts conducted from Northstar Island during this reporting period did not provide evidence, or reason to suspect, that any seals were killed or injured by Northstar-related activities during the 2005 or 2006. During this time there was no impact pile driving or similarly noisy activity that could have exposed any marine mammals to underwater received levels ≥180 or 190 dB re 1 μPa (rms). Impact pile driving did occur on 8–9 May 2006, but that was within the perimeter of Northstar Island. Pipe driving there does not create underwater sounds exceeding 190 dB re 1 μPa (rms) in the water around the island (Blackwell et al. 2004a). There were no spills of liquid hydrocarbons that reached the water under the sea ice.

TABLE 1.13. Number of ringed seals recorded from Northstar Island during 2005 and 2006. "–" indicates days on which no observations were conducted.

	Seals			Seals	
Date	2005	2006	Date	2005	2006
1 May	-	1	21 June	0	1
4 May	-	0	22 June	2	1
5 May	-	0	23 June	4	0
7 May	-	0	24 June	2	0
8 May	-	1	25 June	1	1
11 May	-	1	26 June	1	0
12 May	-	0	27 June	0	1
13 May	-	0	28 June	0	0
14 May	-	1	29 June	0	0
15 May	-	2	30 June	0	1
16 May	-	0	1 July	0	-
17 May	-	0	2 July	2	-
18 May	-	1	3 July	2	-
19 May	-	0	4 July	0	-
20 May	-	1	5 July	0	0
21 May	-	3	6 July	0	0
22 May	-	2	7 July	0	0
23 May	-	2	8 July	17	0
24 May	-	2	9 July	0	0
30 May	-	4	10 July	30	0
2 June	-	3	11 July	124	0
3 June	2	3	12 July	0	0
4 June	2	3	13 July	2	0
5 June	3	-	14 July	0	0
6 June	3	3	15 July	1	0
7 June	3	-	16 July	0	0
8 June	-	4	17 July	0	0
9 June	4	2	18 July	0	0
10 June	3	0	19 July	0	0
11 June	3	1	20 July	0	0
12 June	3	3	30 July	0	-
13 June	3	2	1 Aug.	0	-
14 June	2	1	5 Aug.	0	-
15 June	2	3	9 Aug.	0	-
16 June	1	0	13 Aug.	0	-
17 June	2	1	16 Aug.	0	-
18 June	2	1	18 Aug.	0	-
19 June	2	1	19 Aug.	0	-
20 June	1	1	22 Aug.	0	-
Total seals recorded				229	58
Total observation days				56	63

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ANNEX 1.1: INTERNAL BP MESSAGE RE VESSEL TRAFFIC IN LATE SUMMER

From: Streever, Bill J

To: Nstar, Enviro Spec ; Nstar, Logistics Coordinator ; Nstar, Operations Manager ; Nstar, Ops Team Leader

Sent: Monday, March 19, 2007 5:53 PM

Subject: Northstar vessel traffic in 2006

18 March 2007

All:

I am emailing with regard to vessel traffic in 2006. Based on both activity logs for Northstar and acoustic recordings made offshore from Northstar, it seems as though vessel traffic in September 2006 was higher than in September 2004 and 2005. Northstar-supported marine mammal research shows that sounds associated with vessel traffic may deflect bowhead whales farther offshore than the whales would otherwise occur.

With this in mind, we should do our best to limit the number of vessel trips during late August and September, when most of the bowhead population migrates to the west in a corridor north of Northstar. Anything that you can do to decrease vessel traffic during this period would help decrease Northstar impacts on bowhead whale behavior and the subsistence hunt.

Note that these comments do not apply to the hovercraft, which generates very little sound underwater.

I hope to visit Northstar early this summer, in part to provide a briefing about this study to the camp population if that would be of interest.

Please contact me if you have any questions.

All the best, Bill

Bill Streever, Ph.D.
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CHAPTER 2:

ACOUSTIC MONITORING OF BOWHEAD WHALE MIGRATION, AUTUMN 2006 [1]

by

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March 2007

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[1] Chapter 2 *In:* W.J. Richardson (ed.). 2007. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar oil development, Alaskan Beaufort Sea, 2006: Annual summary report. Rep. from LGL Ltd. (King City, Ont.) and Greeneridge Sciences Inc. (Santa Barbara, CA) for BP Explor. (Alaska) Inc., Anchorage, AK.

ABSTRACT

During the bowhead whale migration in Sept. 2006, Greeneridge Sciences (on behalf of BP) implemented an acoustic monitoring program north-northeast of BP's Northstar oil development. Monitoring objectives in 2006 were identical to those in 2005, 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. 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. The primary objectives in 2006 were two-fold: (1) Monitor sounds produced by Northstar and its associated vessels, and compare the levels and frequencies to those in previous years (2001–2005). (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, bearings, call locations (if available) and call types were to be compared with previous years.

On 7 September 2006, four DASARs were deployed at locations 11.5–16.6 km (7.1–10.3 mi) NNE of Northstar Island. These instruments recorded low-frequency sounds continuously for ~18 days. Simultaneously, near-island recordings were obtained from three DASARs placed 410–465 m (1345–1525 ft) from Northstar over ~27 days (29 Aug. to 25 Sept. 2006). The sounds received in 2006 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 in 2006 increased compared to 2005, but was still below 2001–2003 values. Despite this, median broadband levels over the entire season were lower than in previous years. This is in part the result of a 45% drop in mean wind speeds in 2006 compared to 2005. Overall, industrial sounds from Northstar in 2006 were about the same as in 2004–2005, except for the increased frequency of transient high-level sounds associated with boats.

In total, 1509 bowhead whale calls were recorded in ~18 days at DASAR locations EB (2 recorders), CC, and CA. A total of 677 (38/day) of those calls were detected by DASARs EB and CC combined. This compares to 1542 calls in 2001 (110/day), 4775 calls in 2002 (208/day), 26,401 calls in 2003 (895/day), 31,903 in 2004 (1182/day), and 1020 in 2005 (35/day), based on data from the same two sites each year. The maximum call detection rate in 2006 was low, 67 calls per hour. A comparison of bearings from DASAR EB in 2001–2006 showed that the bearing directions were distributed much as in previous years (except 2005). The low call counts in 2006 are probably related to the presence of heavy nearshore ice during the 2006 season, which may have deflected the migration pathway farther offshore than in years with open water (i.e., 2001–2004).

INTRODUCTION

This chapter is a report on the acoustic monitoring of the bowhead whale migration near the Northstar development during the early autumn of 2006. 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 the month of 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 itself 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 instrumentation, the whale calls recorded by the DASARs were localized by triangulation. The key objective of the monitoring in 2001–2004 was to estimate the offshore displacement of the southern edge of the bowhead migration corridor, if any, at times when higher-than-average levels of underwater sound were being emitted from Northstar Island and its associated vessels. We used quantile regression to compare the locations of whale calls after nominal (15–120 min) periods with low to high average levels of industrial sound (see McDonald et al. 2006). 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 deflection of the southern part of the migration corridor at times with high Northstar sound ranged from a low of 0.66 km (0.41 mi) in 2003 to a high of 2.24 km (1.39 mi) in 2004.

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 2006 effort described in this report is similar to that carried out in 2005, and is a modified effort compared to the work in 2001–2004. The methodology is described in Greene et al. (2004). Results from 2001–2004 are summarized in Greene et al. (2002, 2003a), and Blackwell et al. (2006a, 2006b). Results from 2005 are summarized in Blackwell et al. (2006c).

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 2006, 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 7 July 2006. That LoA was issued under regulations that became effective on 6 April 2006 (NMFS 2006).

The specific objectives in 2006 were as follows:

(1) to measure near-island sounds about 450 m (1476 ft) north of Northstar using DASARs (one primary DASAR whose data were to be analyzed plus two spares for backup), and to compare the amplitude and frequency composition of the sounds with similar data collected in previous years;

(2) to install a small array of DASARs in three of the locations used in previous years (see below), analyze the data from one of these units to count whale calls as in previous years, and compare the whale counts at the chosen DASAR with whale counts obtained at the same location in 2001–2005.

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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 2006 bowhead whale migration as compared to the previous five years. The project design and objectives for 2006 were approved by the peer review group convened by NMFS in April 2006.

After the end of the 2006 field season, BP decided to analyze whale calls from all four DASARs that were deployed in the offshore array (instead of only counting whale calls from a single DASAR, as was originally planned). The additional analyses, whose results are included in this Chapter, added three main objectives to the two original objectives listed above:

(3) obtain whale call counts from all three offshore DASAR locations in 2006, and compare the counts with whale call counts obtained at the same locations in 2001–2005;

(4) obtain bearings to whale calls and localization of calls, if possible. A comparison of the bearings or locations obtained in 2006 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 2006;

(5) compare the types of calls recorded at the DASAR locations used in 2006 with the call types recorded at the same locations in previous years.

METHODS

Summary of Methodology in 2001–2005

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 25.38-GB disk drive. This allows for continuous sampling for up to 45 days and spans an acoustic range up to 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). In ***2005***, DASARs were deployed at three of the locations used in 2001–2004: WB, CC (2 DASARs) and EB. The DASARs recorded continuously for the entire field season, usually late Aug./early Sept. until late Sept./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, a position for the calling whale was obtained by triangulation, using the DASAR bearing information. In 2005 bearings were only obtained for EB (the other DASARs having moved on the seafloor during their deployment), so no whale call positions were calculated.

A continuous record of sounds from Northstar Island and its attending vessels was also obtained by deploying several redundant recorders (either cabled hydrophones, ASARs[3] or DASARs) ~450 m (1476 ft)

[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.

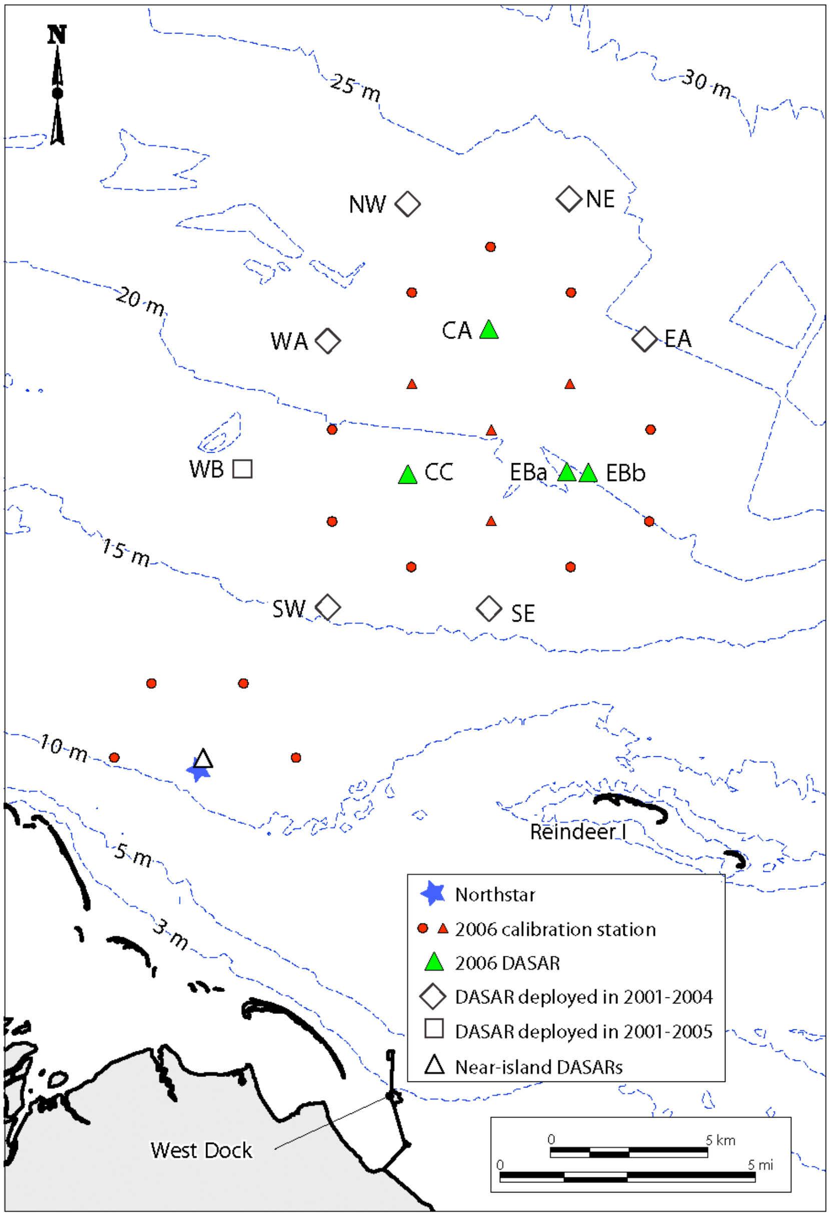

FIGURE 2.1. Locations of four array DASARs, 17 calibration stations, and three near-island DASARs (see Fig. 2.2) with respect to Northstar Island, Sept. 2006. DASAR locations used in 2006 are shown with green triangles. In 2005, locations used were limited by ice, and included WB, CC, and EB. All DASAR locations (including those identified by empty diamonds and squares) were used in some or all of 2001–2004. On 29 Aug. 2006, calibrations were performed at the four locations surrounding Northstar Island. On 7 Sept., calibrations were performed at the locations indicated by red triangles. On 24 Sept., calibrations were performed at all calibration locations that are mapped.

north of the island's north shore (see Fig. 2.1, open triangle). One minute of data was used every 4.37 min (or ~330 times per 24-h day) to calculate 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).

2006 Field Deployments

On 29 Aug. 2006, an attempt was made to deploy DASARs from the ACS vessel *Gwydyr Bay*. As in 2005, there was pack ice around and north of Northstar. We deployed the three near-island DASARs (NSa, NSb, and NSc) ~410 m, 410 m, and 465 m (1345–1525 feet) northeast of Northstar's north shore (Fig. 2.1, Fig. 2.2). Water depth was about 13 m. NSa and NSb were 171 m (560 feet) apart; NSb and NSc were 159 m (522 feet) apart (see Fig. 2.2). They started recording at ~12:00 noon local daylight time on 29 Aug. 2006 (Table 2.1).

The *Gwydyr Bay* then headed NE toward locations CC and EB (see Fig. 2.1), located 11–15 km from Northstar. However, the vessel encountered impassable pack ice 5.7 km from the island. This band of floating ice floes extended in a SW to NE direction and prevented us from getting any closer to the planned locations for the DASARs.

Ice and fog prevented other deployment attempts until 7 Sept. On that day floating ice was still present but not as dense as previously and the ACS vessel *Gwydyr Bay* was able to travel to the deployment areas by weaving between ice floes. The DASARs were deployed at locations EB (2 DASARs), CC, and CA, at distances 11.5–16.6 km (7.1–10.3 mi) NNE of Northstar Island (Fig. 2.1). These DASARs had already started recording at ~18:00 local time on 5 Sept. (Table 2.1). In 2005 DASARs were also deployed at locations EB and CC, but WB was used instead of CA. In order to obtain good positions by triangulation, a triangle-shaped layout (as in 2006) is always preferred over placing DASARs in a line (as in 2005, when ice limited the deployment geometry).

After DASAR deployments on both 29 Aug. and 7 Sept., 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 25 Sept. 2006.

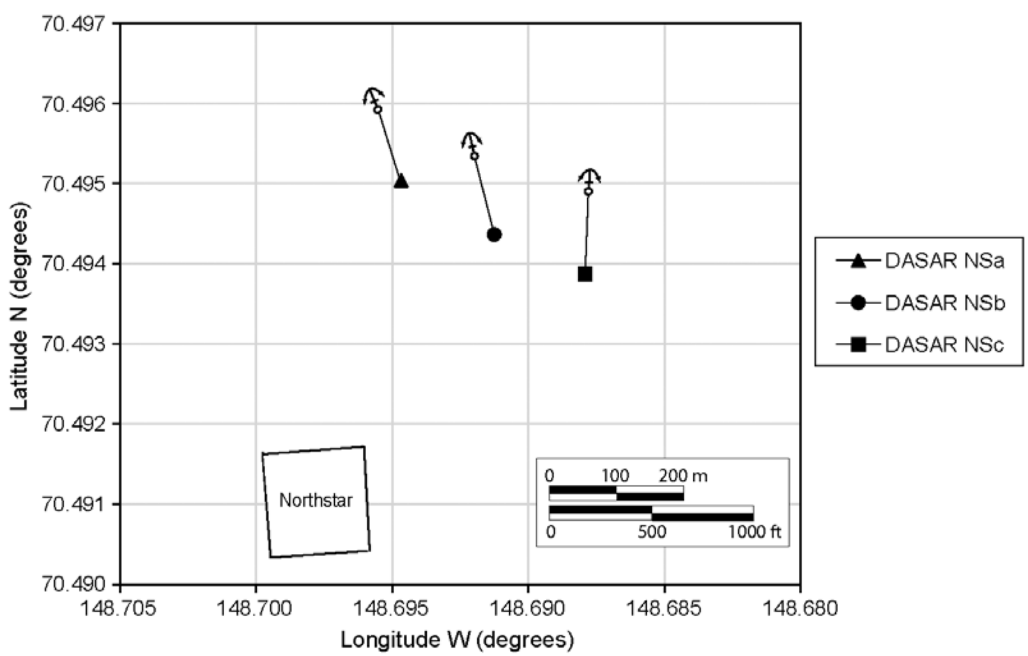

FIGURE 2.2. Deployment locations of near-island DASARs (filled symbols) and their anchors near Northstar Island in 2006. All three DASARs were deployed on 29 Aug., retrieved on 25 Sept., and functioned throughout their deployment period.

TABLE 2.1. DASAR locations in 2006, with installation date and time, start and end of data collection, position, and water depth. All times are local Alaska Daylight Saving times. The "Data End" time is the last stable compass reading prior to recovery, while the DASAR was still sitting on the sea floor. DASAR units 2, 6, 8, and 11 were installed offshore in the array; units 3–5 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	8	7 Sep 2006 10:55	7 Sep 2006 10:55:00	25 Sep 2006 9:34	70.574	148.659	22.3
EBb	6	7 Sep 2006 11:05	7 Sep 2006 11:05:00	25 Sep 2006 9:00	70.576	148.525	22.9
CC	11	7 Sep 2006 11:45	7 Sep 2006 11:45:00	25 Sep 2006 10:48	70.576	148.530	19.8
CA	2	7 Sep 2006 12:00	7 Sep 2006 12:00:00	25 Sep 2006 10:15	70.578	148.387	23.5
NSa	5	29 Aug 2006 11:06	29 Aug 2006 12:00:20	25 Sep 2006 11:39	70.495	148.694	13.1
NSb	3	29 Aug 2006 11:15	29 Aug 2006 12:00:22	25 Sep 2006 11:56	70.494	148.692	13.1
NSc	4	29 Aug 2006 11:22	29 Aug 2006 12:00:22	25 Sep 2006 12:52	70.494	148.686	13.1

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 whale calls, and to synchronize the data from various DASARs when triangulating calls. Calibrations were performed on three days during the 2006 field season:

- 29 Aug., four calibration stations near Northstar (see Fig. 2.1). These calibrations were performed after deployment of the three near-island DASARs;
- 7 Sept., four calibration stations in the array (see Fig. 2.1). These calibrations were performed after deployment of the array DASARs. Normally calibrations would be performed at 13 locations around the three array DASARs, but time and weather constraints limited us to four centrally located stations;
- 24 Sept., all calibration stations near Northstar and in the array (17 total), before retrieval of all the instrumentation on 25 Sept.

In 2006 the same J-9 sound projector, amplifier, sound source, GPS timing, and projected waveform were used as in 2003–2005. 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. 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 410–465 m (~1345–1525 ft) from Northstar during the study period, 29 Aug.–25 Sept. 2006. 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 (2001–2005), the near-island recordings in 2006 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 2001–2005 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; Richardson et al. 2003). 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 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 four offshore DASARs (EBa, EBb, CC, and CA) were analyzed in the same way as they have been in the past (2001–2005, see Greene et al. 2002, 2003a; Blackwell et al. 2006a, 2006b, 2006c). As in previous years back to 2002, recordings obtained while the acoustic crew's vessel was in the DASAR array were not analyzed. 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 the spectrogram and on 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) inflected calls, "∪" and "∩".
- ***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 was determined automatically. In 2001–2004, the bearings from various DASARs had been used to calculate positions of calling whales. In 2005, three out of the four array DASARs (WB, CCa, and CCb) and all near-island DASARs were moved on the seafloor by currents or surge one or more times during their deployment. Consequently positions could not be determined. In 2006, all DASARs were stable on the seafloor (see *DASAR Operations in 2006* in *Results*), so a bearing was obtained for each call and whale positions were obtained for those calls detected by at least two DASARs. Bearings in 2006 were compared with those from all previous years (2001–2005). Two variables 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 a set of 9 bearings. The vector mean bearing for each year indicates the general direction to the majority of calls for 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 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 (e.g., 4 bearings, at 0°, 90°, 180°, and 270°), then the vector mean would be indeterminate and the mean vector length would be 0.

The proportions of calls "offshore" versus "inshore" (O/I ratio) were also calculated for DASARs EBa and CC, to be compared with values from previous years (Blackwell et al. 2006c). Offshore calls were defined as those whose bearings from the DASAR of interest were between 298° and 98° True (including 360°/0°, true north), and inshore calls were defined as those with bearings between 118° and 278° (including 180°, south; Fig. 2.4). These ranges were determined by the orientation of a baseline parallel to the general trend of the shoreline (108° to 288° True), with 20° buffer zones (centered on the baseline) between the offshore and inshore areas. Thus, calls with bearings in the ranges 98°–118° and 278°–298° were not included in the calculation of the O/I ratio (Fig. 2.4).

To provide information on ambient 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.

RESULTS

This section is organized with six main sections describing

1. DASAR operations in 2006;
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. Unidentified sound at nearshore and offshore locations; and
6. Whale call analyses, including (a) the number of whale calls detected at the offshore DASARs and comparisons with previous years; (b) locations of calls received by at least 2 DASARs, bearings to calls and O/I ratios for DASAR EBa in 2006, including comparisons with previous years; (c) analysis of call types in 2006 and comparison with call types obtained at the same locations in previous years.

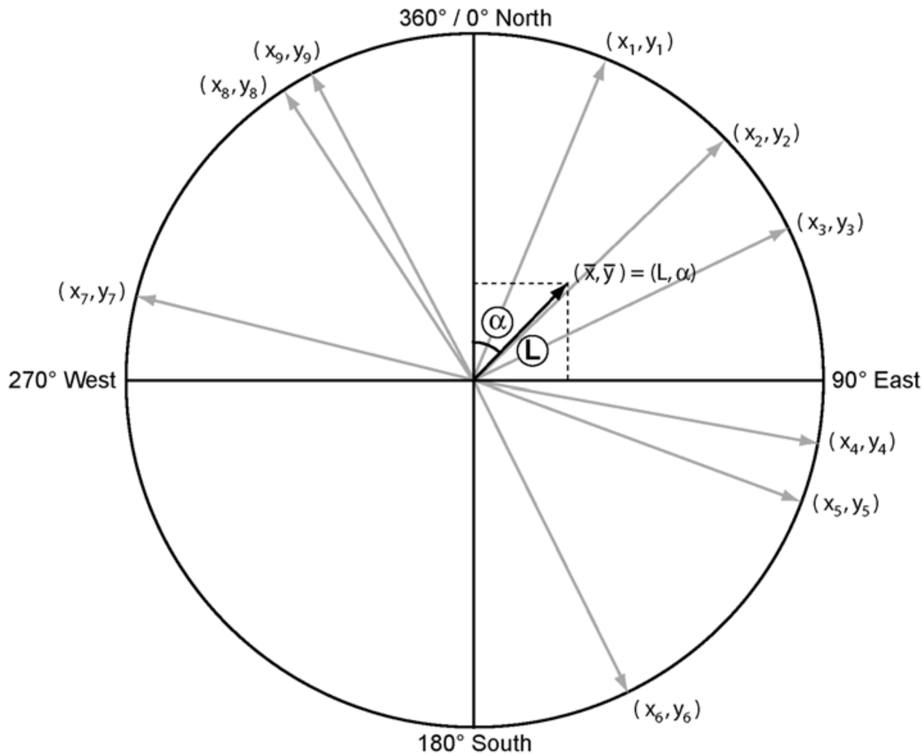

FIGURE 2.3. Average bearing calculation. The gray arrows are example bearings from a DASAR (located in the center of the circle). Mean bearing angle α = $\arctan(\bar{x}, \bar{y})$, where $\bar{x}$ and $\bar{y}$ are the average cos and sin, respectively, of all bearings obtained at one DASAR during a 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.

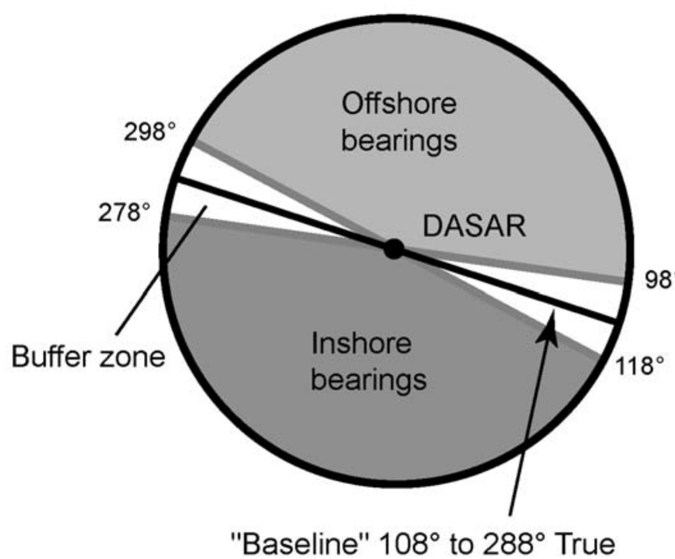

FIGURE 2.4. Definition of the "offshore" and "inshore" sectors in relation to the "baseline" and DASAR location (filled circle in center). See text for details.

DASAR Operations in 2006

All DASARs functioned throughout their deployment. The magnetic compass data indicated that the seven DASARs did not rotate on their bases while sitting on the seafloor in 2006, contrary to 2005 when six of seven DASARs moved. The lack of rotation in 2006 is illustrated in Figure 2.5, showing the magnetic compass headings for one near-island DASAR (NSb) and one offshore (=array) DASAR (CC) over their entire deployment periods. The lack of DASAR movement on the seafloor is likely in large part due to the lower mean wind speeds in 2006 compared to previous years, particularly 2005 (see below).

Calibration of the DASAR Clocks

The results of the clock drift calibrations are presented in Table 2.2. 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 –1.4 to +1.2 seconds per day.

Underwater Sounds at Northstar

Broadband Sounds

The sound levels recorded by the three near-island DASARs (NSa, NSb, and NSc) were in close agreement, with differences that are well within the variation one might expect based on reception at slightly different locations. The data collected by NSb and NSc were very similar; NSa had a slightly higher noise floor (by ~2 dB), which could have been due to a deployment location with more currents. We decided to

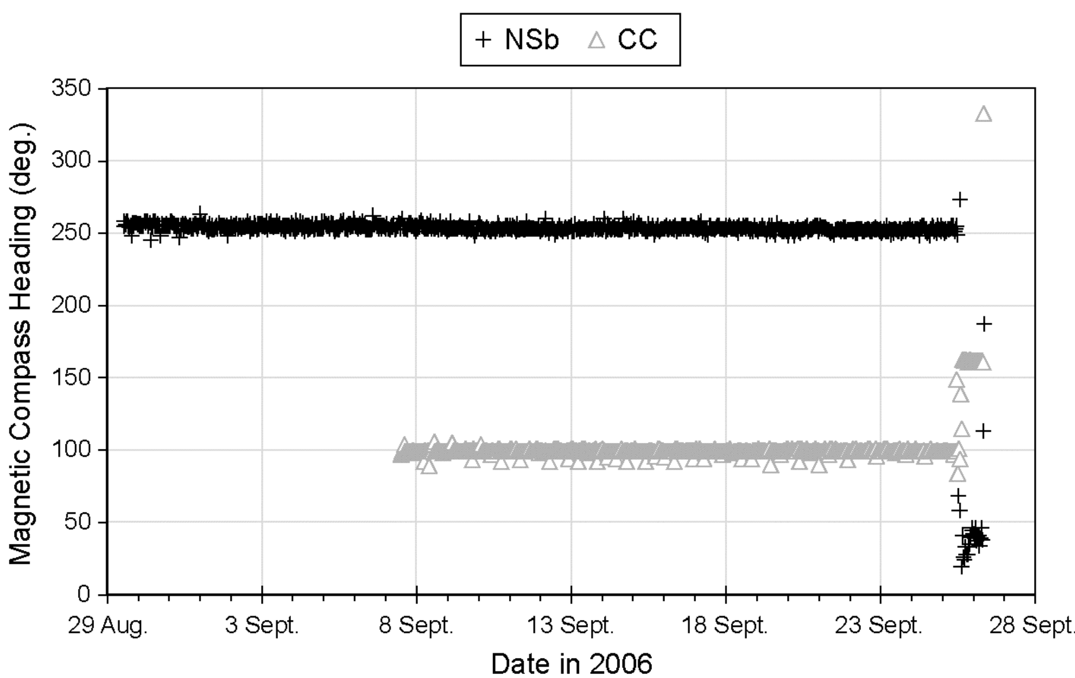

FIGURE 2.5. Magnetic compass heading vs. time for representative near-island (NSb) and offshore (=array) DASARs (CC) over their respective deployment periods in 2006. Both DASARs were retrieved on 25 Sept. 2006, as indicated by the large shifts in compass heading then.

TABLE 2.2. DASAR clock drift rate in 2006. Clock drift is characterized by its rate or "slope", in seconds per day, and by the standard deviation of the residuals (in seconds).

			Clock drift	
DASAR	**Unit #**	**# Pings**	**S.D. of residuals (s)**	**Slope (s/day)**
EBa	8	19	0.230	1.080
EBb	6	11	0.140	1.174
CC	11	5	0.250	0.750
CA	2	16	0.250	1.043
NSa	5	16	0.310	-1.375
NSb	4	12	0.150	-1.138
NSc	3	11	0.130	-0.997

use the data collected by DASAR NSc as this DASAR had the most stable compass bearings over its deployment. The signals from DASAR NSc 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 in Figure 2.6B for the period 31 Aug.–24 Sept. 2006. The range of broadband levels shown for 2006, 90–131 dB re 1 µPa, is similar to that reported for 2002, 2003, 2004, and 2005: 90–135, 90–137, 92–133, and 88–136 dB re 1 µPa, respectively (see Fig. 2.10, later).

Broadband levels close to Northstar are mainly determined by a combination of two factors: sound-generating industrial activities at and near Northstar (including associated vessels) and wind speed, which determines ambient sound levels. Mean hourly wind speed in 2006 was 5.7 m/s (12.8 mph) during the period 31 Aug.–30 Sept. This is 45% lower than in 2005 (8.3 m/s or 18.6 mph), 14% lower than in 2004 (6.5 m/s or 14.5 mph), 17% lower than in 2003 (6.7 m/s or 15.0 mph), 2% higher than in 2002 (5.6 m/s or 12.5 mph), and 46% higher than in 2001 (3.9 m/s or 8.7 mph). Figure 2.6A shows mean hourly wind speed as recorded by the Northstar weather station[4]. The lowest levels in Figure 2.6B are indicative of the quietest times in the water near the island, and generally correspond to times with low wind speeds. Conversely, times of high wind speed (e.g., 12, 17, or 22 Sept.) usually correspond to increased broadband levels in the DASAR record (Fig. 2.6B). However, there are many additional times with elevated broadband levels that do not correspond with periods of high wind speed. Data from previous years have shown that most of the peaks not related to high wind speed are attributable to industrial sound, and most often to vessel activity (Blackwell and Greene 2006).

Industrial Sound Index (ISI)

As in 2001–2005, the sum of sound components in the frequency range 28 to 90 Hz defined the ISI. The ISI for the 2006 study period is shown in Figure 2.6C as a function of time. As in previous years the ISI was closely related to the overall 10–450 Hz level, but the ISI tended to be a few decibels lower (as a consequence of excluding sound components at frequencies 10–28 Hz and 90–450 Hz.).

[4] Northstar weather data are available at http://www.resdat.com/mms/

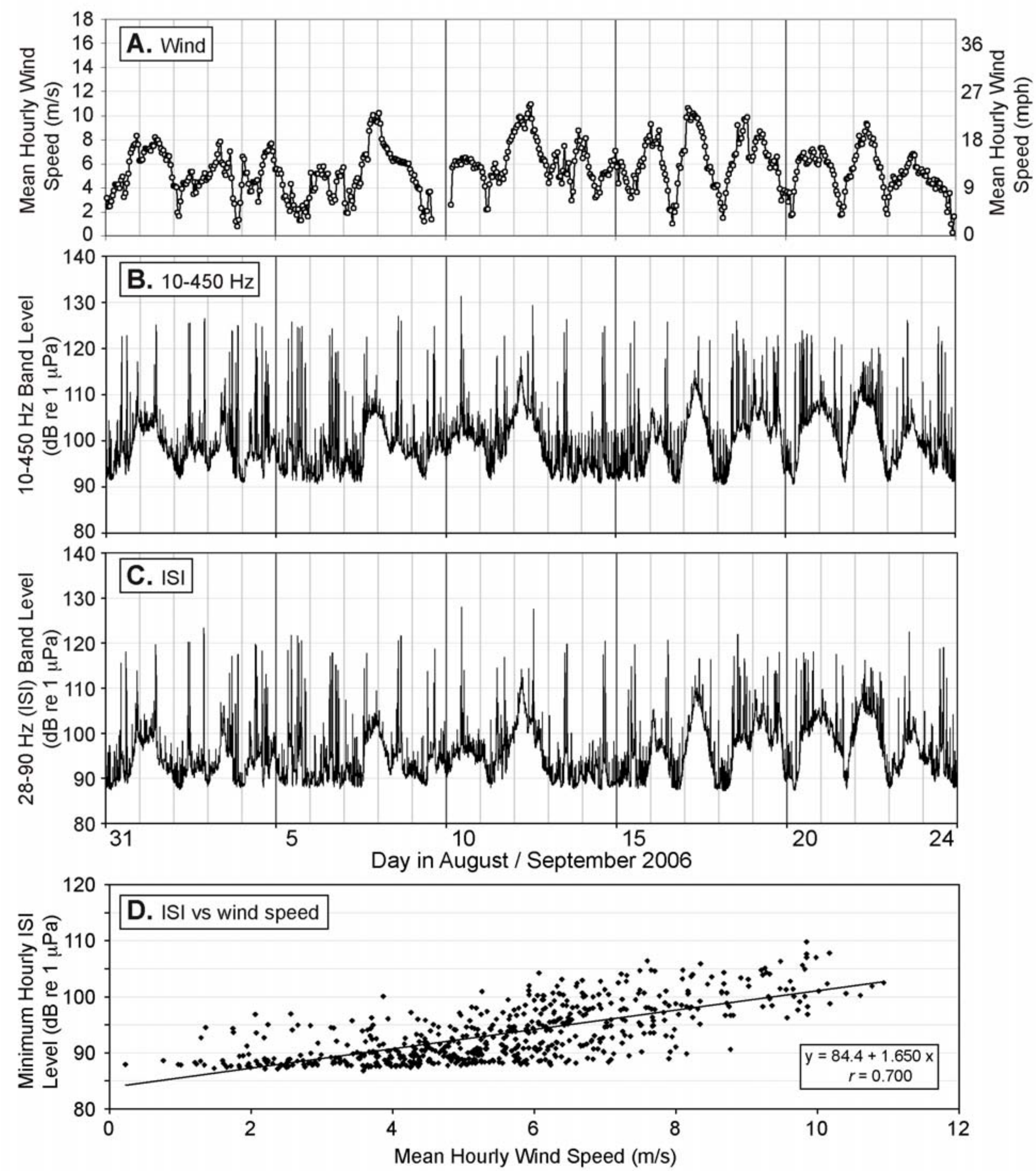

FIGURE 2.6. Variation in levels of underwater sound near Northstar in relation to date/time and wind speed, 31 Aug.–24 Sept. 2006. ***(A)*** Mean hourly wind speed as recorded by the Northstar weather station. Note that this weather station does not record north winds correctly, as the wind vane is shielded by a building in that direction. ***(B)*** Broadband (10–450 Hz) levels of underwater sound near Northstar vs. time, as recorded by DASAR NSc. This recorder was deployed 465 m (1525 ft) north of Northstar. ***(C)*** Corresponding ISI band level (~28–90 Hz) from DASAR NSc. ***(D)*** Minimum hourly ISI level versus mean hourly wind speed for 2006.

Direct comparison of the two values showed that 1-min ISI values were, on average, 4.2 dB below 10–450 Hz broadband values in 2006. This difference was 5.7 dB in 2005, 5.0 dB in 2004, and 5.7 dB in 2003.

Figure 2.6D shows the relationship between the mean wind speed and the minimum ISI value on an hourly basis for the 2006 season (r = 0.70, n = 648; for comparison, these values were r = 0.75, n = 743 in 2005). As in previous years this means that when wind speed was high so were average broadband and ISI levels. Mean wind speed and minimum ISI values were less closely correlated in 2006 than in 2005. The unusually close relationship between wind speed and sound levels in 2005 was probably due to unusually high wind speeds that season (see Blackwell et al. 2006c).

In 2006 there were no unusual production events at Northstar such as partial or complete shut downs. The low wind speeds and the presence of ice floes around the island throughout the 2006 season contributed to the low base levels (i.e., compare Fig. 2.10E,F, later).

Statistical Spectra of Island Sounds

To characterize the sounds near Northstar during the study period in 2006, statistical spectrum and one-third octave band levels were calculated for DASAR NSc (Fig. 2.7). Overall, these spectra are similar to those from previous years (see Fig. 2.8 in Blackwell et al. 2006a, Fig. 8.9 in Blackwell et al. 2006b, Fig. 7.16 in Blackwell et al. 2006c, Fig. 6.19 in Blackwell 2003, Fig. 7.19 in Blackwell and Greene 2002, and 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, and another at ~24 Hz, which was also present in 2002 and 2004. Percentile levels of broadband sound as recorded by the near-island recorders in 2001–2006 are compared in Table 2.3 and Figure 2.8. In 2006, the 50th percentile level was the lowest over the six years of data collection, and the 95th percentile and maximum levels were second to the lowest. The relatively low levels in 2006 were attributable to low wind speeds in 2006 and the fact that island sounds in 2006 were driven mainly by production, as opposed to the construction that occurred in 2001. Maximum levels, which are principally determined by boats, were similar to those in previous years.

Specific Island Sound Sources

Vessels.—As has been the case 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 an average of one trip per day to the island during Sept. 2006. The daily number of round trips by the hovercraft, tugs[5] (usually accompanied by a barge), and ACS vessels are shown in Figure 2.9. These records were compiled by the Crowley Marine dispatcher's office at West Dock, ACS, and were supplemented by information from the Northstar daily report.

- The *hovercraft* made a total of 141 round trips to Northstar during the 32 days for which we have information (30 Aug.–30 Sept.), or on average 4.4 trips/day. (All references to "trips" in this subsection refer to round trips.) This is 2.8 and 7.3 times the mean number of daily trips in 2005 (1.6 trips/day) and 2004 (0.6 trips/day). Mechanical problems prevented use of the hovercraft on 19–20 Sept. As in previous years, the arrivals and departures of the hovercraft at

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[5] These were the *Kuparuk River* (made >75% of trips), *Kavik River, Siku*, and *Sinuk.*

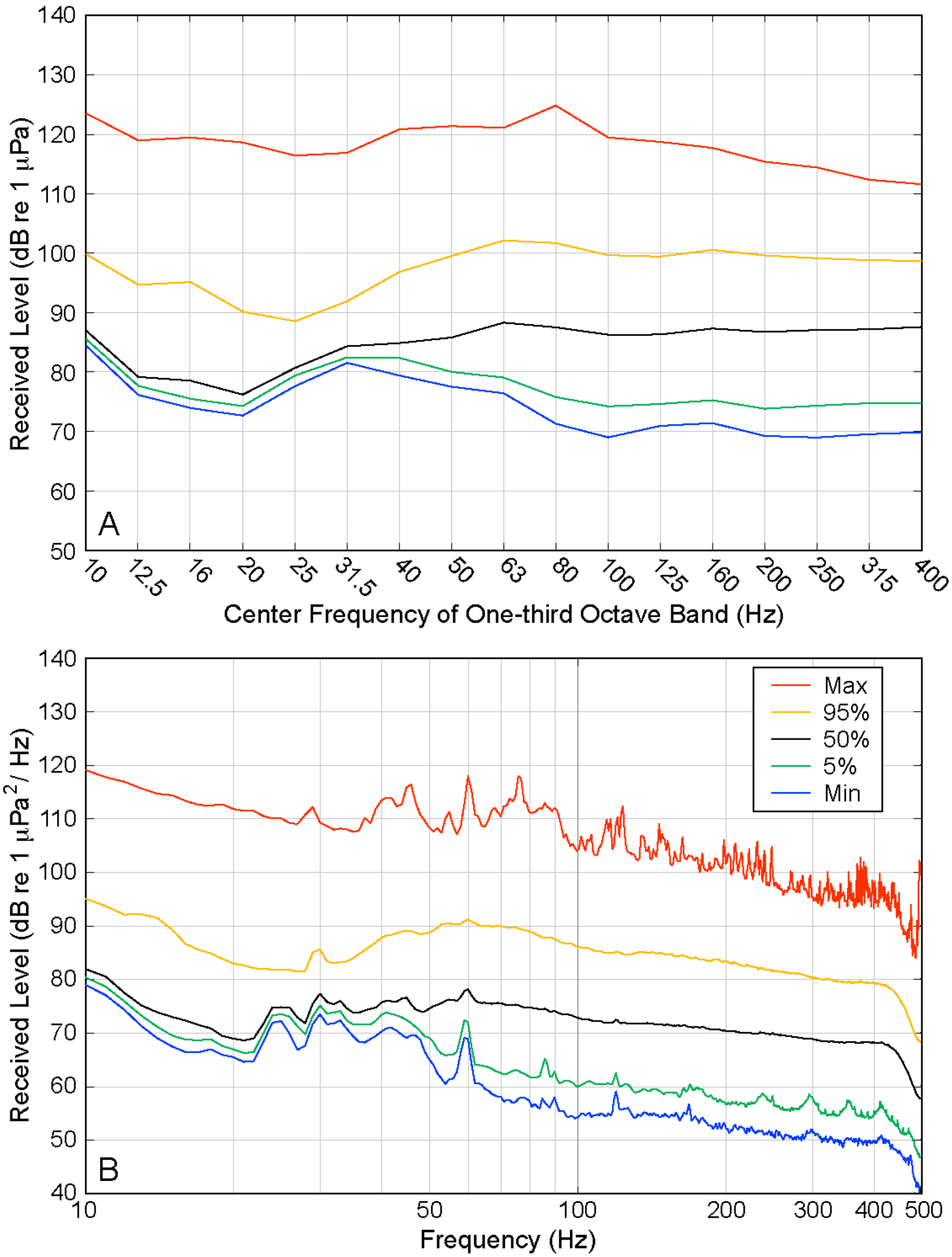

FIGURE 2.7. Statistical spectra for sounds recorded by DASAR NSc during the period 29 Aug.–25 Sept. 2006. ***(A)*** One-third octave band levels. ***(B)*** Sound spectral density levels. In both plots the five curves show, for each frequency, the minimum, the 5th, 50th, 95th percentiles, and the maximum. For both plots the number of 1-min measurements used was 8,907. The rapidly dropping values at frequencies close to 500 Hz, seen in data collected by DASARs (whose sampling rate is 1 kHz), are an effect of the anti-aliasing filter applied to the data.

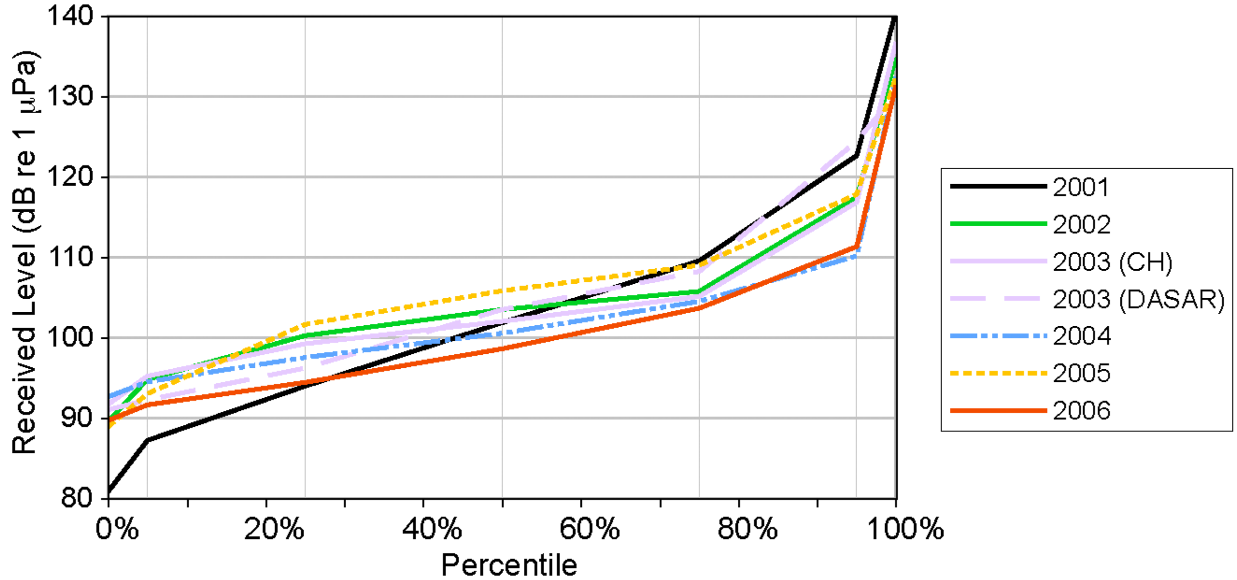

FIGURE 2.8. Minimum, 5th, 25th, 50th, 75th, and 95th percentiles, and maximum received levels of broadband (10-450 Hz) sound at the near-island recorder (cabled hydrophone or DASAR) for 2001–2006. The number of 1-min measurements for each year was as follows: 11,486 for 2001, 7551 for 2002, 5162 for 2003 (CH), 3233 for 2003 (DASAR), 10,409 for 2004, 10,999 for 2005, and 8907 for 2006.

TABLE 2.3. Percentile levels of broadband (10–450 Hz) underwater sound recorded near Northstar Island in 2001–2006, in dB re 1 μPa. In 2001 (1–21 Sept.) and 2002 (31 Aug.–23 Sept.) data were collected by cabled hydrophone (CH) #2. In 2003 data were recorded both by CH #2 (29 Aug.–16 Sept.) and DASAR NS (18–28 Sept.). In 2004 data were recorded by DASAR NSa (30 Aug.–1 Oct.). In 2005 data were recorded by DASAR NSb (1 Sept.–2 Oct.). In 2006 data were recorded by DASAR NSc (30 Aug.–25 Sept.). "Range" is the difference between maximum and minimum. All hydrophones were at similar distances (410–550 m or 1345–1804 feet) north of Northstar. All levels are in dB re 1 μPa.

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

[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.

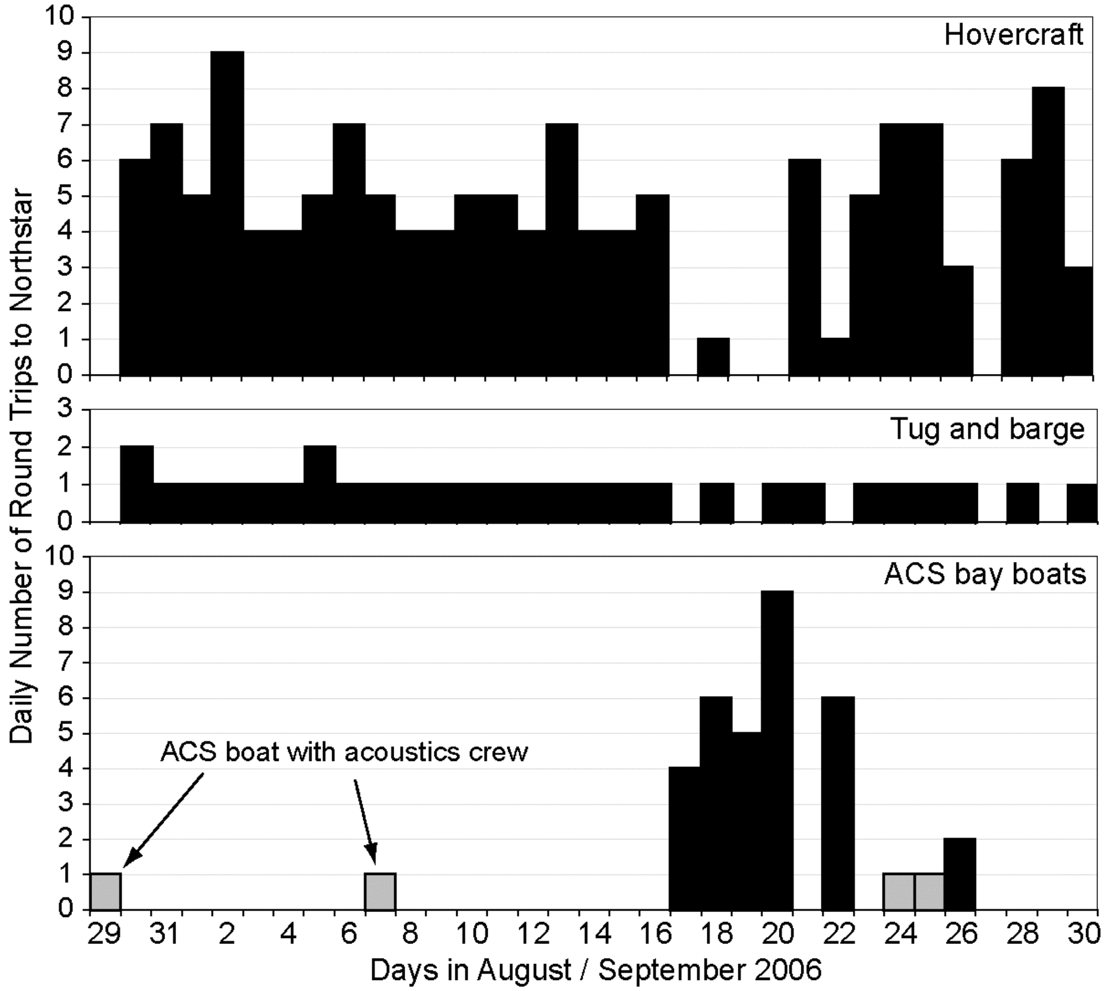

FIGURE 2.9. Daily number of round trips to Northstar Island by the hovercraft, Northstar tug and barge, and ACS vessels operating on behalf of BP (black shading = Northstar related, gray shading = acoustics crew) during the 2006 field season. Information on ACS vessel traffic starts on 29 Aug., whereas information for the hovercraft and barge traffic starts on 30 Aug. 2006.

Northstar were not detectable on DASAR NSc's sound pressure time series (e.g., Fig. 2.6B). However, the hovercraft has the disadvantage of not being useable at wind speeds above ~30 knots (34.5 mph) or wave heights above 1 m (3.3 feet).

- *Tugs and barges* made 29 trips to Northstar in 30 days, i.e., an average of ~1 trip/day. This is higher than in 2005 (0.5 trips/day) and 2004 (0.4 trips/day), but still below the average barge traffic in 2003 (1.6 trips/day).
- *ACS vessels*[6] (excluding the vessel used by the acoustics crew) made 31 round trips to Northstar in 32 days, an average of ~1 trip/day. This is three times the number of daily trips in 2005 (0.33 trips/day), and about 1.5× the number of daily trips in 2004 (0.7 trips/day). According to

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

Jim Nevels at ACS, "Bay" boats did occasional freight runs to the island, but they were mainly used when ice, wind, sea state, or fog conditions precluded the use of the hovercraft or helicopters, or because the hovercraft was down for repairs. Figure 2.9 shows that the majority of round trips to Northstar by ACS vessels took place during a 4–6 day window when the hovercraft could not be used because of weather or maintenance issues. In addition to the ACS vessels used for island runs or oil spill response training, the acoustics crew used an ACS "Bay" boat to deploy, calibrate and retrieve the DASARs in the offshore array and close to Northstar (see gray shading in Fig. 2.9). This boat made a total of 4 trips to Northstar and the DASAR array during the period shown in Fig. 2.9 (29 Aug.–30 Sept.). The number of trips taken by the acoustic crew each year has been as follows: 12, 8, 8, 9, 5, and 5 trips in 2001–2006, respectively. (The acoustic vessel made one scouting trip in 2006 that did not go to or near Northstar, and was therefore not included in Fig. 2.9.)

The figures quoted above for number of trips to Northstar in 2006 pertain to the acoustic monitoring period starting in late August. Chapter 1 gives information about vessel traffic for the 2006 open water season as a whole, including the early part of the open water season in July and much of August.

Round trips to the island by tugs and ACS vessels combined (including the ACS "Bay" boat used for the acoustic work) accounted for >85% of all the large "spikes" in DASAR NSc's sound pressure time series (Fig. 2.6B). This estimate was obtained the same way as in 2005 (see Blackwell et al. 2006c). We matched spikes (or tight groups of spikes) in the sound pressure time series whose maximum level was above 115 dB re 1 μPa 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.

Figure 2.10 shows broadband (10–450 Hz) levels of sound as recorded at the near-island recorders in 2001–2006. In all years vessels operating near Northstar (excluding the hovercraft) had a strong influence on overall sound levels. The number of "vessel spikes" in the sound pressure time series steadily decreased from 2001 through 2004, remained about the same in 2005, and showed an increase in 2006.

Underwater Sounds Offshore at DASAR EB

Figure 2.11 shows broadband (10–450 Hz) levels of sound as recorded offshore at DASAR EB in 2001–2006. DASAR EBa was 15 km (9.3 mi) northeast of Northstar (Fig. 2.1). During calibrations on 24 Sept. 2006 no health checks were performed, so the vessel never got closer than ~2 km from DASAR EBa, which explains the small size of the spike (Fig. 2.11). The vessel was also traveling slower than usual because of the ice. Baseline[7] levels of sound at DASAR EB are mainly a function of sea state, and therefore wind speed. Wind-induced sound levels in 2006 were lower than in 2005 and comparable to the levels obtained in 2001–2004. Figure 2.12 shows percentile levels of underwater sound at DASAR EBa, calculated each year over the entire season. Percentile levels in 2006 were within the range of the years 2001–2004 and noticeably lower than in 2005.

Unidentified Sound at Nearshore and Offshore Locations

During the course of identifying and tallying the whale calls on the array DASARs, the whale call analysts noticed a new type of "call" (sound type 13) that had not been heard before. We do not believe these sounds were produced by whales, but have not discovered their origin(s). These sounds were identi-

[7] The ***baseline*** refers to the lower edge of an "envelope" around the plotted sound pressure time series.

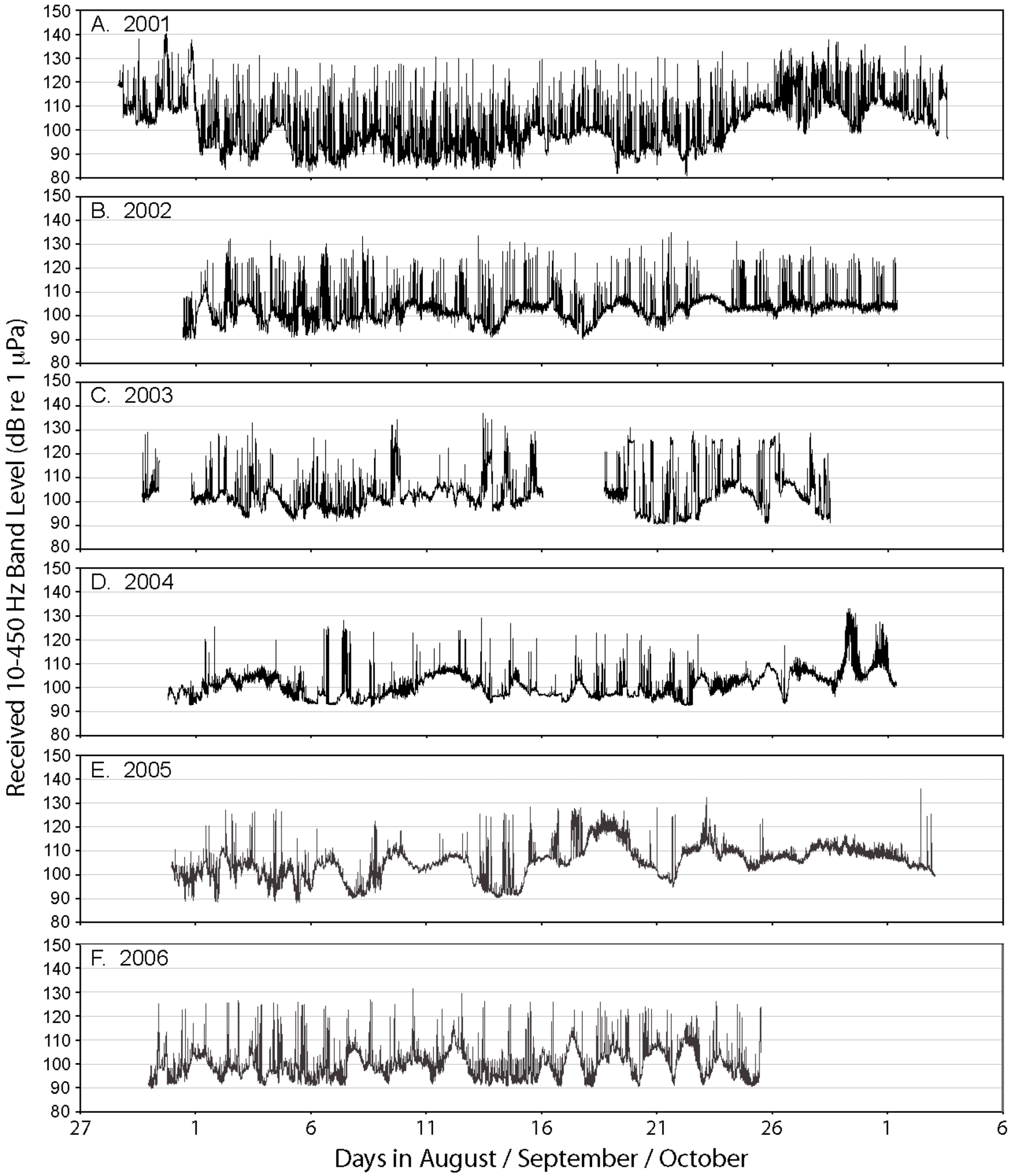

FIGURE 2.10. Sound pressure time series (10–450 Hz band level) for the 2001–2006 seasons, as recorded by the near-island recorders—a cabled hydrophone in 2001, 2002, and the first part of 2003, and a DASAR for the second part of 2003, and all of 2004, 2005, and 2006.

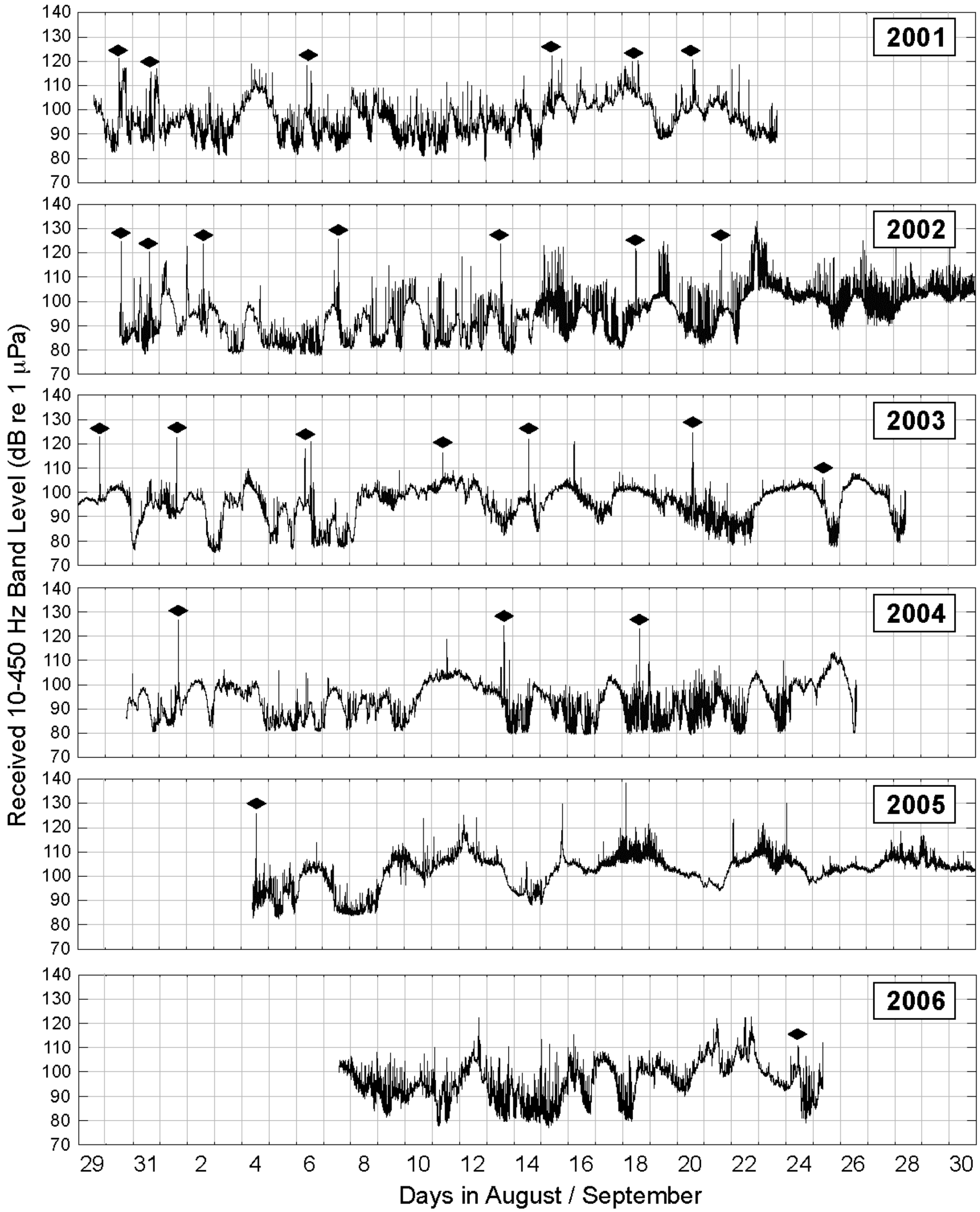

FIGURE 2.11. Broadband (10–450 Hz) sound pressure levels (SPLs) vs. time as recorded by DASAR EB in 2001–2006. Diamonds indicate spikes (brief periods of higher-level sound) created by the acoustic crew's vessel during servicing of the DASAR array.

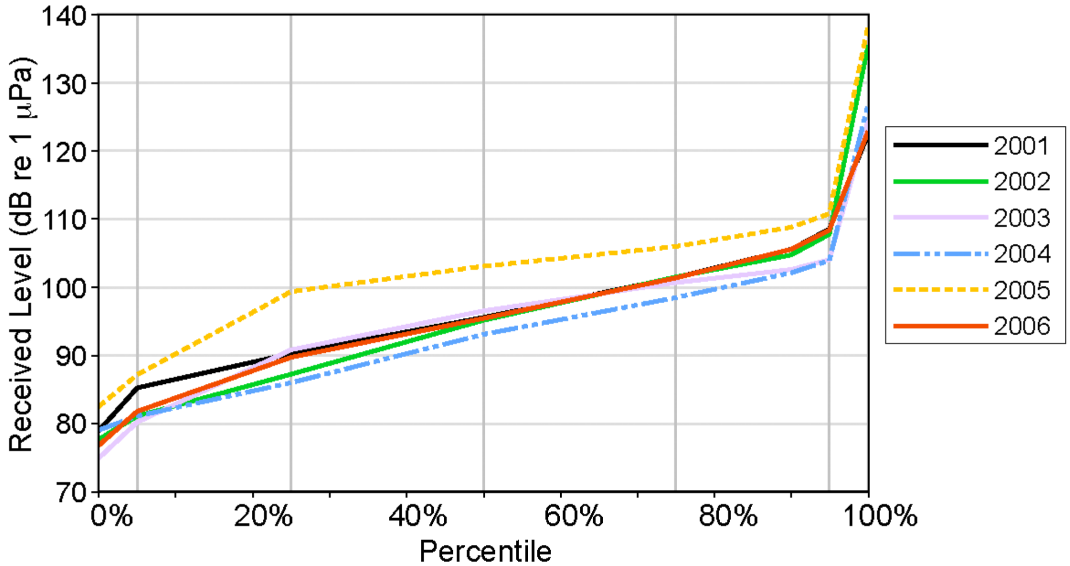

FIGURE 2.12. Minimum, 5th, 25th, 50th, 75th, 90th, and 95th percentiles, and maximum received levels of sound at DASAR EB for 2001–2006. The number of 1-min measurements for each year was as follows: 8276 for 2001, 11,165 for 2002, 10,016 for 2003, 8841 for 2004, 9420 for 2005, and 5862 for 2006.

fied every day from 8 to 25 Sept., but they became so numerous that towards the end of the season the whale call analysts stopped counting them. A total of 2711 type 13's were identified on the four array DASARs and three near-island DASARs. The numbers of these sounds that were heard by one, two, and three DASARs simultaneously were 2246, 260, and 205, respectively. The three near-island DASARs heard 98% of the sound type 13s identified by three DASARs, and only two sound type 13s were heard by both a near-island and an array DASAR simultaneously. Also, 95% of the sound type 13s heard by two DASARs were detected on pairs that were close together, such as EBa and EBb, or two near-island DASARs. This indicates that these sounds were not very strong or did not propagate well, which could happen if the source was shallow.

On spectrograms, sound type 13 had the characteristic shape of an upside-down "V". To our ears, it sounded like an outboard engine being revved up and down over several seconds. Figure 2.13 shows spectrograms featuring sounds of type 13. Locations were obtained for 233 sounds of type 13. These locations mainly extended north and northeast of Northstar and are shown in Figure 2.14.

Whale Call Analyses

Number of Whale Calls Detected

A total of 1509 calls were detected on the records of DASARs CC, EBa, EBb, and CA combined during the 7 Sept. to 25 Sept. period in 2006 (another 7 calls were only heard by the near-island DASARs). These figures exclude all "type 13" sounds. This is the lowest seasonal call count for these DASARs for the period 2001–2006, but it should also be noted that 2006 was the year with the fewest days of recordings offshore. Table 2.4 compares call counts in the different years. In 2006, there were two DASARs at location EB (EBa and EBb), so to allow meaningful comparisons with previous years we have only included one of the EB DASARs (EBa) in Table 2.4. (EBa was chosen over EBb because EBa

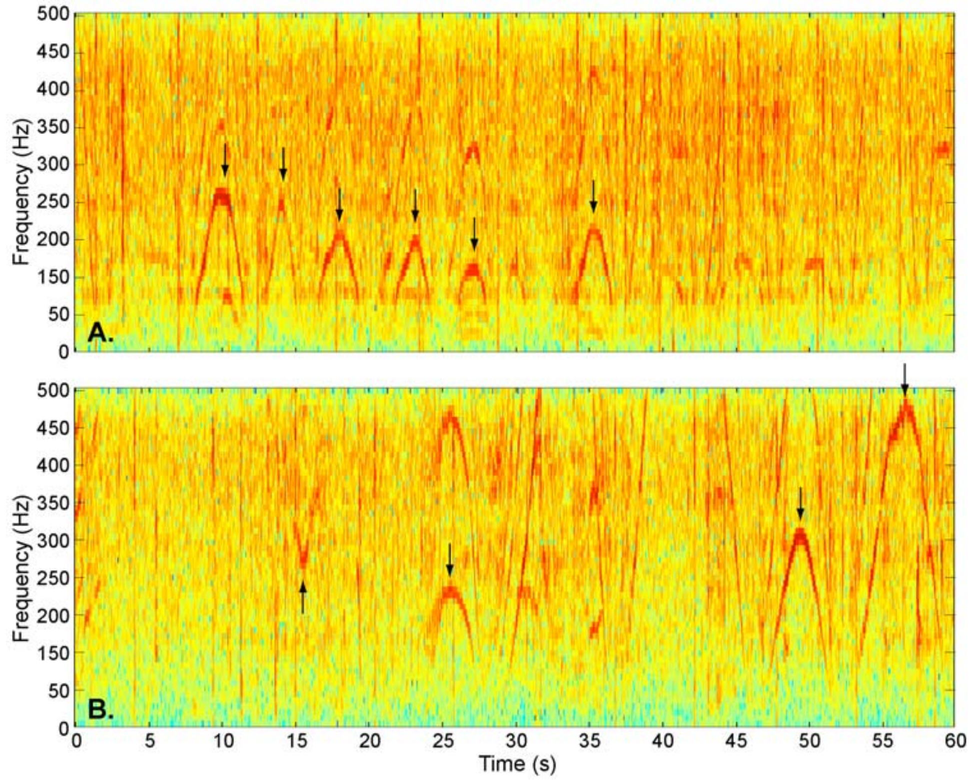

FIGURE 2.13. Examples of sound type 13. ***(A)*** DASAR CA, 15 Sept. at 16:40 local. ***(B)*** DASAR EBa, 15 Sept. at 01:23. The downward pointing arrows show examples of sound type 13; the upward pointing arrow shows an example of a whale call (∪-shaped undulation).

TABLE 2.4. Comparison of bowhead whale call counts via DASARs EB (EBa in 2006) and CC (CCa in 2005) combined in 2001–2006. 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

[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. For each year, these values consider days when both of these DASARs were operating.

[b] In **2000**, the DASAR array was 1 n.mi. farther north than in 2001–2006, with no functional DASAR near EB. The recorders closest to DASAR CC were SW1 located 1850 m north of CC, and SW2 ~4650 m 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.

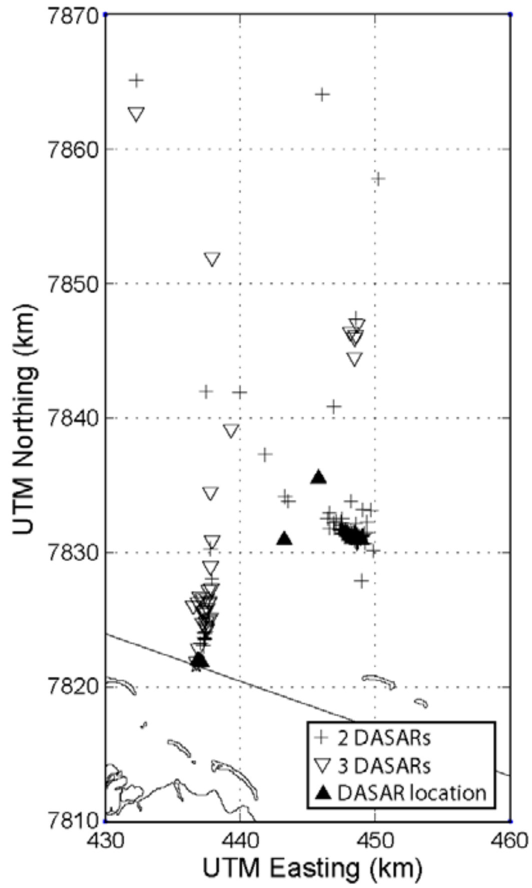

FIGURE 2.14. Estimated locations of all analyzed sounds of type 13 that were detected by two or three DASARs.

was closest to the EB locations of previous years.) Also, to allow comparison of 2006 values with all previous years, Table 2.4 only shows counts for DASARs EB and CC. (CA could not be deployed in 2005 due to ice.) The mean number of calls detected per day was calculated using only days when both recorders 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; and 2006: 18 out of 18 days). The percentages of calls detected at CC and EB add up to more than 100% because some calls were heard by both DASARs. Note however that when expressed as a number of calls per day, the 2006 number was slightly higher than the 2005 number for the same DASARs (Table 2.4).

In 2006 there were a total of 1887 separate call detections at the four offshore DASARs. DASAR CA detected close to twice as many calls as the other three DASARs: 773 (41.0%), versus 386 (20.5%) via CC, 332 (17.6%) via EBa, and 396 (21.0%) via EBb. (The number of call detections is higher than the total number of whale calls shown in Table 2.4 because some of the calls were detected by more than one DASAR.) The percentages of calls detected by 1, 2, 3, and 4 DASARs were 86%, 6%, 6%, and 2%, respectively. The percentage of calls detected by a single DASAR was much higher in 2006 (86%) than in previous years. In 2004, for example, only 22% of calls were detected by only one DASAR (Blackwell et al. 2006b). In 2005, the other year when a 4-DASAR array was deployed, 65% of calls were detected by only one DASAR. The low percentage of multiple-DASAR detections in 2005 and 2006 was partly a function of the lower number of DASARs used in those years. In 2005, exceptionally high mean wind speeds resulted in background sound levels that were higher than normal, and that could have contributed in part to a low percentage of multiple-DASAR detections. However, this was not the case in 2006.

Figure 2.15 shows the call detection rate for the entire 2006 season, considering calls from DASARs EBa, CC, and CA combined. The highest rate of call detection for the three DASARs combined was 67 calls/hour on 11 Sept. 2006, which was about half of the maximum in 2005 (112 calls/hour), but at about the same date (13 Sept. in 2005). In 2006 there were three peaks in call detections: one early in the season (9–11 Sept.) and two late in our field season (19 and 23–24 Sept.), which corresponds to the middle of the bowhead migration season in the fall. Note however that the numbers involved are so small that interpretation of these peaks is difficult.

Figure 2.16 compares daily number of calls detected by DASARs EB and CC combined in 2006 and in previous years. In 2001, most of the calls were detected in the first part of the season, before 15 Sept., whereas in 2002, 2003 and 2004 most of the calls were detected after 15 Sept. (This is the later part of our field season but the middle part of the bowhead migration period, which extends until mid- to late-October.) The two years with the largest call counts (2003 and 2004) showed three peaks (Fig. 2.16): a small peak in early Sept., a second peak in mid-Sept., and a third (and largest) peak on 21 Sept. Similarly, 2005 and 2006 exhibited several peaks over the course of the season: 7, 14, and 20 Sept. in 2005, and 11 and 23 Sept. in 2006. One must keep in mind, however, that sample sizes in 2005–2006 and 2003–2004 differ by nearly two orders of magnitude.

Figure 2.17 shows the number of whale calls detected by DASAR EB as a function of mean wind speed, for each hour of available data in 2002, 2003, 2005, and 2006. (2002 and 2003 are example years with low and high call counts, respectively.) Hours during which the acoustics vessel was in the DASAR array were not included. In 2005, this Figure was included to help us gauge the contribution of strong wind conditions to the low whale call counts in 2005, since strong winds raise ambient noise and decrease the detectability of calls. In 2006, mean wind speeds were quite low (e.g., no hours with mean speed above

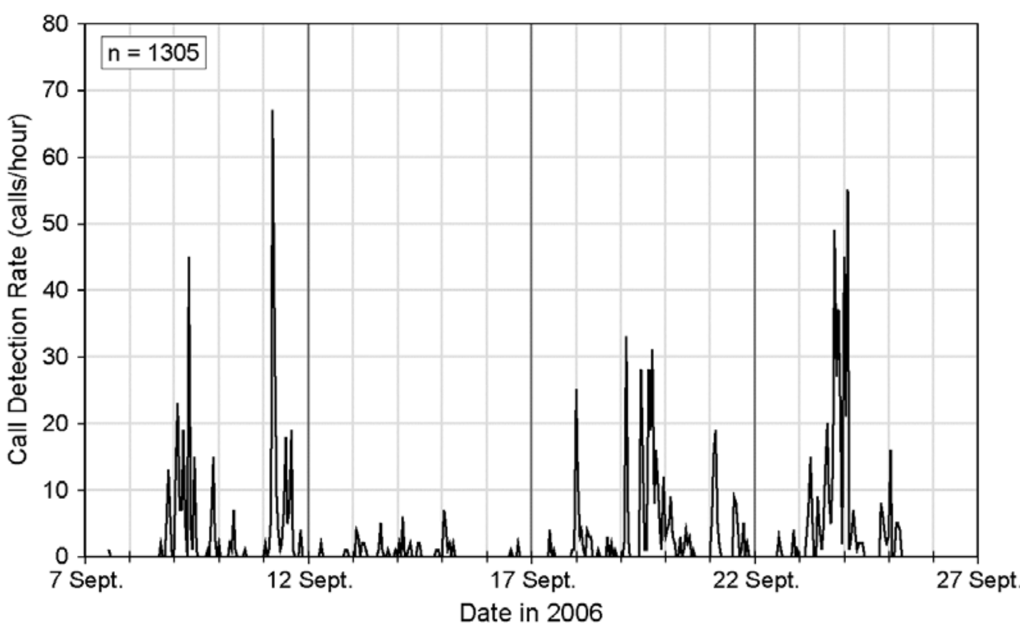

FIGURE 2.15. Hourly detection rate of whale calls as a function of time in Sept. 2006. Includes all calls detected via DASARs EBa, CC, CA, and the near-island DASARs except those occurring while the acoustic vessel was in the array. Total number of calls considered in this diagram was 1305. Tick-marks on X-axis represent midnight. The highest call detection rate was 67 calls/hour on 11 Sept.

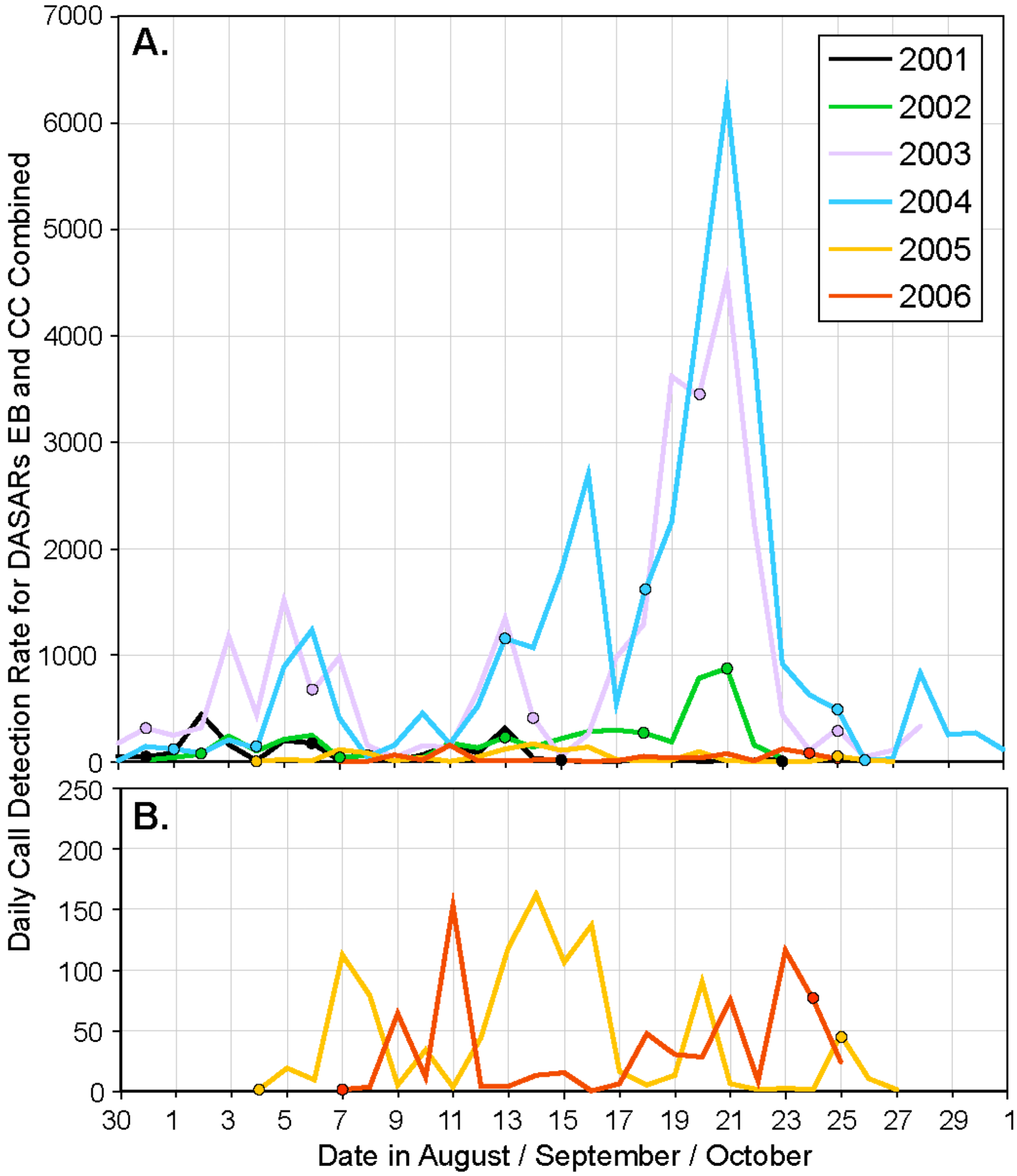

FIGURE 2.16. Daily number of bowhead calls detected by DASARs EB and CC combined for the entire 2001–2006 seasons. ***(A)*** 2001–2006, and ***(B)*** 2005 and 2006, on an enlarged scale. Daily counts marked with a dot indicate days when the acoustic vessel went into the area of the DASAR array to service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

12.1 m/s, see Fig. 2.17) and therefore cannot be a strong contributing factor to low call counts. For any one narrow range of wind speeds, call detection rates can be compared directly from one year to the next. Figure 2.17 shows that, for particular wind speeds, call detection rates were low in 2002, and comparatively very low in 2005 and 2006.

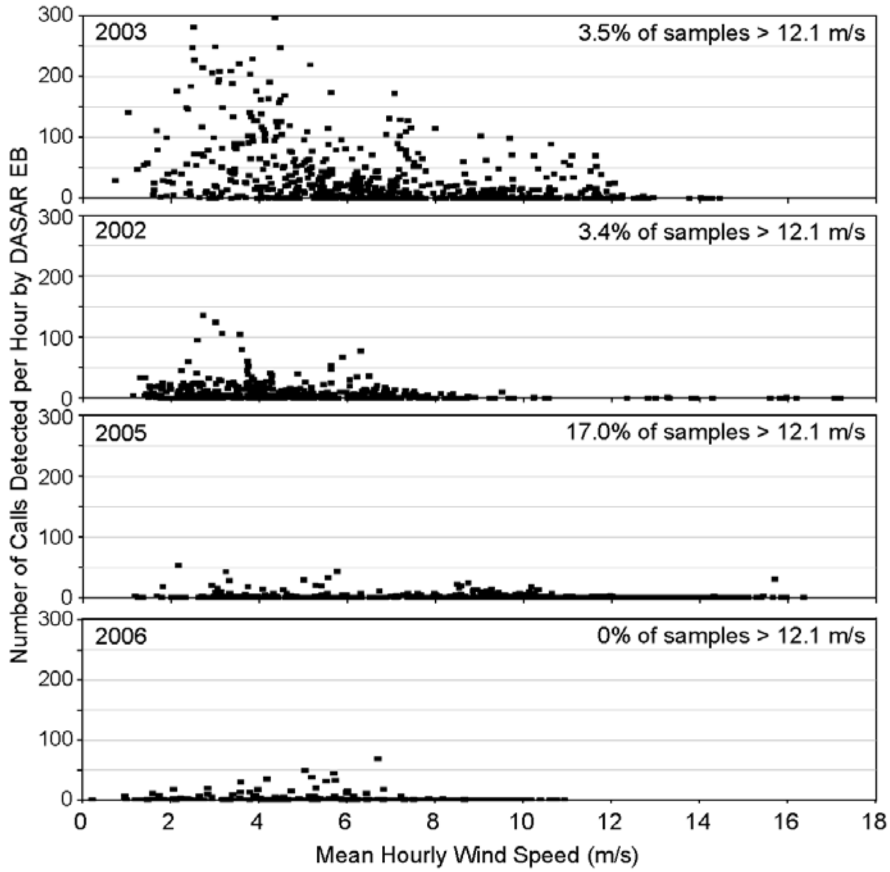

FIGURE 2.17. Hourly number of bowhead calls detected by DASAR EB as a function of mean hourly wind speed recorded at Northstar Island for 2003, 2002, 2005, and 2006 (in order of decreasing numbers of calls).

The analysis of all the records from DASARs placed offshore in 2006 (and other years) supports the general conclusion that 2005 and 2006 were years with low call-counts. In 2006, the mean number of calls detected per day by the combined DASARs EB and CC was 35% of that in 2001, 18% of that in 2002, 3–4% of the numbers detected in 2003 and 2004, and 109% of that in 2005.

Bearing Analyses and Call Locations

In 2006, the DASARs did not move on the sea floor during the deployment, so we have location information for all whale calls that were recorded by two or more DASARs, i.e., for 214 of the 1509 calls detected by one or more of the four array DASARs. Figure 2.18 shows the estimated locations of these 214 calls in relation to Northstar and the four-DASAR array. It should be noted that uncertainty in these estimated locations increases with increasing distance from the DASARs. Uncertainty in radial distance from the DASARs is greater than uncertainty in tangential position (McDonald et al. 2006, Annex 9.1).

Table 2.5 summarizes some of the main results of the bearing analyses. EB is the only DASAR location for which six consecutive years of bearing data exist. In 2005, bearings from CCa could not be relied upon because that DASAR was moved by currents between successive calibrations of its compass, and CA was not deployed due to ice. Considering all six seasons (2001–2006), vector mean bearings to the whale calls detected by these DASARs were most often in the range NNW through N to E (i.e., offshore). Out of the 16 vector mean bearings shown in Table 2.5, 15 are between 288° and 360° or between 0° and 108°, i.e., on

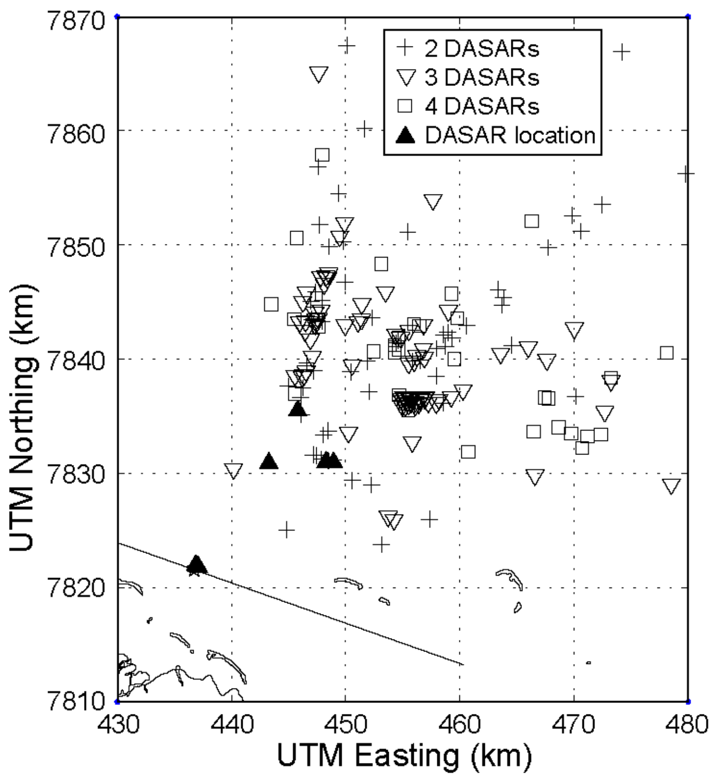

FIGURE 2.18. Estimated locations of all whale calls that were detected by two, three or four offshore DASARs in 2006.

TABLE 2.5. Results of the bearing analyses for DASARs EB (EBa in 2006), CC, and CA in 2001–2006. 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. See text and Figure 2.4 for definitions of offshore and inshore, and Figure 2.1 for a map of DASAR locations.

	EB			**CC**			**CA**		
	α (°)	**L**	**O/I**	**α (°)**	**L**	**O/I**	**α (°)**	**L**	**O/I**
2001	44	0.65	6.5	61	0.39	2.0	72	0.36	1.7
2002	64	0.74	21.4	51	0.66	42.4	42	0.55	10.7
2003	78	0.55	2.9	66	0.54	6.4	104	0.39	1.0
2004	69	0.42	2.9	67	0.52	6.2	109	0.32	1.0
2005	348	0.14	1.3	-	-	-	-	-	-
2006	33	0.46	4.6	308	0.04	1.2	38	0.45	4.2

the offshore side of the baseline. For all DASARs, 2002 was the year with the longest mean vector length (L), i.e., the strongest tendency for calls to be toward the NE–ENE direction 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 2005 the length of the mean vector (L) was very small for EB (0.14, see Table 2.5), indicating that calls detected by DASAR EB were more evenly spread in all directions than in previous years. In 2006 CC's L value was very small (0.04) whereas EB's L value was back to where it was in 2003–2004, when the migration corridor was closer to shore than in 2001–2002. In 2006 the O/I ratio for DASARs EB, CC, and CA was in the range 1.2–4.6, i.e., there were 1.2× to 4.6× more calls offshore than calls inshore. These numbers are in the range of previous years, except for 2002 which had distinctly higher O/I ratios (10.7–42.2, see Table 2.5).

Figure 2.19 shows the percentage distribution of all bearings obtained via DASAR EB in each year from 2001 to 2006. 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° were rare that season, whereas bearings in the range 85°–105° were most common. In terms of their general orientation, DASAR EBa's bearings in 2006 were similar to those in 2001. The 2006 season was similar to 2005 in the presence of ice and the low whale call counts, but the distribution of the bearings was quite different (Fig. 2.19).

Figure 2.19 shows that in 2001–2004 and 2006 the vast majority of bearings from DASAR EB to calls were in the 20°–120° range, i.e., ~NNE to ESE. This is not what we would expect if the whale calls were omnidirectional and the whale calling rate was constant as they swam through the DASAR array past Northstar. This skew towards the east was also seen in DASARs CC and WB in 2001–2004 (not shown), except for DASAR WB in 2001 for which the skew was in the opposite direction (40% of bearings were in the 265°–275° range). It is unlikely that the DASARs would have a bias towards picking up signals from the east if the calls are equally strong "ahead of" and "behind" the predominantly westbound whales. There is some equally indirect evidence of call directionality for bowheads migrating in spring (Clark et al. 1986). The remaining hypothesis, that there is some difference in whale behavior to the west vs. east of the DASARs, has recently received some support. Based on an analysis of bowhead calls in 2001–2004, Blackwell et al. (in prep.) showed that calling rates were significantly higher to the east of Northstar than to the west, with the boundary between "east" and "west" being a line going from Northstar through the center of the DASAR array as deployed in those years, i.e. through DASARs SW, CC, CA, and NE (see Fig. 2.1).

It should be noted that in 2003, 2004, and (to a lesser degree) 2002, a large percentage of the bearings from DASAR EB to calls were inside the "buffer zone" (see Fig. 2.4 and 2.19), i.e., alongshore, and therefore are excluded from the calculation of the O/I ratio. The percentage of such calls was ~17% in 2002, 24% in 2003, and 27% in 2004, but only 10% in 2006.

Call Types

Figure 2.20 shows a percentage breakdown of all bowhead whale calls detected by DASARs EB and CC by call type for 2001–2006. 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. For downsweeps, constant calls, ∪-shaped undulations, and complex calls, the percentages in 2006 were within the ranges of values obtained in previous years. Two call type percentages changed in 2006 (Fig. 2.20): the percentage upsweeps decreased to 12.5%, the lowest value recorded (max = 27.4% in 2003), and the percentage of ∩-shaped undulations nearly tripled compared to any previous years, reaching 31.4% (previous max = 11.5% in 2005).

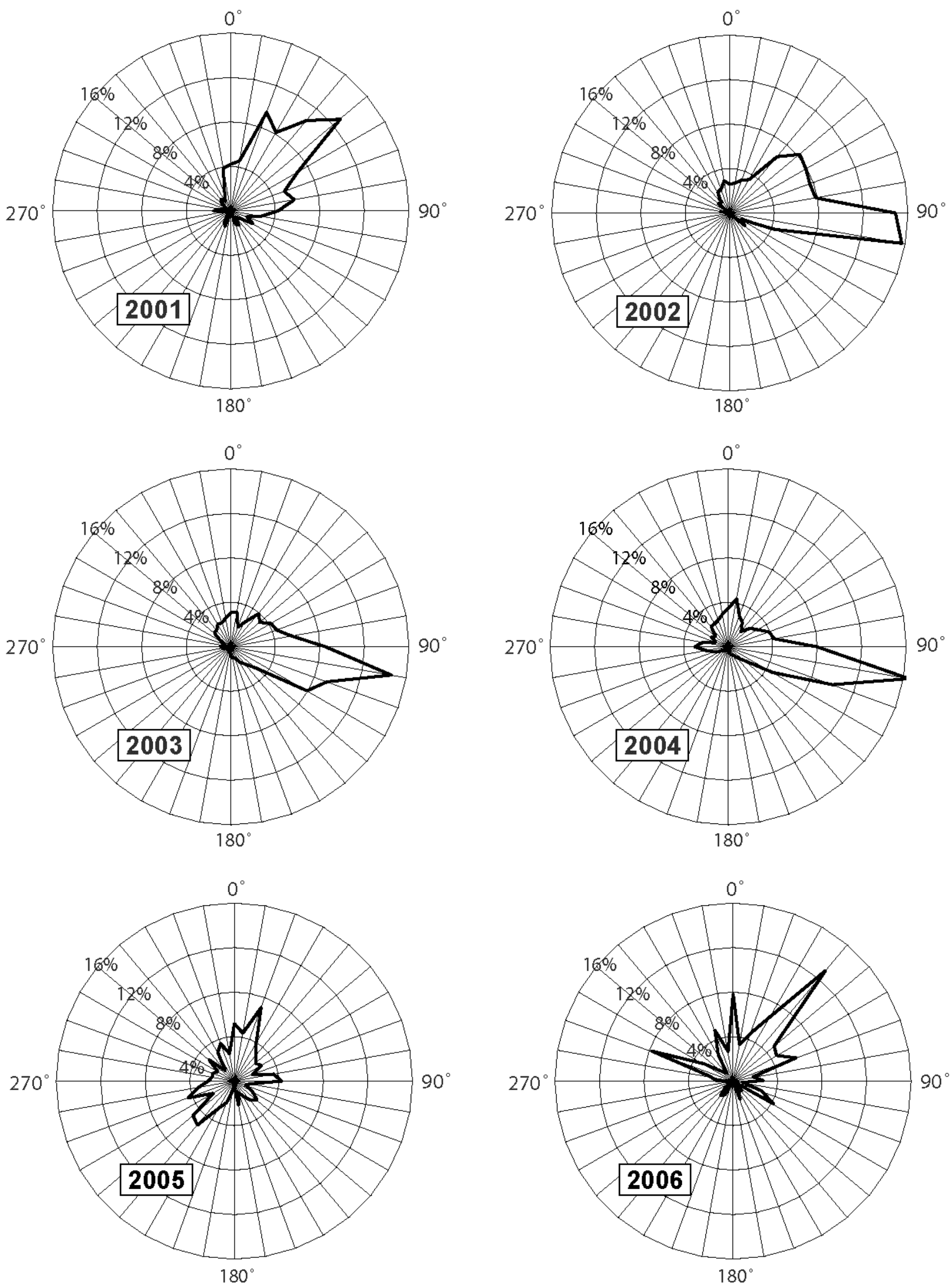

FIGURE 2.19. Directional distribution of bearings to bowhead whale calls detected via DASAR EB in 2001–2006. Results for each 10° sector are expressed as a percentage of all bearings obtained via DASAR EB that year. Sample sizes vary widely, from ~330 in 2006 to ~26,500 in 2004, and can be obtained from Table 2.4 by applying the “percentage detected by EB” to the “total detected by EB and/or CC”.

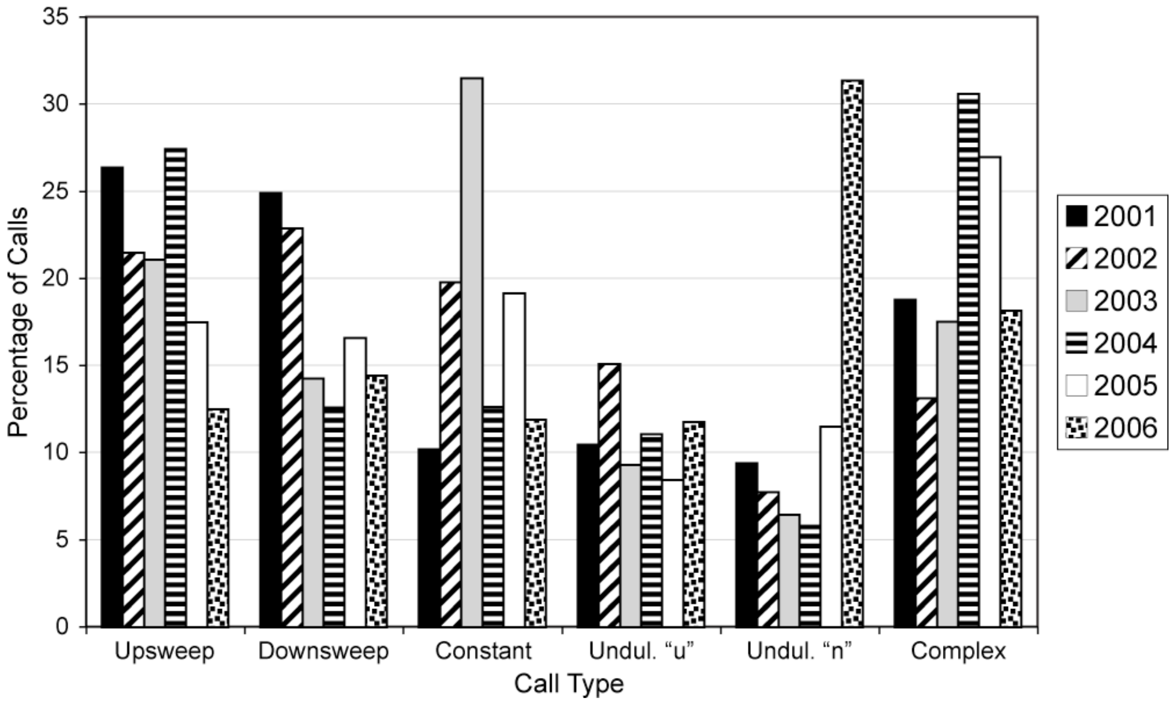

FIGURE 2.20. Percentage breakdown by call type in 2001–2006 for calls detected by one or more of DASARs EB and CC. Simple calls include upsweeps, downsweeps, constant calls, "∪" undulations, and "∩" undulations. Call sequences, which were detected only in 2004, were not included in these percentages.

DISCUSSION

Underwater Sounds at Northstar

Figure 2.10 shows that boat traffic to Northstar Island during the monitoring period in 2006 was increased compared to 2005. (The same was true for the open-water season as a whole—see Chapter 1.) Both tugs and ACS "Bay" boats made more daily round trips to the island, on average, than in 2004 or 2005. Round trips to the island by the hovercraft also increased, with ~3 and ~7 times more trips during the monitoring period in 2006 than in 2005 and 2004, respectively. While cruising, the hovercraft causes increases in sound levels underwater that are short enough that they do not register on the sound pressure time series, as recorded by the near-island recorders (Blackwell and Greene 2005). For that reason the hovercraft does not count as a major sound source around Northstar, and only the tugs and ACS vessels need to be considered. We do not know the reasons for the increased boat traffic to Northstar, but they probably have to do with increased maintenance activities or other projects on the island. Also, the weather was so poor (because of wind) during the 2005 open-water season that some island activities may have been postponed until 2006. Annex 1.1 (in Chapter 1) includes a message sent by Dr. Bill Streever of BP to Northstar personnel about vessel sound issues.

Figure 2.10 also shows that after three yearly increases in mean wind speeds (2001–02, 2002–03, and 2004–05), 2006 was a calm year with few days of stormy weather. As a result, 2006 had the lowest and second to the lowest 50^{th} and 95^{th} percentile levels of sound since the beginning of the island sound monitoring in 2001. The maximum percentile level was also amongst the lowest in 2006, but this does not have much significance since maximum levels are mainly determined by boats.

The statistical spectra shown in Figure 2.7 are similar to those obtained in previous years (see Fig. 2.8 in Blackwell et al. 2006a, Fig. 8.9 in Blackwell et al. 2006b, Fig. 7.16 in Blackwell et al. 2006c, Fig. 6.19 in Blackwell 2003, Fig. 7.19 in Blackwell and Greene 2002, and Fig. 7.31 in Blackwell and Greene 2001). Comparison of these spectra between years is based on the lower percentiles (i.e., minimum and 5th percentile), because those are the least affected by ambient sounds, which are strongly dependent on wind conditions in the year in question. The "5-band ISI" is 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, because in the past these one-third octave bands appeared to be dominated by industrial components. For consistency, the ISI in 2006 was calculated as described above, even though levels in the one-third octave bands centered at 25 Hz and 20 Hz were higher in 2006 than that centered at 80 Hz.

In 2006, broadband (10–450 Hz) sound levels recorded 15 km (9.3 mi) from Northstar at the DASAR EBa location (Fig. 2.11) 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. For 2006, the sound pressure time series shown in Fig. 2.11 contains very few spikes of the type we usually associate with the passage of a vessel. This certainly has to do with the pack ice, which covered the area of the array to some extent for all, or nearly all of the deployment period, and therefore limited boat traffic. The presence of ice also helps explain the small size of the spike created by the acoustic vessel on 24 Sept. during calibrations, as travel speed among ice floes was much reduced compared to that in open water conditions.

Whale Calls and Locations

The fall migration of bowhead whales has been monitored acoustically offshore of Northstar Island since 2001. In the first four 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 2006 season was the second year of the modified effort. The modified effort was designed to allow comparisons with data collected in previous years. However, the two recent years with a modified monitoring effort also happen to be years with ice conditions that were very different from those experienced in the first four years of the study. This makes it more difficult to compare data collected with the original (2001–2004) and modified (2005–2006) procedures.

Based on the call counts presented in Table 2.4, 2006 was very similar to 2005. At first glance it seems call counts in 2005 were higher, but that is because the 2006 season started late (~7–9 days later than usual) and ended early (~3–8 days earlier than usual). In 2006, deployment of the offshore DASARs was delayed by ice. However, conditions at the start of the potential retrieval period were good, so retrieval was relatively early. Daily call counts at DASARs EB and CC combined were virtually the same in the two years (35 and 38 calls / day for 2005 and 2006, respectively). Wind and sea state conditions in 2005 were generally poor. This provided a possible explanation for lower call counts, i.e., high ambient noise masks calls and makes them harder to detect. In 2006, however, wind and sea state conditions were comparatively very good, so other factors contributed to the low call counts.

The location of the bowhead whale migration corridor varies from one year to the next and it may have tended to be farther offshore or more scattered in 2005 and 2006 compared to some previous years. 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 showed that, in 2004, bowhead whales were sighted on average closer to shore than in previous years (1982–2001; Monnett and Treacy, 2005). Early in the 2005 season (early September), MMS aerial surveyors sighted bowheads north of the area of drifting ice, i.e., several to many miles north of Northstar. Later in the 2005 season very few flights could take place because of the poor weather conditions. Thus sample sizes over the season were low and it may not be possible to meaningfully compare distances from shore in 2005 vs. previous years (C. Monnett, MMS, pers. comm.). When available, the MMS aerial survey data for 2005 and 2006 will be useful in documenting the overall position and width of the migration corridor in 2005 and 2006 compared to 2001–2004.

The distribution of bearings to whale calls from DASAR EB in 2006, as shown in Table 2.5 and in Figure 2.19, was most similar to that in 2001 and quite different from that in 2005, the other year with low call counts. In 2006 calls were mainly coming from the NE, with 51% of calls in the 0–90° quadrant (N to E). The distribution of call locations, shown in Fig. 2.18, has one striking feature: the complete lack of detected calls west of Northstar's longitude, and the very low number anywhere west of the DASARs. Very few calls were detected west of UTM Easting 445 km in Figure 2.18; Northstar is at UTM Easting 437 km. This is very different from the distribution of calls in 2002, 2003, and 2004 (see Fig. 9.4 for 2002, Fig. 7.21 for 2003, and Fig. 8.18 for 2004, all in Richardson [ed.] 2006), but somewhat reminiscent of the distribution of calls in 2001 (Fig. 9.3 in Richardson [ed.] 2006). In 2001, like 2006, the total number of calls detected was low, and the proportion of those that were west of Northstar's longitude was very low.

As was hypothesized for the 2005 season, it is likely that the presence of ice in 2006 was important in causing the low call counts. Figure 2.21 shows an ice map from 12 Sept. 2006, with an arrow pointing towards Prudhoe Bay and with Northstar indicated by a black star. The map shows extended ice coverage along the coast offshore of Northstar, with a band of denser ice (yellow, 40–60% coverage) surrounded on both sides (N and S) by less dense ice (green, 10–30% coverage). The ice maps did not change much during the course of the 2006 field season. It is therefore conceivable that most migrating bowheads would avoid the ice and migrate in open water ~25 n.mi. (~46 km or 29 mi) from shore when near our study area on 12 Sept. Using aerial survey data, Moore (2000) and Treacy et al. (2006) have shown that bowheads tend to select shallow inner-shelf waters close to shore during years with moderate and light ice, and deeper slope habitat farther from shore in heavy ice conditions.

The Nuiqsut whale hunters on Cross Island are always a good source of information on the abundance of bowhead whales during the fall migration. For the 2006 whaling season (2–22 Sept.) the whalers reported that very few whales (~4) were seen during scouting days in early Sept., when ice confined the whalers within the barrier islands. Starting on 10 Sept. the whalers were able to reach the open water beyond the barrier islands (see Fig. 2.21), where they saw more whales. The whalers thought that the presence of ice pushed the migration farther north than in years with open water conditions. Nevertheless, they caught their quota of four whales, whereas in 2005 they were never able to get north of the pack ice and only caught one whale. More information on this topic is given in Chapter 3.

The call type analysis (Fig. 2.20) showed two major changes in call type percentages in 2006 compared to previous years: a large decrease in upsweeps and a large increase in ∩-shaped undulations. Because little is known about the behavioral significance of bowhead call types, these changes are difficult to interpret. However, the presence of "sound type 13" (see Results) in 2006 may have something to do with the increase in ∩-shaped undulations. It is conceivable that some additional cases of "sound type 13" over and above those shown in Figure 2.14 could have been mistakenly classified as ∩-shaped undulations produced by bowheads. If there were 150 misclassified ∩-shaped undulations (only ~5% of the number of type 13 sounds identified before the analysts stopped tagging these sounds in the DASAR records), that would account for the unusually high percentage of ∩-shaped undulations in 2006.

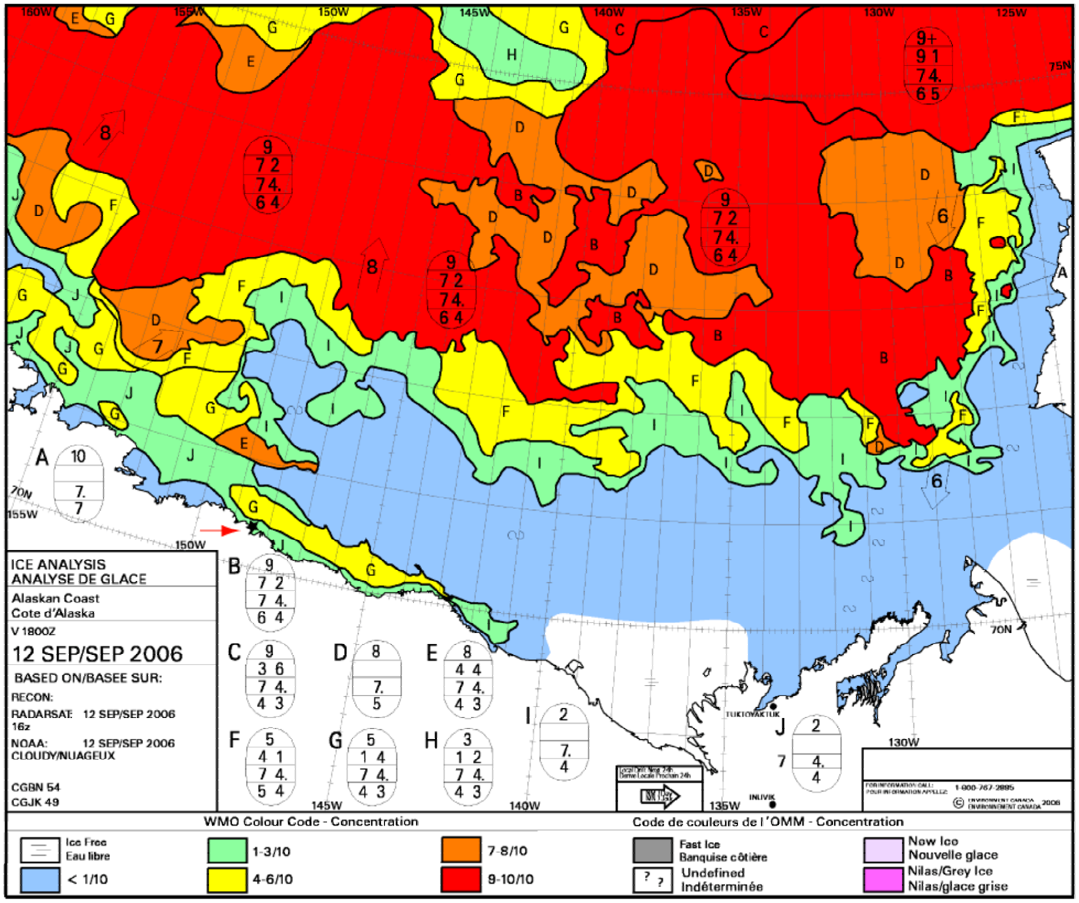

FIGURE 2.21. Ice chart for the Beaufort Sea as of 12 Sept. 2006. The red arrow points toward Prudhoe Bay and Northstar is shown as a black star. Colors indicate the percentage ice cover, with blue <10%, green = 10–30%, yellow = 40–60%, orange = 70–80%, and red = 90–100%. Source: Environment Canada.

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 (Blackwell et al., in prep.). 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 2006 was a modified version of the project as implemented in 2001–2004, but was similar to the implementation in 2005. It provided the data needed to characterize sounds from Northstar Island during much of the 2006 bowhead migration period, including a comparison of their levels and frequencies with previous years. Counting whale calls at three DASAR locations in 2006 provided data that were directly comparable with previous years. The 2005 season was considered an outlier year because of low call counts and high mean wind speeds. The 2006 season was similar to 2005 in terms of call counts, but mean wind speeds were within the range seen in previous years.

Sound emissions associated with Northstar activities in 2006 were probably somewhat higher than in 2005, and this difference would mainly be attributable to extra boat traffic rather than island sounds *per se*. Nevertheless, sound emissions associated with Northstar activities in 2006 were below sound emissions in 2001, 2002, and 2003. The number of whales deflected offshore in response to Northstar operations in 2006 cannot be estimated by the methods that have been applied to the more extensive datasets acquired in 2001–2004. However, if the overall migration corridor in the central Alaskan Beaufort Sea was farther offshore in 2006 than in some other recent years, as various indicators suggest, then Northstar sounds would have been (on average) less audible to bowhead whales than at some times in the past. In that case, the number of whales deflected by Northstar-related sounds in 2006 would likely be toward the low end of the range for 2001–2004.

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CHAPTER 3:

SUMMARY OF THE 2006 SUBSISTENCE WHALING SEASON, AT CROSS ISLAND[1,2]

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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 2006 phase of the Minerals Management Service project "Annual assessment of subsistence bowhead whaling near Cross Island". Data analysis and additional interviews with the whalers focussing on specific aspects of the 2006 season relevant to BP's Northstar monitoring program supplemented those data. The interviews concentrated on whalers' encounters or concerns with non-whaling vessels in 2006, the whalers' observations of the general offshore distribution of whales, whale feeding behavior (if any), and "skittish" behavior.

In 2006, the first whaling crew went to Cross Island on 2 September, and the fourth and last crew arrived on Cross Island 3 September. Overall, reasonably good weather and seas marked the 2006 Nuiqsut whaling season, with only four scouting days lost to poor weather. Ice conditions limited the whalers' areas of activities early in the season. During the first four scouting days of the season, few whales were seen—no whales on one of these days, one whale on each of two days, and one or two on the fourth. The whalers saw non-whaling vessels on all four days of scouting activity. Once the ice conditions moderated, whalers could reach open water beyond the barrier islands, saw more whales and did not report seeing non-whaling vessels. They went out scouting a total of ten days. They saw whales on eight of them, and took single whales on each of the last four days on which they went out scouting. The whalers called a cease fire on 18 September because they had completed their quota of four whales. They spent several days completing the tasks of butchering the whales, cleaning up the island, and packing, and left for Nuiqsut on 22 September.

In summary, the 2006 Cross Island hunt was quite successful. The full quota of whales was taken. Total whaling effort expended in 2006 was greater than in each of the previous three years (2003–2005) but less than in either 2001 or 2002. Whalers reported that ice conditions were apparently affecting the distribution of whales, but other than requiring more effort and longer trips, did not negatively affect the season. Sea conditions were not ideal, but again the weather cooperated at least enough to allow for a successful hunt. 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, although one of the single whales taken had mud on its jaw.

INTRODUCTION

During the autumn migration period of bowhead whales, subsistence hunters from Nuiqsut travel to Cross Island, 17.5 miles (28 km) 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). 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. 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 agreed to augment the ongoing MMS-supported program during 2005 and 2006, to compile the specific types of information mentioned by the SAC.

This chapter of BP's 2006 Annual Summary Report describes information provided by the Nuiqsut subsistence whalers on selected aspects of the 2006 whaling season. This included the general offshore distribution of whales in 2006, 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 2006 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 2006 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).

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 2001–2006. 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. 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 is then mapped, and 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 position at the time a whale or group of whales was seen. These whales may be quite close or miles away (depending on the conditions of the day).

This information was supplemented by subsequent conversations with each boat crew, while reviewing the mapped GPS information on a laptop computer with them. When reviewing tracks after their return, crew members would often identify locations where they saw whales, and these points were added to the GPS information. Some of these points were boat positions, and some were estimated positions of whales (and thus not on a boat track). Other points were reference coordinates and may represent past whale sightings, so they also may not be 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 focussed 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 following material is understandable. For a broader review, see Stoker and Krupnik (1993) or Rexford (1997).

The community of Nuiqsut is located about 16 miles 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 10 miles north of Endicott, 15 miles NW of West Dock, and 17 miles east of Northstar (see Fig. 1.1 in Chapter 1). There are currently four to six active whaling crews in Nuiqsut. 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 18 to 24 feet long, with either aluminum or fiberglass hulls, and single outboard motors of 70 to 250 horsepower. The bylaws of the Alaska Eskimo Whaling Commission 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 (although this pattern may be changing – see discussion of the 2006 season below). Whalers invariably use the term "scouting" rather than "hunting". 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 5 mph, or even 10 mph, are acceptable. Sea conditions generally correspond with wind speed. 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 single boats do take whales on occasion, it is not encouraged and Nuiqsut boats almost always scout for whales with at least one other boat, in case of mechanical break downs or other emergencies. Whaling crews with two or three boats are willing to whale on their own, but it is commonly agreed that five to seven boats is a preferable number to have available for whaling on a given day (but again, see the discussion of the 2006 season below). More boats would be useful, and 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 25 to 35 feet 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 approach it so that it dives again, and so on. 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 finally get close enough to the whale while it is on the surface to strike it 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: via a darting gun attached to a harpoon, or via 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 10 or 15 feet, 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 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 fins or quarrels to help stabilize its flight in the air (the more recent "super bomb" can only be used on the darting gun, and not with the shoulder gun). 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 several bombs, as long as the barrel is cleaned after each shot.

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 knifes 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	Hammerhead prospect drilling (also 1985); Corona drilling
1987	?	1	0	
1989	2	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; industry effects (Galahad)
1992	3	2	1	Kuvlum prospect drilling
1993	3	3	0	Very favorable whaling conditions; Kuvlum prospect drilling
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 conditions; 8 or 10 d season to fill quota
2001	4	3	0	
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, disruption by vessels
2006	4	4	0	Adverse ice conditions first half of season

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) specifically 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 2001–2006 whaling seasons.

THE 2006 WHALING SEASON

Four crews whaled from Cross Island in 2006. Some crews initially thought that they might leave for Cross Island late in August, but they in fact did not do so. The researcher (Galginaitis) accompanied three of the crews out to Cross Island on 2 Sept. The fourth crew arrived on Cross Island on 3 Sept. All crews left Cross Island on 22 Sept., although one boat experienced electrical problems and did not arrive in Nuiqsut until 23 Sept. Each of the four crews took a whale, so Nuiqsut whalers harvested their full quota of four whales.

The whaling seasons for the four crews ranged in length from 20 to 22 days, counting travel days. The seasons for the individual crews were 20, 21, 21, and 22 days. Conditions during the 2006 season were much improved over those of 2005. Even though ice coverage was greater than in most years, there was less ice near Cross Island than in 2005, and whalers were able to navigate through the ice. The ice conditions in 2006 probably increased the distance traveled during scouting and thus the effort required to harvest whales as compared with an average year, but did not prevent the harvest of whales. The weather was also more moderate than in 2005. Winds were not as strong or constant as in 2005 and only four scouting days were lost due to weather. Wind readings from the Cross Island weather station were consistent with the wind information reported in Chapter 2.

At least one boat went out scouting for whales on 10 different days (and several small boats also went out without whaling equipment on short trips to hunt seals). The researcher was on Cross Island for the entire whaling season and was able to collect GPS tracks and whaler accounts for all scouting days, although not from all boats. The number of boats scouting on any given day ranged from 3 to 5. One crew scouted on all 10 days (with a total of 12 boat days). Two crews each scouted on nine separate days (and as each used only one boat, each had only nine total boat days. However, one of these crews also assisted in towing the whale taken on the day they did not go out scouting). The fourth crew scouted on eight different days (and used three boats for a total of 17 total boat days). Each crew devoted 2 days or (in one case) 3 days to travel to and from Cross Island. Various boats were disabled at times due to mechanical problems, and weather prevented scouting on four days. Ice and sea conditions limited scouting activities on some days when boats did go out scouting, especially early in the season.

Crews spotted whales on 8 of 10 scouting days, but only saw three or four whales during the first four scouting days (and no whales at all on one of those days). These four days (3 Sept. through 7 Sept.) were also those for which ice conditions confined the whalers within the barrier islands, and were the only days on which whalers reported seeing non-whaling vessel traffic (Fig. 3.1). During the next two scouting days (10 and 11 Sept.) whalers were able to reach open water beyond the barrier islands (Fig. 3.1). On 10 Sept., conditions (fog and rough seas) prevented the whalers from going far from the ice edge, and they did not report spotting any whales. On 11 Sept. they were able to go much farther from the ice edge and saw quite a few whales in total (at least 15 or so). On each of the last four scouting days (13 through 15 Sept., 18 Sept. – Fig. 3.1) a different crew each took a whale, and multiple whales were observed on all but one of these days. Thus, most of the whales seen during the 2006 season were seen on the last five days of scouting activity. Whalers thought that the ice cover probably pushed the whale migration farther from Cross Island than if there had not been much ice, and limited where the whalers could go for the first part of the season. The whalers reported observing barges on at least four days when they were scouting for whales (4 Sept. through 7 Sept.). None of these barges were engaged in Northstar-related activities and whalers did not indicate that these vessels had directly interfered with whaling activities. More detailed information on these barge sightings / interactions and whaler concerns is provided later in the chapter (see *Nuiqsut Whalers' Reports of Vessel Activities, 2006*).

Observed Whale Feeding Behavior In 2006

There were no reports of whale feeding behavior during the 2006 Cross Island whaling season. This does not necessarily mean that feeding did not occur, or that Nuiqsut whalers did not observe it. However, it is an indicator that whale feeding activity was not very obvious in 2006. Stomach contents from only two of the four whales taken were examined, and no samples were taken. One of these stomachs was quite full, and the other was nearly empty. Possible explanations for the relative lack of observed whale feeding behavior, not mutually exclusive, are as follows:

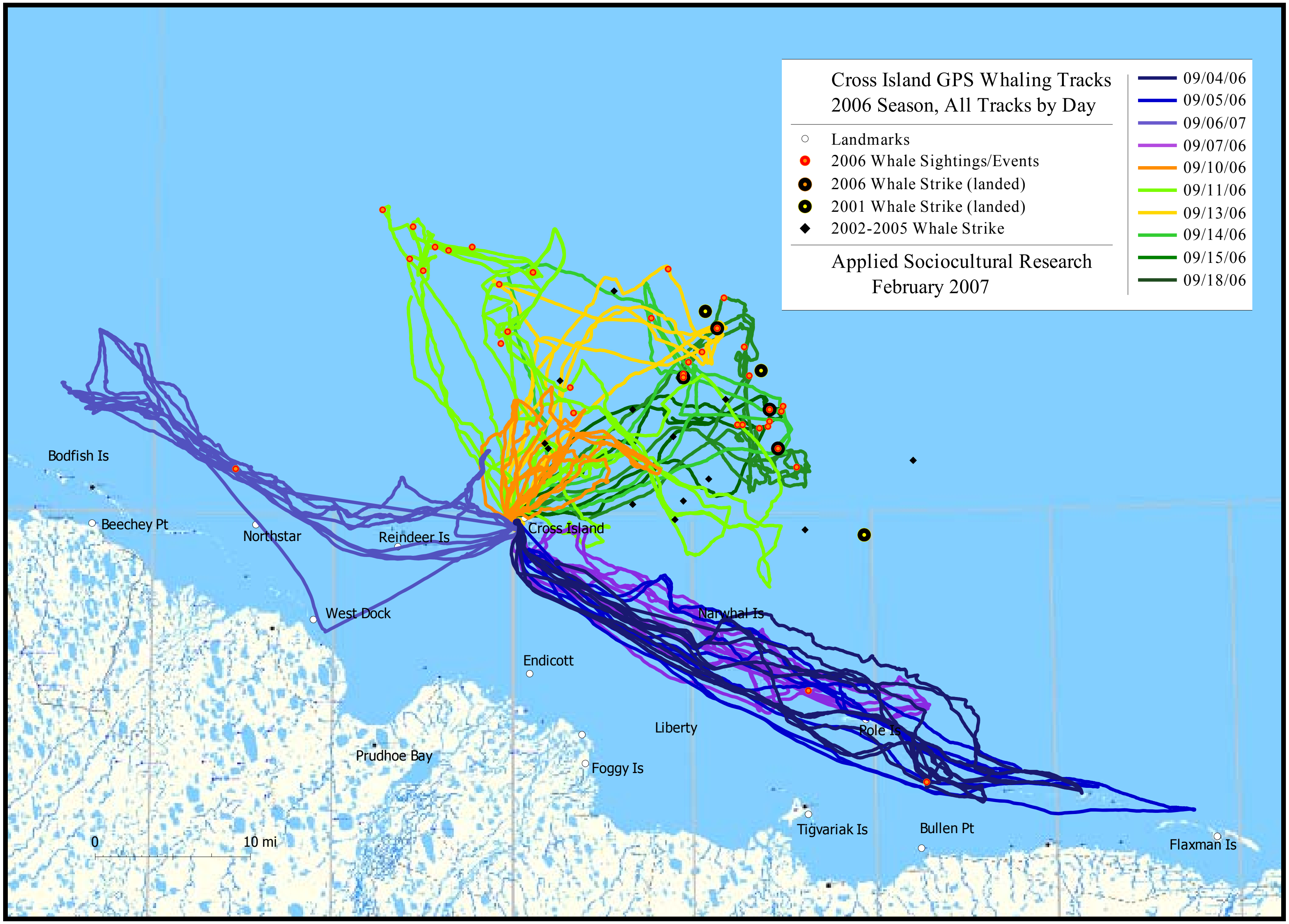

FIGURE 3.1. Cross Island GPS whaling tracks, 2006 season: All tracks by day.

- whale feeding is not commonly observed (or at least not reported) by Nuiqsut whalers near Cross Island (only one incident during the previous five years);
- few whales were observed by whalers on some days during the 2006 season;
- on some days when scouting was possible, ice conditions made it difficult to observe whales for more than the shortest periods of time;
- on some days when scouting was possible, swell and waves (due to wind) still 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;
- barge and other vessel activity may have "spooked" whales early in the season; and
- a major part of the migration may have bypassed the area accessible to the whalers.

For the five years previous to 2006, only one whaler observation of whale feeding was reported and recorded. This was a spectacular sighting, on 14 Sept. 2004, of a whale feeding on the surface with its mouth open, about 7.8 miles (12.6 km) from Cross Island, bearing 34° True. The captain, a very experienced whaler, remarked that this was the first time he had seen this behavior. This does not necessarily indicate that Nuiqsut whalers observed no whale feeding behavior on other occasions in 2001–2006 when scouting for whales. However, it probably means that such observations were not common. If other sorts of feeding behavior had been observed during 2001–2006, they probably would have been reported.

Most feeding by bowhead whales is below the surface and difficult to recognize via surface observations. However, 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). Those authors have also observed cases of bowheads feeding near the bottom and stirring up mud. 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.

"SKITTISH" WHALE BEHAVIOR DURING 2006

For the most part, Nuiqsut whalers reported that, in 2006, when they found whales and could reach them, they were able to follow the whales. However, a few whales were described as appearing to be "spooked" from the time the whalers first saw them. A "spooked" whale may 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 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.

On the first five scouting days (from 4 to 10 Sept.), relatively few whale observations were reported and some of those were described as "spooked". On the last five scouting days (11 to 18 Sept. period), when the most whales were seen, there were also reports of "spooky" behavior. Whether there was a difference in the frequency of "spooked" whales between the first and second parts of the season would be difficult to assess, since so few whales were seen in the first part of the season. Overall, the whalers did not elaborate on possible explanations for the "spooked" behavior and did not make a distinction between the first and second parts of the season in this regard. However, some possibilities (not mutually exclusive or all inclusive) suggested at various times by whalers as possible general explanations for "spooky" behavior suggest that whales could have been expected to be somewhat more "spooky" early in the season

- ice cover persisted throughout the season, but was much more extensive early in the season and confined the whalers, other vessel traffic, and perhaps whales within a relatively confined area;
- non-whaling vessel traffic was much more evident to the whalers in the early part of the season; and
- a higher proportion of the whales seen in the first part of the season were solitary whales — solitary whales may exhibit more "spooky" behavior than do bowheads accompanied by other whales.

In 2001, when whalers reported that whales seemed to be more skittish than normal, they suggested several possible explanations. 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, 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.

The two years (2001 and 2006) were very different in terms of environmental conditions. In ***2001***, there was almost no ice and the whales found by whalers were quite distant from Cross Island. Whalers went far to the NW and NE of Cross Island when scouting for whales in 2001. Acoustic monitoring in 2001 also found that the whales were farther offshore in that year than in some subsequent years—specifically 2003 and 2004 (Richardson [ed.] 2006; Blackwell et al. MS). In ***2006***, Nuiqsut whalers took their whales in that same offshore area (Fig. 3.1), even though ice made this area more difficult to reach in 2006 than in 2001. The whalers suggested that the whales were there in 2006 because the ice conditions prevented their being much closer. In 2001, "spooky" behavior was the more prevalent explanation. Whalers gave the impression that whale sightings were more abundant in this area during 2006 than in 2001 (Fig. 3.1).

GENERAL OFFSHORE DISTRIBUTION OF WHALES, 2006

Although conditions for whaling were much better in 2006 than in 2005, there were still relatively few days on which whalers were able to travel to open water and find whales (5 of 10 scouting days). Of these five days, they saw a good number of whales on only four days (11, 14, 15, and 18 Sept.). Single whales were taken on four days: one whale was taken per day on the three days when good numbers of whales were seen, and one whale was taken on a day (13 Sept.) when it was the only whale seen that day. On some days "surf waves" (large rolling waves) made it difficult if not dangerous to travel in the open water. Also, waves (and fog) can make spotting blows and whales difficult. The whalers did not suggest that there were actually fewer whales in the general Cross Island area at those times. Rather, they theorized that the wedge of pack ice that prevented the whalers from going much north of Cross Island for much of the time also encouraged most of the migrating whales to stay well north of Cross Island, in more open water. This ice allowed the whalers to travel most easily to the SE of Cross Island, and this is the direction that most of their scouting trips took in the early part of the season (Fig. 3.1, 4 Sept. through 10 Sept.). It was only in the latter part of the 2006 season, when whalers were able to make their way through the ice and reach waters well north of Cross Island, that they were able to find a good number of whales and land their quota of four bowhead whales (4 Sept. through 18 Sept.).

The limitation of scouting trips to nearshore waters early in the 2006 season was a pattern very different from that in most other recent years, aside from 2005 when nearly all effort was restricted to the nearshore area and harvest success was low (Galginaitis 2006c). For years prior to 2005, most trips were either NW or NE of Cross Island, with a few more easterly and only a very few with a southerly component (Fig. 3.2). Most scouting activities (and almost all Nuiqsut whale strikes) in other recent years have been north of Cross Island (Fig. 3.2; see also Annex 3.2 at the back of this chapter). In 2006, it was only when whalers were able to make their way through the ice and reach the more offshore area that they were able to find and land a good number of whales to fill their quota (Fig. 3.1).

In general, Nuiqsut whalers report that significant ice cover allows whales to "hide" and thus makes them more difficult to spot. Significant ice cover also allows whales that are seen to escape more easily; it makes them more difficult to follow. Whales can dive under ice, whereas boats must travel around it. Thick ice cover, such as that encountered near Cross Island in 2005, may also direct most of the bowhead migration farther north into more open water, while at the same time effectively preventing Nuiqsut whalers from reaching or accessing those areas. When Nuiqsut whalers were able to reach the more open water to the north of the ice pack, they did find whales and were able to follow and chase them. Nuiqsut whalers believe that the migration of whales in 2006 was similar to that of previous years, but that ice and weather conditions prevented the whalers from reaching and seeing most of the whales. They also believe that many of the whales that they did see, at least in the area SE and E of Cross Island, were affected by non-whaling vessel activity in the area, and that this had a detrimental effect on the success of their subsistence whaling (see following section).

NUIQSUT WHALERS' REPORTS OF VESSEL ACTIVITIES, 2006

Annex 3.1, at the end of this chapter, summarizes the specific observations made by Nuiqsut whalers, during the 2006 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. Summaries are included only for those days on which vessel activity was reported, or for days on which whale scouting activity occurred. For days that are not listed, neither activity was reported. ACS vessel trips to Cross Island are not included in these summaries. Blows of whales were spotted from Cross Island on several days when whaleboats may not have gone out scouting. The log compiled by the Whaling Communications Center has not yet been consulted to verify some of the details of timing and locations. Based on the daily information in Annex 3.1, the following summary has been compiled, attempting to draw some generalizations from the daily information.

Whalers reported seeing activity by commercial vessels on four separate days during the 2006 whaling season, all of which were days when the whalers were actively scouting for whales (9/04, 9/05, 9/06, and 9/07). Although no barge activity was noted on 9/08, two private sailboats overnighted at Cross Island, having come from the east. They traveled west the next day. All five of these days were early in the 2006 whaling season, when ice conditions still confined the whalers inshore of the barrier islands and few whales were being seen. The supposition was that whales were staying in the open water beyond the ice, out of the reach of the whalers. Because of their experience in 2005, when they were able to reach the whales in the open water only during one day and part of another, and were disrupted in their whaling pursuit by commercial vessels, Nuiqsut whalers were very sensitive to the issue of such commercial traffic in 2006.

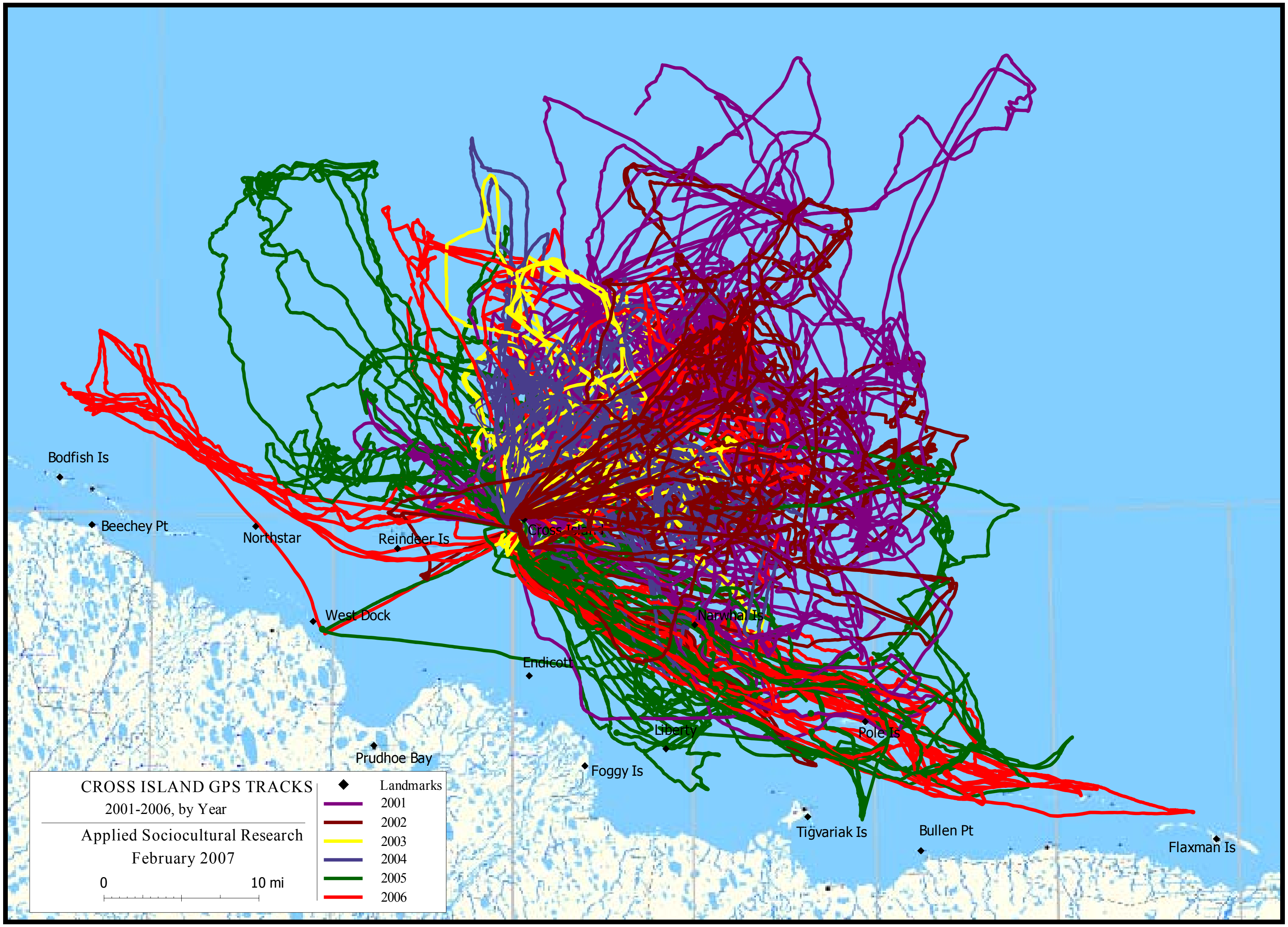

FIGURE 3.2. Cross Island GPS Whaling Tracks by Year, 2001-2006.

Thus, although the whalers did not report that the vessel activity of 4 Sept. through 7 Sept. disrupted their activities, they were concerned with the possibility that the few whales inside of the ice and barrier islands may be harder or impossible to spot and approach because of those vessels. Details concerning who was responsible for each such vessel, and what activity it was engaged in, were not immediately available to the whalers (or the researcher). The information that was available is summarized in Annex 3.1. Even though some of these vessel observations were made while the whalers were returning to Cross Island at high speed after scouting, all fostered long conversations with the Com Center about the provisions of the Conflict Avoidance Agreement (CAA) between the whalers and industry. These concerns were also an important component of two lengthy phone conversations between a representative of the Nuiqsut Whaling Captains Association (NWCA) and the Alaska Eskimo Whaling Commission on 9 Sept. and 12 Sept. Once the whalers were able to reach the open water and the whales (13 Sept. and after), these concerns were no longer so much in evidence. This may have been a result of the physical separation of the whalers and any commercial vessel traffic, the practical fact that whalers could then concentrate on hunting whales rather than the lack of accessible whales, the absence of commercial vessel traffic after 12 Sept., and/or some other factors.

The whalers seemed, in fact, to be relatively satisfied with the implementation of the CAA as it applies to vessels operating on behalf of the oil industry. The logistical support of the Cross Island operation (generator, lights, fuel, and so on) also received high marks. Industry-related vessel activity was, for the most part, identified for the whalers in advance. Whalers exhibited no desire to prevent vessel activity in general—only those activities that could interfere with whaling. For example, on 5 Sept., BP's acoustical crew planned to pass near Cross Island while attempting to move around the ice to the deployment location for their seafloor acoustic recorders. The hunters considered that this was not a potential disruption to whaling, as the whalers were scouting SE of Cross Island. They had no objection to the attempt to deploy buoys offshore of Northstar on 5 Sept. [In fact, ice prevented deployment at the desired location on that date, and the deployment effort had to be repeated—that time successfully—on 7 Sept. (see Chapter 2).] However, when it appeared that such vessel traffic could potentially interfere with whaling activity, the whalers requested that it be deferred. This occurred on 6 Sept., when the deployment of acoustic recording gear (not for BP) offshore of Northstar was postponed; that area was one of the areas open for scouting activity on 6 Sept.

On 9 Sept., the whalers encountered a loud barge engaged in other activities—they thought hauling gravel. The whalers are concerned that the CAA does not cover such vessels and such operations, and contacted the NSB in request that the gravel hauling operation be suspended until after the whaling season.

Once the fourth whale was determined to be dead, on 18 Sept., the Nuiqsut whalers called a cease fire even before it had been towed back to Cross Island, and issued permission for industry activities to proceed with no objections from Nuiqsut whalers. This action was consistent with both the letter and the spirit of the CAA.

In summary, events in 2006 were much less contentious than in 2005. This may have been due primarily to the difference in ice and weather conditions in those two years. Whalers believed that the whales were in the same area both years, but one year (2006) the whalers could get to the whales whereas in the other year (2005) they could not (for the most part). In 2005, whalers and commercial vessels were forced to share the same confined waters, to the discomfort of the whalers. In 2006, once the whalers could reach the open water beyond the ice, they did not report any commercial vessel traffic.

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 (barge, helicopter) from industry are at times requested by the whalers. However, whalers perceive offshore exploration, development, production, and support 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 bowhead migration, from the areas where Nuiqsut whalers normally scout for whales. Thus, they do not expect Northstar to be as problematic in terms of direct effects on whaling as would development to the north and east of Cross Island (Ahmaogak 2002: 5, 14). Nuiqsut whalers prefer, however, not to whale near industry facilities, if they can avoid doing so. In 2005, whalers explicitly indicated that they turned away from Northstar rather than approach it too closely. The closest approach was 2.5 miles, and in general whaling boats maintained a distance of at least 4–5 miles away. In 2006, Nuiqsut whalers only scouted for whales in the direction of Northstar on one day, 6 Sept. Only one boat reported seeing one whale, but that crew had also encountered a very loud tug and barge. They explicitly compared the levels of noise from the tug and barge and from Northstar, and said that the tug and barge was louder. Since the DASAR array could not be deployed offshore until 7 Sept. (see Chapter 2), none of these whaler observations can be linked with the information in Chapter 2.

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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 2006 Cross Island whaling season. This information was recorded by a researcher (MSG) staying with the whalers on Cross Island (CI) and is abstracted from the more general accounts of Cross Island whaling activities. Summaries are included only for those days on which vessel activity was reported, or when concerns for vessel activity effects were discussed.

4 Sept.

Whalers saw a barge while on their way back to CI from scouting. It was inside the barrier islands (as were the whalers) and heading east. It was identified as the fuel barge heading to Kaktovik from Deadhorse. Com Center said that there was another barge at Kaktovik scheduled to return to Deadhorse. There was also another Deadhorse–Kaktovik run scheduled for the next day (9/05). This fostered some talk between the whalers and the Com Center on the CAA provisions.

5 Sept.

Some barge activity noted “near Cross Island” and evidently also an effort to deploy BP’s seafloor acoustic recorders offshore of Northstar. This again fostered some discussion of the CAA arrangements.

6 Sept.

Com Center calls whalers about ACS vessel to deploy acoustic instruments (not for BP) north of Northstar. Discussion with the whalers, who plan to be in that area today and thought the acoustic gear had been deployed yesterday. [The effort yesterday was for BP, and was unsuccessful due to ice; today’s effort was for another company.] After discussion, whalers initially agree to it. After further discussion, they ask if the deployment can be delayed, but later seem to come around to allowing it. However, the ACS vessel with the acoustic gear returned to shore, in compliance with the Nuiqsut whalers’ initial request. The whalers do hear a barge while out scouting and say that it is quite loud. This may have been a barge on its way to Cape Simpson.

7 Sept.

At 06:40 AM, the Com Center radios Nuiqsut whalers and asks if the ACS vessel, operating for BP, can deploy recording gear offshore of Northstar today. Since the whalers intend to scout SE today they give their okay. Com Center says there will also be a barge from Point Thomson to Kaktovik and one or two others (details not recorded). This sparks a whaler–Com Center discussion on the level of vessel activity. There are the deployments of acoustic gear in the west for BP and another operator, and quite a bit of barge activity in the east—at least three that Com Center enumerates. The whalers specifically request that the Point Thomson gravel haul operation be suspended until after their whaling season is over. The whalers agree that the fuel barges can operate—fuel is essential for the villages—but request that activities with more operational flexibility such as gravel haul be deferred until after their whaling season. Their spokesman said that they had not seen any whales so far (which was not quite true—but they had seen only a very few). While out scouting, the whalers did see one barge south of them heading towards West Dock or Endicott (10:30–11:00 AM). This could well have been one of the fuel barges.

8 Sept.

No barge activity noted but two private sailboats overnight at Cross Island. They came for the east and leave to the west on 9/09.

9 Sept.

No vessel traffic noted, but there was a phone conversation between the NWCA and AEWC concerning the barges and the sail boats.

12 Sept.

No barge traffic noted but NWCA and AEWC had another phone conversation, at least part of which was about barge traffic.

ANNEX 3.2: GPS TRACKS FOR NUIQSUT WHALING IN 2001–2005

The following five maps show the GPS tracks for whaling in 2001, 2002, 2003, 2004, and 2005 as documented by Galginaitis and Funk (2004, 2005) and Galginaitis (2006a,c). The maps have been reformatted and placed on a larger basemap because, during the 2006 whaling season, the Nuiqsut whalers ranged farther both to the east and to the west than they had in the five previous years.

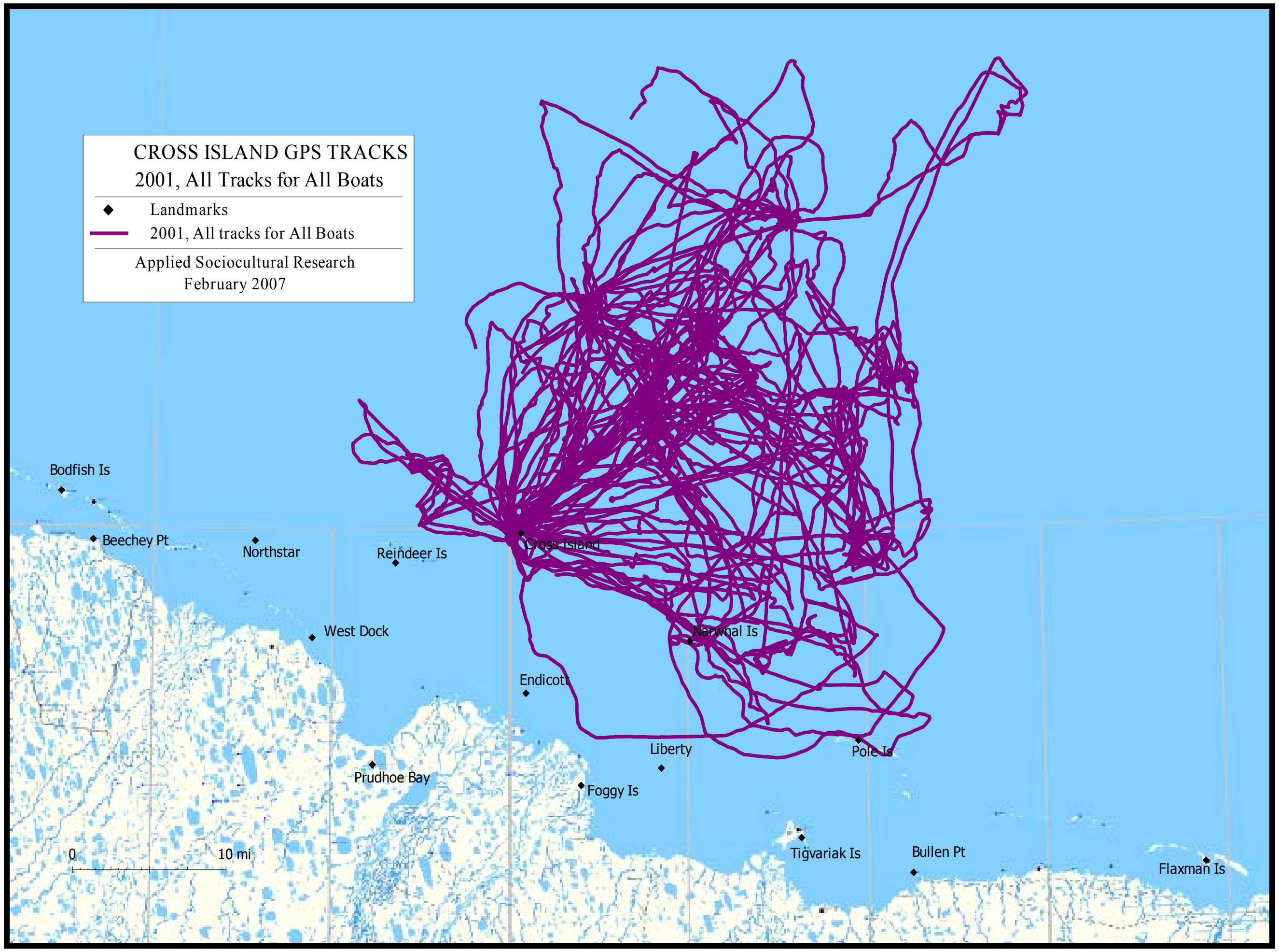

FIGURE 3.3. Nuiqsut whaling, 2001: All GPS tracks.

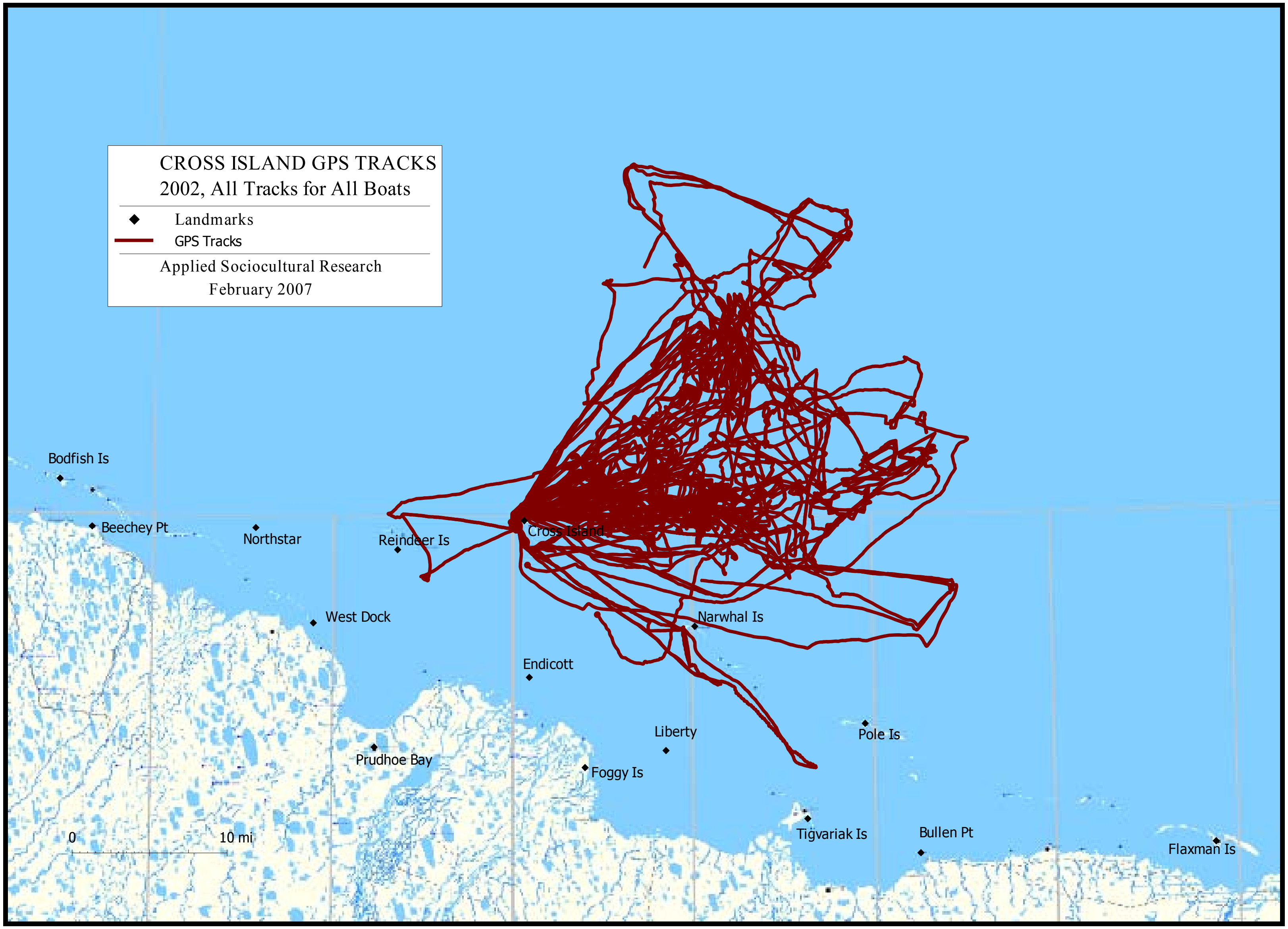

FIGURE 3.4. Nuiqsut whaling, 2002: All GPS tracks.

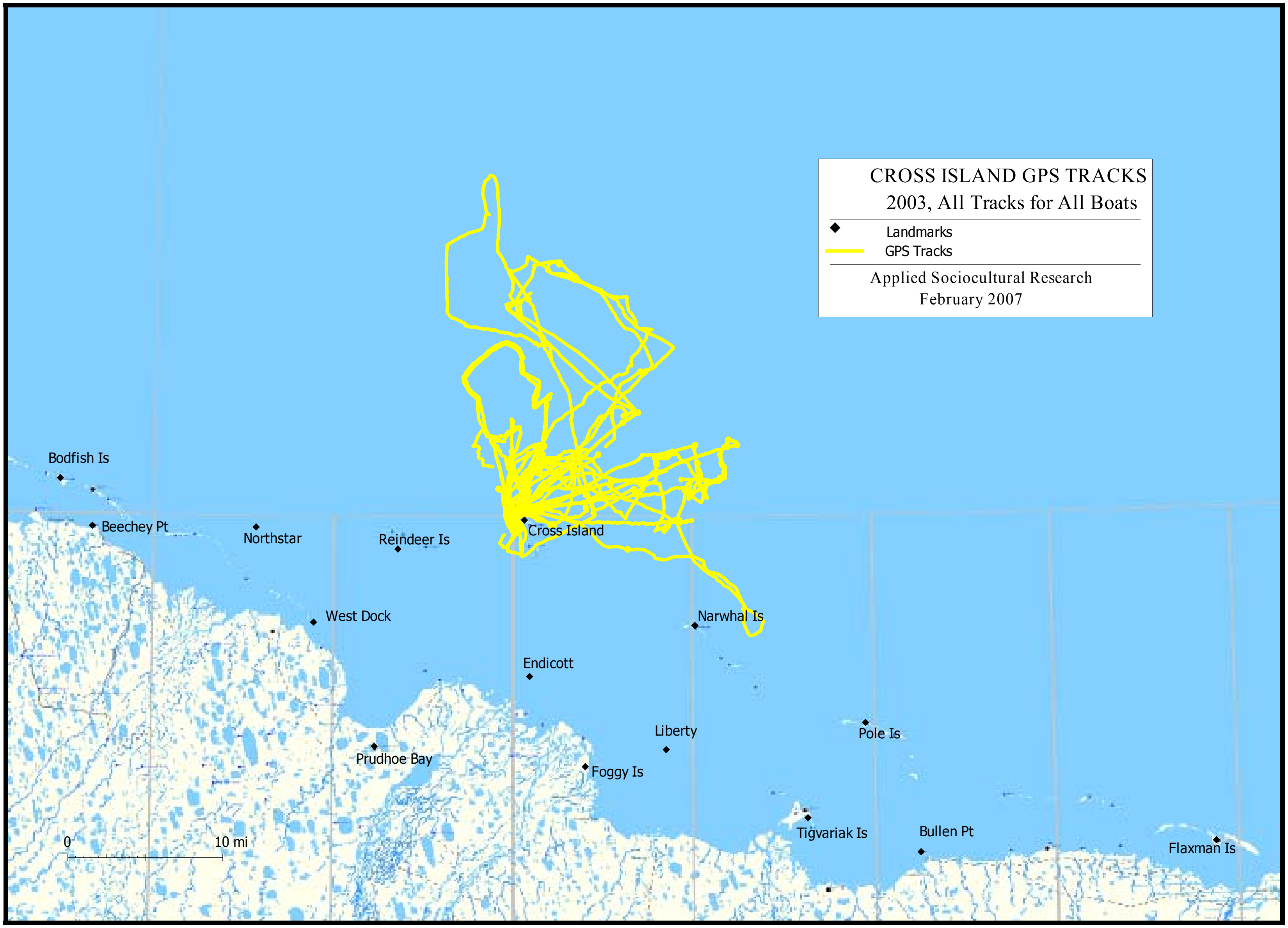

FIGURE 3.5. Nuiqsut whaling, 2003: All GPS tracks.

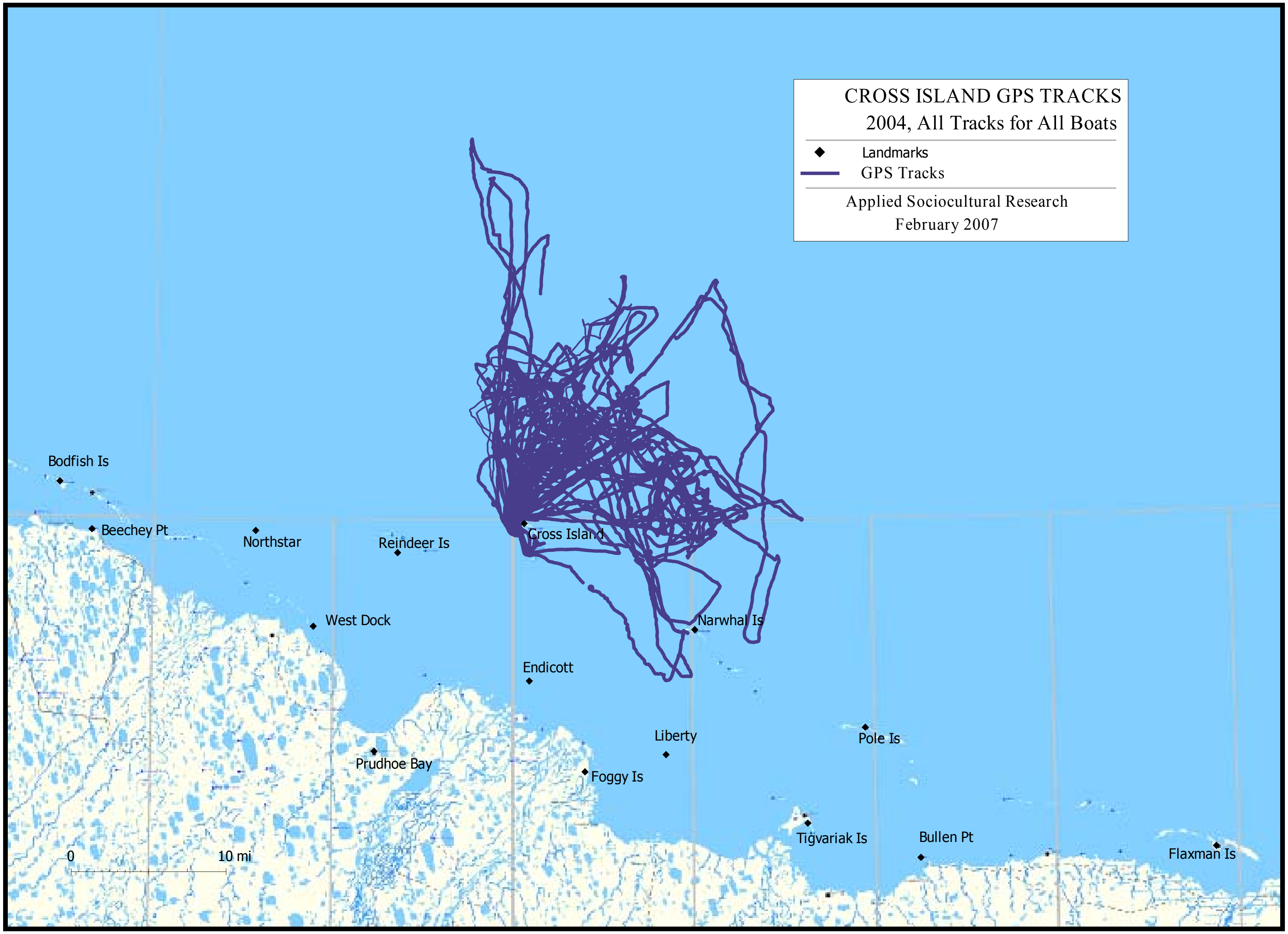

FIGURE 3.6. Nuiqsut whaling, 2004: All GPS tracks.

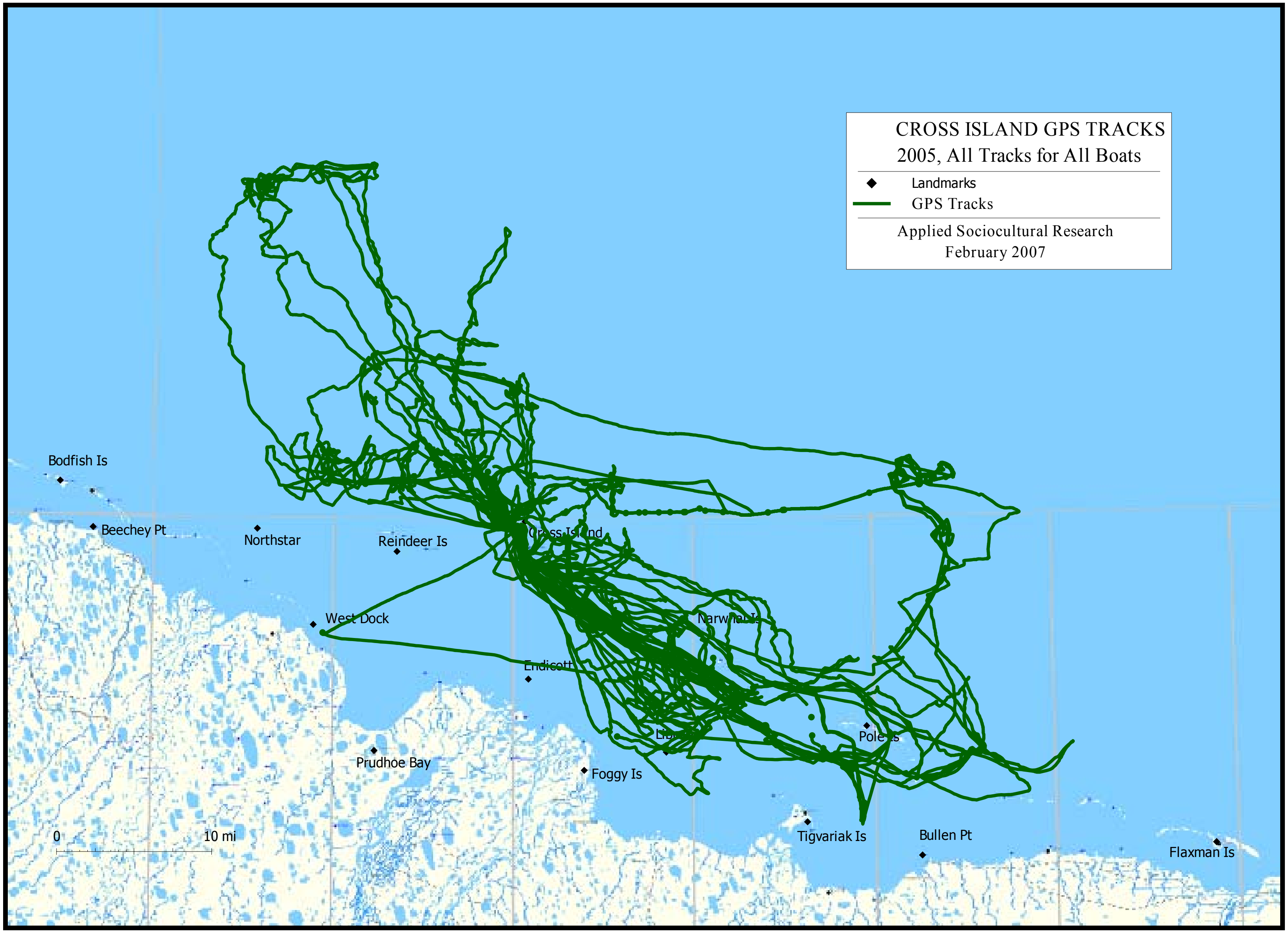

FIGURE 3.7. Nuiqsut whaling, 2005: All GPS tracks.