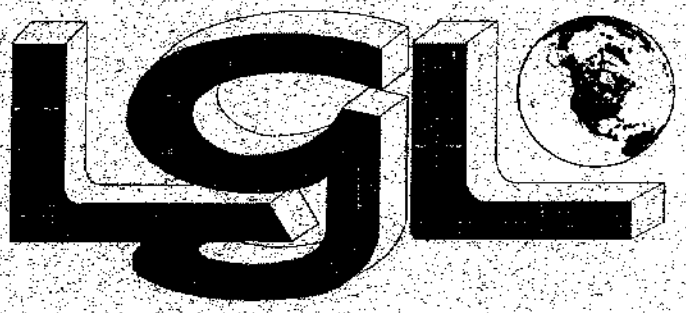
Marine Mammal and Acoustic Monitoring Plan for WesternGeco's 2001 Open-Water Seismic Program, Alaskan Beaufort Sea

from



and

Greeneridge Sciences Inc.
4512 Via Huerto, Santa Barbara, CA 93110

for

WesternGeco, LLC
351 East International Airport Rd.
Anchorage, AK 99518

Attention: Mr. P. Van Borssum

Additional Materials to Exxon (Per PTU Dev.)
AUHF02820

LGL Report TA2564-1

April 2001

Marine Mammal and Acoustic Monitoring Plan for WesternGeco's 2001 Open-Water Seismic Program, Alaskan Beaufort Sea

from

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1. INTRODUCTION

WesternGeco, LLC, plans to conduct an Ocean Bottom Cable (OBC) seismic program in selected nearshore portions of the central Alaskan Beaufort Sea (primarily near Simpson Lagoon) during the 2001 open-water season. In April 2001, WesternGeco will submit an application to the National Marine Fisheries Service for an Incidental Harassment Authorization (IHA) to authorize disturbance of marine mammals during the planned 2001 seismic program. This document is entitled

> *"Request by WesternGeco, LLC, for an Incidental Harassment Authorization to Allow the Incidental Take of Whales and Seals During an Open-Water Seismic Program in the Alaskan Beaufort Sea, Summer-Autumn 2001".*

The 2001 OBC seismic program in the Beaufort Sea proposed by WesternGeco would be similar to the OBC programs conducted in the same area by Western Geophysical during 1998, 1999 and 2000. All planned geophysical data acquisition activities will be conducted by WesternGeco (formally Western Geophysical). The 2001 program would survey previously-unsurveyed patches (locations) within the same general region where the 1998-2000 projects were conducted.

- The 1998 monitoring work was described in Western Geophysical's final 1998 Monitoring Plan, dated 13 July 1998 (LGL and Greeneridge 1998), and in the final report on the 1998 monitoring work (Richardson [ed.] 1999).
- The 1999 monitoring work was described in Western's final 1999 Monitoring Plan, dated 27 August 1999 (LGL and Greeneridge 1999), and in the final report on the 1999 monitoring work (Richardson [ed.] 2000a).
- The 2000 monitoring work was described in Western's final 2000 Monitoring Plan, dated July 2000 (LGL and Greeneridge 2000), and in the 90-day report on the 2000 monitoring work (Richardson [ed.] 2000b). A draft final report on the 2000 work is in preparation.

The same general approach is planned for the 2001 OBC operations and the associated monitoring as for 1998-2000, but some amendments in procedures are planned. The planned changes in monitoring procedures are listed below and described in detail in later sections of this Monitoring Plan:

VESSEL-BASED OBSERVERS: • As in 1999 and 2000, WesternGeco plans to use four marine mammal observers aboard the larger source vessel (*Arctic Star*), allowing two observers to be on watch simultaneously during a substantial portion of the hours of operation. On the smaller source vessel (*Peregrine*), to be used in shallow water, space considerations limit WesternGeco to having two observers on board who will alternate watch duties every four hours. Where possible, the off-duty observer will overlap with the on-duty observer to provide two-observer coverage. If operations continue for substantially more than 12 hours per day, 1 or 2 alternate observers will rotate with the initial two observers.

AERIAL SURVEYS: The aerial survey approach planned for 2001 is identical to that agreed to at the 2000 peer-review meeting and incorporated into the final monitoring plan for 2000: • If seismic work occurs in September/October 2001, aerial surveys are proposed to extend slightly farther east-west than in previous years, to help resolve how far east and west the diversion effects on bowheads extend (total of

18 transects vs. 16 in 1998 and 12 in 1996-97). (There were no aerial survey programs in 1999 and 2000 because there were no seismic operations during the main period of bowhead whale migration.) • The "intensive grid" close to the seismic operation will not be flown in 2001; the flight hours that were devoted to the intensive grid in 1996-98 will, in 2001, be used to extend the aerial surveys farther east and west. • If seismic work occurs after 31 Aug., aerial surveys would occur from 1 Sept. (or the date that seismic work resumes if it is shut down on 1 Sept.) until one day after the end of airgun array operations.

ACOUSTICAL DATA: • Because the same 1210 in^3 array of airguns used in 1999 and 2000 is to be used again in 2001 as one of the sound sources, no additional short-range measurements of the sound pulses from that array are planned. • A smaller airgun array (640 in^3) will be used in shallower waters, mainly inside lagoons. Safety radii appropriate to the larger 1210 in^3 array will also be used for the 640 in^3 array. • If OBC seismic operations occur in Sept.-Oct. 2001, seafloor recorders will be deployed either in late Aug./early Sept. or later in the autumn (depending on the timing of autumn seismic operations) to document long-range propagation of seismic pulses and whale calling patterns. • Also, air-dropped sonobuoys will be used during aerial surveys to document seismic pulses as received near whales and (simultaneously) at three or four distances to the east of the seismic operation.

Other components of the marine mammal and acoustical monitoring work for the OBC program will be essentially unchanged from 1998-2000.

The overall objective has been to develop a 2001 Monitoring Plan that

- satisfies the monitoring and mitigation requirements, including estimation of "take" and estimation of effects on accessibility of whales and seals for subsistence purposes, and
- answers still-unresolved questions about seismic effects on whales and seals in the study area, while not unnecessarily repeating observations and measurements pertaining to questions that have already been answered by the closely-related 1996-2000 seismic monitoring programs.

The monitoring work described below has been planned as a self-contained project independent of any other related monitoring projects that might occur simultaneously in the same region. As in 1998-2000, WesternGeco is prepared to coordinate its monitoring program with that of other project(s), if appropriate. WesternGeco will seek to negotiate cooperative arrangements with any other group planning related monitoring work during the 2001 open-water season so as to maximize effectiveness and minimize unnecessary overlap. Whenever practical during the 2001 WesternGeco project, marine mammal and acoustic data will be collected in a manner consistent with that applied during Western's 1998, 1999 and 2000, and BP's 1996 and 1997, seismic monitoring work to facilitate comparisons and combined analyses. As in prior years, the Minerals Management Service (MMS) is expected to conduct broad-scale aerial surveys including the area of interest to WesternGeco during Sept.-Oct. 2001. MMS has indicated willingness to share aerial survey data again in 2001 (S. Treacy, pers. comm., March 2001).

1.1 Monitoring Requirements

Development of Monitoring Requirements

The marine mammal and acoustical monitoring requirements for industry projects in the Beaufort Sea began to evolve in the mid-1980s. Marine mammal monitoring programs (mainly concerning bowhead whales) were required in support of seismic, construction, and drilling activities in the Alaskan Beaufort Sea during the autumn migration season for bowhead whales (e.g., Gallaway [ed.] 1983; Ljungblad et al. 1984; Davis et al. 1985; Fraker et al. 1985; Johnson et al. 1986; LGL and Greeneridge 1987; and others). Those early monitoring programs included studies of the movements and behavior of migrating bowhead whales past the industry sites. Those programs also included studies of the characteristics and propagation of underwater noise from the industrial activities.

From 1990 to 1995, a Letter of Authorization (LoA) system was in place, under the Marine Mammal Protection Act (MMPA) and associated NMFS regulations, to authorize incidental non-lethal "takes" of bowhead whales and five other species of whales and seals during open-water seismic and drilling programs in the Beaufort Sea. A similar system was established, under Fish & Wildlife Service regulations, concerning walruses and polar bears. The LoA system authorized the incidental, non-intentional, non-lethal harassment of small numbers of marine mammals by certain industrial activities, provided that these were likely to have no more than negligible impacts on marine mammal populations. Under the LoA process, monitoring was required to assess whether the prediction of negligible "take" was correct.

When the LoA system was implemented in the early 1990s, NMFS issued informal guidelines for monitoring. The required types of monitoring were similar to those conducted since the mid-1980s. The guidelines issued by NMFS in 1991 (also applicable in 1992) stated that

> "Monitoring methods should be appropriate to determine distribution and behavioral responses of potentially affected species before, during, and after exposure to the activities. The area to be monitored must extend beyond the zone of potential influence. Proper design...must incorporate a control group outside this zone and prior to potential influence."

There were requirements to document numbers, distribution and behavior of marine mammals, and various aspects of underwater noise including source characteristics, propagation, ambient noise, and animal calls. Supplementary data were to be collected on environmental conditions and other human activities. The Marine Mammal Commission also provided guidance (Swartz and Hofman 1991). The NMFS guidelines have not been revised or re-issued on paper since 1992.

Marine mammal monitoring programs done in the Beaufort Sea under the LoA system that applied in the early 1990s included a series of studies by COPAC around caissons and drillships. The most recent of those projects was Hall et al. (1994) concerning the Kuvlum drilling program. Results of these studies as regards marine mammal distribution, movements and behavior near industrial operations were reviewed by Richardson and Malme (1993) and Richardson et al. (1995: Chap. 9). Noise from many of these industrial activities was measured during monitoring and studies funded by industry and governments from 1980 to the present (reviewed by Greene and Moore 1995).

Current Monitoring Requirements

The 5-year regulations governing LoAs for the six species of whales and seals expired in August 1995. Under the 1994 amendments to the MMPA, a new system of 1-year "Incidental Harassment Authorizations" (IHA) was established under 50 CFR § 216.104 and § 216.107 (NMFS 1996). Those regulations provided a simpler procedure under which a U.S. citizen or corporation may obtain authorization to non-lethally "harass" small numbers of marine mammals incidental to other legitimate activities, such as those of the seismic or oil industries. The IHA regulations for arctic areas require an approved and peer-reviewed monitoring plan, and a Plan of Cooperation for coordination with subsistence hunters. The latter includes a requirement for consultation with the hunters, and a good-faith effort to negotiate a "Conflict Avoidance Agreement".

The holder of an IHA is required to conduct monitoring work to estimate the number of "takes" and the associated effects both on mammal populations and on subsistence activities. IHA regulations for arctic waters (NMFS 1996) state that the holder of an IHA may be required

> "to designate at least one qualified biological observer or another appropriately experienced individual to observe and record the effects of activities on marine mammals. The number of observers...will be specified in the incidental harassment authorization... The monitoring program must, if appropriate, document the effects (including acoustical) on marine mammals and document or estimate the actual level of take... Where the proposed activity may affect the availability of a species or stock of marine mammal for subsistence purposes, proposed monitoring plans or other research proposals must be independently peer-reviewed prior to issuance of an incidental harassment authorization..."

For several years, one guideline for monitoring in the Alaskan Beaufort Sea was that, in the Prudhoe Bay area, autumn-migrating bowhead whales are likely to arrive around 8 Sept. Therefore, prior to 1996, monitoring requirements became more stringent on 8 Sept. In practice, this usually meant that intensive aerial monitoring, mainly designed to document bowhead movements, was not required in the Prudhoe Bay area before 8 Sept. However, recent aerial and acoustic studies, along with observations by Nuiqsut whalers, have shown that substantial numbers of bowhead whales often are present near Prudhoe Bay during the first week of September. Consequently, since 1996 it has been agreed by the peer/stakeholder group that the more intensive monitoring work (including aerial surveys) should begin on 1 Sept. (As noted above, there were no seismic operations and no industry-funded aerial surveys during the main bowhead migration season in 1999 and 2000.)

In 2001, it is proposed to begin the aerial surveys on 1 Sept. if OBC seismic operations are continuing at that time. That starting date is the same as used during the 1996-98 seismic monitoring projects. A 1 September starting date would mean that the aerial surveys are very likely to be underway before the Nuiqsut and Kaktovik hunters begin active hunting for bowheads. (They usually start hunting during the first week in September.) In addition, if OBC seismic work is expected to continue into early Sept. 2001, we plan to conduct acoustical monitoring for calling whales commencing by 1 Sept. If OBC seismic work is suspended on 31 Aug. but resumes later, aerial surveys and acoustical monitoring will commence when seismic work resumes.

During seismic programs conducted under IHA procedures, marine mammal observers are needed on seismic vessel(s) before as well as after early September. Vessel-based observers are needed for two reasons: (1) To document "take by harassment" under IHA provisions, and (2) to comply with mitigation requirements written into the IHA and, if applicable, other permits. The Plan of Cooperation for 2001 again calls for Inupiat participation in the vessel-based observer program. As shown by the 1996-2000 monitoring work, vessel-based observers often see seals but rarely see whales.

The greatest concern is with bowhead whales, given their endangered status, presumed low-frequency hearing capabilities, importance to Inupiat whalers, and general high profile—locally, nationally and internationally. However, other species of marine mammals occurring in the study area are also protected by the MMPA, and all species of whales and seals are part of the NMFS IHA process. There will be a need for estimates of the numbers of marine mammals "taken", their general activities, and the nature of the "taking", including supporting data on the sounds to which the animals were exposed. Supporting data on other relevant factors, including weather, ice, and human activities, are needed for the monitoring period. Monitoring guidelines established by NMFS call for monitoring to extend beyond the maximum anticipated radius of influence of the industrial activity, to provide a basis for comparing potentially affected areas and mammals with "control" conditions farther away. The need for monitoring to extend beyond the maximum anticipated radius of influence was also noted by participants at the "Arctic Seismic Synthesis and Mitigating Measures Workshop", Barrow, AK, 5 – 6 March 1997 (MMS 1997) and at annual peer/stakeholder review meetings, most recently in May 2000 in Seattle.

Inupiat whalers are especially concerned that seismic programs displace some bowhead whales farther offshore, making them less accessible to hunters (Jolles [ed.] 1995; Rexford 1996). This was emphasized at the aforementioned March 1997 workshop in Barrow (MMS 1997) and in other forums. NMFS requires that the monitoring include efforts to determine, insofar as possible, whether the industrial activity causes effects of this type, and to what extent. Inupiat whalers are also concerned that bowheads exposed to seismic noise may become "skittish" and more difficult to approach.

The open-water seismic survey techniques that have been used in the Beaufort Sea since 1996 differ considerably from those that were used during earlier years when the concerns of the Inupiat hunters were formulated. The 1996-2000 seismic programs and the planned 2001 program involve operations with smaller arrays of airguns than were often used in years prior to 1996. The 1996-2001 work is in relatively shallow water, and at any given time is confined to one relatively small "patch". All of these changes from pre-1996 methods of operation are expected to reduce the extent of offshore displacement of bowhead whales. In addition, the provisions of the Conflict Avoidance Agreements between the seismic operators and the Inupiat hunters have had an important role in avoiding effects, real and perceived, on the subsistence hunt for bowheads. Even though the 1996-98 seismic programs were indeed demonstrated to displace the bowhead migration corridor (Miller et al. 1999), there has been no perceived effect on the hunt because the seismic operations during the hunting season were in areas selected to avoid potential effects on the hunt.

Results from the 1996-98 monitoring work indicate that most bowhead whales avoided an area with a radius of roughly 20 km (12.4 mi) centered on the seismic vessel when it was active but not when it was inactive (Miller et al. 1998, 1999). Analysis of the fractions of the whales showing avoidance at various distances indicated that, at least in 1998, some bowheads showed avoidance at distances as large as 25-30 km (16-19 mi) (Miller et al. 1999). Additional data would be valuable in refining these results,

and especially to determine how far east and west of the active seismic operation the deflection extends. The 2001 monitoring program is designed (in combination with the existing 1996-98 data) to help answer these questions. In particular, extension of the aerial surveys farther to the west in 1998 and 2001 (as compared with 1996-97) will help determine the western extent of the deflection.

In commenting on the 1998 seismic monitoring plans, the Marine Mammal Commission (MMC) recommended that NMFS review whether analyses of monitoring data can resolve whether the migratory path of bowheads is affected by seismic profiling. If NMFS concludes that monitoring data cannot resolve this question, then the MMC suggests that NMFS consult with the applicant(s) to determine whether the uncertainty "could be resolved by stopping seismic operations several times during the fall bowhead migration, for periods that it would take whales to transit the area..., and monitoring the migratory paths taken by the whales...before, during, and after these experimental periods...". This approach would result in very significant costs and inefficiencies for the seismic operators. It appears that the question of displacement of the bowhead migration corridor can be resolved without imposing these constraints on industry. The approach described by the MMC would have scientific merit if seismic operations were continuous or nearly so. However, seismic operations during September of 1996-98 were intermittent due to weather, ice, and equipment problems. Also, airgun operations were periodically shut down while waiting for OBC cables to be deployed. These situations provided more than enough interruptions of seismic operations to accomplish the objective outlined by the MMC:

- At least in 1996-97, the analysis of seismic effects on the bowhead migration corridor would have been more powerful if seismic operations had occurred for a *higher* (not lower) proportion of the season. In late autumn of 1999, when Western tried to resume operations after the autumn bowhead hunt at Cross Island had ended, bad weather prevented any seismic operations.
- In 1998, Western was able to operate with fewer weather- or equipment-related interruptions than occurred in 1996-97, and the numbers of bowhead sightings with and without seismic were more similar to one another than had been the case in earlier years. This provided a good basis for comparing the 1998 migration corridor at times with and without seismic (Miller et al. 1999).

In combination, the 1996-98 data show that the migration corridor was affected (Miller et al. 1999). With the addition of 2001 data (if seismic work and thus aerial surveys occur in Sept./Oct. 2001), the combined 1996-98 plus 2001 data should more precisely characterize the extent of displacement east of, offshore of, and west of the area of seismic operations.

The monitoring plan must be agreed upon in advance through a process of consultation and peer review. Meetings with whalers and their representative organizations have been held on the North Slope periodically since 1996 to discuss the monitoring plans and results. The 1999 and 2000 post-season meeting were waived by the AEWC because there had been no seismic operations during the whale hunting period in 1999 and 2000. The present monitoring plan for 2001 closely follows the final monitoring plan for 2000 (LGL and Greeneridge 2000), which took account of comments received at the peer/stakeholder review meeting in Seattle in May 2000. That meeting included representatives of the Nuiqsut Whaling Captains Association and AEWC, NSB, and MMS as well as NMFS. The present monitoring plan for 2001 will be circulated to those groups. It is assumed that the present plan will be discussed at a similar meeting in Seattle in spring 2001, and that (if necessary) it will be revised and finalized thereafter, taking account of comments received on the present document.

WesternGeco, LGL and Greeneridge will, if requested, attend meetings on the North Slope and in Seattle after the 2001 field season to describe and discuss the 2001 monitoring results, and to receive comments. It is understood that the results of the 2001 monitoring work will be reviewed and that the review comments will be taken into account in the final report. IHA procedures call for a preliminary report within 90 days after the end of the seismic field program. This plan provides for preparation of (1) the required "90-day report" in late 2001, (2) a more detailed draft technical report in the spring of 2002, and (3) a final technical report after receipt of comments on the draft. Comments on report (1) will be taken into account in report (2), and comments on (2) will be taken into account in (3).

The 2001 "Plan of Cooperation" is described in Section XII of WesternGeco's IHA Application for 2001. As noted there, an updated "Conflict Avoidance Agreement" for 2001 will be developed through discussions among the AEWC, the local Whaling Captains' Associations, and WesternGeco during the spring of 2001.

1.2 General Approach

WesternGeco's planned 2001 seismic program is scheduled for the summer and possibly the autumn of 2001. Monitoring under the IHA provisions will be required throughout the seismic program, although with different approaches up to and after 31 Aug. Vessel-based monitoring for marine mammals will be done throughout the period of OBC seismic operations (details in Section 2.2, later). If OBC seismic operations occur after 31 Aug., we will

- use seafloor acoustic recorders to monitor seismic sounds and whale calls at various locations offshore and east of the seismic area (see §2.4);
- conduct daily (weather permitting) aerial surveys for marine mammals from 1 Sept. (or from the date when seismic work resumes if it is shut down on 1 Sept.) until one day after airgun operations end; and
- drop sonobuoys from the aircraft to obtain additional acoustic data, especially near bowheads.

Through coordination with the MMS aerial survey program, we will have access to their aerial survey data for the period from approximately 31 Aug. through early-or mid-October. Those data will supplement and extend the more intensive site-specific data that we will collect if seismic operations occur during the autumn (see §2.3).

The area within which OBC seismic exploration is planned during 2001 is outlined in Figure 1. **The actual area surveyed will be a small proportion of the outlined area.** OBC seismic operations will likely end by 31 Aug. in 2001. However, WesternGeco may continue or resume OBC seismic operations in September/October 2001, depending on priorities, ongoing discussions with the subsistence hunters and other regulatory agencies, and weather and ice conditions during the summer and autumn of 2001. At any one time, OBC seismic operations will be confined to one or perhaps two small portions of this area, as described in Section I of WesternGeco's 2001 IHA Application.

In most years, much of the autumn migration corridor of bowhead whales is north of the area where seismic exploration is planned during 2001 (Fig. 1) . However, there is overlap between the southern part of the migration corridor and the northern part of the planned area of seismic operations.

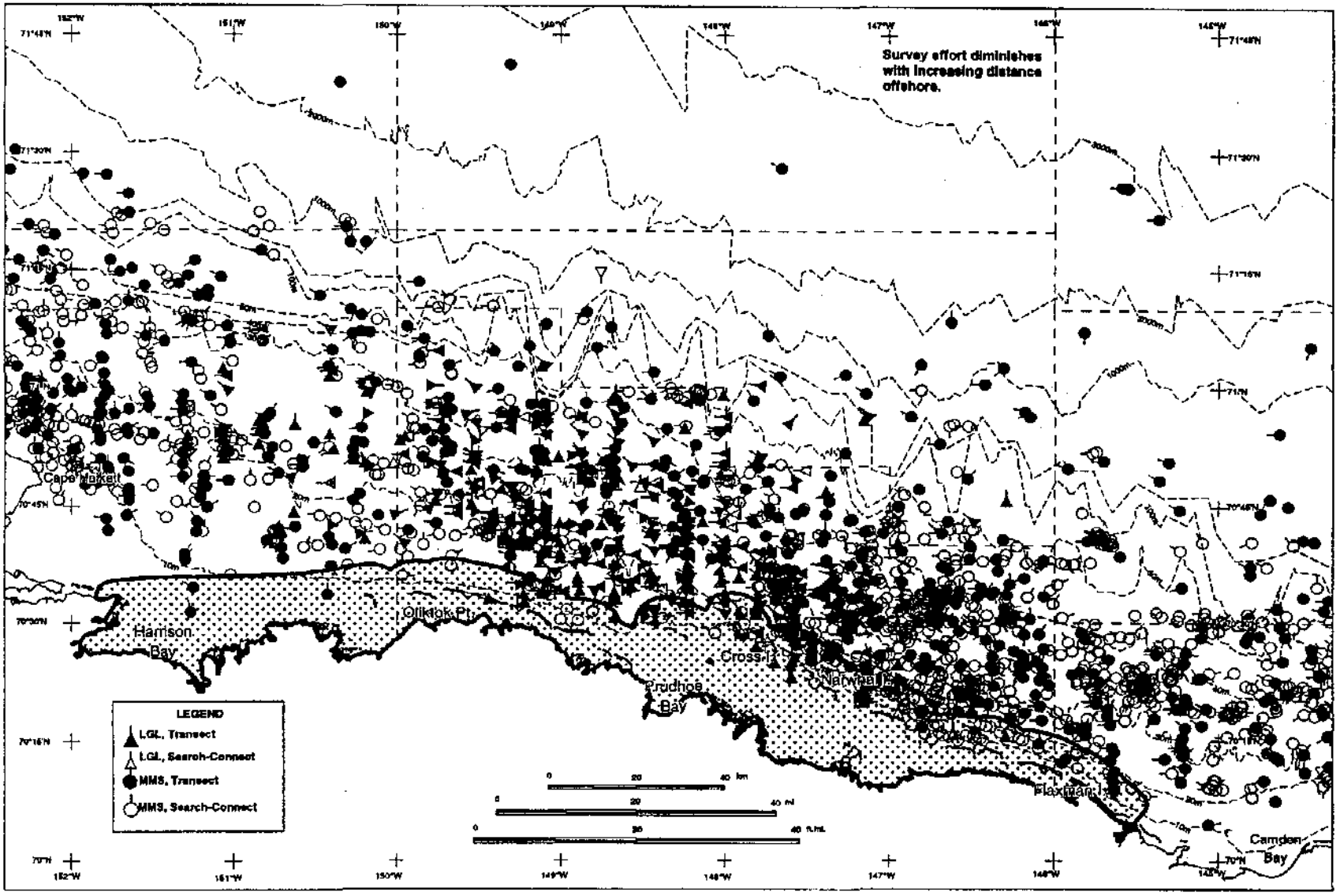

FIGURE 1. Sightings of bowhead whales in the central Alaskan Beaufort Sea during late summer/autumn aerial surveys by or for MMS during 1979-99 (MMS data courtesy S. Treacy), and by LGL in 1996-98 (Miller et al. 1997, 1998, 1999). Shaded area shows area within which WesternGeco's 2001 open-water seismic program will occur; only a small proportion of this area will be surveyed in 2001.

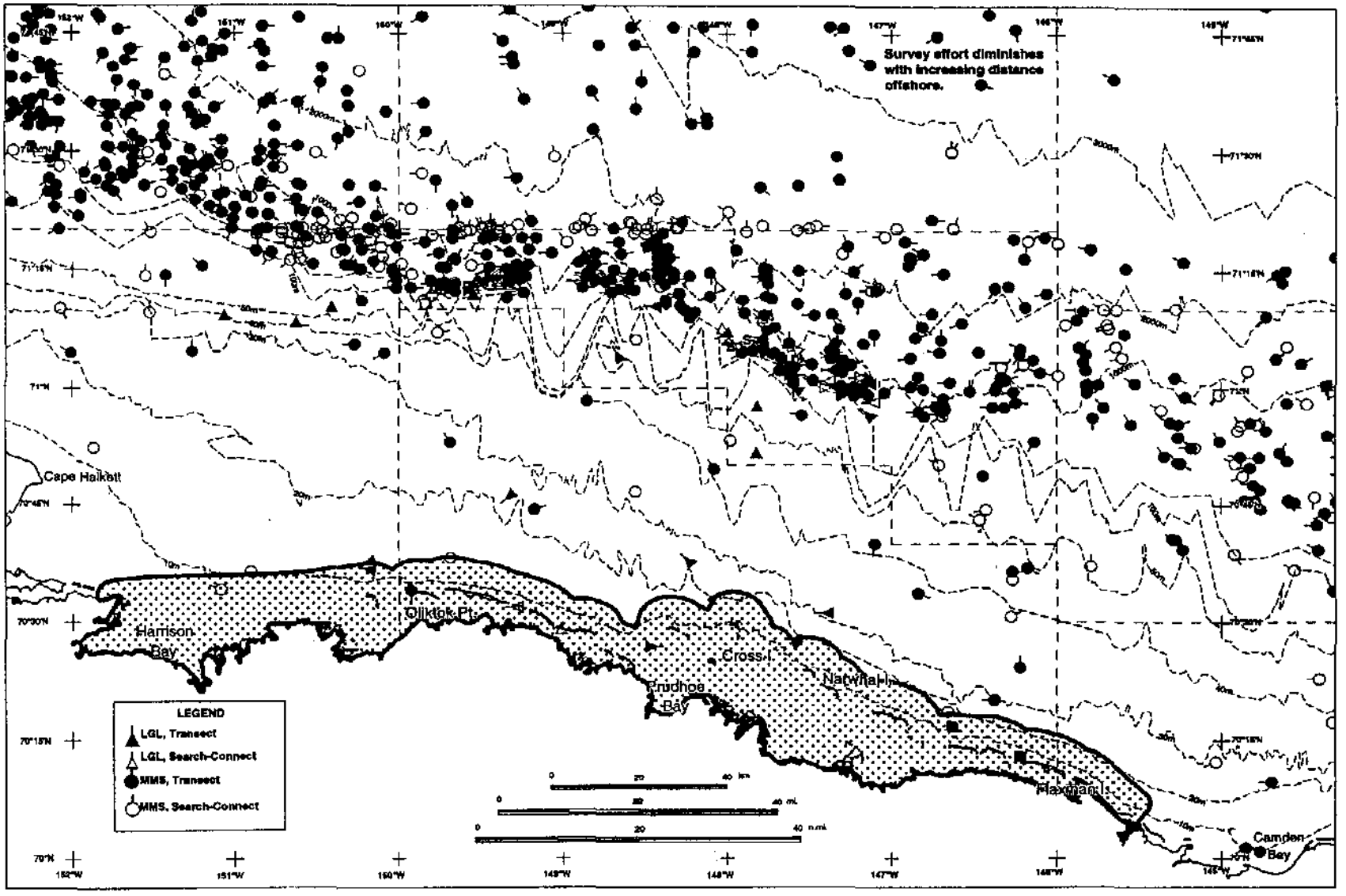

FIGURE 2. Sightings of beluga whales in the central Alaskan Beaufort Sea during late summer/autumn aerial surveys by or for MMS during 1979-99 (MMS data courtesy S. Treacy), and by LGL in 1996-98 (Miller et al. 1997, 1998, 1999). Shaded area shows area within which WesternGeco's 2001 open-water seismic program will occur; only a small proportion of this area will be surveyed in 2001.

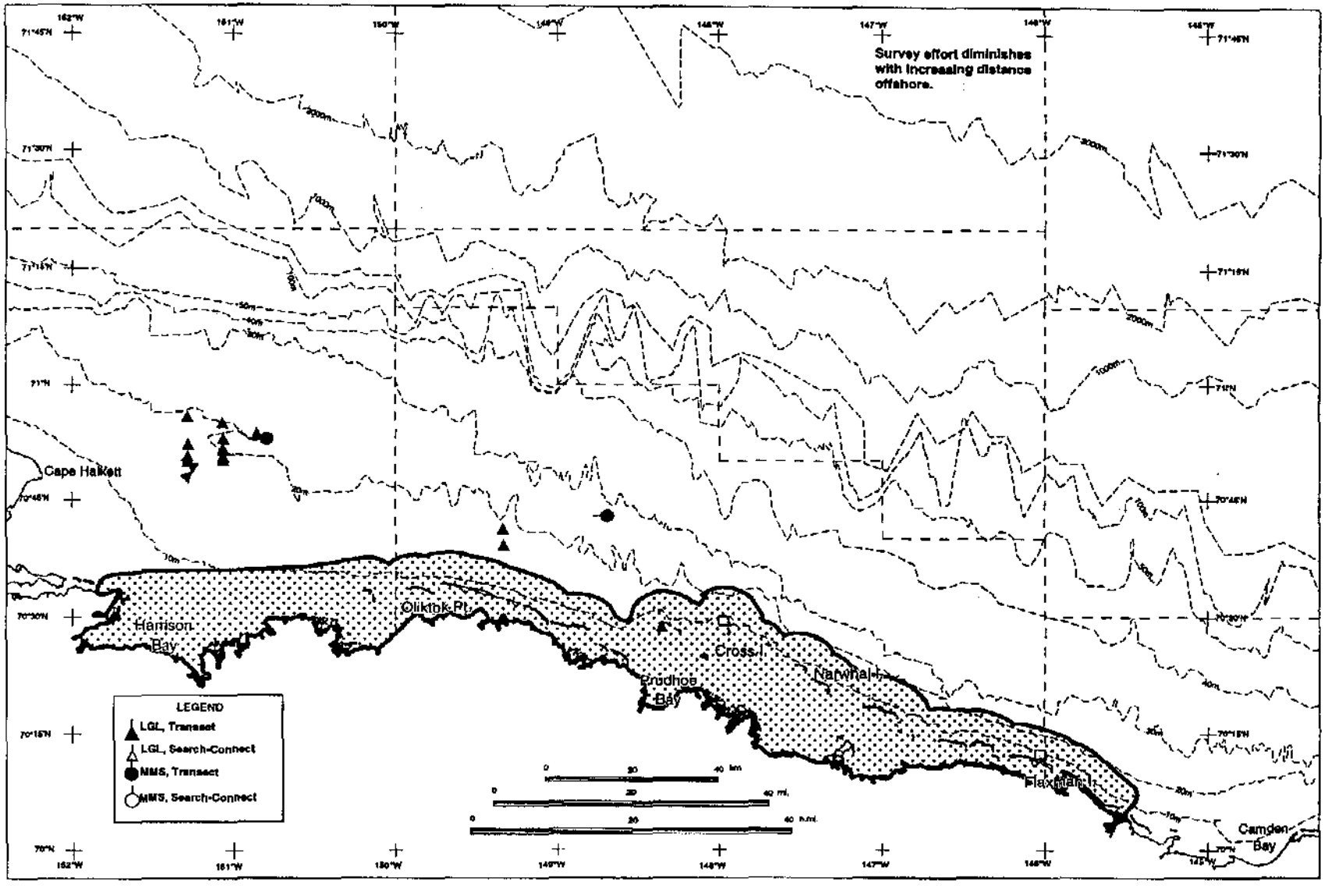

FIGURE 3. Sightings of gray whales in the central Alaskan Beaufort Sea during late summer/autumn aerial surveys by or for MMS during 1979-99 (Treacy 2000; pers. comm.), and by LGL in 1996-98 (Miller et al. 1997, 1998, 1999). Squares indicate two gray whales sighted from Western Geophysical vessels during non-seismic operations in 1998. Shaded area shows area within which WesternGeco's 2001 open-water seismic program will occur; only a small proportion of this area will be surveyed in 2001.

The migration corridor varies from year to year. In some years (e.g., 1997), many bowheads are seen relatively close to shore, including some within the northern margin of the area of planned seismic operations (Fig. 1). Also, underwater noise from seismic exploration in the planned exploration area will extend well to the north of that area, at least when seismic work is occurring near the northern edge of the planned area. Monitoring needs to extend beyond the anticipated zone of impact (e.g., MMS 1997, p. 70). Hence, surveys of marine mammals must extend well north of the planned seismic exploration area, and received levels of seismic pulses north and east of that area need to be documented.

A 1210 in^3 airgun array, deployed from the *Arctic Star*, is to be used for some of the 2001 OBC work. This is the same unit as used in Western Geophysical's 1999 and 2000 programs. In 1999, detailed acoustic measurements of sounds from this airgun array were made at short-medium ranges. Short-medium range acoustic measurements of sounds from this array will not be repeated in 2001. Safety radii appropriate to the 1210 in^3 array will also be used during operations with the smaller array (640 in^3), to be deployed from the *Peregrine* in shallower waters (mainly in lagoons). No short-medium range acoustic measurements of sounds from the 640 in^3 array will be obtained.

Seafloor recorders and sonobuoys will be used to obtain long-distance acoustic data if OBC seismic operations with either airgun array occur during Sept.-Oct. 2001. No long-distance acoustic measurements were obtained in 1999 and 2000, given the lack of seismic operations during the Sept.-Oct. period. The peer/stakeholder group concluded in 2000 that additional long-distance data are required both offshore and to the east.

The following is a list of the field tasks that are planned for inclusion in WesternGeco's monitoring program in 2001. Collectively, these types of fieldwork will satisfy the monitoring requirements as summarized above. These types of fieldwork will provide the data needed to address the questions listed in the subsequent two subsections:

Vessel-Based Observers

- Provide qualified marine mammal observers (biologists and Inupiat observers) for the two seismic source vessels throughout the OBC seismic exploration period in 2001. These observers will monitor the occurrence and behavior of marine mammals near each seismic source during daytime and nighttime periods when it is and is not operating. This will fulfil the vessel-based monitoring and mitigation conditions of the IHA, along with the anticipated requirement for involvement of Inupiat observers. Enhanced vessel lighting (on the *Arctic Star*) and night vision equipment (image intensifier) will be used at night.

Aerial Surveys

- If OBC seismic operations occur after 31 Aug., conduct aerial surveys to monitor the distribution, movements and general activities of bowheads and other marine mammals in and near the seismic exploration area. These surveys are to provide the data needed to estimate "take by harassment", to characterize the anticipated displacement of the bowhead migration corridor during seismic operations, and to evaluate any potential effects on subsistence hunting. Aerial survey work will occur from 1 Sept. (or the date when seismic operations resume if they are shut down on 1 Sept.) until 1 day after airgun operations end.

- If OBC seismic work occurs after 31 Aug., exchange 2001 aerial survey data with MMS. As compared with the proposed WesternGeco/LGL aerial surveys, the MMS surveys will cover a longer period and a larger area but will provide fewer data from any one location. MMS surveys will begin on or about 31 Aug. 2001 and continue until the end of the bowhead migration season. Use of MMS data will (a) increase the sample size in the area of seismic operations, and (b) help place the results from the WesternGeco/LGL surveys into a broader regional and seasonal context.

Acoustical Data

- If OBC seismic work occurs after 31 Aug., use autonomous seafloor acoustic recorders (ASARs) to document bowhead whale calling rates continuously during September (ice permitting) at a location near the seismic operations area, at a "reference" site farther offshore, and at another reference location about 40 km to the east. Calling rates at these locations will be documented and compared at times with and without seismic work.
- If OBC seismic work occurs after 31 Aug., document characteristics of seismic pulses at locations within the bowhead migration corridor offshore and east of the area of seismic operations. Corresponding ambient noise levels will also be determined, allowing seismic-to-ambient ratios. This work will be done using seafloor recorders and air-dropped sonobuoys.

Analyses and Reporting

The various types of data described above will be analyzed to address the questions listed in the following "Objectives" subsection. Preliminary results, including preliminary estimates of "take by harassment", will be included in the "90 day report" on the monitoring and a subsequent comprehensive report on all aspects of the 2001 work.

1.3 Objectives of the 2001 Monitoring Program

The following subsections list the objectives of the monitoring program to be conducted in 2001. Because the 2000 seismic and monitoring programs did not extend into the bowhead migration season, the objectives related to bowheads are the same for 2001 as they were for 2000. Many of these objectives can only be addressed effectively by analysis of combined data from the closely-related seismic monitoring projects in 1996-2000. Combined 1996-2001 analyses are planned. The objectives pertaining to bowhead whales and long-distance sound propagation (italicized below) will be addressed only if the 2001 seismic program continues in Sept./Oct. The other objectives will be addressed whether or not the 2001 work extends into Sept./Oct.

Bowhead Whales

1. *Determine the migration corridor, headings, activities, migration timing, and abundance indices of bowhead whales passing the seismic exploration area during autumn 2001, and during the 1996-98 plus 2001 seismic programs generally.*

2. *Determine whether the migration corridor, headings, and activities of bowheads differ at times with and without seismic exploration during 2001, and during 1996-98 plus 2001 combined.*

- *Determine whether the migration corridor through the area of seismic exploration is farther offshore when airguns are active, and (if so) by how much.*
- *Determine whether headings and activities of bowheads approaching, passing, and west of the area of seismic exploration differ at times with and without airgun operations.*

3. *Determine how far to the east and west of the active seismic operation the offshore deflection of the bowhead migration corridor extends based on combined 1996-98 plus 2001 data, and obtain more precise estimates of the extent of offshore deflection when bowheads were passing the active seismic operation in those years.*

4. *Determine whether there are differences in the pattern of bowhead call detection rates near, offshore of, and east of the seismic exploration area at times with and without active seismic operations based on 2001 data and 1996-98 plus 2001 data. If so, use the combined acoustic and aerial survey data to evaluate whether the noise-related differences in call detection rate are attributable to differences in calling behavior, whale distribution, or a combination of the two.*

Other Species of Marine Mammals

5. Determine the distributions, behaviors, seasonal timing, and abundance indices of beluga and gray whales (if any), and of ringed, bearded and spotted seals, in and near the seismic exploration area during late summer and autumn based on data from 2001 and from 1996-2001 combined.

6. Determine whether the local distribution, behavior and abundance of seals differ at times with and without seismic exploration during 2001 and 1996-2001 combined. If so, determine the nature of the differences, the geographic extent of the effects, and the received sound levels associated with the effects.

Physical Acoustics Measurements

7. *If seismic operations continue in Sept./Oct. 2001, determine the characteristics of airgun array pulses as received in the bowhead migration corridor at varying distances offshore and to the east of the area of seismic exploration in 2001 and in 1996-98 plus 2001 combined. Pulse characteristics to be determined are received levels (peak, rms, energy) and pulse durations vs. range offshore and to the east, spectral properties, and signal-to-ambient ratios.*

Impacts on Marine Mammals and Subsistence

8. Estimate how many marine mammals of each species are "taken by harassment" or exposed to specified levels of pulsed sounds during WesternGeco's 2001 seismic program. Estimates are required based on each of the criteria applied in previous years of seismic monitoring, plus any new criteria stipulated in the IHA for 2001. Criteria will include the numbers of seals exposed to a received level of 190 dB re 1 μPa (rms), the numbers of cetaceans exposed to 180 dB, the

numbers of both seals and cetaceans exposed to 160 dB, and the numbers of bowheads that would have passed within 20 km of the operating seismic vessel if they had not avoided.

9. Determine the nature of the takes to be reported under (8), and under what circumstances (e.g., distance, sound exposure levels, signal-to-ambient ratios) they occurred.

10. If the 2001 seismic program continues into September, determine whether the migration corridor of bowheads was altered during periods of seismic exploration in 2001. Based on combined 1996-98 and 2001 data, determine how far the displacement effect extended to the east, offshore, and to the west, and determine the received sound levels at those distances offshore and alongshore to the east.

11. Assess whether the 2001 seismic program had unmitigated adverse effects on the accessibility of bowheads or other marine mammals to subsistence hunters

The MMPA definition of "take by harassment" is subject to interpretation, and NMFS definitions and requirements for estimating "take" are evolving (e.g., NMFS 2000). Consequently, more than one answer is required in response to objective (8), with the estimated number of "takes" varying according to the definition used.

Objective (10) can be difficult or impossible to answer based on the data from one year, as demonstrated by the 1996-97 monitoring results. If seismic (and thus monitoring) operations occur in areas not sheltered by barrier islands[1] for a span of at least 10 days during Sept./Oct. 2001, the combined data from 1996-98 plus 2001 should provide the basis for a more complete treatment of objective (10) than is presently possible based on combined 1996-98 data. If such seismic operations occur for less than 10 days in Sept./Oct. 2001, the combined 1996-2001 monitoring data will be described but detailed analysis will probably not be useful.[2]

The results relevant to objective (10) will provide much of the information needed to address objective (10). The success of the 2001 bowhead hunt, and information provided by the hunters regarding any perceived interference, will also be key considerations in addressing objective (10).

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[1] Data acquired when the airgun sounds are blocked or strongly attenuated by intervening barrier islands or shallows cannot be used in testing hypotheses about the responses of bowheads to airguns.

[2] If seismic work in areas not sheltered by barrier islands spans <10 days during Sept./Oct. 2001, the additional data from 2001 are unlikely to augment the combined 1996-98 + 2000 results appreciably as compared with the 1996-98 results already reported by Miller et al. (1999). In this situation, it will not be useful to undertake a detailed re-analysis of the combined multi-year dataset. Note that, if there are few days with seismic operations outside the barrier islands during Sept./Oct., extending the monitoring period for more than 1 day after seismic surveys cease would be of little or no value in addressing project hypotheses.

1.4 Hypotheses to be Tested

Several of the objectives listed above will be addressed by specific statistical tests. The following are the main null and alternate hypotheses that will be evaluated. The hypotheses involving bowheads will be evaluated in detail only if seismic and monitoring work occurs outside the barrier islands in Sept./Oct. 2001 for a period (e.g. 10+ days) sufficient to provide a useful increment of data.

Bowhead Migration Corridor

One possible formulation of the key null hypothesis regarding effects of airgun operations on the bowhead migration corridor is an adaptation of one suggested by Dr. Tom Albert (see Appendix):

- There is no difference in the distribution of bowhead whales, during seismic operation as compared to no seismic operation, at points 10, 20, 30 and 40 km (a) offshore of the seismic area, (b) "upstream" (to the east) of the seismic area, and (c) "downstream" (to the west) of the seismic area, considering times when there are no islands or shallows between the seismic area and the whales.

This actually a set of 12 related hypothesis concerning three different directions (offshore, east and west) and, for each of these directions, four different distances. The associated set of 12 alternate hypotheses would be that the migration corridor is displaced offshore in some or all of these 12 locations.

This formulation of a null hypothesis is one approach to determining how far the displacement effect extends in the three directions of particular interest *(cf.* objectives 2 and 3 in §1.3, above). The 1998 aerial surveys, and those planned for 2001, provide data relevant to all three parts of this hypothesis. The 1996-97 aerial surveys provided data relevant to (a) and (b), but did not extend far enough west to address (c) adequately. The hypothesis cannot be addressed adequately with any one year's data, but can be addressed with increasing precision as data accumulate across years. If substantial additional data are acquired in Sept./Oct. 2001, the (a), (b) and (c) parts of this hypothesis will be tested using log-linear models contrasting sighting rates vs. distance and direction at times affected by and not affected by seismic operations.

Bowhead Headings

The 1996-98 data did not show any statistically significant difference in the headings of bowheads approaching the operating seismic vessel. However, there was a slight indication that, in the area 21-60 km east of the seismic vessel, headings of westbound bowheads tended to be deflected slightly to the right (offshore) at times influence by the airgun array (see Fig. 5.17 and Table 5.10 *in* Miller et al. 1999; vector mean heading 302°T with seismic vs. 286° without). As noted in Miller et al. (1999), most bowheads were demonstrated to deflect offshore to avoid the area within 20 km of the operating seismic vessel. Some also avoided the 20-30 km zone. Consequently, there must have been a deflection in headings even if this was not demonstrated statistically with the 1996-98 heading data. This effect would presumably become more evident with a larger sample size. However, a more relevant question is "how far to the east do the headings begin to show a deflection?" This question can be formulated as the following testable hypothesis:

- There is no difference in the headings of bowhead whales, as observed by aerial surveyors, during seismic operation as compared to no seismic operation, in areas 10, 20, 30, 40, 50 and 60 km "upstream" (to the east) of the seismic area, considering times when there are no islands or shallows between the seismic area and the whales.

If substantial additional data are acquired in Sept./Oct. 2001, the combined 1996-98 plus 2001 results will be used to test this hypothesis. If no significant effect is found, we will evaluate the power of the analysis to detect an effect if one occurs.

Bowhead Call Detection Rates

Acoustic monitoring results from 1996 and 1998 have shown statistically significant differences in the relative call detection rates at different distances offshore and east of the area of seismic operations at times when the airguns were and were not operating. However, the results from those two years differed. Call detection rate at the closest monitoring site was lower in 1996 but higher in 1998 at times when the airguns were active. This difference was hypothesized by Greene et al. (1999) to have been related to the fact that the closest monitoring location was within 20 km of the area of seismic operations in 1996, but beyond 20 km in 1998. Additional acoustical monitoring data are needed to assess this interpretation. The proposed layout of monitoring sites in 2001 will accomplish this by replicating the layout of the three key monitoring sites used in 1996. Our null and alternate hypotheses are as follows:

- There is no difference in mean call detection rates with and without airgun operations at a location close to the seismic operation, or at a location farther offshore, or at a third location farther east, considering times when there are no islands or shallows between the seismic area and the whales.

The alternate hypothesis includes two components: (1) At one or more of those locations, there will be differences in call detection rates with and without airguns. (2) The pattern of differences will be consistent with either a reduction in calling rate at the closest site at times with airgun operations, or a displacement of calling whales away from the closest site and toward the site farther offshore, or both. If there is evidence for the alternate hypothesis in 2001 and/or in all years combined, we will assess whether the geographic displacement evident from aerial survey results is consistent with the effect evident from the call data. If not, this will provide evidence that, in addition to the geographic displacement evident from aerial surveys, the calling rate of whales approaching the area of seismic operations is also affected.

Dr. T. Albert has suggested a more refined and complex hypothesis (see Appendix): "There is no difference in the call rate of bowhead whales, during seismic operation as compared to no seismic operation, at points 10, 20, 30, 40 km (a) offshore of the seismic area, (b) "upstream" (to the east) of the seismic area, and (c) "downstream," (to the west) of the seismic area."

To address this null hypothesis in its entirety with the existing type of seafloor recorders, it would be necessary to obtain acoustic data from the 12 locations referenced in the hypothesis (3 directions × 4 distances). This would provide valuable data, but it is not logistically practical for 2001. It is desirable to place two recorders at key locations in order to have reasonable assurance of obtaining data from at least one recorder per location. Thus, it is proposed to retain the design discussed in Seattle on 30 June – 1 July 1999 and 24-25 May 2000: deploy a pair of seafloor recorders at each of three locations – one site

just offshore of the seismic area (approx. 15 km from its northern edge), one site farther offshore of that area, and one site about 40 km to the east. This replicates key features of the 1996 layout, which provided notable results that need replication (given the seemingly different results from 1998).

Effects on Seal Distribution and Behavior

Seal monitoring results from 1996-2000 in the Beaufort Sea have, during some but not all years, revealed statistically significant differences in the seal sighting rates, or the distances between the source vessel and the seals, or both, at times when the airguns were and were not operating. However, differences in the behavior of seals during non-seismic and seismic periods, whether inside the safety radii or not, were not distinctive or conspicuous. Based on these results, our null hypotheses for the 2001 program, and for the 1996-2001 programs combined, are as follows:

- There are no differences in the distribution and distances of visible seals relative to the source vessel during periods with vs. without airgun operations, or in relation to the specific airgun array in use.
- There are no differences in the numbers of seals visible near the seismic vessel during periods with vs. without airgun operations, or in relation to the specific airgun array in use.
- There is no visible difference in seal behavior during periods with vs. without airgun operations, or in relation to the seals' distance from the sound source or its acoustic characteristics.

These hypotheses pertaining to seals will be tested based on 2001 data alone, and again based on the combined 1996-2001 results. In particular, we hope that the larger sample size resulting from another season will improve the power of the analyses to detect behavioral effects if they occur.

1.5 Project Team

The prime contractor for the monitoring work will be **LGL Ltd., environmental research associates,** of King City, Ont., and its affiliate **LGL Alaska Research Associates Inc.** of Anchorage, Alaska. LGL is responsible for most biological components, project management, contacts with WesternGeco, and (with WesternGeco's approval) contacts with agencies. The project director will be W. John Richardson of LGL. John W. Lawson will be the field manager.

Greeneridge Sciences Inc. of Santa Barbara, CA, is the subcontractor for acoustical components of the work. Greeneridge specializes in providing physical acoustics support for marine mammal/noise studies, especially in the Arctic. Since 1980, LGL and Greeneridge have worked together on many such projects, most in the Beaufort Sea.

The project team will be the same as for the seismic monitoring work conducted in the same area in 1996-2000. This will assure consistent field and analysis methods, and will facilitate combining results across years where relevant.

2. METHODS

2.1 Planning, Permits and Meetings (Task 1)

The 2001 seismic monitoring program is proposed to be conducted under a 1-year Incidental Harassment Authorization or IHA (see §1.1). The stages of the IHA process at which LGL and Greeneridge have been involved, or expect to be involved, include

- prepare IHA request to NMFS (March 2001);
- prepare draft monitoring plan (March 2001, this document) and, after the peer/stakeholder review meeting, prepare a final monitoring plan (approx. July 2001);
- participate in meetings with whalers and their representative organizations before the 2001 field season if requested (spring 2001), the peer/stakeholder review meeting (late spring 2001), and post-season follow-up meetings with the whalers and NMFS;
- implement 2001 monitoring and mitigation plan during the portion of the July-October 2001 period when seismic surveys are underway; and
- prepare required 90-day, draft final, and final reports on that work.

2.2 Vessel-Based Observers (Task 2)

WesternGeco's seismic program is planned to commence as early in July 2001 as ice conditions allow. Depending on business and other considerations, the seismic program may continue as long into the autumn as ice conditions allow, or may be terminated at some earlier date. At least one experienced marine mammal observer will need to be on duty aboard the seismic source vessel (*Arctic Star* or *Peregrine*) whenever it is operating in order to allow un-interrupted seismic shooting, to advise the seismic survey personnel of the presence of mammals within designated "safety zones", and to document "take by harassment". It is anticipated that (as in 1999 and 2000) NMFS will require that two observers be on duty during times when OBC airgun operations are commencing (ramping up). The vessel-based observations will be done in a manner consistent with that applied during the corresponding monitoring work during the 1998-2000 seismic projects by Western Geophysical (Lawson and Moulton 1999; Moulton and Lawson 2000a,b). This will facilitate comparison and pooling of data where appropriate in testing the hypotheses regarding "Effects on Seal Distribution and Behavior" in §1.4.

Observations During OBC Seismic Surveys

LGL plans to place three biologist-observers on the source vessel *Arctic Star* during OBC seismic operations. In addition, an Inupiat observer will be employed on that vessel to serve as a fourth observer and, if operations occur during the whaling season, as a part-time Communicator with whaling crews and with an industry/whaler coordination center. The requirement for, and role of, the Inupiat observer are expected to be defined in the 2001 version of a "Conflict Avoidance Agreement" between WesternGeco and the hunters, as described in Section XII of WesternGeco's IHA Application. Most if not all observers employed in 2001 will be individuals with experience as observers during one or more of the 1996-2000 seismic monitoring projects for Western Geophysical or BP. Due to space limitations, only two observers will be stationed aboard the second source vessel, the *Peregrine*, at any one time.

The observers will fulfil the NMFS IHA requirement for ship-based monitoring, and any other applicable permit requirements pertaining to marine mammal observations. The vessel-based monitoring will extend from the start of seismic operations in July until the end of operations.

Biologist-observers to be assigned by LGL will have previous marine mammal observation experience, and LGL's field crew leaders will be highly experienced with previous vessel-based seismic monitoring projects. The Inupiat observer will be experienced in the region, familiar with the marine mammals of the area, and will have worked as a marine mammal observer during previous LGL marine mammal monitoring projects. Most observers will complete a one-day training and refresher session on marine mammal monitoring, to be conducted shortly before the anticipated start of the 2001 open-water season. (Any exceptions will have or receive equivalent experience or training.) Primary objectives of this course include

- review of the marine mammal monitoring plan for this project (this document), including any amendments specified by NMFS in the IHA;
- review of marine mammal sighting, identification, and distance estimation methods, including any amendments specified by NMFS in the 2001 IHA;
- review of operation of specialized equipment (reticle binoculars, night vision devices (NVD), and GPS system);
- review of, and classroom practice with, LGL's data recording and data entry systems, including procedures for recording data on mammal sightings, seismic and monitoring operations, environmental conditions, and entry error control. These procedures will be implemented through use of a customized computer database and laptop computers;
- review of the 2001 Conflict Avoidance Agreement, including the specific tasks of the Inupiat part-time Communicator.

At least one observer will be on duty at all times when seismic operations are underway. A biologist or Inupiat observer will watch for and observe marine mammals at all times, day or night, when shooting is underway and, for comparative purposes, some fraction of the times with no shooting. Two observers will be on duty during all ramp-ups of the seismic array. The observer(s) will watch for marine mammals from the bridge of the operating source vessel, scanning systematically with the naked eye and 7 × 50 reticle binoculars, supplemented with night-vision equipment when needed. WesternGeco personnel on the bridge will again (as in 1998-2000) assist the marine mammal observer(s) in watching for seals and whales.

Aboard *Arctic Star*, use of four observers will permit two observers to be on duty simultaneously for approximately 1/3rd of the hours when the airguns are in operation, and perhaps as much as 1/2 of the hours. (The specific fraction will depend on the consistency of airgun operations and other scheduling factors that are not fully predictable.) The fourth observer will rotate his/her schedule forward one hour each day such that, over the course of 12 days, there will be two-observer observation data throughout the 24 hour cycle (as well as during ramp-ups). Use of two observers at a time increases the effectiveness of monitoring by a significant amount (Harris et al. 1998; Lawson and Moulton 1999; Moulton and Lawson 2000a,b). Limited accommodations aboard the source vessel would make it very difficult to assign more than four observers, which would be necessary to maintain two observers on watch at all times.

During operations by *Peregrine,* a minimum of two observers will be aboard. If operations continue for substantially more than 12 hours per day, 1 or 2 additional observers will be required on a rotating basis. Some or all observers for the *Peregrine* are expected to be provided from the *Arctic Star*'s observation team at times when the *Star* is not operating its airguns. The *Peregrine* itself can accommodate only two observers aboard at any time.

The observer(s) will watch for marine mammals for a period of at least 30 min (or such other time as the IHA may specify) preceding the planned start of shooting and during OBC shooting as well as during all times with airgun operations. Watches by an individual observer will normally be limited to no more than four consecutive hours. The observer(s) will give particular attention to the areas within the "safety radii" that are expected to be defined around the source vessel (see Section XI of IHA Application). The radii proposed in WesternGeco's 2001 IHA application for the 1210 in^3 airgun array are 150-900 m (492-2953 ft) for cetaceans and 100-260 m (328-853 ft) for other marine mammals. Within these two ranges, the specific safety radii would depend on the tow depth of the airgun array in the water and on water depth. (See Section XI of WesternGeco's 2001 IHA Application.) These radii are the maximum distances within which received levels may exceed 180 dB re 1 μPa (rms) for cetaceans, or 190 dB re 1 μPa (rms) for other marine mammals. They are based on extensive acoustical measurements during the 1999 field season around WesternGeco's 1210 in^3 airgun array operating at both shallow and deeper depths (see §2.4 and Greene and McLennan 2000).

The safety radii used for the 1210 in^3 array will also be used for the 640 in^3 array. The 190, 180 and 160 dB radii for this array will be smaller than the corresponding radii for the 1210 in^3 array, given the design and lower source level of the 640 in^3 array, its shallower gun depth (1 vs. 2.3 m), and its shallow operating locations (mainly in lagoons). Use of safety radii appropriate to the 1210 in^3 array (at 2.3 m gun depth) during work with the 640 in^3 array (at 1 m gun depth) is a precautionary approach.

Night-vision equipment, specifically two ITT F5000 Series "Generation 3" binocular image intensifiers, will be available for use when needed. (Prior to mid-August, there will be no hours of total darkness.) However, observations with night-vision devices are not as effective as visual observation during daylight hours (Harris et al. 1997, 1998; Lawson and Moulton 1999; Moulton and Lawson 2000a,b), As in 1999 and 2000, the main method to be used in 2001 to improve the effectiveness of monitoring at night is the use of high-intensity lights mounted above the bridge of the *Arctic Star* and on the bow of the *Peregrine* (see Section I of WesternGeco's 2001 IHA Application).

Information to be recorded by marine mammal observers will include the same types of information that were recorded during Western's 1998-2000 seismic monitoring project (Lawson and Moulton 1999; Moulton and Lawson 2000a,b):

1. When a mammal sighting is made, the following information about the sighting will be recorded: species, group size, age/size/sex categories (if determinable), behavior when first sighted (e.g., sink, front dive, thrash, unspecified dive, look, swim, other [specify]), behavior after initial sighting (same categories as behavior when first sighted), movement relative to the source vessel (e.g., swim toward, swim away, swim parallel, flee, mill), heading relative to the source vessel (if consistent), bearing, distance from seismic vessel, sighting cue (e.g., head body, splash), and behavioral pace (e.g., vigorous, sedate, unknown).

2. Location, heading, speed, and activity of the vessel (shooting or not; number and volume of airguns in use) will be recorded at the time of each mammal sighting, along with ice cover, visibility, obstructions to visibility (e.g., snow, fog, darkness), glare, and sea state.

3. The positions of the other vessel(s) involved in the seismic project will also be recorded at the times of mammal sightings. If possible, this will be done by a WesternGeco data logging system based on automatic Differential Global Positioning System (DGPS) position reports received from project vessels via telemetry. Otherwise, this information will be recorded manually by LGL at times of whale (but not seal) sightings.

The data listed under (2) will also be recorded at the start and end of each observation watch, and, during a watch, whenever there is a change in one or more of these variables. Visibility and sun glare will also be recorded at these times. In addition, positions of all vessels engaged in the seismic program will also be recorded automatically at least once every 2 min by Western's data logging system.

Distances to nearby marine mammals, e.g., those within or near the 190 dB (or other) safety zone applicable to pinnipeds, will be estimated with binoculars (Fujinon model FMTRC-SX, 7 × 50) containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon.[3] For water less than 10 m deep, the maximum potential 190 dB radius will be about 100 m for Western's 1210 in^3 array operating at either 2.3 or 5 m array depth, respectively (see Greene and McLennan [2000] and Section XI of WesternGeco's IHA Application). For water greater than 10 m deep, the maximum 190 dB radius will be about 160 and 260 m for 2.3 and 5 m array depths, respectively. Reticle readings are accurate within ±1 reticle interval, i.e. within 0.14-0.28°. If accuracy is 0.25° (a conservative assumption) and eye-height is 5.6 m (18.5 ft; for the *Arctic Star*) above the water, the uncertainty at a distance of 260 m is from about 216 to 326 m. With experience in estimating distances during good visibility in daytime, observers are able to achieve reasonable accuracy in estimating distances out to 260 m at night even if the horizon is not visible. Similar methods will be employed on the *Peregrine*, although the 640 in^3 array will operate at only 1 m gun depth. Observers will use the same radii as for the 1210 in^3 array operating at 2.3 m gun depth.

The reticle in 7 × 50 binoculars will be of less use in estimating distances to cetaceans near the more distant 180 dB safety radius (approx. 150-900 m), given the low vantage points on the seismic vessels. For the *Arctic Star*, with eye level 5.6 m above water, a 0.25° vertical uncertainty corresponds to a 473-1805 m range of uncertainty for an object 750 m away. The height of the vantage point in the *Peregrine* is slightly lower than that on the *Star*, and reticle-based distance estimates will be revised accordingly.

Observers will use a Bushnell Lytespeed 800 laser rangefinder with 4× optics to test and improve their abilities for visually estimating distances to objects in the water. Previous experience showed that this Class 1 eye-safe device was not able to measure distances to seals more than about 70 m (230 ft) away. However, it was very useful in improving the distance estimation abilities of the observers at

[3] We have not corrected the manufacturer's reticle conversion factor to account for the findings of Kinzey and Gerrodette (2001). The difference in the manufacturer's and the new conversion factor determined by Kinzey and Gerrodette was quite small. The authors clearly state that the manufacturer's conversion factor is sufficient for practical purposes.

distances up to about 600 m (1968 ft)—the maximum range at which the device could measure distances to highly reflective objects such as other vessels. In our experience, humans observing objects of more-or-less known size via a standard observation protocol, in this case from a standard height above water, quickly become able to estimate distances within about ±20% when given immediate feedback about actual distances during training.

When a marine mammal is seen within the safety radius applicable to that species, the geophysical crew will be notified immediately so that mitigation measures called for by the IHA can be implemented. As in 1996-2000, it is expected that the airgun arrays will be shut down within several seconds—often before the next shot would be fired, and almost always before more than one additional shot is fired. The marine mammal observer will then maintain a watch to determine when the mammal(s) appear to be outside the safety zone such that airgun operations can resume. Airgun operations were interrupted on 57, 10 and 14 occasions in 1998, 1999 and 2000, respectively, when seals were seen within or near the safety radii (Lawson and Moulton 1999; Moulton and Lawson 2000a,b). In 1996 and 1997 there were 112 and 12 shutdowns, respectively, during BP's seismic operations when a seal was seen within the safety radii (Harris et al. 1998, in press). There was one additional shutdown in 1997 when a bowhead whale was seen within the safety radius; that was the only whale sighting near the operating airguns in 1996-2000 (Miller et al. 1997, 1998, 1999; Richardson and Miller 2000; Richardson [ed.] 2000b).

The observers on the seismic source vessel will record the observations onto datasheets. During periods between watches and periods when operations are suspended, these data will be entered into a laptop computer running a custom computer database. The accuracy of the data entry will be verified by computerized validity checks as the data are entered and by subsequent manual checking of the database printouts. These procedures will allow initial summaries of data to be prepared during and shortly after the field season, and will facilitate transfer of the data to statistical, graphical or other programs for further processing. LGL's field crew leader will provide a brief progress report at least once per week to WesternGeco and to NMFS (as the IHA is likely to require).

Inupiat observers will be encouraged to record comments about their observations into the "comment" field in the database. Copies of these records will be available to the Inupiat observers for reference if they wish to prepare a statement about their observations. If prepared, this statement would be included in the 90-day and final reports documenting the monitoring work (as in 1998-2000).

Results from the vessel-based work will provide

(a) the basis for real-time mitigation (airgun shutdown),

(b) information needed to estimate the "take" of marine mammals by harassment, which must be reported to NMFS,

(c) data on the occurrence, distribution, and activities of marine mammals in the area where the seismic program is conducted,

(d) information to compare the distance and distribution of marine mammals relative to the source vessel at times with and without seismic activity,

(e) data on the behavior and movement patterns of marine mammals seen at times with and without seismic activity, and

(f) information to compare the efficacy of one versus two observer marine mammal watches.

The "90-day report" required 90 days after the end of the field season will, as a minimum, describe (a) - (d) based on the 2001 data. The draft final and final reports to WesternGeco and NMFS will include information about all six topics, including combined 1996-2001 analyses where needed to address project objectives (§1.3) and to test the hypotheses regarding "Effects on Seal Distribution and Behavior" (§1.4).

2.3 Aerial Surveys (Task 3)

Surveys Funded by WesternGeco

If OBC seismic operations occur in Sept./Oct. 2001, WesternGeco plans to conduct aerial surveys of the seismic exploration area and nearby areas on a daily basis, weather permitting:

- If OBC seismic work continues without interruption from Aug. into early Sept., aerial surveys will be conducted daily, weather permitting, from 1 Sept. 2001 until one day after the end of airgun array operations.
- If OBC seismic work is suspended on 31 Aug. (or at some later time), but resumes later in autumn, aerial surveys will start (or resume) when seismic work resumes, and will continue until one day after the end of airgun array operations.

The aerial survey procedures during each day with surveys will be generally consistent with those during the 1998 Western Geophysical project (Miller et al. 1999). This will facilitate comparison and pooling of data where appropriate. However, the specific survey grid and procedures will be amended as agreed to at the May 2000 peer/stakeholder review meeting and described in the final monitoring plan for 2000 (LGL and Greeneridge 2000). In addition, WesternGeco will again coordinate and cooperate with the aerial surveys conducted by the Minerals Management Service in the same region (see below).

Survey Design.—WesternGeco's aerial surveys are designed to obtain detailed daily data (weather permitting) on the occurrence, distribution, and movements of marine mammals within about 65 km to the east and west of the OBC seismic exploration area, and north to about 65 km offshore. This site-specific survey coverage will complement the simultaneous MMS survey coverage. The extensive survey grid planned for use in 2001 will extend about 8 km farther east and 8 km farther west as compared with the extensive grid used in 1998. This survey coverage will provide data both within and beyond the anticipated immediate zone of influence of the seismic program, as required by NMFS monitoring guidelines. This extended coverage will document where the main bowhead whale migration corridor is located in early September 2001, relative to the seismic exploration area. It is also expected to extend far enough east to be able to document the distance to the east at which bowheads begin to deflect offshore. It may extend far enough west to document the distance to the west at which deflected bowheads return to their "normal" migration corridor. (A further extension to the west would only be possible by spreading the survey lines farther apart. That would be undesirable for several reasons, as agreed by the peer/stake-holder group during discussions at their 1999 and 2000 meetings.)

The extensive survey grid proposed for 2001, involving a series of north-south transects during each day of flying (Fig. 4), is similar to the extensive grid used during the 1998 seismic monitoring program for Western Geophysical. It is also consistent with the extensive grid used during the 1996-97

surveys for BP, with the exception that the 1998 and especially the planned 2001 surveys for WesternGeco extend considerably farther west of the seismic operations, and include 16-18 rather than 12 transects. (The westward extension in 1998 and the further east and west extensions in 2001 improve the ability of the surveys to determine how far east and west any deflection of the bowhead migration corridor extends.)

Figure 4 shows the lines that would be surveyed if seismic exploration were underway on one particular patch northwest of Prudhoe Bay. The 2001 seismic program is expected to include seismic exploration at various locations within the nearshore region that is outlined on Figure 4. The aerial survey grid will be moved east or west along the coast so as to be centered near the then-active patch, as in 1998.

As agreed at the May 2000 peer/stakeholder meeting, WesternGeco does not plan to fly a smaller "intensive" survey grid in 2001. In previous years, a separate grid of 4-6 shorter transects was flown daily, weather and time permitting, to provide additional survey coverage within about 20 km of the seismic operations. These lines were spaced mid-way between the longer lines of the extensive grid, but did not extend as far to the east, west, or offshore. This extra coverage was designed to provide additional data on marine mammal utilization of the actual area of seismic exploration and immediately adjacent waters. The 1996-98 studies showed that bowhead whales were almost entirely absent from the area within 20 km of the seismic operation at times when the airguns were active (Miller et al. 1997, 1998, 1999). Thus, it is not a priority to obtain extra survey coverage of this area in 2001. The planned "extensive survey grid" will continue to provide daily aerial survey coverage of areas within 20 km of the seismic operation. However, the region within 20 km will now receive the same intensity of survey coverage as regions 20 to 40 km away, as compared with more intensive coverage within 20 km in previous years.

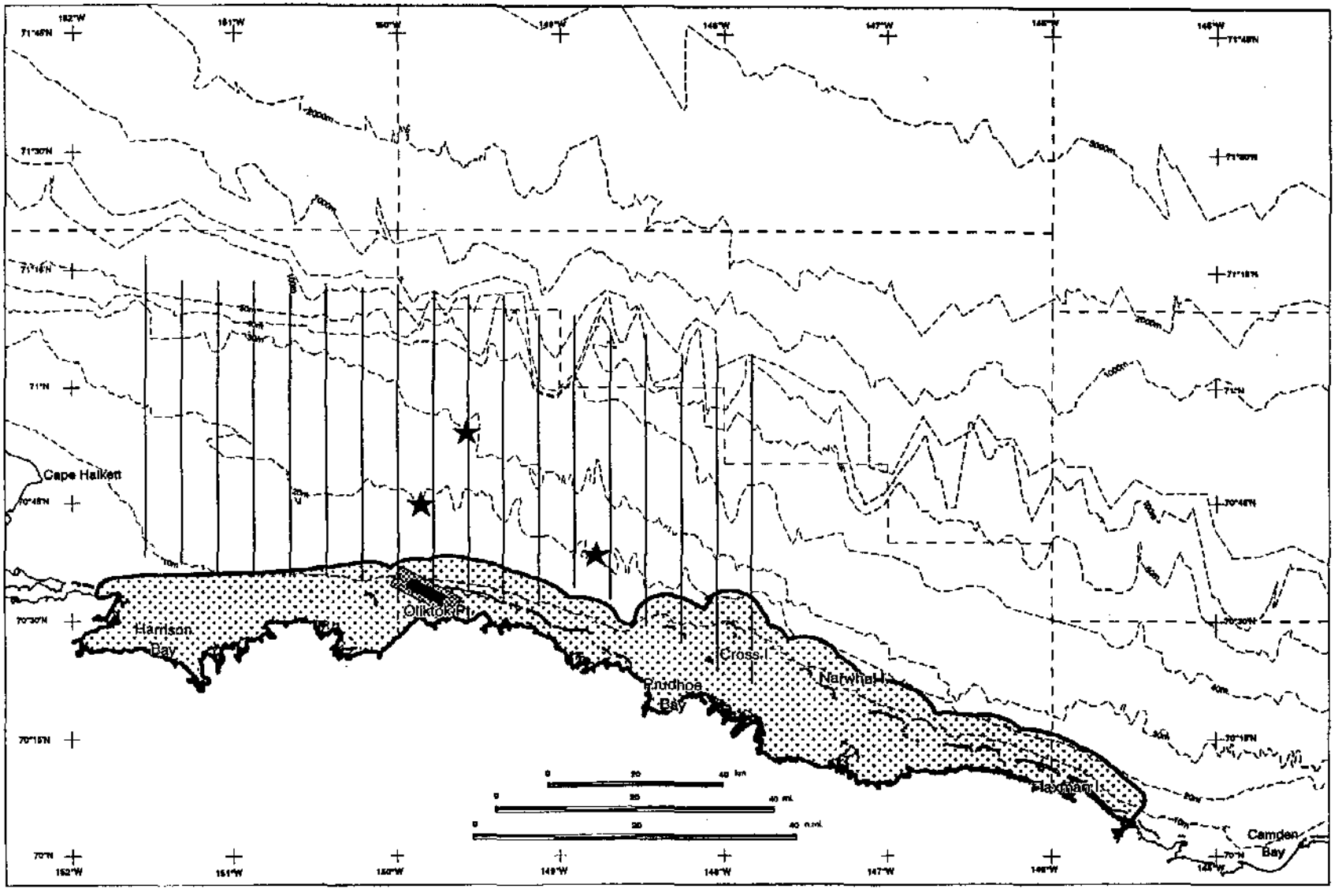

FIGURE 4. Central Alaskan Beaufort Sea showing aerial survey lines and bottom-mounted acoustic recorder locations (stars) to be used if seismic surveys were occurring in the designated "Assumed Operational Patch" west of Prudhoe Bay. Survey grids and bottom recorders will be moved east or west depending on the location of the seismic surveys.

Survey Grid.—This will consist of up to 18 lines spaced 8 km apart covering the area from about 65 km west of the western side of the then-current seismic exploration area to 65 km east of its eastern edge, and from the barrier islands north to approximately the 100 m depth contour. The 100 m contour ranges from approximately 70°50'N to 71°15'N latitude, depending on east-west position (Fig. 4). As previously described, when the seismic program moves east or west, the aerial survey grids will also be relocated a corresponding distance along the coast.

The proposed 18-line grid will extend about 65 km east of the seismic area—about the same distance east as in 1996-98, or sometimes 1 line (8 km) farther east. Based on results from 1996-98, survey coverage extending ~65 km east of the seismic area will extend sufficiently far beyond the distance where deflection of bowheads apparently begins to provide adequate documentation of that distance. The proposed grid will extend 4-5 lines (32-40 km) farther west than in 1996-97, and 1-2 lines (8-16 km) farther west than in 1998. This will provide extended coverage to the west to help determine the westward extent of the offshore displacement of whales by seismic work. The aerial survey grid was extended to the west in 1998 at the suggestion of the AEWC and NSB, and is further extended in 2001 at the suggestion of the peer and stakeholder review group during their 30 June – 1 July 1999 and 24-25 May 2000 meetings.

The grid will total about 1300 km in length, requiring 6 h to survey at a speed of 220 km/h (120 knots), plus total ferry time of about 2 h to and from Prudhoe Bay and between lines. Exact lengths and durations will vary somewhat depending on the east-west position of the seismic operations area and thus of the grid, the sequence in which lines are flown (often affected by weather), and the number of refueling/rest stops at Prudhoe Bay.

As in 1998, we propose that, while whaling is underway from camps at Cross Island, we will not survey the southern portions of survey lines that approach within about 15 km (8 n.mi.) of Cross Island and the McClure Islands unless the Nuiqsut whalers agree that this can be done without interfering with their activities. This will reduce (but not eliminate) the potential for overflying whalers and whales that are being approached by whalers. Some of the autumn bowhead sightings in the region do occur in this "nearshore" area (Fig. 1), and these whales will not be documented if the survey aircraft remains 15+ km offshore in this area. If we do not survey this area while whaling is occurring, we will reduce the potential for aircraft-whaler interactions at the expense of reducing our ability to assess seismic effects on bowheads, other marine mammals, and subsistence activities in that nearshore area.

From a monitoring and scientific viewpoint, it would be preferable to extend the aerial surveys closer to the islands. We propose to survey the southern portions of these lines at times when whaling is not going on: (a) if whaling at Cross Island does not begin until after aerial surveys commence on 1 Sept., or (b) if whaling is temporarily suspended during the whaling season, or (c) if the seismic and marine mammal monitoring programs continue after whaling at Cross Island has ended for the autumn. All three of these situations occurred during the 1996-98 seismic monitoring programs.

Transect Positions and Sequence.—For the purposes of this project, which primarily concern migrating bowheads, the transect lines in the grid should be oriented north-south, equally spaced, and at consistent locations from day to day. If the primary purpose were to estimate numbers of non-migrating mammals, there would be statistical reasons for partially randomizing the transect locations, either once or daily. However, these reasons do not apply in the present study concentrating on migrating animals.

Weather permitting, the transects making up the grid will be flown in sequence from west to east. This reduces difficulties associated with double counting of whales that are migrating westward. However, if cloud, fog or high sea-state prevents coverage of the western part of the grid early in the day, the eastern portion will be surveyed first. If, after that is done, conditions on the western portion have become tractable, the western portion of the grid would then be surveyed.

Survey Procedures.—Standard aerial survey procedures as used in many previous marine mammal projects will be followed. The aircraft will be flown at 120 knots ground speed and usually at an altitude of 1000 ft. An altitude of 900-1000 ft is the lowest survey altitude that can normally be flown without concern about potential "take" by aircraft disturbance; it is the altitude recommended for IHA monitoring efforts. The 2001 "Conflict Avoidance Agreements" between the whalers and WesternGeco is expected to authorize aerial surveys at an altitude of 1000 ft. Aerial surveys at altitude 1000 ft do not provide much information about pinnipeds but are suitable for both bowhead and beluga whales. The need for a 900-1000+ ft cloud ceiling will limit the dates and times when surveys can be flown. During the 1998 Western/LGL seismic monitoring program, partial or complete surveys were possible on 35 days of the 45-day field period (Miller et al. 1999). In most other years, the proportion of the days when surveys were possible was lower than in 1998.

Two primary observers will be seated in the copilot's seat and behind the pilot. A third observer will be seated behind the copilot's position, observing part time but also operating a data logger and sonobuoy receiving equipment (see Section 2.4 "Acoustic Measurements", below). All observers will have bubble windows to facilitate downward viewing. For each whale sighting, the observer will dictate the species, number, size/age/sex class when determinable, activity, heading, swimming speed category (if traveling), sighting cue, ice conditions, and inclinometer reading. The inclinometer reading will be taken when the animal's location is 90° to the side of the aircraft track, allowing calculation of lateral distance.

Sighting data will be entered into a GPS-linked data logger by the third observer, and simultaneously recorded on audiotape for backup and validation. In addition, the observers will record the time, visibility, sea state, ice cover and sun glare at the start and end of each transect, and at 2-min intervals along the transect. This will provide data in units suitable for statistical summaries and analyses of effects of these variables on the probability of detecting animals (see Davis et al. 1982). The data logger will automatically record time and aircraft position (latitude and longitude) for sightings and transect waypoints, and at frequent intervals along the transects.

If marine mammals are seen within any "safety zone" around the seismic source vessel that may be defined, or heading toward that zone, the aerial observers will notify personnel on the seismic source vessel by radio.

Selection of Aircraft.—We plan to use either a Grand Commander 680FL (modified) or a Turbo Commander available from Commander Northwest of Anchorage. Their aircraft have been used extensively by NMFS, ADF&G, COPAC, and LGL during many recent marine mammal projects in Alaska. These types of aircraft have been found to be very suitable for survey work, and are more economical than potential alternatives. Among the essential or desirable features are a high wing, dual GPS systems, bubble windows, sonobuoy chute and antenna, VHF/SSB/FM radios, AC inverter, high-quality intercom, active noise-canceling headsets, adjustable seating positions, and movable computer desk. Endurance

depends on whether the piston-or turbine-engined aircraft is used, plus load and airspeed, but is adequate for this project.

For safety reasons, the aircraft will be operated with two pilots. The copilot will occupy the copilot's seat during takeoffs, landings, and prolonged ferry flights, but will move to a vacant rear seat during surveys to allow a biologist to observe from the copilot's seat during surveys. The proposed aircraft can accommodate an additional passenger if necessary. However, that requires installing an extra seat in a space normally occupied by gear. Space then becomes very cramped.

Avoiding Fatigue.—The size of the survey grid planned for 2001 is comparable in total length to that in 1998, and larger than that in 1996-97. The planned surveys will require about 8 hours of flying per day, weather permitting. A single team of observers cannot survey for that many hours on a daily basis without becoming fatigued and missing more mammals than normal. This is especially so when good flying weather persists for 2 or 3 days in a row. Fatigue is exacerbated by the need to spend considerable time on the ground coordinating with other vessel-based and aerial field crews in the morning and evening, and organizing each day's data for the required evening transmissions to MMS and NMFS. To minimize the fatigue problem, a four-person aerial survey crew will be used, as in 1998 (two primary observers; data-logger/secondary observer; additional alternate observer). The alternate will rotate observation duties with the other three observers, and will share the coordination and data summarization responsibilities.

It will often be feasible for the "extra" observer to remain on the ground, with rotation occurring when the aircraft lands to refuel or for a brief break. However, at some times the off-duty observer will need to ride in the aircraft.

Similarly, the length of the extensive survey grid means that the two pilots will need to share the flying duties. In 2001, as in 1998, we will ask the aircraft charter company to supply two senior pilots who can rotate the "left seat" flying duties during transect flying. The other pilot can rest in the rear of the aircraft during routine survey flying.

Supplementary Data

Weather, ice and sightability data for 2001 will be recorded systematically during all surveys. Percent ice cover and severity of sun glare will be recorded by each primary observer for every 2-minute interval along transects. Ice observations during aerial surveys will be mapped when ice is present.

We will, as a high priority, assemble the information needed to relate marine mammal observations to the shooting schedule and locations of the OBC seismic vessel, and to the received levels of seismic pulses at mammal locations. Data on the shooting schedule, seismic tracklines, and heading of the seismic vessel will normally be available from records maintained by the seismic contractor and by the marine mammal observers on the seismic source vessel (see §2.2).

Sonobuoys will be dropped from the survey aircraft near bowheads that are sighted within 30 km of the OBC seismic vessel, near some of the more distant bowheads, and at other offshore locations (see §2.4). The purposes will be to measure, at whale locations,

- received levels and characteristics of seismic pulses, and
- signal-to-ambient ratios.

When other industry vessels, whaling vessels, low-flying aircraft, or any other human activities are seen in the survey area during the 2001 aerial surveys, we will record this information, along with the type of vessel or activity, position, time, vessel heading (if moving), and any other potentially relevant information.

MMS Aerial Surveys, Autumn 2001

The Minerals Management Service is planning to continue its wide-ranging aerial surveys of bowhead whales and other marine mammals in the Beaufort Sea during the autumn of 2001 (S. Treacy, MMS, pers. comm.). Their surveys include the present study area, but also extend much farther to the east and west and somewhat farther to the north. MMS has given preliminary assurance that they will again provide us with access to their data, both during the 2001 field season and for use in analyses and reports (S. Treacy, MMS, pers. comm., March 2001).

We will continue to consult with MMS regarding coordination and sharing of data. Our aims will be

- to ensure aircraft separation when both crews conduct surveys in the same general region;
- to coordinate the 2001 aerial survey projects in order to maximize consistency and minimize duplication;
- to use data from MMS's broad-scale surveys to supplement the results of the WesternGeco/LGL surveys for purposes of assessing seismic effects on whales and estimating "take by harassment";
- to maximize consistency with previous years' efforts insofar as feasible;
- to maximize the power of the combined datasets in addressing the objectives listed in §1.3.

It is expected that raw bowhead sighting and flightline data will be exchanged between MMS and LGL on a daily basis in Prudhoe Bay during the 2001 field season, and that each team will also submit its sighting information to NMFS in Anchorage each day. After the WesternGeco/LGL and MMS data files have been reviewed and finalized, they will be exchanged in digital form.

We are not aware of any other aerial survey programs presently scheduled to occur in the Alaskan Beaufort Sea during Sept./Oct. 2001. If another aerial survey project is planned, WesternGeco and LGL will seek to coordinate with that project to ensure aircraft separation, maximize consistency, minimize duplication, and share data.

Analysis of Aerial Survey Data

The key questions to be addressed if the seismic program extends into September are summarized in the Introduction (Section 1). These questions to which aerial surveys are relevant are similar to those addressed by Western's 1998 seismic monitoring programs (see Miller et al. 1999). Objectives 1-3, pertaining to the distribution, movements, headings and abundance of bowheads, will be addressed for 2001. During the 2001 analyses, emphasis will be placed on estimating the numbers, distribution, movements, and activities of bowheads exposed to airgun sounds, and on comparing these results with corresponding data from times without seismic sounds. Sound levels to which bowheads are exposed will also

be determined based on data from Task 4, "Acoustic Measurements" (§2.4). All of these results will be important in determining estimated "take" by harassment (§2.5).

These aerial survey results concerning bowhead whales in 2001 will be compared and combined with data from Western/LGL, BP/LGL and MMS surveys in the area during 1996-98. These analyses will address objectives 1, 2 and 3 from §1.3 concerning the occurrence and movements of bowheads in the areas of seismic exploration during 1996-98 plus 2001 combined. As described in §1.3, the analyses will be done in detail if a substantial increment of data on bowheads is obtained in Sept./Oct. 2001, and in less detail if few new data pertaining to bowheads are obtained.

Location of Migration Corridor.—To test for effects of active OBC seismic work on the onshore-offshore position of the bowhead migration corridor (if seismic work occurs in Sept./Oct. during 2001), we will contrast the numbers of bowhead sightings and individuals vs. distance from shore

- during periods with vs. without seismic operations, and
- near vs. east vs. west of the seismic exploration area.

The distance from shore categories will be linked to received sound levels based on the results from Task 4, the acoustic measurement task. Analyses will be done on a sightings per unit effort basis to allow meaningful interpretation even though aerial survey effort is inevitably inconsistent at different distances offshore. Aerial survey data collected in the Prudhoe Bay area in prior years have already been formatted ready for these analyses. If sufficient data are obtained, we will again use the Kolmogorov-Smirnov (K-S) approach as applied to the 1996-98 and 1979-95 data by LGL and Greeneridge (1996) and Miller et al. (1997, 1998, 1999). Hollander and Wolfe (1973) describe the basic K-S method and Miller et al. (1999) describe its most recent application to this situation.

Zone of Avoidance.—To determine how far east, north and west displacement effects extend, additional analyses will be conducted on bowhead sightings and survey effort in relation to distance and bearing from the seismic operation during times with and without active airgun operations. Results from 1996-98 indicate that this approach is more sensitive than the one described in the preceding paragraph for detecting avoidance of the area around the seismic operation.

The combined 1996-98 plus 2001 dataset from the seismic monitoring and MMS surveys may be large enough to permit a meaningful analysis of the probability of avoidance reactions in relation to distance east and west as well as north (offshore) of the seismic operation. If the 2001 seismic and aerial surveys extend well into September and provide a substantial increment of data, we will perform a log-linear analysis of combined-year sightings relative to survey effort in various bearing and distance categories at times with and without OBC seismic operations. This will test the hypothesis that there is no difference in the distribution of bowhead whales, during seismic operation as compared to no seismic operation, at points 10, 20, 30, 40 km (a) offshore of the seismic area, (b) "upstream" (to the east) of the seismic area, and (c) "downstream" (to the west) of the seismic area. If sufficient data are available after the 2001 season, a multivariate analysis (logistic regression) of the combined-year data will also be done to assess sighting probability in relation to distance and direction from the active vs. suspended seismic operation. This will allow for confounding factors such as distance from shore, water depth, sea state, visibility, ice cover, and date within the migration season.

The aerial survey data pertaining to other species of marine mammals will also be mapped and analyzed insofar as this is useful (see objectives 5 and 6 in §1.3). However, the main migration corridor of belugas is far offshore, north of the area to be surveyed in the surveys proposed here. Gray whales and walruses are unlikely to be seen because of their rarity in the central Beaufort Sea area (although gray whales were seen in the area in 1998—Miller et al. 1999). Therefore, the proposed aerial surveys are expected to document the infrequent use of the area by beluga whales, gray whales and walruses, but detailed analyses for these species probably will not be warranted. Seals cannot be surveyed quantitatively by aerial surveys at altitudes 900 to 1500 ft over open water. The aerial surveys will provide only incidental data on the occurrence of bearded and especially ringed seals in the area. (The vessel-based observations [§2.2] will provide more detailed data on seals.)

Level of Detail in Analysis.—If, during Sept./Oct. 2001, seismic surveys continue for a period spanning at least 10 days in areas not sheltered by barrier islands or shallows, the combined aerial survey datasets from 1996-98 plus 2001, along with related MMS aerial survey data, should provide sample sizes large enough to warrant detailed quantitative analysis of the bowhead objectives and hypotheses identified in sections 1.3 and 1.4. Analyses of combined 1996-98 aerial survey data are included in the final report on the 1998 seismic monitoring work. Those 1996-98 analyses will provide a foundation for analysis of the combined 1996-98 plus 2001 dataset. If any of the major null hypotheses cannot be rejected, statistical power analysis will be done to determine (1) how large an effect would have been necessary in order to reject the null hypothesis, and/or (2) how large a sample size would have been needed for the observed effect size to be statistically significant. These points will apply to analyses of vessel-based observations (§2.2) as well as aerial surveys.

2.4 Acoustic Measurements (Task 4)

Introduction

The acoustic program proposed as part of WesternGeco's 2001 seismic project is designed to provide, in conjunction with existing results from previous years, the specific acoustic data needed to document the seismic sounds to which marine mammals will be exposed in 2001. This information is needed to estimate "take" and to interpret the observations of marine mammal distribution, behavior, and headings.

The basic objectives of the acoustic measurements include one physical acoustics objective plus one biological objective. Emphasis will be on situations and locations not studied in detail during previous operations. The physical acoustics objectives (numbered as in §1.3) are as follows:

7. If seismic operations continue in Sept./Oct. 2001, determine the characteristics of airgun array pulses as received in the bowhead migration corridor at varying distances offshore and to the east of the area of seismic exploration in 2001 and in 1996-98 plus 2001 combined. Pulse characteristics to be determined are received levels (peak, rms, energy) and pulse durations vs. range offshore and to the east, spectral properties, and signal-to-ambient ratios.

In addition, another objective of the acoustic program (also from §1.3) is

4. Determine whether there are differences in the pattern of bowhead call detection rates near, offshore of, and east of the seismic exploration area at times with and without active seismic operations based on 2001 data and 1996-98 plus 2001 data. If so, use the combined acoustic and aerial survey data to evaluate whether the noise-related differences in call detection rate are attributable to differences in calling behavior, whale distribution, or a combination of the two.

WesternGeco's acoustic measurement program for 2001 is planned to include (a) deployment in late August/September of autonomous seafloor acoustic recorders (ASARs) to provide continuous acoustic data for extended periods; and (b) use of air-dropped sonobuoys in Sept./Oct. These methods will only be used if OBC surveys occur in Sept./Oct.

Method (a) ASARs, will provide a large number of measurements of received characteristics of seismic pulses in the whale migration corridor well offshore and east of the area of OBC seismic exploration, as relevant to objective (7), above. ASARs will also provide continuous data on whale calling patterns at times with and times without airgun operations, relevant to objective (4). ***Method (b), sonobuoys,*** will provide specific measurements of seismic sounds received near bowhead whales, also relevant to objective (7). Neither method (a) nor method (b) was applied in 1999 or 2000 because there were no seismic operations after 1 Sept. Therefore, there are no existing data of these types during operation of the 12-airgun 1210 in^3 array used in 1999-2000 or of the "new" 16-airgun 640 in^3 array.

The 2001 program will not unnecessarily duplicate measurements that are already available from previous studies (e.g., Greene 1997; Greene et al. 1998; Burgess and Greene 1999; Greene and Burgess 2000; Greene and McLennan 2000). In particular, the larger airgun array to be used by WesternGeco in 2001, with 12 airguns of total volume 1210 in^3, will be identical to the array deployed by the source vessel *Arctic Star* in 1999 and 2000. The sound characteristics of that array, and their propagation to short and moderate ranges, have already been determined in detail (Greene and Burgess 2000; Greene and McLennan 2000). The specific locations to be surveyed by WesternGeco in 2001 will be within the same general region where many propagation measurements were taken during the 1996-2000 seismic monitoring projects. Much additional information about sound transmission loss and ambient noise in that region was obtained in 1996-2000 and prior years (e.g., Miles et al. 1987; Greene 1997; Greene et al. 1998; Burgess and Greene 1999; Greene and Burgess 2000; Greene and McLennan 2000). Thus, characteristics of the sounds propagating horizontally from the 1210 in^3 12-gun array to distances out to about 10 km do not need to be measured again in 2001.

Autonomous Seafloor Acoustic Recorders

The 2001 seafloor recorder program would involve deploying autonomous seafloor acoustic recorders (ASARs) at three locations in late August or September if OBC seismic work extends into the Sept./Oct. 2001 period. Following the practice in earlier years, two locations will be offshore of the seismic exploration region near the 25 m and 35-40 m depth contours. The third location will be near the 25-m contour about 40 km farther east (similar to the configuration shown in Fig. 4). If the 25-m contour is more than 15 km seaward of the northern edge of the area of seismic operations (as is likely), the "25-m" units would be placed inshore of the 25-m contour so the closest unit is no more than 15 km from the area of seismic operations. The objective is to obtain continuous records of seismic sound pulses, whale calls, and (incidentally) ambient noise at locations of interest in or near the whale migration corridor.

- If seismic work is to continue without interruption into early Sept., ASARs will be installed around 25-28 August, and programmed to start recording on 29 August. Normal recording life of the existing units is ~22 days. The ASARs will be retrieved when their storage capacity is reached (~19 Sept. for the existing units), at the end of the seismic program if that occurs before 19 Sept., or at an earlier date if ice conditions threaten to prevent retrieval of the ASARs. If seismic work is continuing when the ASARs are recovered, they will be refurbished and re-deployed if it is likely that seismic operations will continue for at least 5 additional days, and if ice is not threatening. Whether or not to re-deploy the ASARs after initial retrieval will be at the discretion of the acoustics field crew, as discussed at the peer/ stakeholder review meeting in May 2000.
- If seismic work is scheduled to be suspended on 31 Aug. but may resume later, the ASARs will not be deployed on 25-28 August, but will be deployed upon resumption of offshore work — weather, ice, and whaling permitting.

In any case, the ASARs may need to be retrieved before the end of seismic operations in order to reduce the risk that ice will prevent retrieval before winter. (If ice does prevent recovery of the ASARs in the autumn of 2001, the data stored in them will not be available for use in the reports on the 2001 monitoring project, and there will be increased risk that the ASARs and the data within them will be damaged or lost permanently.) Vessel operations near and east of Cross Island during the whaling season, to deploy or retrieve ASARs, would be coordinated with the Nuiqsut hunters to avoid any potential interference.

If practical, six ASARs will be used, with two units placed at each of the three locations. This "redundant" deployment will provide greater assurance that acoustic data will be obtained from each recording site. If each of two co-located units operate successfully, only one of these redundant datasets will be analyzed in detail.

These recorders will have, as a minimum, the same capabilities as those used during the 1996-98 seismic monitoring programs in the Beaufort Sea (Greene 1997; Greene et al. 1998; Burgess and Greene 1999). Assuming that at least one of the redundant ASARs at each location operates properly and can be retrieved, the ASARs will provide extended series of data of the following types:

- Bowhead whale call detection rates at the three ASAR locations will be determined and compared for periods with and periods without active seismic exploration, following procedures applied to the 1996 and 1998 data (Greene 1997; Greene et al. 1998, 1999).
- Seismic pulse levels and characteristics will be determined as received by the ASARs at various distances and bearings from the seismic source vessel while it moves back and forth within the survey patches. This dataset, like corresponding 1996-98 datasets described by Greene (1997), Greene et al. (1998), and Burgess and Greene (1999), is expected to include information about the received levels of thousands of seismic pulses recorded at a wide range of distances out to about 40 km offshore to the north and 40-50 km alongshore to the east. The array type (1210 in^3 vs. 640 in^3), gun configuration, location, aspect, water depth, and gun depth will be recorded for every airgun pulse. We will analyze the relationships between these variables and the pulse levels and other pulse characteristics as received at the ASARs, taking account of the occurrence of any islands or shallow areas between the source and the ASARs.

- Ambient noise levels and characteristics will also be recorded at the ASAR locations and analyzed in ways consistent with those applied during the 1996-98 seismic monitoring projects.

Sonobuoys

If OBC seismic work occurs in Sept./Oct., sonobuoys will be dropped from the survey aircraft at locations near whales. Sonobuoys will provide data on received levels and other characteristics of Western's seismic pulses as received in the bowhead migration corridor, including some specific locations where bowhead whales are present. The sonobuoys will also provide the ambient noise data needed to estimate signal-to-noise ratios for seismic pulses received by bowheads. Sonobuoy drops will occur during the period while the WesternGeco/LGL aerial surveys are conducted, as described in §2.3, "Aerial Surveys". Sonobuoys will be deployed at an average rate of about two sonobuoys per day of surveys on days when bowheads are seen.

Sonobuoy procedures will be consistent with those in 1996-98. Sonobuoys to be used will be Sparton AN/SSQ-57A omnidirectional, wide-range sonobuoys calibrated (±2 dB) over the frequency range 10-20,000 Hz. These sonobuoys were acquired in 1999 in anticipation of use in Sept./Oct. 1999. As in 1998, the sonobuoys were modified during manufacture to deploy the hydrophone to a depth of 10 m instead of the standard 18 m. This will permit deployment of some sonobuoys in waters shallower than 18 m if needed. In addition, some sonobuoys desensitized by known amounts (20-40 dB) are available to provide undistorted data at sites close to the airgun array, where received levels of seismic pulses are high. On the aircraft, a four-channel sonobuoy receiver will be connected to an external antenna through a low-noise RF preamplifier. Signals will be recorded on an instrumentation-quality DAT recorder.

On at least one day during Sept./Oct., and twice if feasible, sonobuoys will be deployed simultaneously at 3 or 4 locations at varying distances east of the operating airgun array to provide additional data on alongshore sound propagation. These measurements will be taken on days when there are no islands or shallows between the airgun array and the open sea. (This task would not be done if there are no seismic survey operations outside the lagoons at times when sonobuoys can be dropped.) Sonobuoys will be dropped at distances of approximately 20, 40 and 60 km east of the airguns, and monitored simultaneously via the multi-channel sonobuoy receiving and recording system aboard the project aircraft. Received pulses will be recorded while the seismic vessel operates at both the north and south edges of the current patch.

Signal Analysis

Digital signal analysis techniques will be applied by Greeneridge in analyzing received levels and characteristics of seismic sounds, other man-made sounds, and ambient noise. Similar techniques will be applicable to data from autonomous seafloor recorders and OBC signals. These techniques are based on the use of computer workstations equipped with dual-channel 16-bit Sigma-Delta analog-to-digital converters and digital signal processors. The analysis routines have evolved over more than 20 years of analyzing ambient and industrial noise data, including seismic pulses, specifically for purposes of marine mammal and noise studies. The procedures now include archiving of results in a standard database format, and export of essential results to spreadsheets for further analyses and graphing. Spectral density

analyses, cross-correlation, and time series analyses are all done routinely on the recorded sounds, including displays of narrowband and 1/3-octave band spectra, waterfalls, and spectrograms (sonograms).

Seismic pulses will be characterized in the same ways as used during the 1996-2000 acoustic monitoring work (Greene 1997; Greene et al. 1998; Burgess and Greene 1999; Greene and Burgess 2000; Greene and McLennan 2000). For each pulse analyzed, the peak level, root-mean-square (rms) pulse level, duration, and energy will be determined. Seismic pulses have been measured in varying ways during different projects, often producing non-comparable results (Greene 1995). Our main measure of the received level of seismic pulses will be the rms pressure averaged over the duration of the pulse, in dB re 1 μPa (Greene 1997). This procedure is consistent with that of Malme et al. (1984) and with the 1996-2000 seismic monitoring projects in the Beaufort Sea. However, the relationships of rms, peak, energy, and duration measures, as determined in previous years, will be verified for 2001. It is recognized that there is an increasingly prevalent view that studies concerning effects of pulsed sounds on marine mammals should use the energy in the pulse(s) as the primary measure of sound exposure. As in the 1996-2000 seismic monitoring studies in the Beaufort Sea, energy content as well as the rms (and peak) pressure will be determined for each pulse that is measured.

This approach, combined with the high-quality calibrated equipment to be used, along with suitable backup equipment, will assure that high-quality results will be obtained. These results will be consistent with those obtained in previous years, which will allow related data from different years to be compared or combined during analysis when appropriate.

2.5 Estimated "Take" by Harassment

The main purposes of the 2001 monitoring program insofar as the IHA requirements are concerned are to provide the data needed to determine how many marine mammals of each species were "taken by harassment" by the seismic program, the nature of those takes, their likely consequences for the marine mammal populations, and whether there was any effect on the accessibility of marine mammals to subsistence hunters (see §1.3, "Objectives", items 9-12). NMFS requires these data to ensure that the seismic program had no more than a negligible impact on species or stocks of marine mammals, and no unmitigable adverse impact on their availability for subsistence hunting. The data to be collected by the vessel-based observers, aerial surveys, and acoustic programs, and the associated analyses of these data and of prior years' data, will provide the needed information.

The criteria to be used in tabulating and estimating numbers of mammals "taken" will be consistent with those used during previous related projects in 1996-2000 unless otherwise directed by NMFS. As in previous studies, we anticipate that there will be four components:

1. *Numbers of mammals observed within the area ensonified strongly by the OBC seismic vessel.* For ***cetaceans***, we will estimate the numbers of animals exposed to received rms levels of OBC seismic sounds exceeding 160 dB and 180 dB re 1 μPa. The 160 dB criterion is based on observations of the situations when bowhead and gray whales showed consistent, strong reactions to seismic vessels (Malme et al. 1984; Richardson et al. 1986; Ljungblad et al. 1988). In the Beaufort Sea, received levels may exceed 160 dB (rms) out to several kilometers from a seismic vessel (Greene and Richardson 1988; Greene and Moore 1995; Greene 1997). We will also estimate the number of cetaceans exposed to received levels ≥180 dB (rms). This is the

received level above which there is some suspicion that seismic pulses might affect hearing sensitivity or perhaps some other physiological processes of baleen whales (NMFS 1995, 2000; HESS 1999).

For ***pinnipeds***, we will estimate the number of animals exposed to received levels of OBC seismic sounds exceeding 160 dB and 190 dB re 1 µPa (rms). The 190 dB figure is based on the minimum received level at which effects on pinniped hearing sensitivity, or other physical effects, might occur (NMFS 1995, 2000). There is no specific evidence that seismic pulses with a received level of 160 dB re 1 µPa (rms) elicit disturbance or other deleterious effects on seals. However, NMFS (1999) indicated that the zone of influence of airgun pulses should be considered the distance within which the received level could be ≥160 dB re1 µPa SPL (=rms).

2. *Numbers of mammals observed showing apparent reactions to seismic pulses, e.g., heading in an "atypical" direction.* Animals exhibiting apparent responses to the noise will be counted as taken if they were exposed to OBC seismic pulses.

3. *Numbers estimated to have been subject to "takes" of types (1) and (2) when no monitoring observations were possible.* This will involve using the observations from the vessel-based observers and survey aircraft (WesternGeco/LGL and MMS) to estimate how many marine mammals of each species were exposed, over the full course of WesternGeco's 2001 seismic program, to situations where "takes" of types (1) or (2) were likely. In the case of the bowhead whale, we will estimate the proportions of the observed whales that were, simultaneously, ♦ close enough to shore to pass through the area where "take" would occur, and ♦ have passed while OBC seismic operations were underway. Our aerial survey design (§2.3), together with the complementary aerial surveys to be conducted by MMS, will provide the needed data if seismic operations continue after 31 August.

4. *The number of bowheads whose migration routes came within 20 km of the operating OBC seismic vessel, or would have done so if they had not been displaced farther offshore, will be estimated.* If the 2001 or combined 1996-1998 plus 2001 data indicate that the avoidance distance exceeds 20 km, the larger avoidance distance will also be used. These estimates will be obtained by determining the displacement distance based on the aerial survey results, and then estimating how many bowheads were likely to approach the avoided area during times while the airgun array was operating. This method was used in previous years to estimate the number of bowheads that may have avoided the area within 20 km of the seismic operations (Miller et al. 1998, 1999).

3. PERSONNEL

The project will be directed by Dr. W. John Richardson of LGL. The vessel-based marine mammal observations will be supervised by Dr. John W. Lawson, and the field crew leader for that work will be one of the following: John W. Lawson, Gary W. Miller, Valerie D. Moulton, Ross E. Harris, Michael T. Williams, Larry Martin, Beth Haley, or Jessy Coltrane, all of LGL. If seismic work occurs in Sept./Oct., the crew leader for the aerial-survey work is expected to be Gary Miller, although any of the following could substitute as crew leader if necessary: Dr. Stephen R. Johnson, William R. Koski, Valerie Moulton, or W. John Richardson, all of LGL. All of these biologists participated extensively in similar roles during

similar seismic monitoring projects in 1996-2000. Other LGL biologists, most of whom also participated in the 1996-2000 seismic monitoring programs, will be available to participate in the monitoring at various times if needed, including Mike Bentley, Lynn Noel, Craig S. Perham, Shawn P. Haskell, and Tannis Thomas, all of LGL. Robert E. Elliott of LGL will again be the primary data analyst, assisting the other biologists with analysis and mapping tasks.

In charge of the acoustical measurements will be Dr. Charles R. Greene Jr. of Greeneridge Sciences. Dr. William Burgess, Dr. Susanna Blackwell, and/or Robert Norman will assist with acoustic fieldwork, analysis, and reporting. Bob Blaylock will again work with the senior acousticians to perform the acoustical signal analyses at the Greeneridge laboratory.

Specialized statistical assistance for the 1998 phase of this project was provided by Dr. Naomi Altman, Biometrics Unit, Cornell University (time-series analysis of whale calls), and Dr. Trent McDonald and colleagues of WEST Inc., Cheyenne, WY (whale distribution relative to seismic vessel). We expect that both will assist again in 2001 if substantial monitoring work occurs in Sept./Oct. 2001, necessitating analysis of whale call and whale distribution data.

The following sections summarize the qualifications of the LGL and Greeneridge personnel.

3.1 LGL Personnel

W. John Richardson, Ph.D., Executive Vice President of LGL Ltd., the project director, is an animal behaviorist. He was project director for the 1998-2000 marine mammal monitoring programs for Western Geophysical and the 1995-97 programs for BP, and was field crew leader for the first week of aerial surveys in 1996. Since 1980, he has conducted many field studies, reviews, and environmental assessments of noise effects on marine mammals, working closely with physical acousticians. He was project director for a major 4-year field test of industrial noise effects on bowhead and beluga whales near Barrow, AK (completed in 1995). In 1980-85 he directed the first experimental study of noise effects (including seismic effects) on bowheads, and in 1985-86 and 1998-2000 he directed bowhead feeding ecology projects in the eastern Alaskan Beaufort Sea. In 1984-86 he also helped supervise several industry-funded monitoring programs in the Alaskan Beaufort. He has been field crew leader during about 1000 hours of aerial survey/aerial observation work over the Beaufort Sea, mainly concerning disturbance effects on marine mammals.

Dr. Richardson is knowledgeable about research and incidental take permitting. He has experience in coordinating marine mammal projects with agency requirements and Inupiat groups. He is author of numerous refereed papers and technical reports on marine mammals and noise, and is senior author of the book *Marine Mammals and Noise*, published in 1995 by Academic Press (reprinted 1998). In 1992-94, he was a member of a U.S. National Research Council committee that reviewed the Office of Naval Research program on marine mammals and noise. He is Chairman of the Advisory Board evaluating the marine mammal research associated with the Acoustic Thermometry of Ocean Climate (ATOC) project.

John W. Lawson, Ph.D., a marine biologist specializing in pinnipeds, joined LGL's staff during 1998. He was senior crew leader for Western's 1998-2000 vessel-based marine mammal monitoring programs, and an author of six chapters of the resulting reports ("Seismic Program Described" and "Seals" in each of three years). He assisted with the planning of 1998-2000 monitoring projects and the

now-planned 2001 project. He has participated in peer/stakeholder review meetings in Seattle since 1998 and also the February 1999 post-season meeting with whaling captains. At LGL, he has also prepared major parts of several EISs concerning disturbance and other effects of military operations on pinnipeds and cetaceans. In 1999 Dr. Lawson designed and co-taught a course to train selected Navy personnel from Naval Air Warfare Center Weapons Division Point Mugu to become marine mammal observers acceptable to NMFS. Dr. Lawson has much experience in studies of seal behavior, ecology, diet, and digestive physiology in the North Atlantic in both Canada and Europe. He has experience in aerial, shipboard, and shore-based techniques as applied to seals, including radio and satellite telemetry methods. He has done about 250 hours of aerial surveys of seals on the ice offshore of Newfoundland. Dr. Lawson has published numerous papers on harp, harbor, gray and ringed seals. Although employed full time at LGL, he retains an adjunct faculty appointment at Memorial University of Newfoundland.

William R. Koski, M.Sc., a senior wildlife biologist on LGL's staff, was field crew leader for most of the aerial surveys during the 1996 seismic monitoring project, and for some of the surveys during the follow-on 1997 and 1998 projects. Mr. Koski has been with LGL since 1973. Since 1977, he has been a field supervisor and/or participant in most of LGL's major marine mammal projects in the Arctic. He has over 3500 hours of aerial survey or aerial observation experience, mostly Arctic. Besides systematic surveys, this includes eight seasons of experience in conducting systematic behavioral observations of bowheads. Sonobuoys were dropped and monitored during several of those projects. Also, beginning in 1981, he developed the vertical photography method used by LGL, NMFS, and others to measure and re-identify bowhead whales. In 1991-92 he assisted an industry consortium (including Western Geophysical) to obtain the USFWS Incidental Take Regulations for walruses and polar bears. In 1997-2000 he assisted Western Geophysical and other industry groups in renewing the NMFS Incidental Take Regulations for ringed seals and on-ice seismic activities. He has prepared many reports and papers on arctic mammals, including the "Reproduction" chapter in the 1993 book, *The bowhead whale*.

Stephen R. Johnson, Ph.D., a senior wildlife ecologist with LGL since 1975, was aerial-survey crew leader during the August 1995 and most of the September 1997 marine mammal monitoring work for BP. Dr. Johnson has conducted over 2000 hours of aerial surveys for marine mammals and birds in many parts of the Arctic, including much work in Alaska. For example, he was field leader for aerial monitoring of marine mammals near Sandpiper Island in 1985 (Johnson et al. 1986) and the Corona and Hammerhead drillsites in 1986 (LGL and Greeneridge 1987), including surveys, sonobuoy drops, and behavioral monitoring.

Gary W. Miller, B.S., a wildlife biologist with LGL since 1977, participated in the 1995, 1996 and 1997 aerial surveys for BP, and was crew leader for many of the 1998 aerial surveys for Western Geophysical. He was also a crew leader for much of the vessel-based marine mammal monitoring in July and August 1996-2000. He was senior author of the "whales" portions of the 1996-98 seismic monitoring reports. A large proportion of his work for more than 20 years has been on studies of arctic marine mammals, including aircraft-, vessel-, ice- and shore-based surveys, behavioral observations, and acoustical work in the Beaufort Sea, Bering Sea, and Canadian High Arctic. Among many related projects prior to the 1995-2000 work, he participated in aerial monitoring of marine mammals near seismic vessels in the Alaskan Beaufort Sea, vessel-based single-airgun tests of bowhead reactions to airgun pulses, and aircraft- and vessel-based acoustic monitoring of noise from seismic vessels.

Valerie D. Moulton, M.Sc., conducted her Masters thesis research on activity and haul-out behavior of harp seals. Before joining LGL in 1998, she worked with the marine mammal branch of the Canadian Dept of Fisheries and Oceans; there she worked on diet analysis of phocids. She served as a marine mammal observer and crew leader during vessel-based seismic monitoring programs for Western Geophysical in 1998 and 1999, and was co-author (1998) or senior author (1999 and 2000) of the resulting reports on seals in relation to seismic operations. She was also a marine mammal observer and crew leader during the autumn 1998 aerial surveys for Western Geophysical, and during spring 1999 and 2000 aerial surveys of ringed seals near BP's Northstar project. Ms. Moulton was senior author of the reports on the latter ringed seal study.

Ross E. Harris, M.Sc., is a wildlife biologist who has worked with LGL since 1977. He was one of the marine mammal observers and crew leaders during the 1996-2000 vessel-based seismic monitoring programs. He was senior author of the portions of the 1996 and 1997 reports concerning seals exposed to seismic operations. In prior years, he has conducted aerial surveys for marine mammals in the Alaskan Beaufort Sea, the Canadian High Arctic, and the northwest Atlantic off Newfoundland and Labrador. He has also conducted bird surveys in the Prudhoe Bay area.

Tannis A. Thomas, M.Sc., joined LGL in 1998 as a marine mammal biologist. She has been working with bowhead whales since 1996, where her main focus has been on whale behavior and habitat. Since 1998 she has also worked on photoidentification and density estimates of bowhead whales in the Alaskan Beaufort Sea. She was a member of the aircraft-based crew for LGL's 1998-2000 bowhead feeding ecology project in the eastern Alaskan Beaufort Sea, conducting aerial surveys and behavioral observations of these whales. She also has experience with cetacean bioacoustics (analysis of vocalizations and localization of calls), where she worked as a contractor with the marine mammal branch of the Canadian Department of Fisheries and Oceans.

Larry Martin, B.S., a marine biologist on LGL's staff for many years, has participated in several LGL marine mammal projects in the Beaufort and Bering Seas, including vessel-based marine mammal monitoring during BP's 1996 seismic project at Northstar and BP's 1997 shallow-hazards program. He has also been one of the primary field biologists during LGL's bowhead whale feeding ecology studies in the eastern Alaskan Beaufort Sea in 1985-86 and 1998-2000, and during a gray whale study in the northern Bering Sea. He also has many years of experience in conducting marine fisheries projects in the present study area.

Michael T. Williams, M.S., conducted his Masters thesis research on the impact of aircraft activity on the behavior and productivity of northern fur seals on St. George Island, Alaska. He has worked with NMFS on fur seal and Steller sea lion issues, liaison with native groups, hazardous waste cleanup, and other conservation issues. Mr. Williams joined the staff of LGL Alaska Research Associates in 1998. He served as one of the marine mammal observers and crew leaders during the 1998 vessel-based seismic monitoring program for Western Geophysical. At LGL Alaska, he is project coordinator for mammal permitting and field studies associated with the Northstar development.

Beth Haley, B.A., is a fisheries biologist who has worked with LGL Alaska Research Associates for several years. Ms. Haley participated in the 1996 and 1997 BP, and 1998 and 2000 Western Geophysical, vessel-based monitoring programs; she was the field-crew leader for some of this vessel-based

monitoring. She also has many years of experience as a fisheries and marine mammal observer for Alaska Dept. of Fish & Game and NMFS.

Jessy Coltrane, M.S., is a wildlife biologist who joined LGL Alaska in 1999. Ms. Coltrane participated in Western Geophysical's 1999 and 2000 vessel-based monitoring program as a marine mammal observer. Since joining LGL, Ms. Coltrane has also participated in on-ice ringed seal monitoring. Previously, she worked for the New England Aquarium, monitoring the North Atlantic right whale population. In addition, she worked as a consultant, monitoring endangered species harassment due to dredge vessels.

Craig S. Perham, M.S., is a wildlife biologist who has been with LGL Alaska Research Associates since 1998. Mr. Perham participated in Western Geophysical's 1999 vessel-based monitoring program as a marine mammal observer. As a field manager for monitoring work associated with the Northstar Development project in the North Slope, Mr. Perham was responsible for organizing and participating in on-ice ringed seal monitoring work. He also assisted with marine mammal permitting for the Northstar development. While with LGL, Mr. Perham has also conducted arctic fox denning surveys, assisted with large mammal aerial, waterfowl surveys, and vegetative mapping.

Shawn P. Haskell, B.S., joined LGL Alaska Research Associates as a wildlife research technician in 1999. He previously obtained a degree in Wildlife Management from the University of Maine at Orono in 1997. Mr. Haskell has experience working with birds, small mammals, and reptiles. In Alaska, Mr. Haskell has particpiated in a caribou behavioral study along the Badami pipeline, a baseline fish study at Point Thomson, salmon egg retrieval from streams of Prince William Sound, and literature review for the trans-Alaska pipeline EIS project. He was employed as an endangered species observer aboard a dredge vessel in 1999.

Lynn Noel, M.S., a wildlife biologist with LGL Alaska Research Associates since 1993, is available to participate in the aerial surveys. She participated in or led the LGL/BP aerial surveys of ringed seals near Prudhoe Bay in the spring of 1997 and 1998, and has also conducted aerial surveys for bowhead whales. Ms. Noel has much experience in conducting aerial surveys of caribou and snow geese in the Prudhoe Bay area, and in the application of GIS methods (MapInfo) to aerial survey, vegetation, and other data. She has prepared sections for numerous environmental assessments for North Slope oil and gas developments, and has assisted with some of the marine mammal permit-application work associated with Northstar and Liberty. Ms. Noel's background includes aquatic bio-monitoring, studies of wildlife-habitat relationships, literature reviews, data recording and analysis, database preparation, map production, geographic analysis, and report preparation.

Michael Bentley is a wildlife technician who has conducted aerial and ship surveys of marine mammals and seabirds for many years, including LGL bowhead whale surveys in the Beaufort Sea in 1982, 1984, 1997 and 1998. The 1997-98 work was during previous seismic monitoring projects.

Various other biologists with experience in conducting marine mammal observations can be assigned if needed. If any biologist observers not involved in the 1998-2000 Western Geophysical or the 1996-97 BP marine mammal monitoring work are employed in 2001, their résumés will be submitted to the Anchorage office of NMFS in advance. In all cases, they will also have completed the one-day observer training/refresher course or equivalent training at LGL.

Robert Elliott, B.Sc., a data analyst/GIS specialist at LGL, will provide analysis and mapping support to LGL biologists. Mr. Elliott has much experience as a programmer, database manager, statistical analyst, and GIS/mapping specialist for environmental monitoring, research and assessment projects. He has filled this role in MMS/LGL studies of the responses of spring-migrating bowhead and beluga whales to simulated human activities off northern Alaska and of bowhead feeding ecology in the eastern Alaskan Beaufort Sea. He has also filled this role in the 1995 through 2000 seismic monitoring projects for BP and Western Geophysical.

3.2 Greeneridge Personnel

Charles R. Greene, Jr., Ph.D., president and principal scientist with Greeneridge Sciences Inc., will be in charge of the acoustical work, as he was for the 1995-97 BP acoustic measurement programs and the 1998-2000 Western programs. Dr. Greene has S.B. and S.M. degrees in Electrical Engineering from the Massachusetts Institute of Technology and a Ph.D. in EE from the University of California at Santa Barbara; he has specialized for over 30 years in arctic underwater acoustics. He has done arctic fieldwork in all seasons and many regions, from vessels, ice, aircraft and shore. He has expertise in the design and implementation of acoustic recording and signal analysis systems. Before 1980, most of his acoustical work was for the U.S. Navy, mainly in the Arctic. He studied ambient noise and underwater sound propagation, and he designed and implemented various complex acoustical measurement and display systems. Since 1980, he has continued to do some military acoustics work, but has concentrated on studies of oil and seismic industry noise as it may affect marine mammals, mainly in association with LGL. Projects have been supported by major oil companies (Shell Western, Unocal, Texaco, BPXA), by Western Geophysical, and by Canadian and U.S. Government agencies. In 1995 he completed a project for the U.S. Minerals Management Service involving four field seasons at Barrow, Alaska, studying the influence of industrial sounds on migrating arctic whales in springtime. For the past five years he has been measuring and describing the pulsed sounds of airgun arrays operated in the Beaufort Sea in seismic surveys for hydrocarbon deposits. In support of this effort, he has developed and used autonomous seafloor recorders to store sound data for extended periods during seismic surveys and bowhead whale migration. In 2000, he began using a new design of seafloor recorder that records the directions of the sound sources from the recorder.

Dr. Greene was responsible for the physical acoustics fieldwork and analysis for several LGL studies on the disturbance responses of bowhead whales, white whales, and narwhals. He has recorded and analyzed sounds emitted from most types of offshore oil industry activities, including seismic vessels (e.g., Greene and Richardson 1988). He is currently responsible for measuring the industrial sounds in air and underwater associated with the development of the Northstar prospect offshore near Prudhoe Bay. Dr. Greene is the author of three chapters on physical acoustics in the book *Marine Mammals and Noise* published by Academic Press in 1995.

William C. Burgess, Ph.D., received his undergraduate and graduate degrees in Electrical Engineering from Stanford University, and conducted ocean acoustic research under postdoctoral appointments at the Woods Hole Oceanographic Institution (WHOI) and the Monterey Bay Aquarium Research Institute (MBARI). During the latter appointment Dr. Burgess designed, built, and applied an acoustic recording tag to directly measure noise exposure of migrating northern elephant seals. His technical background includes upper-atmosphere geophysics, VLF radio remote sensing, computer systems and networks, research instrumentation, and signal processing. His field experience includes over eight

months at sites in Antarctica, northern Québec, and the Alaskan Arctic, and over two months at sea on research vessels in Arctic, Antarctic, and Atlantic waters. Since joining Greeneridge in early 1998, Dr. Burgess has acquired and analyzed acoustic data to determine exposure of protected species to sounds from jet aircraft, rockets, missiles, vessels, and airguns. He is also developing a "2nd generation" acoustic recording tag that is expected to have broad applicability. Dr. Burgess is the first author of refereed journal articles and papers presented at scientific conferences, and is a member of the Acoustical Society of America, the American Geophysical Union, the Institute of Electrical and Electronics Engineers, and the Society for Marine Mammology.

Susanna B. Blackwell, Ph.D., received her undergraduate degree from the University of Neuchâtel (Switzerland) in Zoology, and her graduate degree from the University of California in Santa Cruz, in Biology. She has held postdoctoral appointments at UCSC (ecology and diving behavior of northern elephant seals), at the University of Stockholm, Sweden (grey seal ecology in Estonia) and at Hopkins Marine Station of Stanford University (bluefin tuna ecology and migratory behavior). At UCSC she was involved in the design and manufacture of data loggers which record underwater sounds during elephant seal migrations, in addition to variables such as depth, temperature, swim-speed and heart rate. As a postdoctoral fellow at Stanford she tracked Pacific bluefin and albacore tuna acoustically. Since joining Greeneridge she has made acoustic recordings at the Northstar project (Prudhoe Bay, AK), Red Dog mine (Kivalina, AK) and with the US Geological Survey (Pt Hueneme, CA), in addition to analyzing collected data. Dr. Blackwell is a first author or co-author of refereed journal articles. She is a member of the Acoustical Society of America, the International Society for Bioluminescence and Chemiluminescence, and the Society for Marine Mammalogy.

Robert G. Norman, consulting engineer at Greeneridge Sciences, Inc., has a B.S. in Electrical Engineering from California State University at Long Beach, California, and an M.S. in Electrical Engineering, emphasis in signals and systems, from University of California , Santa Barbara, California. Mr. Norman has 20 years of experience in electrical and electro-mechanical engineering programs. This experience encompasses system design, hardware/software partitioning, digital signal processing, control systems, and detailed analog circuit and interface design. His work has included development of software for design simulation and verification, and for execution in real-time systems. At Magnavox, Mr. Norman developed analog baseband signal processing circuitry for military and space-based GPS receivers and spread-spectrum communication systems. This work included custom linear IC design and layout. At Delco Electronics, Mr. Norman was technical lead for the development and delivery of a high accuracy single-axis inertial measurement gyroscope. At SAIC MariPro, Mr. Norman was project engineer for the full-field processing system comprised of five vertical hydrophone arrays coupled to shore by means of an electro-optical cable. The system was successfully installed on schedule in the Santa Barbara channel. Each vertical array included 30 sensors, each consisting of an active hydrophone element, low-noise preamp, dual axis inclinometer, and temperature sensor. Additionally, 4 magnetic compasses and 4 high-frequency phones were employed on each vertical array for attitude determination. For Greeneridge, Mr. Norman developed the signal processing tools for analyzing the airgun pulses received during three-dimensional seismic surveys from the 600 to 1300 ocean bottom cable hydrophones. Also for Greeneridge, he developed the software code for demultiplexing the composite signal from DIFAR (Directional Frequency and Recording) sonobuoys. Recently he has designed, built and used direction-sensing seafloor recorders for recording ambient, industrial and whale sounds in the Beaufort Sea.

Bob Blaylock of Greeneridge will conduct much of the laboratory analyses of recorded sounds. He is a computer programmer and digital signal analyst who has performed acoustic signal analysis at Greeneridge for over 14 years, including many of the acoustical analyses for the 1996-2000 acoustical monitoring projects. This work routinely includes A/D conversion, reformatting and scaling, fast Fourier transformations, various types of averaging, and derivation of band levels. He programs in C and C++, Pascal, BASIC and Postscript, and he is an advanced user of several operating systems. He is facile with MATLAB, EXCEL, Word, PageMaker, Photoshop, Illustrator and many other application programs.

4. DELIVERABLES

Final Monitoring Plan: This document will be a revision of the (present) April 2001 draft monitoring plan for WesternGeco's planned Beaufort Sea seismic program. It will take account of any revisions in WesternGeco's plans that may occur after April, and will also take account of the recommendations and agreements to be discussed at the peer/stakeholder review meeting to be held in Seattle in spring 2001.

Field Reports: (1) For the duration of fieldwork in July through September or October 2001, LGL will provide WesternGeco and NMFS with e-mailed or faxed weekly summaries of the results of the vessel-based monitoring. These will briefly describe the monitoring work completed, mammals seen, and any evidence of "take". (2) If operations continue into Sept./Oct., aerial surveys will be conducted; each day's bowhead sightings and survey tracklines will be faxed to WesternGeco, NMFS, and the MMS aerial survey crew no later than the following morning.

90-Day-Report: By 80 days after the end of the seismic program, LGL will provide WesternGeco with a draft of the "90-day report". This report will describe the monitoring activities and results, including the type and nature of "take" for each species, the estimated numbers of each species observed and "taken", any observed changes in behavior, and any apparent effects on the subsistence hunt. Upon finalization, this report will be forwarded to NMFS within 90 days after the end of the seismic field program.

Draft Final Report: By 20 April 2002, we will provide WesternGeco with a draft final technical report including methods, results, interpretation and integration for all 2001 tasks. We will aim to provide all necessary data in the most compact, understandable format practical. Following revision as needed, this draft final report will be submitted to NMFS by 30 April 2002.

Final Report: This report will be submitted to WesternGeco within 45 days after receipt of NMFS and stakeholder/peer review comments on the draft final report. Final text, tables and graphics will be available in digital as well as printed format.

5. SCHEDULE

The **field schedule in 2001** will depend largely on the start and end dates of the WesternGeco open-water seismic program within the July-October 2001 period. The target date for the start of offshore operations is mid July:

- Marine mammal monitoring from seismic vessel: throughout the seismic program.
- Aerial monitoring/sonobuoy drops: If the OBC seismic program continues without interruption from August into September, aerial surveys will be done from 1 Sept. until one day after the end of the airgun

array operations. If OBC seismic work is suspended on 31 Aug. but resumes later, aerial surveys will start when seismic work resumes, and will continue until one day after the end of airgun array operations.

- Autonomous seafloor acoustic recorders: If the seismic program continues without interruption into September, ASARs will be deployed in late August 2001 for operation from 29 Aug. until whichever of the following occurs first: the seismic program ends, or ice conditions threaten to prevent retrieval of the ASARs in autumn 2001. If seismic work is suspended on 31 Aug. but resumes later, the ASARs will be deployed when seismic work resumes, and will be retrieved when seismic work ends, or possibly earlier if ice conditions become threatening. On either schedule, ice could prevent final recovery at the end of field season. This would mean that some or all of the 2001 ASAR data might not be available for use in the reports on the 2001 monitoring program.
- MMS aerial surveys: schedule to be determined by MMS; anticipated start date around 31 Aug.; likely to continue until freeze-up and/or effective end of bowhead migration in mid or late October.

The **report schedule in 2001** is summarized above, under 4. DELIVERABLES.

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APPENDIX:

List of hypotheses provided by Dr. Tom Albert, NSB-DWM

Dr. Tom Albert, North Slope Borough Dept of Wildlife Management, distributed a list of suggestions on the 1998 draft report and the 1999 draft monitoring plan at the 30 June – 1 July 1999 peer/stakeholder review meeting in Seattle. This list was not discussed explicitly, on a point-by-point basis, at that meeting or at the subsequent meeting in May 2000. However, much of the discussion in 1999 did deal indirectly with points on the list. This Appendix includes verbatim quotes of the suggestions as included in Appendix 4 to the "Summary of the 1999 Arctic Seismic Peer Review Workshop", which was distributed by NMFS on 29 July 1999. The italicized paragraphs are responses by LGL to each of the points raised by Dr. Albert, updated very slightly for 2001. These responses were originally prepared for the final 1999 monitoring plan (LGL and Greeneridge 1999). However, they remain relevant as no seismic work or seismic monitoring was done during the Sept./Oct. bowhead migration season in either 1999 or 2000 .

The following are hypotheses, questions, and data needs for seismic monitoring efforts in the Alaskan Beaufort Sea. Distributed by T. Albert during the 1999 Arctic Seismic Peer Review Workshop, 30 June – 1 July 1999.

Hypotheses that seem appropriate to consider

- Monitoring studies, such as conducted during 1996-1998, cannot provide realistic estimates of the extent of disturbance to fall migrating bowhead whales due to seismic exploration noise.

  Results from 1996-98 show that data from a single season are not likely to provide sufficient information to determine the extent of disturbance. However, by collecting data consistently across the 1996-98 period, it has been possible to provide meaningful information about the extent of the offshore displacement. More data are needed to determine how far east and west the displacement effect extends. The 1996-98 data provide a useful starting point for analysis of the east/west distance. It will be advantageous to collect additional data in a manner that allows the results from all years from 1996 to date to be combined. The 2001 aerial surveys are designed with this in mind.

- There is no difference in the distribution of bowhead whales, during seismic operation as compared to no seismic operation, at points 10, 20, 30, 40 km (a) offshore of the seismic area, (b) "upstream" (to the east) of the seismic area, and (c) "downstream" (to the west) of the seismic area.

  This formulation of a null hypothesis is one approach to determining how far the displacement effect extends in the three directions of particular interest. The aerial surveys as conducted in 1998 and as planned for 2001 provide data relevant to all three parts of this hypothesis. The aerial surveys as conducted in 1996-97 provided data relevant to (a) and (b), but the 1996-97 surveys did not extend far enough west to address (c) adequately. The hypothesis cannot be addressed adequately with any one year's data, but can be addressed with increasing precision as data accumulate across years. If additional data are acquired in 2001, the (a), (b) and (c) parts of this hypothesis will be tested using log-linear models contrasting sighting rates vs. distance at times affected by and not affected by seismic operations (see "Analysis of Aerial Survey Data" in §2.3).

- There is no difference in the call rate of bowhead whales, during seismic operation as compared to no seismic operation, at points 10, 20, 30, 40 km (a) offshore of the seismic area, (b) "upstream" (to the east) of the seismic area, and (c) "downstream," (to the west) of the seismic area.

  To address this null hypothesis in its entirety with the existing type of seafloor recorders, it would be necessary to obtain acoustic data from the 12 locations referenced in the hypothesis (3 directions × 4 distances). This would provide very valuable data, but it is not logistically practical for 2001. At present, six-eight seafloor recorders are available. Given the failure rate in past years, it is desirable to place two recorders at key locations in order to have reasonable assurance of obtaining data. Thus, at least for 2001, it is proposed to retain the design discussed in Seattle on 30 June – 1 July 1999: deploy a pair of seafloor recorders at each of three locations – one site just offshore of the seismic area (approx. 15 km from its northern edge), one site farther offshore of that area, and one site about 40 km to the east. This replicates key features of

the 1996 layout, which provided notable results that need replication (given the seemingly different results from 1998).

- There is no relationship between the received level of seismic noise and the sighting of bowhead whales at points 10, 20, 30, 40 km (a) offshore from the seismic area, (b) "upstream" (to the east) of the seismic area, and (c) "downstream" (to the west) of the seismic area.

  This hypothesis would appear to be formulated on the expectation that temporal variability in the received levels of seismic pulses at the 12 specified locations will affect the occurrence of bowheads in at least some of those locations. To test this hypothesis would require an extended series of paired whale surveys and acoustic measurements at each location. The aerial surveys as conducted in 1998 and planned for 2001 provide survey coverage of each of the 12 locations during each date when weather allows the survey to be completed. (The 1996-97 surveys also covered 10 of the 12 locations, excluding the 30 and 40 km west sites.) However, underwater sounds were not measured daily at this or any similar grid of locations in 1996-98, and it is not practical to obtain empirical daily data on sounds at all 12 locations in 2001. There are insufficient ASARs, and both logistical and cost issues would prevent dropping that many sonobuoys each day. Received sound levels at the 12 locations might be estimated (as opposed to measured) if the large body of existing sound measurement data from 1996-99 (plus planned 2001 data) were used to develop a suitable model for estimating received sound levels and signal-to-ambient ratios. However, that is beyond the scope of the project as planned for 2001. Even if such a model could be developed, there would inevitably be uncertainty in the estimates for the designated 12 locations during each day with surveys. Thus, the hypothesis as formulated would appear to be untestable, at least in 2001.

Some questions that seem reasonable

- What is the significance (as regards "take" under the IHA) of the 160 dB level of bowhead exposure? Is this the estimated level at which "disturbance" is likely to occur?

  As discussed at the Seattle meeting on 30 June – 1 July 1999, the 160 dB (re 1 μPa, rms) criterion is based on studies during the 1980s of gray whales and bowhead whales exposed to seismic pulses. At least for autumn-migrating bowheads, it is now evident that avoidance reactions typically occur at substantially lower received levels (Miller et al. 1999). IHAs issued by NMFS have required estimates of the number of bowheads exposed to 160 dB re 1 μPa (rms), so this has been done as part of the recent monitoring efforts. However, other "take estimates", including the number of bowheads that would have been expected to pass within 20 km if they had not been displaced, have also been calculated for each year.

- Why are peak received levels not presented in the *[draft final 1998]* report, such as in the numerous figures showing SPL (rms or sound pressure level) and SEL (sound exposure level)? On page 3-16 *[of the final 1998 report]* it is stated that peak levels were calculated. Page 5-102 (paragr. 3) notes that rms levels are typically about 10 dB below instantaneous peak levels. *[Page number cross references updated to refer to final 1998 report.]*

This question is addressed in the final version of the 1998 report (Chapter 3, sections 3.1.2 and 3.8). Previous reports, especially Chapter 3 of the report on BP's 1996 seismic monitoring project, showed the relationships among peak, rms, and energy measures. For sound pulses shorter than about 0.1-0.2 s, auditory response in mammals is determined primarily by energy content, not peak pressure. This has been shown in humans, other terrestrial mammals, and at least three species of marine mammals (beluga, bottlenose dolphin, and harbor seal) (Richardson et al. 1995:217). For additional discussion, see Chapter 3 of the final version of the report on monitoring of Western Geophysical's 1998 seismic project.

- Based upon the 1996-1998 data, will NMFS call for a more precise estimate of the received level (peak, SPL, SEL) of seismic noise at which fall migrating bowhead whales are impacted by seismic exploration noise? The 20 km radius "exclusion zone" is well documented (1996-1998) and 1998 data show deflection extending 35km (about 21 miles) to the east ("upstream") and at least 40-50 km (about 24-30 miles) to the west ("downstream").

The 1996-99 studies provided extensive data on the variability in received levels of seismic pulses at distances ranging from about 100 m to 50+ km. The final version of the 1998 report includes more explicit conclusions about the received levels at relevant distances such as 20, 30 and 35 km (p. 5-77 and 5-78 in Miller et al. 1999). For 1996-98, most of the long-range data (>20 km) came from offshore rather than alongshore (east or west) of the seismic operation. (However, in 1996, a few measurements were obtained at long range to the east.) Additional data of this type, including both offshore and alongshore data, will be obtained in 2001 if OBC seismic work continues beyond 31 Aug. In Sept.-Oct. 2001, additional effort will be directed toward obtaining received level data at long distances to the east. This will be done in two ways: by deploying a pair of seafloor recorders about 40 km east of the area of seismic operations, and by simultaneous use of sonobuoys at 3 or 4 distances to the east on at least one date. (If the 2001 seismic work is limited to July-Aug., bowhead whales will not be an issue, and sound measurements will be limited to the area within several kilometers of the seismic vessel.)

Some obvious data needs ([future] monitoring)

- Need more measurement data on received levels (RL) at distances to the east (upstream) from the seismic boat. Note that the "summary figure" (Fig. 5.21) on page 5-76 *[of the final 1998 report]* is mostly based on offshore data, not along shore data (to the east), and this is stated on page 5-78 [lines 3-4 of 2nd paragraph].

Note: page number references updated to reference the final 1998 report (Miller et al. 1999). See response to previous related question.

- Need to determine the received level (RL) at the point to the east (upstream) at which the whales begin to deflect. This RL will show NMFS the dB level at which avoidance (impact) begins in the approaching whales. Data from 1996-1988 clearly show that the dB level at which avoidance begins is much, much below 160 dB.

This will require both (a) the "alongshore" measurements of received sound levels discussed in the previous two questions and (b) determination of the distance at which approaching bowheads begin to show avoidance. We are seeking to determine (b) based on aerial survey results from combined years. As noted earlier, it is unlikely that sufficient survey data can be acquired in any single year to determine how far east the displacement effect extends.

- Need to determine the distance to the east (upstream) from the seismic boat at which whales begin to deviate seaward. 1998 data indicate that it is about 35 km (about 21 miles) east of seismic boat (page 5-78 and section 5.3.5 *of the final 1998 report*).

  It is agreed that this is an important question, and the aerial surveys are designed to address it (see also the response to the previous related question). Also note that the 35 km figure quoted from the final 1998 report is based on 1996-98 data (not just 1998), and is imprecise because of sample size limitations within the critical area east of the seismic operation.

- Since the whales deflect seaward at about 35 km (about 21 miles), it is for sure that they must change their "heading" (direction of swimming). Therefore, need to determine the distance to the east from seismic boat at which the whales change their "heading".

  Headings have been analyzed based on 1996-98 aerial survey data, but sample size in the key area to the east is limited. Addition of 2001 aerial survey data to the existing 1996-98 dataset should enlarge the dataset available for this analysis, and may make it practical to analyze the data on a finer geographic scale. However, it may prove to be the case that headings are sufficiently variable, and the angular deflection sufficiently small, to make it impractical to obtain enough data from aerial surveys to determine a specific distance where deflection begins.

- Need to determine the distance to the west (downstream) from the seismic boat at which the deflected whales return to their migratory path. The 1998 data indicate whales are still deflected at 40-50 km (24-30 miles) to the west of the seismic boat [page 5-59, paragraph 4].

It is agreed that this is an important question, and the aerial surveys are designed to address it at least in part. The westward extent of the surveys was increased in 1998 from 1996-97, and is further increased for 2001. However, as discussed at the Seattle peer/stakeholder meetings in spring 1999 and 2000, it is not certain that aerial surveys extending about 65 km west of the seismic area go far enough to fully address this question. It is not practical to survey farther to the west while, at the same time, (a) surveying far enough east to document the onset of deflection east of the seismic vessel, and (b) maintain an 8-km interval between adjacent transects. The consensus at the 1999 and 2000 Seattle meetings was that, for the next set of aerial surveys, documenting the eastward extent of the displacement effect (point a) was a higher priority than documenting its westward extent. Maintaining an 8-km transect spacing is important for consistency with previous years' surveys. Also, use of wider transect spacing would reduce the number of sightings at each distance from the seismic operation. As there were no seismic operations in Sept.-Oct. in 1999 or 2000, no new data relevant to this issue are available. Hence, the same considerations would apply in 2001.