13 July 2001

Final Contract Report
Sakhalin Marine Mammal Monitoring and Research Program
Sakhalin Energy Investment Company

Gray Whales off Sakhalin Island, Russia: June – September 2000
A Joint U.S. – Russian Scientific Investigation

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OVERVIEW

This report presents results from the fourth year of western gray whale (*Eschrichtius robustus*) research conducted by Texas A&M University (TAMU) and the Kamchatka Institute of Ecology and Nature Management (KIENM). The scope of work for the 2000 research program was to conduct photo-identification surveys designed to examine occurrence patterns, site fidelity, and habitat use of gray whales occurring near the Piltun-Astokhskoye field off northeastern Sakhalin Island. Additional parameters measured within the broader framework of the 2000 scope of work consisted of monitoring calf production, assessing the return of known individuals including reproductive females, follow up evaluation of whales identified as "skinny" in 1999, and documentation of any "skinny" individuals in 2000.

INTRODUCTION

Numerous species of marine mammals inhabit the Sea of Okhotsk. Three of the most endangered populations of large whales in the world; the Okhotsk bowhead whales (*Balaena mysticetus*), western North Pacific right whales (*Eubalaena glacialis*), and the western Okhotsk-Korean gray whale are known to occur in this sea (Brownell *et al.*1997, Clapham *et al.*1999, Weller *et al*. 1999). Concerns regarding the status of these whale populations have been intensified by the recent onset of U.S.-Russian oil and gas development programs in Okhotsk waters. Anthropogenic activities related to oil and gas exploration off the northeastern Sakhalin Island shelf, including geophysical seismic surveying, drilling and production operations, vessel and aircraft traffic, and oil or other habitat perturbations pose potential new threats to the marine ecosystem, and may impact the critically endangered western gray whale population (Weller and Brownell 2000). However, a properly designed biological monitoring and Habitat Conservation Plan (U.S. Fish and Wildlife Service 1998) can provide the requisite information needed to prevent significant impacts, and in some cases help to mitigate unavoidable impacts to acceptable levels. Studies in the U.S. and Canadian arctic or near-arctic, on bowhead whales, white whales (*Delphinapterus leucas*), and gray whales have demonstrated that knowledge of habitat use and behavioral reactions can help to plan industrial activities in a fashion that allows animals and human development to coexist (summaries in Würsig 1990,

Richardson and Würsig 1995, 1997). Therefore, it has been recommended by the Russian and U.S. governments that biological investigations of potential industry-related ecosystem impacts off the coast of Sakhalin Island and elsewhere in Russia be conducted concurrent to oil and gas development projects (Anonymous 1997).

Detailed information on responses of marine mammals to industrial activities and noise can help to gauge potential ecosystem effects (Richardson *et al.*1995, Richardson and Würsig 1997). Results from studies on the reactions of cetaceans to underwater noise and other human-related activities are highly variable, ranging from no apparent response to active avoidance (for review see Richardson *et al.*1995). While many studies have documented no or only subtle short-term changes in behavior, it is important to recognize that tolerance of noise does not necessarily indicate that it has no deleterious effects (Richardson and Würsig 1997). Long-term effects of noise and disturbance at the individual and population levels are presently little understood. Gray whales provide the best example of long-term behavioral changes as a result of industrial activities. Several studies on eastern gray whales have documented behavioral changes (Malme *et al.* 1988, Würsig *et al.* 1999), and distributional shifts or complete abandonment of known wintering areas (Bryant *et al.*1984) in relation to increased anthropogenic activity (for review see Richardson *et al.*1995).

RATIONALE

Oil and gas exploration, development, and production activities are currently underway off the northeastern coast of Sakhalin Island, Russia (Fig. 1). High intensity 3-D geophysical surveying of a feature named “Piltun-Astokhskoye” (PA) off the northeastern Sakhalin coast (Fig. 2) was conducted during summer of 1997. The PA field overlaps in latitude with the waters adjacent to Piltun Lagoon (Fig. 3), a region recognized as the primary feeding ground of western gray whales (Weller *et al*. 1999). In 1998, the temporary-drilling rig *Sakhalinskaya* (located at ~52°54’ N, 143°29’ E), and permanent offshore production platform, *Molikpaq* (located at ~52°43’ N, 143°34’ E), were installed in the PA field. The Molikpaq, located approximately 24 km southeast of the entrance to Piltun Lagoon, was in operation during 1999, and by late summer began production activities including transfer of oil via seabed pipeline to a floating storage and

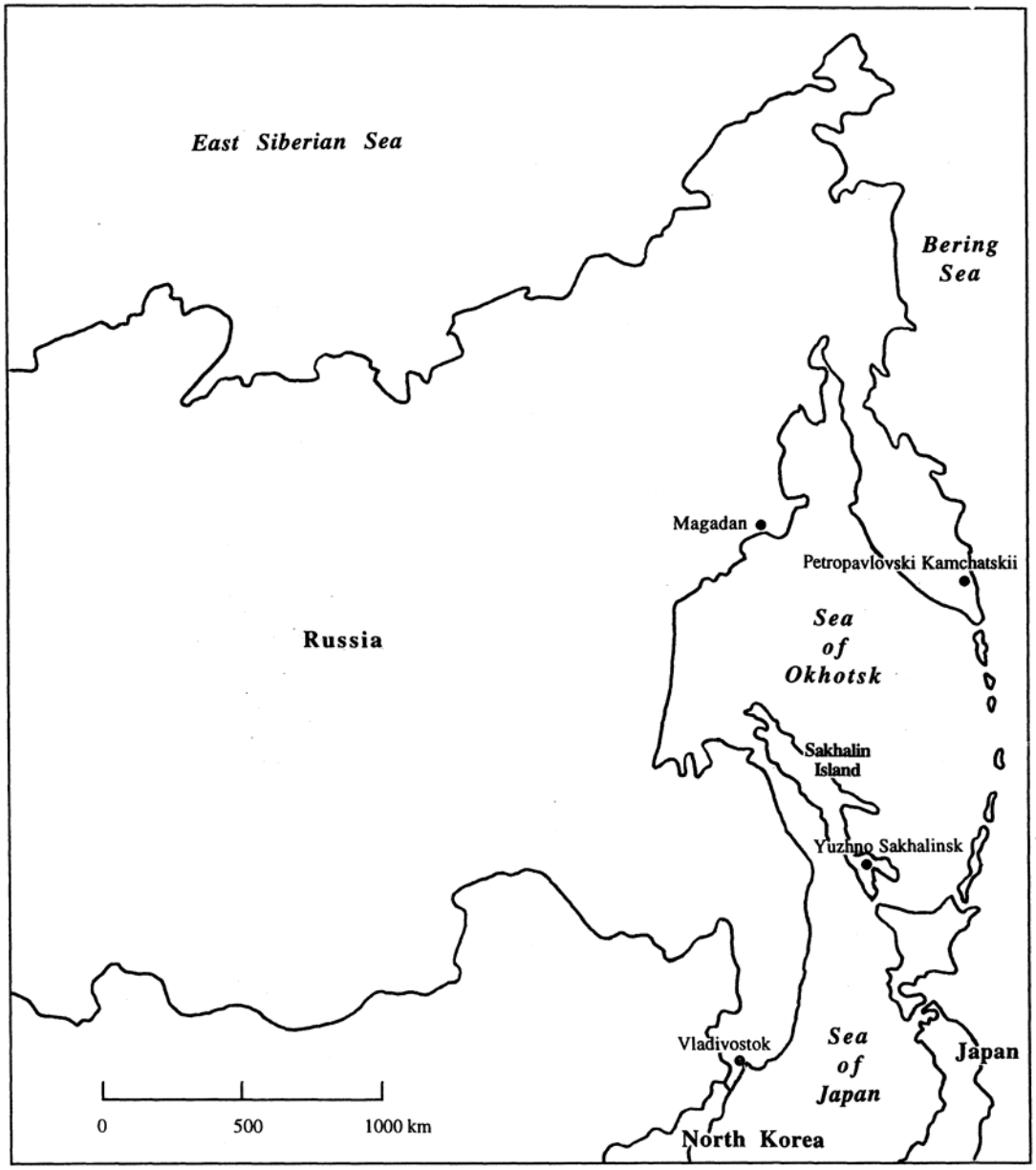

Figure 1. Far East Russia, showing the location of Sakhalin Island in the southwestern Okhotsk Sea.

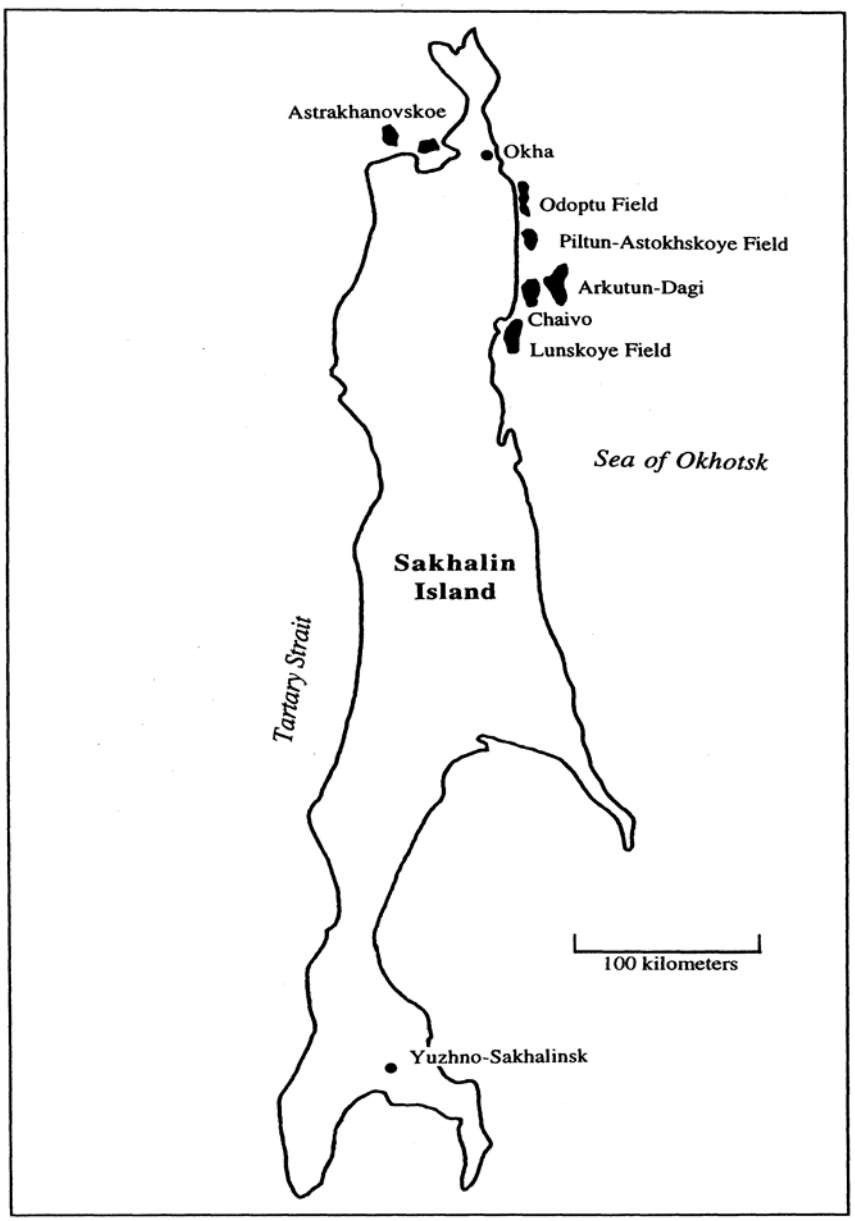

Figure 2. Sakhalin Island, showing major oceanic oil fields along the northeastern coast.

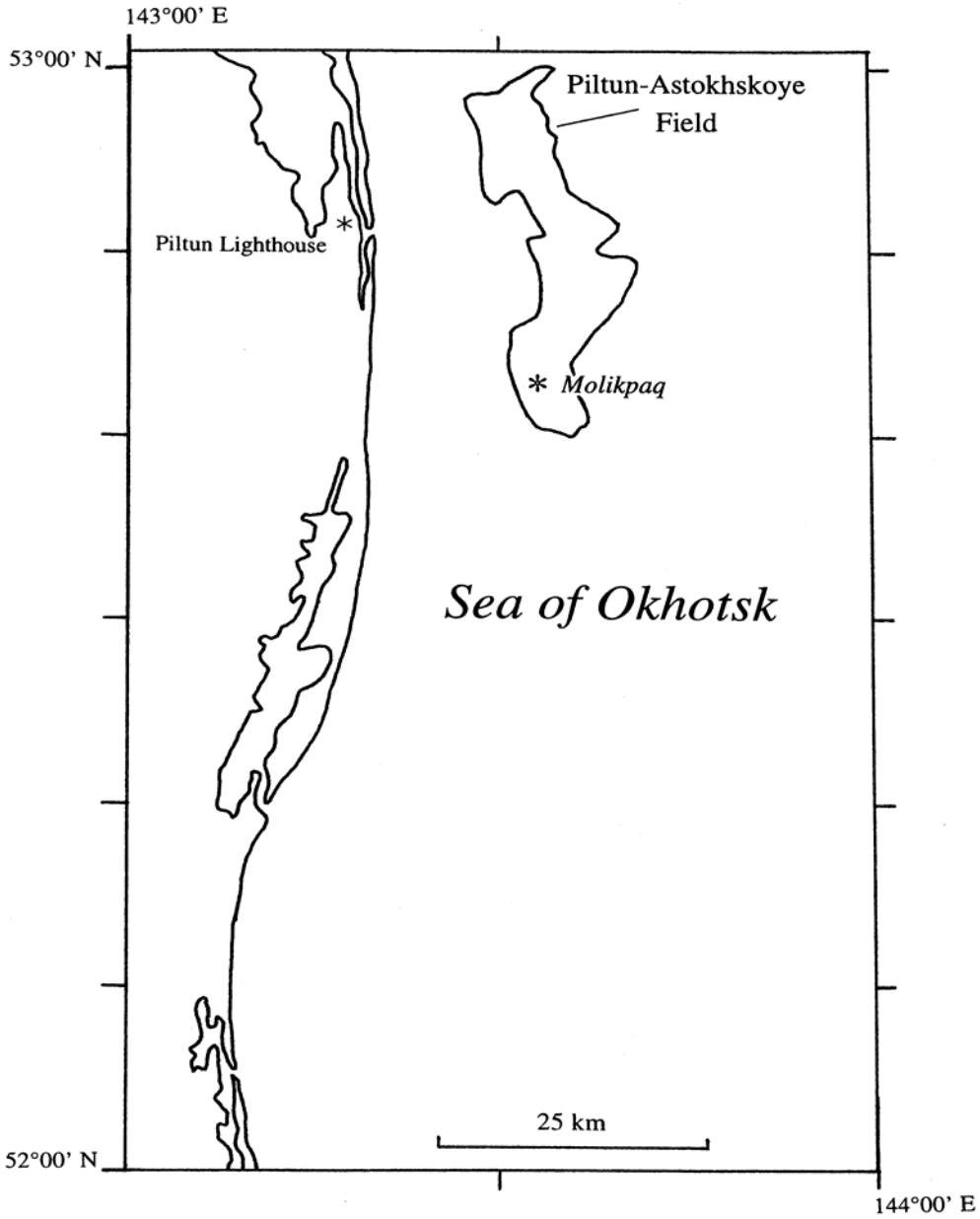

Figure 3. Location of the Piltun-Astokhskoye oil field in relation to the Piltun Lighthouse at the inner entrance channel of Piltun Lagoon.

offloading unit. In 2000, the Molikpaq continued production activities, a temporary-drilling rig was stationed within 15 km of the lagoon entrance, and seismic survey work was conducted in the PA area during June (personal communication from James Robinson, SEIC).

Sighting records from Russian aerial and vessel surveys in the Okhotsk Sea between 1979 and 1989 (Blokhin *et al.*1985, Votrogov and Bogoslovskaya 1986, Berzin *et al.*1988, Berzin *et al.* 1990, Berzin *et al.* 1991, Blokhin 1996, Berzin in press), and results from aerial surveys in 1998 (Würsig *et al.* 2000, Weller *et al.* in press) and 1999 (Sobolevsky 2000) indicated that gray whales aggregate predominantly along the shallow-water shelf region located off Piltun Lagoon. This region of the Okhotsk Sea is characterized by high benthic biomass densities of 1,000,000 kg/km^2 (Koblikov 1986), and is the only currently known feeding ground for western gray whales (Blokhin *et al.*1985, Brownell *et al.*1997, Weller *et al.*1999, Würsig *et al.* 1999, Weller and Brownell 2000, Weller *et al.* 2000, Würsig *et al.* 2000). Out of concern about the small size of the western population, its future survival, and the potential for increased industry-related disturbance on their feeding grounds, a joint U.S.-Russian research program on gray whales was initiated in 1995 as part of the Marine Mammal Project under Area V: Protection of Nature and the Organization of Reserves within the U.S.-Russia Agreement on Cooperation in the field of Environmental Protection. Between 1997-2000, an ongoing research program on western gray whales (and other marine mammals) off the northeastern Sakhalin coast has been conducted under sponsorship of Sakhalin Energy Investment Company (SEIC), Exxon Neftegas Limited (ENL), National Fish and Wildlife Foundation, and the International Fund for Animal Welfare.

Oil development involves industrial activities that pose potential threats to western gray whales, as has been documented for marine mammals elsewhere (see review by Geraci and St. Aubin 1990). Potential problems include those associated with oil spills, ship strikes, entanglements in cables or lines, pollution from drilling muds or similar materials, and physical habitat changes such as those caused by dredging or sand pumping (review by Richardson *et al.*1989, and Clapham *et al.*1999). For example, on 27 September 1999 an oil spill (< 2 bbls) occurred at the Molikpaq site, and was caused by the parting of a break-away coupling when a hawser connecting the FSO to the SALM

failed. While the influence of this apparently small oil spill was thought to be negligible (personal communication Marathon Upstream Sakhalin Services, Ltd., 19 May 2000), the impact of a larger spill on the surrounding marine flora and fauna is poorly understood. In addition, displacement of whales from critical feeding and migratory habitat is possible due to the disturbance from seismic surveys, or other industrial noise and activity. For example, strong acoustic sources such as the open-water seismic exploration conducted in the PA field during 1997 were probably audible to gray whales at distances exceeding 100 km (Richardson *et al.* 1995). Acoustic monitoring during 1997 in the PA field revealed nearshore received sound levels from seismic pulses of approximately 153 dB re 1 µPa, zero-to-peak; 159 dB re 1 µPa, peak-to-peak; and 139 dB re 1 µPa, averaged over one second, while the seismic survey vessel was 30-35 km from shore (Würsig *et al.* 1999). These findings indicated that even at relatively large distances, seismic noise was detectable within the near-shore area where gray whales were typically located.

A significant shift in pod distribution during 1997 indicated that whales moved into deeper water as the summer season progressed. This distribution change indicated that pods remained closer to shore during seismic periods (July to mid-August) and shifted to more offshore waters (late-August to early-September) once seismic surveying was terminated (Würsig *et al.* 1999). The 1997 data, however, represented relatively small sample sizes collected during a short period within one season. Therefore, other potential natural causes of the observed distribution shift cannot be ruled out. A similar change in pod distribution, showing that whales moved into deeper water as the summer season progressed was observed in 1998 (Würsig *et al*. 2000) when no seismic surveys were conducted. However, in 1998 the Sakhalinskaya and Molikpaq were installed near the feeding grounds and represented novel acoustic stimuli in the environment. Although whales were present in the study area throughout the 1998 research period, they were especially low in numbers between 31 August and 5 September (Wursig *et al*. 2000). This period of particularly low abundance overlapped precisely with the arrival of the Molikpaq and the associated 10-15 support vessels. While speculative, the noticeable but temporary decline in the number of whales in the study area at that time may have represented a short-term shift in distribution, resulting from unusually high industrial activity. While industry-related impacts cannot be ruled out as contributing to the 1997

and 1998 shifts in distribution, events such as changes in prey abundance and availability or other naturally occurring phenomenon may also have substantial explanatory power.

BACKGROUND

The Okhotsk-Korean or western North Pacific gray whale population is one of the most endangered and little known in the world (Clapham *et al*. 1999, Weller and Brownell 2000). Western gray whales were thought to be extinct as recently as 1972 (Bowen 1974), but are known to survive today as a small remnant population (Berzin 1974, Brownell and Chun 1977, Weller *et al*. 1999, Weller and Brownell 2000). In contrast to the recovery from low numbers of the eastern gray whale, the western population remains severely depleted (Weller *et al.* 1999, Weller and Brownell 2000). The decline of the western population can be attributed largely to modern commercial whaling off Korea and Japan between the 1890s and 1960s.

Recent findings show that eastern and western North Pacific gray whales can be genetically differentiated at the population level, and should be recognized as geographically and genetically isolated population units (LeDuc *et al*. 2000). Two population estimates of 100 and 250 have been reported in the Russian literature (Vladimirov 1994, Blokhin 1996), but the quantitative basis for these assessments were not provided. Therefore, these estimates cannot be considered reliable or used as the foundation for understanding the current population status of western gray whales. The actual population size of western gray whales, based on contemporary photo-identification data, is estimated to be less than 100 (Weller *et al*. 1999, Weller and Brownell 2000, Weller *et al.* 2000). The small number of whales remaining in the population, in combination with the possibility that fewer than 50 reproductive individuals exist, served as the basis for The World Conservation Union's (IUCN) recent listing of the western gray whale as Critically Endangered (Hilton-Taylor 2000, Weller and Brownell 2000).

Reviews of Russian aerial and ship-based sighting records in the Sea of Okhotsk during the 1960s, 1970s, and 1980s (Berzin 1974, Vladimirov 1994, Berzin in press) indicated that gray whales were distributed predominantly along the shallow-water shelf off northeastern Sakhalin Island during summer-autumn. Particularly high numbers of

whales were observed off the southern portion of Piltun Lagoon (see also Blokhin *et al*. 1985, Blokhin 1996). The calving and breeding grounds of this population remain presently unknown. However, reliable records from the Yellow Sea, East China Sea, and the South China Sea suggest that this region is located off Southern China (Henderson 1972, 1984, 1990, Wang 1978, 1984, Omura 1988, Kato and Kasuya in press).

Recent photo-identification research (1994-2000), shore-based studies (1997-1999), and aerial surveys (1998-2000) have corroborated the earlier Russian survey data by documenting the annual occurrence of gray whales off Piltun Lagoon (Brownell *et al*. 1997, Sobolevsky 2000, Weller and Brownell 2000, Weller *et al*. 1999, Weller *et al.* 2000, Würsig *et al.* 1999, Würsig *et al.* 2000, Weller *et al*. in press). Photo-recognition research identified 88 individuals between 1994-1999, and documented high levels of annual return and seasonal site fidelity for a majority of all known whales (Weller *et al*. 1999, Würsig *et al*. 1999, Weller and Brownell 2000, Weller *et al.* 2000, Würsig *et al*. 2000). Shore-based counts and theodolite determined sighting data indicated that 95% of all observed gray whale groups were located within 5 km of shore (Ivaschenko 1999, Würsig *et al*. 1999, Würsig *et al.* 2000). Although feeding gray whales have been observed > 15 km from shore in the Piltun area, such sightings are unusual (Weller *et al*. 1999, Würsig *et al*. 1999, Sobolevsky 2000, Würsig *et al*. 2000, Weller *et al*. in press).

Gray whales aggregate off northeastern Sakhalin Island during summer-autumn to feed on benthic and near-benthic prey. Therefore, the observed inter- and intra-annual occurrence and distribution patterns of known individuals emphasize the ecological importance of the Piltun region, and suggest that it is likely to be the primary feeding habitat for western gray whales. Activities related to oil and gas exploration and production, including increased vessel and aircraft traffic, geophysical seismic surveys, well-drilling and production operations have recently been initiated in near proximity to the Piltun feeding grounds. Long-term effects of such industrial disturbance at both the individual and population level are poorly understood (for reviews see Richardson *et al*. 1995, Richardson and Würsig 1997). Studies on eastern gray whales have documented behavioral changes, distribution shifts, and temporary abandonment of known wintering areas in relation to increased anthropogenic activity (Bryant *et al*. 1984, Malme *et al*. 1988, Moore and Clarke in press).

The poorly understood status of western gray whales, in combination with the potential for increased industry-related disturbance on their feeding grounds, provided the impetus to initiate a joint U.S.-Russian research program in 1995 as part of the Marine Mammal Project under Area V: Protection of Nature and the Organization of Reserves within the U.S.-Russia Agreement on Cooperation in the field of Environmental Protection (Brownell *et al*. 1997). Between 1997-1998, gray whale studies by TAMU and KIENM off Piltun were sponsored by SEIC and ENL (see Würsig *et al*. 1999, Würsig *et al*. 2000). In 1999 (see Weller *et al*. 2000) and 2000 (this report), SEIC continued to support studies by TAMU and KIENM. By agreement with Dr. Larry Reitsema of SEIC, TAMU-KIENM were required to secure one third of total funding for 2000 photo-identification research from "outside sources". This "outside" support was provided by: 1) National Fish and Wildlife Foundation; 2) Ocean Park Conservation Foundation; and 3) International Fund for Animal Welfare. SEIC and ENL jointly sponsored aerial survey and acoustic studies by the Russian Institute of Marine Biology in 1999 (see Sobolevsky 2000), and SEIC supported the same in 2000 (see Sobolevsky in prep).

In addition to the photo-identification studies sponsored by SEIC in 2000, other research including biopsy sampling, benthic/prey sampling, and shore-based behavior observations were conducted for other sponsors or personally financed by the authors of this report. Although presentation of results from these studies is beyond the scope of the present contract report, Appendix 1 presents major research findings from studies conducted by TAMU and KIENM for SEIC and ENL between 1997-1999. It is important to note that some results in Appendix 1 have changed slightly since they were originally collected, but we believe that it is nevertheless valuable to provide such here so that information collected in 2000 can be understood with a broader context.

METHODS

Final contract negotiations regarding the 2000 field season were completed in the second week of July, and Texas A&M University Research Foundation was able to release partial project funding on 12 July. The Russian contingent of our team arrived to the field site on 22 June, and promptly began fieldwork. Researchers from the US

departed for Russia on 15 July. The later portion of June and most of July were characterized by unusually heavy sea fog. This weather pattern significantly hindered photographic work from our small research vessel. Fog also prevented helicopter access to the field camp, delaying the arrival of US researchers by nearly two weeks. Although several days of photo-identification research were completed in late-June and July, our systematic surveys commenced on 30 July and ended on 16 September (when eight consecutive days of dense fog descended upon the field camp). Despite the generally poor weather experienced during the 2000 field season, August and the first half of September were characterized by mostly good conditions, and a total of forty days of photo-identification research were conducted in that period.

Photo-identification research methodologies employed during the 2000 field study were identical to those employed during earlier studies by our team between 1997-1999. The overall consistency in research design, data collection and analysis maintained in 2000 permits inter-annual comparisons to be made. Additional information collected during independent surveys off Piltun in 1994 and 1995 (Brownell *et al.* 1997, Weller *et al.* 1999) are also presented here to better describe interannual trends and facilitate a long-term interpretation for some of the results. Data from these independent studies include gray whale photographs obtained between 7-12 September 1994 during the filming of a wildlife documentary by H. Minakuchi (for description see Weller *et al.* 1999), and from 14-20 August 1995 during a pilot study to determine the feasibility of conducting boat- and shore-based research in the Piltun area (Brownell *et al.* 1997).

Study Area

Zaliv Pil'tun (referred to as Piltun Lagoon) is on the northeastern shore of Sakhalin Island, Russia (Fig. 4). The lagoon is approximately 90 km long and 15 km across at its widest point. A single channel connecting the inner lagoon with the Okhotsk Sea occurs at 52°50' N 143°20' E, and has considerable biological influence on the surrounding coastal waters. A lighthouse, near this channel, served as the base from which studies reported here were conducted. The near-shore marine environment of the study site is mostly sand substrate, characterized by a gradually sloping and broad continental shelf. Water depths within 5 km of shore are uniformly less than 20 m deep.

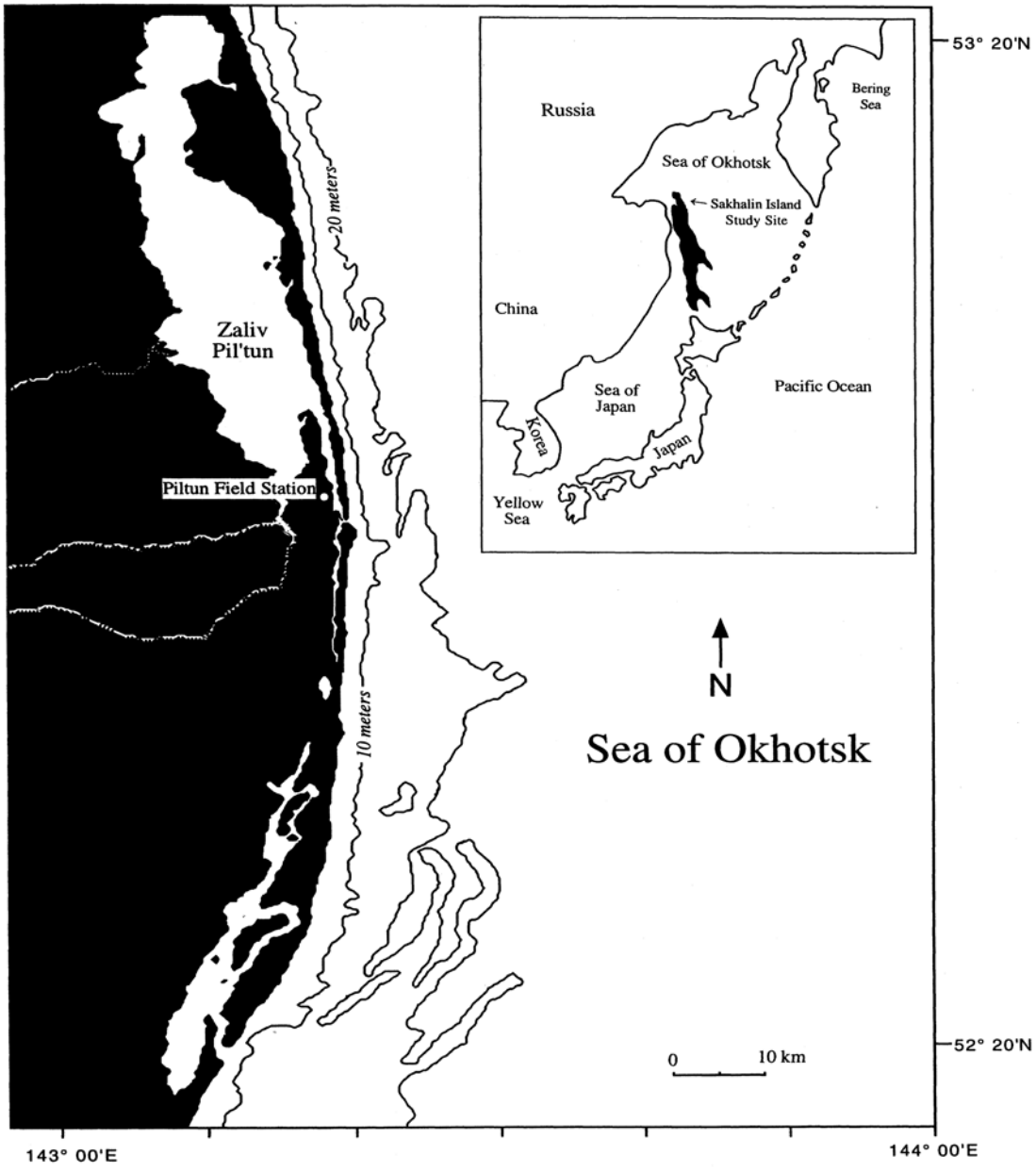

Figure 4. Map of the Piltun study area. Inset shows relative location of Sakhalin Island in the Sea of Okhotsk.

Sea surface temperature and salinity in 2000, as measured from our research vessel during Beaufort sea state conditions ≤ 3 (winds ≤ 7-10 kts), ranged from 5.1-15.1°C and 25-36 ppt, respectively (Table 1). Periods free of sea ice occur mainly between late May and early December.

Table 1. Temperature and salinity statistics associated with pod sighting locations, 2000.

Variable	Sample Size	Mean	SD	Median	Mode	Range
Temperature (°C)	36	10.4	2.78	11.2	13.1	5.1-15.1
Salinity (ppt)	39	31.4	2.35	31	31	25-36

Photo-Identification Surveys

Photo-identification methods have proven extremely useful for gray whale studies (Darling 1984, Jones 1990, Weller *et al.*1999), as individuals are particularly well marked along their sides, backs, and flukes (Fig. 5). Boat-based photo-identification surveys were conducted on all good weather days during the 2000 study period. Identical methodology was employed during each survey, with the primary objective of encountering and photographically identifying as many whales as possible. Previous photo-identification data gathered in the Piltun area in 1994-1999 used mainly right-side dorsal flank markings for identification (Brownell *et al.*1997, Weller *et al.*1999, Würsig *et al.*1999, Würsig *et al.* 2000), and for the sake of intra- and inter-annual reliability, we continued this methodological approach.

Photographic surveys involved slow travel in a 4.5-m outboard-powered inflatable boat. The research team consisted of a boat driver, data recorder, digital video camera operator, and 35-mm camera photographer. Systematic search from the survey vessel was maintained until a whale sighting was made. Upon initial sighting of a pod, the survey vessel slowed to idle speed, and maneuvered to a vantage point approximately 50 m from the whale(s). From this position, observations on pod location (as determined by Global Positioning System, or GPS), time, behavior, and number of whales were recorded.

The research vessel was then moved within 3-12 m of the whale pod and individuals were photographed. During the photographic effort, a running commentary regarding the film frame and video counter number as related to particular whales was recorded onto data sheets. Measures of water depth (as determined by digital depth

Figure 5. Pigmentation and other patterns used to photographically identify individual whales.

sounder), location (as determined by GPS), and environmental conditions were recorded every 3-5 min throughout each photographic session. In all cases, attempts were made to simultaneously photograph and videotape the right dorsal flank of each whale, followed then by photos of the left dorsal flank and flukes. Photographs were taken with a Nikon F5 35-mm camera equipped with a 100-300 mm zoom telephoto lens, high-speed motordrive, and databack. Video footage was recorded on a Sony DCR-VX1000 digital video camera. Two 35-mm film types were used: Kodachrome 200 ISO color slide film, and Fujichrome 400 ISO color slide film.

Contact with whale pods was maintained until all individuals encountered had been photographed. The boat was then motored away from the pod, where initial estimates of pod size and composition were revised if necessary, and all film and written records reviewed for completeness. These procedures were repeated as the research vessel resumed travel and additional whale pods were encountered.

A pod was defined as either a solitary individual, or two or more whales observed in close spatial proximity (within several body lengths of each other), and swimming in close association and generally coordinating their diving or direction of movement (see Clapham 1993). Pod size estimates were based on field observations, and represented the product of a consensus among observers on the survey vessel. The term “calf” is used here to refer to young of the year. In all cases, calves were initially identified by their small body size (about one-third that of a mature adult), and constant association with a particular adult whale. Calves that were documented to disaffiliate from their mothers at some point during the field season were termed “newly-independent calves”.

Photo and Video Analysis

A total of 76 rolls of film were taken during the 2000 field season. Images of individual gray whales consisted of various aspects of the body, including head, back, dorsal flanks, and flukes. Based on the photographic methodology employed during 1995-1999 field efforts in the Piltun area (Brownell *et al.*1997, Weller *et al.* 1999, Würsig *et al.*1999, Würsig *et al.* 2000), the 2000 research team also targeted the right dorsal flank of each whale as the primary body aspect for identification purposes. Attempts were made in all cases to follow this standard approach; however, it was not

always possible. Therefore, to maximize the collection of data, whales were photographed sequentially from head to fluke on either the left or right side, and the top and bottom of their flukes. Written observations and video footage collected at the time of each photographic session were used to link inter-individual aspects whenever possible.

Photographic images were first examined on a light table using an 8x loupe. A whale was not given a permanent subject identification number unless its right dorsal flank was photographed at some point during the field season. Additional aspects of the body were used as identification tools only if they were first matched with their respective right flank. In an effort to identify as many whales as possible, all images of acceptable quality (even if unmatched) were archived for subsequent identification purposes.

Photographic "matching" was done by comparing a "new" individual to all images of already-cataloged whales. If a prospective match was determined, the current image was repeatedly compared to previous images, and was required to match before being confirmed as a reidentification of a known individual. If a photograph could not be matched, then photographs of remaining individuals were inspected. Although labor intensive, this systematic search process increased the probability that most, if not all, previously-sighted whales would be resighted. If a match was not found after this comprehensive inspection, the individual was considered a new sighting.

Digital video footage was collected simultaneously to still photography during photo-identification surveys. A total of 3.0 hrs of digital video footage, acquired at 30 frames per second, was obtained during the 2000 research effort. Each video session was subsequently reviewed frame by frame to verify and enhance the already established 35-mm photographic catalog. A data code containing date and running time information allowed for separation of whale pods. When analyzing each pod session, video frames of marked whales were compared to the corresponding 35-mm images for that group. If the video image(s) matched a whale already cataloged, a note was made in the video log and the next surfacing sequence was examined. If the video images did not match a previously known whale, then a print was made on a digital video color printer. Such prints were set aside for later comparison with the 35-mm photographic catalogs. If the

videographer recorded a previously unphotographed aspect of an identified whale, then a print was made of that aspect. The print was labeled with the appropriate identification number and added to the identification catalogs.

After all digital video footage was analyzed and necessary prints made, images of whales not accounted for by 35-mm photographs were systematically "matched" following the same procedure as that described for photo-identification. The use of digital video proved to be a valuable tool in creating the photo-identification catalogs. Although the quality of the video images was slightly lower than the 35-mm photographic images, the resulting footage nevertheless provided additional identification information for some whales. Upon completion of the 2000 photo-identification catalog, comparisons were made with whales identified in the Piltun study area between 1994-1999, and a database containing information on each whale identified between 1994-2000 was established.

RESULTS

Survey Effort

Forty photo-identification surveys were conducted between 25 June and 16 September 2000. Approximately 192 hrs of survey effort was conducted and 56.5 hrs were spent in direct observation of 365 pods. Seventy-six rolls of film and 3 hrs of digital video were used for individual identification (Table 2).

Table 2. Annual survey effort, number of pods encountered, and whales identified, 1994-2000.

Year	Sampling period (mo, d)	Number of surveys	Hours of observation	Rolls of film used	Pods encountered	Whales identified
1994	09/07 - 09/12	-	-	-	-	10
1995	08/15 - 08/19	5	10.1	15	23	27
1997	07/09 - 09/08	22	33.4	72	114	47
1998	07/06 - 09/29	35	50.5	91	125	54
1999	06/29 – 10/13	56	122.0	160	434	70
2000	06/25 – 09/16	40	56.5	76	365	58
Overall		158	272.5	414	1061	94*

* The number of whales identified annually includes resightings of individuals from previous years, resulting in a total of 94 known individuals.

Pod Size and Distribution Patterns

Mean pod size for the 365 pods encountered during 2000 was 1.6 (± s.d. 0.84) with a range of 1-5 whales per pod (Table 3). A majority of pods (97.0%) was composed of three whales or less (Fig. 6). The mean water depth in which pods were encountered was 11.2 m (± s.d. 3.37, n = 362) with a range of 3.3 – 27.0 m. Ninety-six percent of all pods were distributed in waters < 18 m deep (Fig. 7).

Table 3. Pod size summary statistics, 1995-2000.

Year	Number of pods	Mean pod size	Median pod size	Mode pod size	± S.D. pod size	Range in pod size
1995	23	2.3	2	2	± 1.18	1-6
1997	114	1.8	1	1	± 1.33	1-9
1998	125	2.0	2	2	± 1.02	1-6
1999	434	1.8	1	1	± 1.03	1-7
2000	365	1.6	1	1	± 0.84	1-5
Overall	1061	1.9	1.4	1.4	± 1.08	1-9

GPS determined pod locations were generally within 5 km of shore (Fig. 8), a pattern similar to that observed since 1995 (Appendix 2). On several occasions, exceptional sea conditions allowed us to expand our more typical survey coverage to include areas ~60 km north and up to 25 km south of the entrance to Piltun Lagoon. In all cases, whales photographed to the north and south were individuals known to also occur off the lagoon channel mouth. Many surveys documented individual whales moving distances of 50 km or more in less than 24 hours, while other whales demonstrated strong site fidelity (sometimes over days) to regions less that 500 m^2. In general, the 2000 season was seemingly characterized by a more northern distribution of pods than had been detected during previous studies between 1997-1998, but similar to findings from 1999 (Würsig *et al*. 1999, Würsig *et al*. 2000).

Individual Recognition and Sighting Patterns

Fifty-eight naturally marked individual whales, including three calves, were identified during 2000. The rate at which individual whales were first identified during each field season between 1994-2000 is presented in Figure 9. This figure displays the cumulative number of whales identified over time. The rapid increase in the slope of the

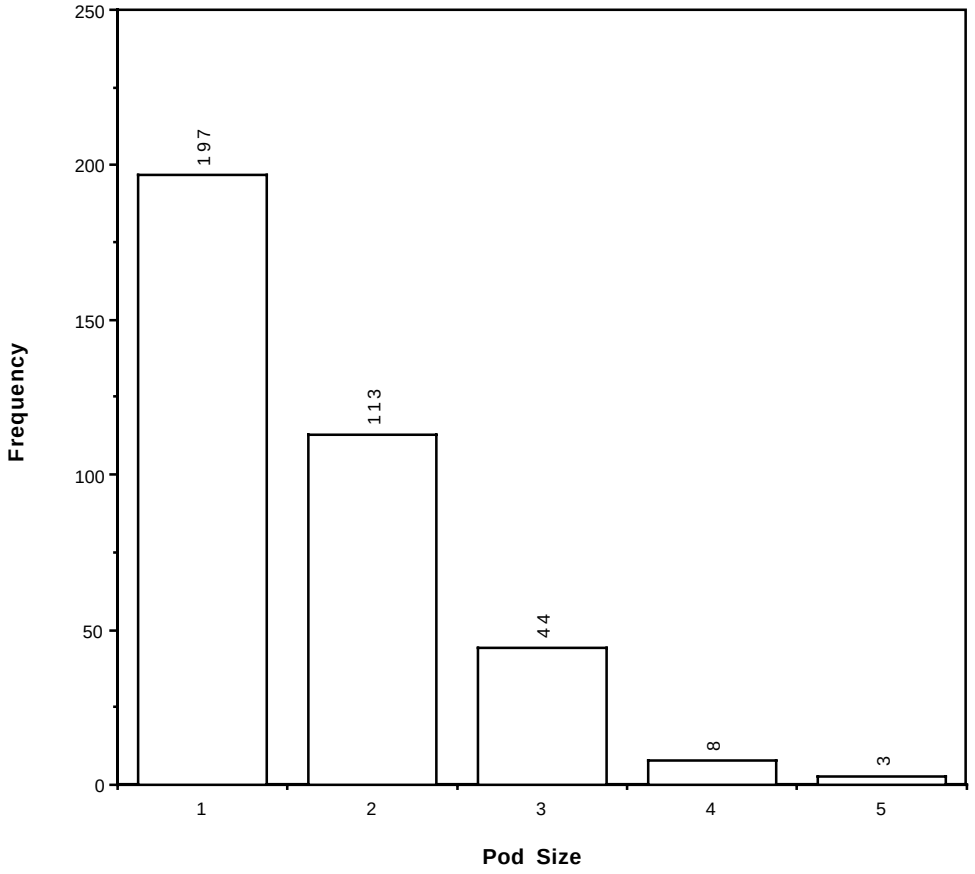

Figure 6. Distribution of pod sizes encountered.

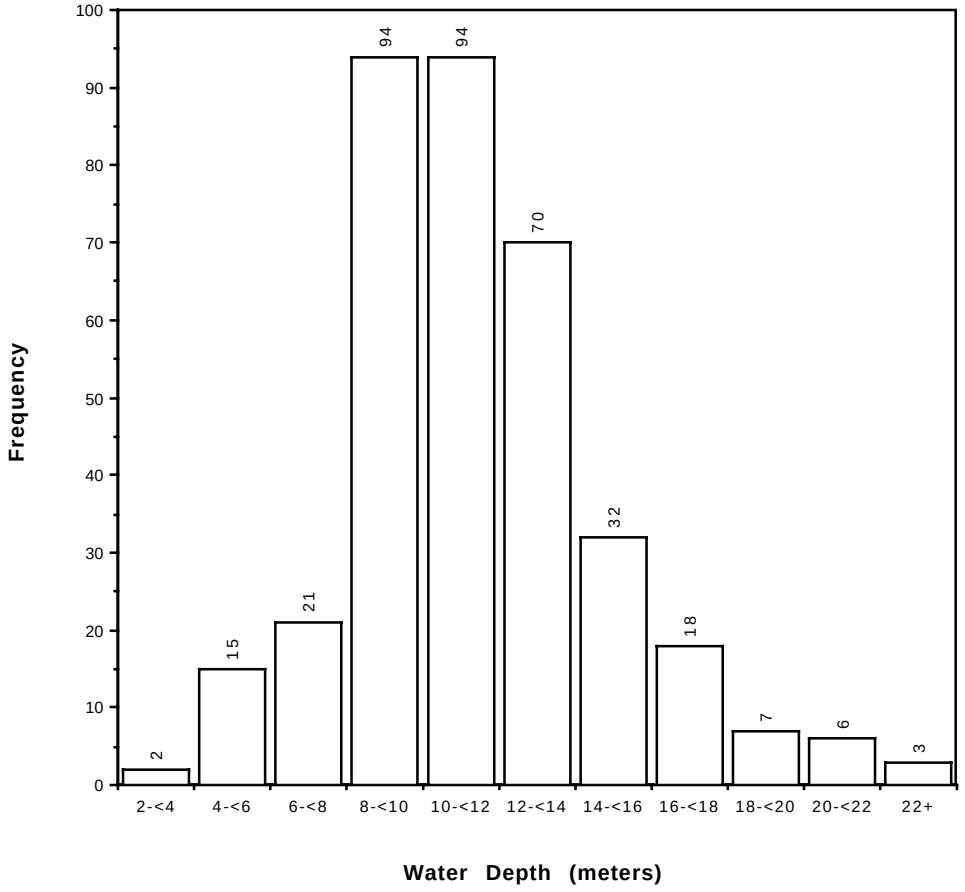

Figure 7. Distribution of water depths for pods encountered.

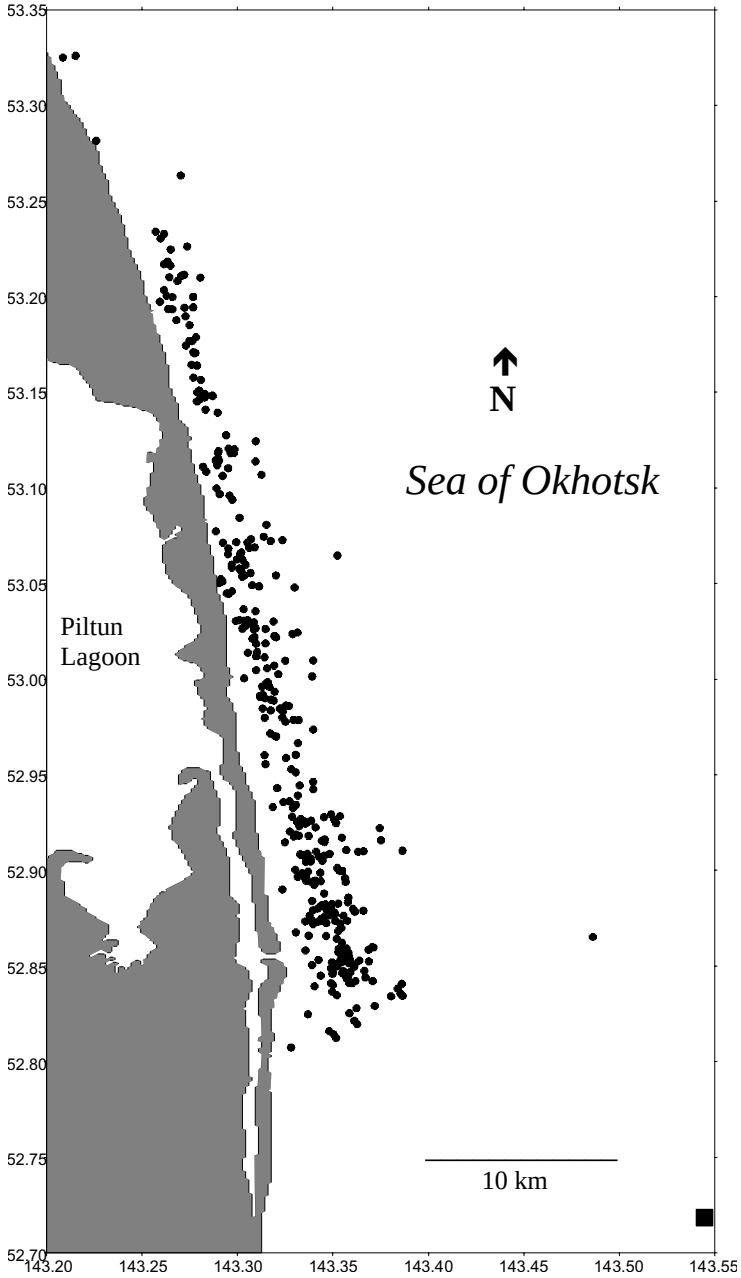

Figure 8. Spatial distribution of pods encountered, 2000. The Molikpaq location is denoted by a black square at the lower right side of the figure. Latitude and longitude are displayed in decimal degrees.

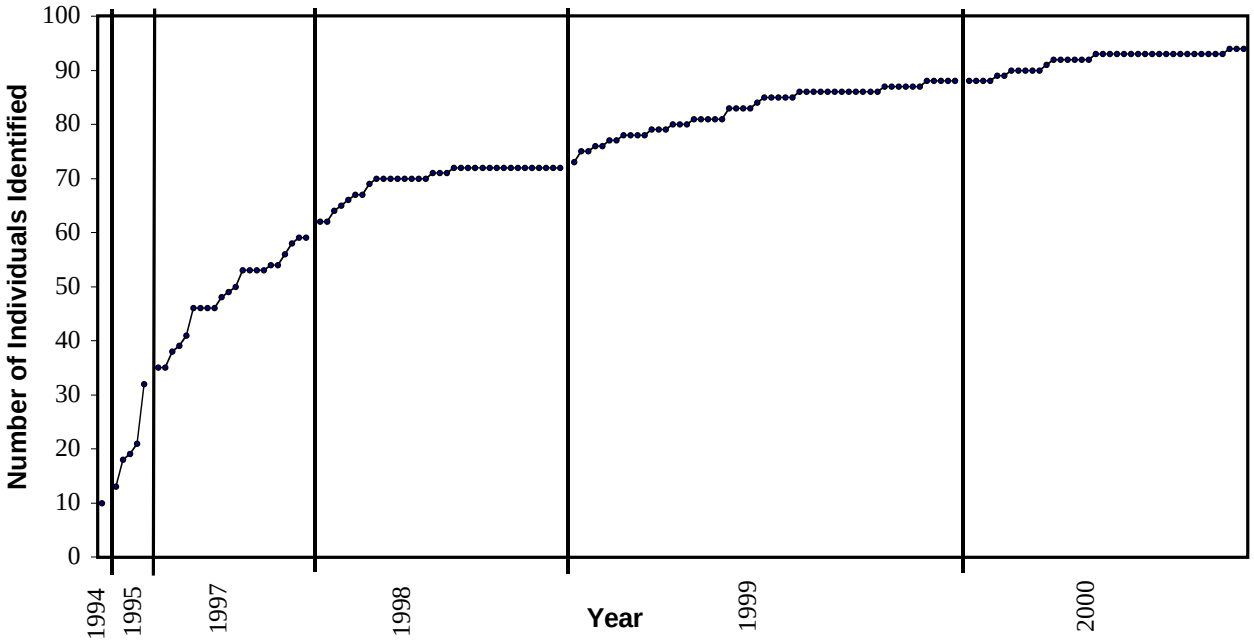

Figure 9. Rate of discovery curve for whales identified between 1994-2000. A black circle represents each survey date, and vertical lines separate each survey year.

curve during 1994-1997 represents the initial identification of unrecognized whales. Sightings of new animals, however, leveled dramatically early in 1998. The rate of increase in this function was relatively limited in 1999, with only 14 additional non-calves identified. The leveling in the slope of the discovery curve at the end of the 1998,1999 and 2000 field efforts suggests that all whales present in the search area during each respective year had been identified. This trend was particularly apparent in 2000, with only three previously unknown non-calves identified during the entire season.

Occurrence Patterns

The monthly presence or absence of identified whales during 2000, and for the previous 1994-1999 photographic efforts, are presented in Figure 10. The mean number of months in which whales were identified during 2000 was 1.9 ($\pm$ s.d. 0.68) with a range of 1-3 months. Seventeen whales (29.3%) were sighted in only one month, 31 (53.4%) were sighted in two months, 10 (17.2%) were sighted in three months, and no whales were sighted in all four months. It is important to note however, that our systematic survey effort was conducted between 30 July and 16 September. Opportunistic photography, on two days in June and four days in July, greatly diminished the opportunity for whales to be sighted in the 3-4 month categories. Of the seventeen whales sighted in only one month, < 1.0% (n = 1) were identified in June, 17.6% (n = 3) were sighted in July, 58.8% (n = 10) were observed in August, and 17.6% (n = 3) were sighted in September.

Resighting and Site Fidelity Patterns

The 58 whales identified during the 2000 field season consisted of 55 non-calves (i.e. adults or subadults) and three young of the year calves. When the six whales first identified in 2000 were combined with the 88 individuals identified between 1994-1999, a total of 94 whales have been photographically identified (Table 2). Of the 55 non-calves identified during 2000, 94.5% (n = 52) had been previously identified in Piltun during 1994-1999 photographic efforts (Table 4). Sighting frequencies for recognized individuals, based on a one-sighting-per-day criterion, ranged between 1-19 with an overall mean of 8.3 ($\pm$ s.d. 5.43) sightings per whale (Fig. 11).

Whale ID number	1994	Aug-95	Jul-97	Aug-97	Sep-97	Jul-98	Aug-98	Sep-98	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99	Jun-00	Jul-00	Aug-00	Sep-00
001																	
002																	
003																	
004																	
005						**M**	**M**										
006																	
007																	
008																	
009						**M**	**M**										
010																	
011																	
012																	
013																	
014																	
015						**M**	**M**	**M**									
016																	
017																	
018		**M**				**M**	**M**	**M**									
019		**M**	**M**	**M**											**M**	**M**	**M**
020			**C**	**C**	**C**												
021																	
022																	
023																	
024																	
025																	
026																	
027																	
028																	
029																	
030																	
031			**M**	**M**	**M**												
032			**C**	**C**	**C**												
033																	
034																	
035																	
036						**M**	**M**	**M**									
037																	
038									**M**	**M**	**M**						
039																	
040										**M**	**M**	**M**					
041																	
042																	
043																	
044																	
045		**C**															
046		**C**															
047																	
048																	

Figure 10. Occurrence patterns of whales identified between 1994-2000. Shaded areas indicated presence of specific individuals in the study area. **M** = Mother and **C** = Calf.

Whale ID number	1994	Aug-95	Jul-97	Aug-97	Sep-97	Jul-98	Aug-98	Sep-98	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99	Jun-00	Jul-00	Aug-00	Sep-00
049																	
050																	
051																	
052																	
053																	
054																	
055						M	M	M									
056						C	C										
057						C	C	C									
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087																M	
088																	
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091																	C
092																	
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Figure 10. Continued.

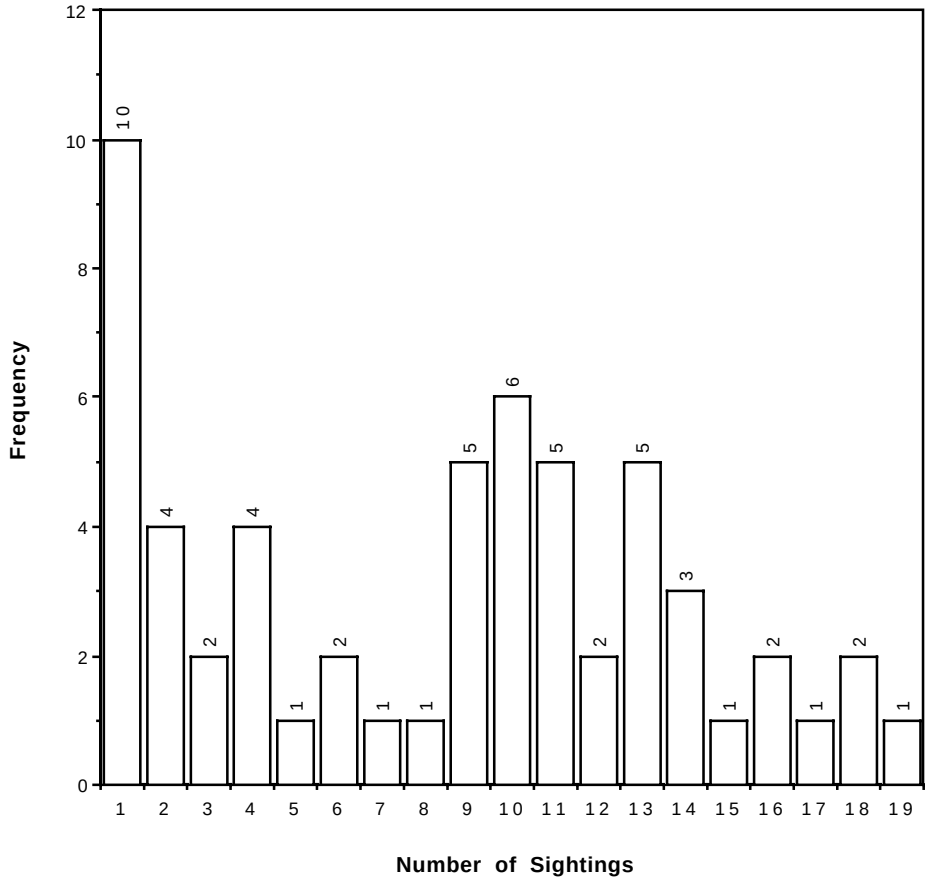

Figure 11. Sighting frequencies for whales identified in 2000.

Table 4. Annual sighting trends and resighting percentages of whales photo-identified.

Year	Whales identified	Calves/non-calves identified (Crude birth rate)	New whales identified	Percentage of non-calves identified from previous years
1994	10	-	10	N/A
1995	27	2/25	22	20.0% (*n* = 5)
1997	47	2/45 (4.3%)	27	44.4% (*n* = 20)
1998	54	8/46 (14.8%)	13	89.1% (*n* = 41)
1999	70	3/67 (4.3%)	16	80.6% (*n* = 54)
2000	58	3/55 (5.2%)	6	94.5% (n = 52)

Mother-Calf Pairs

Two mother-calf pairs (019/089 and 087/090) and one already disaffiliated calf (091) were identified during 2000 (Table 5), and ranked among some of the most-frequently sighted whales (Figure 10). Of the two mothers identified in 2000, one (019) was seen in four previous years and first identified in 1995 while the other was observed in one previous year and first identified in 1999. Whale 019 was also identified as a mother in 1995 and 1997. Both of the mothers identified in 2000 were sighted off Piltun in 1999 when they were pregnant. These findings emphasize the multiple year return to the Piltun region by reproductive females, a trend also evident in the 1997-1999 data sets.

Table 5. Mother-calf pairs identified between 1997-2000.

Mother ID	Calf ID	Year
019	020	1997
031	032	1997
005	060	1998
009	058	1998
015	057	1998
018	061	1998
036	062	1998
055	056	1998
063	064	1998
NA	066	1998
038	071	1999
040	077	1999
NA	086	1999
019	089	2000
087	090	2000
NA	091	2000

To date, 1998 was characterized by the highest calf production, with eight calves observed. We expected that at least some of the eight 1998 mothers would be accompanied by calves in 2000. This was not the case however. Seven of the 1998 mothers identified that year were also observed off Piltun in 2000, but none of them had calves. Thus, the majority of 1998 mothers either did not produce calves or lost them before arriving to the feeding grounds. Additionally, four of the seven identified 1998 mothers were tentatively identified as unusually thin in 2000. The lower than expected number of calves observed off Piltun in 2000 may be due to the poor physical condition (i.e. thinness) of some females, as "skinny whales" are unlikely to become pregnant, carry a fetus to term, or successfully suckle a new born calf.

The observed crude birth rate for 2000, as calculated by dividing the number of calves observed by the total number of all whales identified (including calves) in a given year (see Clapham and Mayo 1990), was 5.2%. Of the 16 calves identified between 1997-1999, five (31.3%) have been sighted in at least two years. Four (80.0%) of these five calves were born and first sighted in 1998. While it is presently undetermined if calf return rates correspond with calf survivorship, these findings suggest that overall calf mortality within the first year may be relatively high.

Physical Condition and Health Status

During the 2000 field season, as was also true in 1999, our team regularly observed and documented whales that appeared to be unusually thin. The evident thinness of these animals could be noticed, in most cases, within several minutes of approaching individuals by small boat for photo-identification purposes. Field records and photographic analysis suggest that as many as 27 whales were identified as thin. Similar observations, albeit of fewer animals, were documented off Piltun in 1999. Laboratory analysis of 1999-2000 photographs and video revealed several morphological attributes correlated with a particular individual being described as thin. Diagnostic features varied between individuals, but consisted of at least one of the following: 1) an obvious subdermal protrusion of the scapula (shoulder blade) from the body with an associated thoracic depression surrounding the insertion of the flipper; 2) the presence of

a post-cranial depression; and 3) a pronounced ridge along the dorsal aspect of the lumbar and caudal vertebrae resulting in the appearance of a “bulge” along the lateral flank.

DISCUSSION

Industrial activities on the continental shelf off eastern Sakhalin Island have steadily increased in the past five years, and are scheduled to continue. The nearly constant drilling and production activities during ice-free periods, in addition to the associated increase in aircraft and shipping traffic now occurring off Piltun Lagoon, have introduced new sources of potential disturbance to western gray whales on their feeding grounds. Planned industrial development in other regions off eastern Sakhalin Island will also introduce probable sources of disturbance to gray whales as they migrate to and from their southern breeding grounds.

Photo-identification studies (1994-1995 and 1997-2000) on the primary feeding grounds off northeastern Sakhalin Island have identified a total of 94 individual whales. These photo-identification data indicate high levels of annual return and pronounced seasonal site fidelity for a majority of all whales. While new individuals continue to be identified annually, the rate at which this is occurring has been near asymptote sine 1998. This finding suggests that a majority of the population had been identified between 1994-1997 (Weller *et al*. 2000). Although data collected in 1997 and 1998 revealed subtle behavior shifts possibly related to industrial activity (Würsig *et al*. 1999, Würsig *et al*. 2000), the high level of annual return and seasonal site fidelity to the Piltun region suggest that whales have not abandoned their summer feeding grounds in response to an increased anthropogenic presence. However, the possibility of a northern distribution shift for many pods during 1999 and 2000, in combination with the reported poor physical condition of some whales, are clearly points of potential concern.

The occurrence of unusually skinny whales in 1999 and 2000 remains unexplained. After reviewing photographs of thin whales taken in 1999, a group of ten experts on large whales (not affiliated with our project), including biologists, toxicologists, physiologists, and veterinarians, concluded that the whales were abnormally thin, had significantly diminished overall muscle mass, and appeared to be in generally “poor” physical condition. The increase in the number of whales reported to be

thin during 2000 is certainly of concern. While the causal mechanism(s) for the observed deterioration in physical condition of some whales off Piltun in 1999 and 2000 is unknown, any of the following factors may be contributing alone or in combination: 1) disease; 2) stress induced metabolic shifts; 3) natural or human produced changes in prey availability; 4) habitat perturbation by industrial activities.

Interestingly, during 1999 the eastern gray whale population experienced unusually high mortality of immature/adult whales, and low calf production (LeBoeuf *et al*. 2000). Although the causal mechanism(s) responsible for this event are currently unknown, LeBoeuf *et al*. (2000) hypothesize that gray whale benthic prey biomass has been depleted due to the combined influence of increased annual water temperatures in the Bering Sea and over grazing of the feeding grounds by a population that may now exceed pre-exploitation levels. Two unusually thin stranded whales were reported during 1999 off San Francisco and many other stranded whales off California were thought to be thin but blubber thickness of these whales was not measured. In addition, shore-based observations of apparently thin whales migrating north were also observed off California (personal communication, National Marine Fisheries Service, 1999).

While the above explanations for the reported trends in the eastern population appear plausible, observations of "skinny" western population gray whales during 1999 and 2000 on the Okhotsk Sea feeding grounds prove puzzling. The western population, at fewer than 100 individuals, is not likely to be over grazing their benthic food base or exceeding the carrying capacity of the Okhotsk Sea feeding grounds (Brownell and Weller 2001). Nevertheless, as is true for the eastern population, the western population has also experienced at least some level of apparent malnourishment. Therefore, the simultaneously occurring "skinny" whale phenomenon in both the eastern and western populations suggest that the variables underlying the "skinny" whale phenomenon may be global or ocean basin wide in nature, rather than regional (Brownell and Weller 2001). However, it is also possible that influences from industrial activities near the feeding grounds and other potential factors in the southern range of the western population are contributing to the skinny whale phenomenon, and any connection to similar events in the eastern population are purely coincidence. For example, the poor physical condition noted for some whales during 1999 and 2000 may be related to cumulative physiological

stress correlated with long-term exposure to anthropogenic variables such as underwater noise (Richardson *et al*. 1995).

Similarly, factors contributing to the possible northern shift in distribution observed in 1999 and 2000 may simply reflect naturally occurring fluctuations in gray whale prey distribution and abundance. However, it is also possible that this suspected change is due to industry-related effects on the benthic biomass of the general area or as a result of whales moving away from the primary sources of anthropogenic noise occurring at the southern end of their feeding habitat.

RESEACH RECOMMENDATIONS

- The health status of unusually thin whales off Piltun needs further follow-up evaluation using a suite of techniques including benthic assessments of prey density, and physiological and toxicological evaluations of blubber, skin, and fecal samples to assess the potential contribution of disease, stress, and diet.

- In order to further monitor the survivorship, annual return, and health-related status of individually identified whales (especially those deemed to be in poor physical condition during 1999 and 2000), we strongly recommend that the current photo-recognition research be continued in 2001 and combined with benthic, physiological, and telemetric studies.

- Benthic studies designed to obtain a baseline understanding of gray whale prey distribution and availability are strongly recommended. Without data regarding this topic, it would be difficult to determine the ecological impacts on the nearshore benthic community caused by a catastrophic industrial accident (e.g. oil spill).

- Shore-based behavioral studies incorporating theodolite and focal observation techniques following those developed by Würsig *et al*. (1999, 2000) be conducted concurrent to continuous acoustic monitoring are recommended to evaluate the relationship between industrial activity and whale behavior.

- With regard to mitigation strategies, some industry operations such as seismic surveying, blasting, and dredging of the sea floor should be timed so as not to overlap with periods of high whale abundance (June-October) on the feeding grounds. Further, ship and air traffic should maintain appropriate distance and altitude to prevent possible disturbance of whales.

CONCLUSIONS

Given the critically endangered status of the western gray whale population, and the increasing number of unusually thin individuals, we strongly recommend that the current research effort be continued to further monitor the health status, annual return, calf and adult survivorship, and crude birth rates, while at the same time expanding to incorporate studies on: behavioral reactions of whales to industrial noise including aircraft and vessel traffic; nearshore benthic habitat and prey communities; distribution and occurrence patterns of whales at broader spatial scales along the eastern Sakhalin coast; and local movement patterns and migratory routes to and from the Piltun area by radio and satellite telemetry. These types of studies, in combination, have proven highly valuable in evaluating the influence of oil and gas development on bowhead whales feeding in the Arctic Ocean (see Richardson *et al*. 1989, National Marine Mammal Laboratory 2000).

ACKNOWLEDGEMENTS

In the field we were fortunate to work with Sergey Blokhin, Amanda Bradford, Galya Fesenko, Dima and Lena Golovenkova, Yulia Ivaschenko, Sergei and Zhana Osokin, Yuri Shvetsov, Grigory Tsidulko, and Yuri and Irina Zhalinsky. Preparations for the study were provided by Stacie Arms and Janice Blum. Glenn Gailey provided GIS and figure preparation expertise, and Susan Reeve helped to develop field methods and data collection protocols. Thanks to Dr. Robert Brownell, Dr. Phil Clapham, Dr. Jim Darling, Dr. Doug DeMaster, Dr. Toshio Kasuya, Dr. Steve Reilly, Dr. Steve Swartz, Wayne Perryman, and Dr. Alexey Yablokov for their excellent advice and willingness to serve as scientific advisors. Sakhalin Energy Investment Company partially funded the 2000 study, and we acknowledge the assistance of Nancy Kralik, Dr. Lawrence A.

Reitsema, and James Robinson. We also acknowledge the financial support of the National Fish and Wildlife Foundation and the International Fund for Animal Welfare. This project was conducted as part of the Marine Mammal Project under Area V: Protection of Nature and the Organization of Reserves within the U.S.-Russia Agreement on Cooperation in the field of Environmental Protection.

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APPENDIX 1

Summary of major findings from studies conducted in 1997-1999 by
Texas A&M University and Kamchatka Institute of Ecology and Nature Management

SUMMARY OF MAJOR RESEARCH FINDINGS - 1997

Aerial and vessel surveys suggested that while gray whales were detected to the north and south of Piltun Lagoon, the only major concentrations observed were located near the study site. These findings are in support of previous TINRO aerial and ship-based survey results which also reported that major concentrations of gray whales in the coastal waters of Sakhalin were observed predominately near Piltun Lagoon.

Acoustic monitoring of geophysical survey activity revealed received sound levels from seismic pulses of approximately 153 dB re 1 μPa, zero-to-peak; 159 dB re 1 μPa, peak-to-peak; and 139 dB re 1 μPa, averaged over one second while the seismic survey vessel was 30-35 km from shore. These findings indicated that even at relatively large distances, seismic noise was detectable within the nearshore area that gray whales were typically located.

Theodolite tracking determined that most pods were sighted within 6 km of shore. Intra-seasonal changes in pod distribution indicated that whales moved into deeper water as the summer season progressed. This distributional change suggested that pods may have remained closer to shore during seismic periods (July to mid-August) and shifted to more offshore waters (late-August to early-September) once seismic surveying was terminated.

Shore-based scans counted 397 pods, with an average of 4.8 pods and 8.4 whales per scan. Scans collected during non-seismic, seismic, and post-seismic periods showed a trend of fewer pods being detected immediately after seismic periods than during non-seismic periods. This pattern suggested that pods began to shift their distribution out of the study site during periods of seismic noise, resulting in the lower whale numbers counted during the subsequent post-seismic condition.

Photo-identification surveys identified 46 whales, and revealed high levels of seasonal site fidelity, and annual return of previously identified individuals. These occurrence patterns, in combination with the regular observation of several mother-calf pairs, emphasizes the importance of the Piltun area as a major feeding ground for at least part of the population.

Theodolite tracks during focal observations detected changes in whale swim speeds and orientations relative to seismic sound. Alterations in leg speed, leg delta, and linearity indicated a trend of faster and straighter swimming over larger areas during seismic periods. We hypothesize that these behavioral changes may be indicative of disturbance to feeding behavior which is generally characterized by limited linear movement and a high degree of angular change between surfacings.

Focal pod observations revealed that whales had the longest intervals between exhalations during non-seismic periods. The more rapid breathing rate detected during seismic and post-seismic periods is difficult to interpret but clearly indicates a fundamental physiological change which may or may not prove deleterious to individual whales.

SUMMARY OF MAJOR RESEARCH FINDINGS - 1998

Aerial surveys suggested that gray whales generally remained within 5 km of shore, and were distributed mostly off the mouth of Piltun Lagoon, or to the north. These results support our shore-based observations during 1997 and 1998, and closely resemble earlier TINRO aerial and ship-based survey results that found large aggregations of gray whales predominantly near Piltun Lagoon. Further, the lack of sightings in waters surrounding the Sakhalinskaya and Molikpaq suggest that more offshore waters are probably not typical gray whale habitat. Based on these findings, and in order to minimize any potential disturbance impacts, we recommend that industry-related vessel and aircraft traffic remain outside the area of high whale numbers between June and November (when whales are actively feeding) and maintain a minimum distance from shore of 8-10 km.

Comparisons of benthic organisms collected near the Molikpaq, and prey items identified from gray whale feces showed nearly no overlap. This apparent discrepancy in species composition may explain the strong nearshore affinity of whales off Piltun. Thus, findings from benthic studies near the Molikpaq do not appear directly comparable to more nearshore regions, and therefore may not adequately characterize gray whale feeding habitat. The ecology of the nearshore benthic community off Piltun is poorly known. In order to assess changes in gray whale prey density and availability related to potential industrial impacts (e.g. oil spills), in addition to understanding naturally occurring seasonal and annual fluctuations, we recommend that detailed benthic studies be conducted in regions where gray whales are known to feed.

Whales were present throughout the research period, but were especially low in numbers between 31 August and 5 September. This period of particularly low abundance overlapped precisely with the arrival of the Molikpaq and the associated 10-15 support vessels. While speculative, the noticeable but temporary decline in the number of whales in the study area at that time may have represented a short-term shift in distribution, resulting from unusually high industrial activity. The cumulative effects of such short-term responses over extended periods of time (e.g. year after year) are presently unresolved, and can only be assessed by additional long-term study. Therefore, we recommend that shore-based behavioral studies incorporating theodolite and focal observation techniques be conducted concurrent to continuous acoustic monitoring in order to evaluate the relationship between industrial activity and whale behavior.

The mean numbers of pods and whales detected per scan were lower overall than those reported by our research team in 1997. Without further data, it is impossible to determine if this pattern represents a gradual decline in the number of whales returning to the area, perhaps as a result of increased industrial activity, or merely represents a natural annual fluctuation in abundance. These findings represent a point of potential concern, and we recommend that detailed shore-based studies of the kind described in this report be continued for at least several additional years to monitor this situation.

Similar to the results obtained by the 1998 aerial surveys, theodolite-tracking determined that a majority of pods were sighted within 5 km of shore. Intra-seasonal changes in pod distribution indicated that whales moved into deeper water as the summer season progressed. This pattern was also documented in 1997, and may reflect a seasonal change in prey abundance and availability. As stated above, in order to minimize any potential disturbance impacts from industry-related activities, we recommend that vessel and aircraft traffic remain outside the area of high whale numbers between June and November (when whales are actively feeding) and maintain a minimum distance from shore of 8-10 km.

Photo-identification surveys in 1998 identified 53 whales, with only six previously unidentified non-calves sighted. The asymptote in the rate at which new individuals were discovered, combined with high inter-annual resighting rates, suggest that the western population of gray whales may be smaller than previously estimated. The continued photographic monitoring of this population is an essential step in assessing the true population level, and is necessary for proper development of conservation policies. We recommend that this research program be continued, and closely coordinated with genetic studies to determine population identity and individual relationships. In addition, it would be of significant value to conduct photo-identification surveys along the entire eastern Sakhalin Island coast to determine if other gray whale feeding areas exist, and if gray whales identified off Piltun utilize such areas.

Seven mother-calf pairs were identified during the 1998 field season, and the estimated crude birth rate for 1998 was approximately twice as high as that reported for 1997. Of the seven mothers identified in 1998, six were sighted in 1997 when they were newly-pregnant. Both lactating and pregnant females are under especially high energetic demands, probably making it imperative that they feed in regions capable of meeting their elevated metabolic requirements. The seasonal site fidelity and annual return of reproductive females reported here, combined with their need for high-quality habitat, suggest that the northeastern Sakhalin Island coast is of particular biological importance to this whale population. Therefore, we recommend that benthic studies designed to obtain a baseline understanding of gray whale prey distribution and availability be implemented. Without proper baseline data regarding this topic, it would be difficult to determine the ecological impacts, or lack thereof, on the nearshore benthic community caused by a catastrophic industrial accident (e.g. oil spill).

SUMMARY OF MAJOR RESEARCH FINDINGS - 1999

Mean pod size for the 434 pods encountered during 1999 was 1.8 (+ s.d. 1.03) with a range of 1-7 whales per pod. A majority of pods (97.0%) were composed of four whales or less. The mean water depth in which pods were encountered was 12.9 m ($\pm$ s.d. 3.63, n = 423) with a range of 2.9 – 24.0 m. Ninety-four percent of all pod locations were distributed in waters < 18 m deep. GPS determined pod locations were generally within 5 km of shore.

Many surveys documented individual whales moving distances of 50 km or more in less than 24 hours, while other whales demonstrated strong site fidelity (sometimes over days) to regions less that 500 m^2.

In general, the 1999 season was seemingly characterized by a more northern distribution of pods than had been detected during previous studies in 1997 and 1998. This finding was supported by data collected during several hundred counts from the Piltun lighthouse between May and November of 1999, and the encounter data from photo-identification surveys conducted in 1999.

A total of 70 naturally marked individual whales were identified, including two calves. Of the 68 non-calves identified during 1999, 79.4% (n = 54) had been previously identified in Piltun during 1994-1998 photographic efforts. Sighting frequencies for recognized individuals, based on a one-sighting-per-day criterion, ranged between 1-30 with an overall mean of 8.1 ($\pm$ s.d. 5.92) sighting per whale.

The mean number of months in which whales were identified during 1999 was 2.7 ($\pm$ s.d. 1.06) with a range of 1-5 months. Eleven whales (15.7%) were sighted in only one month, 18 (25.7%) were sighted in two months, 25 whales (35.7%) were sighted in three months, 14 whales (20.0%) were sighted in four months, and two whales (3.0%) were sighted in all five months of the study. The period between the first and last sighting for individual whales ranged from 2 to 105 days with a mean of 57.2 days (± SD 25.60).

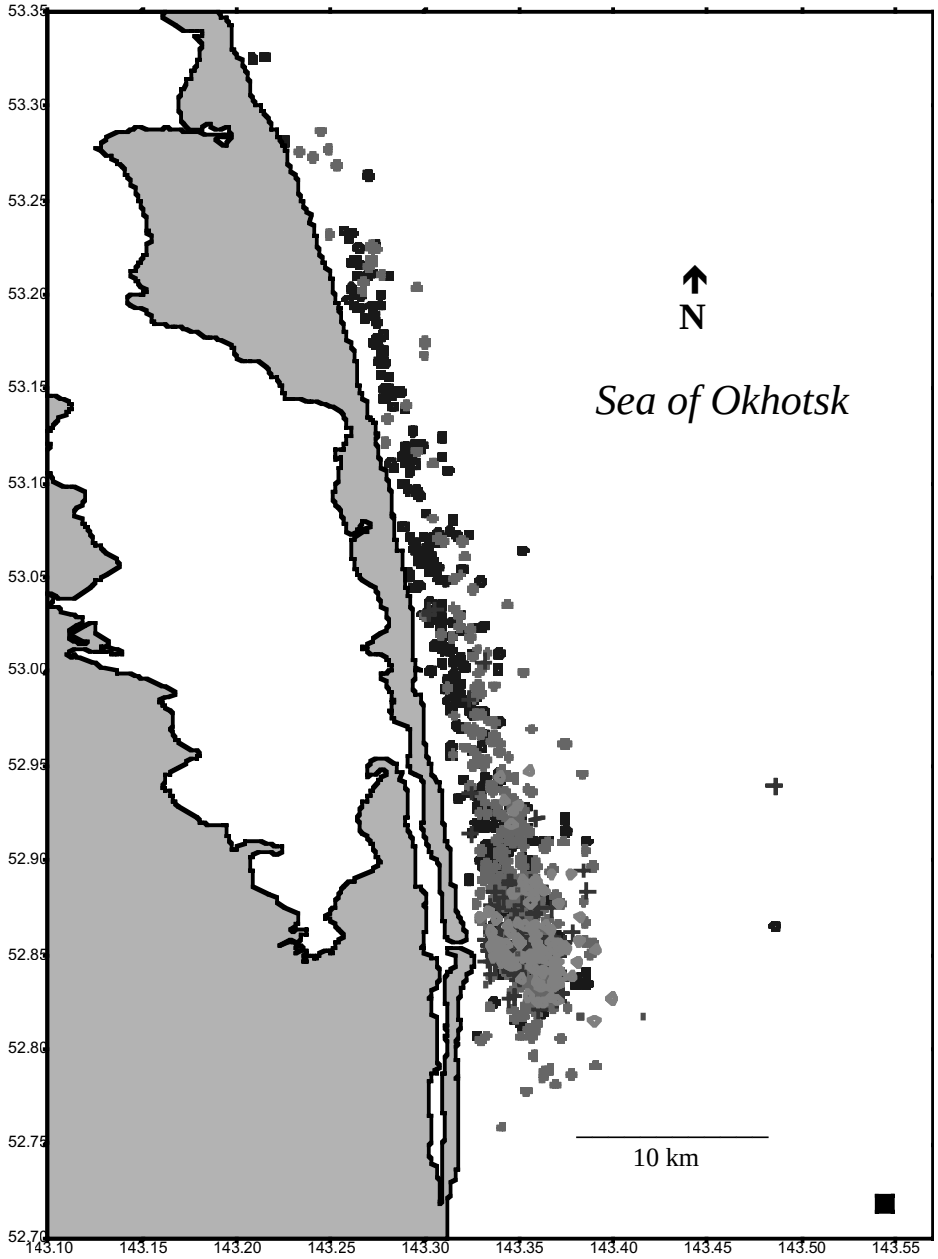
Two mother-calf pairs (040/077 and 038/071) were identified during the study, and ranked among some of the most-frequently sighted whales. Of the two mothers identified in 1999, one was seen in three previous years and first identified in 1995 while the other was observed in two previous years and first identified in 1997. Although neither of these two whales had been previously identified as mothers, both were sighted in 1998 when they were pregnant. These findings emphasize the multiple year return to this region by reproductive females, a trend also evident in the 1997-1998 datasets. The observed crude birth rate for 1999 was 2.9%. This rate was considerably lower than the 4.3% and 13.2% reported for 1997 and 1998, respectively. Of the 11 calves identified between 1995-1998, five (45.5%) were sighted in at least two years. Of these five calves, four were born and first sighted in 1998 and resighted in 1999. While it is presently undetermined if calf return rates correspond with calf survivorship, these findings suggest that calf mortality within the first year may be relatively high.

During the 1999 field season, our team regularly observed and documented at least 10 whales that appeared to be unusually thin. The evident thinness of these animals could be noticed, in most cases, within several minutes of approaching individuals by small boat for photo-identification purposes. Similar observations were not documented during previous studies off Piltun in 1997 and 1998. Laboratory analysis of 1999 photographs and video revealed several morphological attributes correlated with a particular individual being described as thin. Diagnostic features varied between individuals, but consisted of at least one of the following: 1) an obvious subdermal protrusion of the scapula (shoulder blade) from the body with an associated thoracic depression

surrounding the insertion of the flipper; 2) the presence of a post-cranial depression; and 3) a pronounced ridge along the dorsal aspect of the lumbar and caudal vertebrae resulting in the appearance of a “bulge” along the lateral flank.

Appendix II

Pod sighting locations 1995-2000



Spatial distribution of pods encountered, 1995-2000. The Molikpaq location is denoted by a black square at the lower right side of the figure. Latitude and longitude are displayed in decimal degrees. 1995 sightings = Blue Square, 1997 sightings = Purple Diamond, 1998 sightings = Light Purple +, 1999 sightings = Green +, 2000 = Red Circle.

APPENDIX III

Sighting records for whales photographically identified in 2000

Whale ID number	Aspect	Date	Group number	Initial sighting location (degrees north)	Initial sighting location (minutes north)	Initial sighting location (degrees east)	Initial sighting location (minutes east)	Initial depth (m)	Sea surface temperature
002	R,L	00/06/25	1	52	51.411	143	21.234		6.0
002	R,L	00/07/30	4	52	55.084	143	19.926	9.2	
002	R,L	00/08/02	3	52	51.541	143	21.186	11.5	
002	R,L	00/08/09	9	53	11.983	143	15.956	7.6	
002	R	00/08/12	19	53	12.964	143	15.891	12.0	
002	R,L	00/08/13	19	53	8.842	143	16.967	9.0	
002	R,L	00/08/21	10	52	58.782	143	18.857	8.3	
002	R,L	00/08/21	12	52	59.435	143	18.718	8.7	11.9
002	R,L	00/08/24	7	52	59.882	143	18.906	10.0	
002	R,L	00/08/25	4	52	51.147	143	21.460	13.0	
004	R,L	00/06/27	1	52	51.954	143	20.860		
004	R,L	00/08/02	5	52	51.485	143	20.137		
004	L	00/08/09	14	53	13.822	143	15.578	9.7	
004	R,L	00/08/12	1	52	50.398	143	21.002	6.7	
004	R	00/08/12	3	52	52.398	143	20.129	8.6	
004	R	00/08/12	4	52	52.782	143	20.797	12.0	
004	L	00/08/21	16	53	7.083	143	17.785	11.5	
004	L	00/08/25	2	52	50.971	143	21.659	15.0	
004	L	00/08/26	1	52	51.508	143	21.313	13.5	
004	L	00/08/27	13	53	1.736	143	18.398	8.5	
004	R,L	00/09/02	1	52	51.113	143	20.969	s	
004	L	00/09/02	10	52	49.487	143	20.210	4.1	
004	R	00/09/03	1	52	49.749	143	22.313	14.0	8.6
004	L	00/09/06	5	52	54.615	143	23.184	20.0	7.5
004	L	00/09/06	21	52	59.018	143	19.040	10.0	
004	R	00/09/10	8	53	7.210	143	17.906	11.5	13.1
004	L	00/09/15	1	52	55.959	143	19.743	10.0	
005	L	00/08/12	16	53	12.596	143	16.828	13.0	
005	L,F	00/09/06	4	52	54.941	143	22.511	21.0	
005	F	00/09/10	10	53	11.663	143	16.605	10.5	
005	R,L	00/09/14	9	53	4.364	143	19.411	17.5	
005	R	00/09/15	11	53	10.606	143	16.582	9.5	
006	R,L	00/08/12	3	52	52.398	143	20.129	8.6	
006	R,L	00/08/12	4	52	52.782	143	20.797	12.0	
006	R	00/08/21	18	53	9.457	143	16.609	8.5	
006	R,L	00/08/24	6	52	57.621	143	19.830	12.0	
006	R	00/08/25	4	52	51.147	143	21.460	13.0	
006	R	00/08/26	1	52	51.508	143	21.313	13.5	
006	L	00/08/26	3	52	51.381	143	21.467	14.0	
006	R	00/08/27	10	52	59.078	143	19.353	11.0	12.5
006	L	00/09/10	13	53	12.642	143	16.228	10.0	13.5
006	R,L	00/09/14	10	53	6.829	143	18.561	15.0	
006	L	00/09/14	19	53	8.708	143	16.719	7.6	
006	R	00/09/15	14	53	12.489	143	16.109	10.0	
007	R,L,F	00/08/09	13	53	13.965	143	15.689	10.5	
007	R,L,F	00/08/11	2	52	55.075	143	20.233	11.0	
007	R,L,F	00/08/12	5	52	51.203	143	21.530	14.0	
007	R,F	00/08/14	2	52	49.280	143	21.671	9.5	
007	L	00/08/14	4	52	49.675	143	21.736	12.0	
007	R	00/08/21	8	52	57.333	143	18.878	6.0	
007	R,L,F	00/08/21	12	52	59.435	143	18.718	8.7	11.9
007	R,F	00/08/22	9	52	56.137	143	19.443	8.7	10.5
007	R,L,F	00/08/24	16	53	4.290	143	17.960	10.0	
007	L,F	00/08/26	1	52	51.508	143	21.313	13.5	
007	R,L,F	00/08/27	2	52	52.886	143	20.622	10.5	12.1
007	R,L,F	00/08/28	4	52	52.404	143	20.659	10.0	
007	L	00/08/29	5	52	55.507	143	20.188	11.5	
007	R	00/09/06	2	52	54.887	143	20.730	13.0	
007	R	00/09/06	8	52	54.601	143	21.962	19.5	
007	F	00/09/06	24	52	54.877	143	19.485	7.3	
007	F	00/09/10	13	53	12.642	143	16.228	10.0	13.5
007	R,L	00/09/15	10	53	10.465	143	16.380	8.5	
008	R,L,F	00/08/11	2	52	55.075	143	20.233	11.0	
008	R,L	00/08/23	4	52	51.595	143	22.226	16.5	

Whale ID number	Aspect	Date	Group number	Initial sighting location (degrees north)	Initial sighting location (minutes north)	Initial sighting location (degrees east)	Initial sighting location (minutes east)	Initial depth (m)	Sea surface temperature
008	R	00/08/25	5	52	52.936	143	20.970	12.5	
008	L	00/08/25	6	52	52.997	143	21.472	15.5	12.6
008	R,L,F	00/08/26	4	52	50.635	143	22.022	16.5	12.4
009	R,L,F	00/08/05	8	52	55.671	143	20.717	12.5	
009	L	00/08/13	12	53	6.929	143	17.377	9.0	
009	R,L	00/08/22	5	52	52.579	143	21.324	13.0	
009	R,F	00/08/25	5	52	52.936	143	20.970	12.5	
009	L	00/09/05	1	52	50.843	143	21.327	12.5	
009	R	00/09/06	9	52	54.432	143	20.551	12.5	7.5
009	R,L	00/09/10	3	52	55.685	143	19.707	9.2	
009	L	00/09/11	4	52	59.754	143	19.001	10.5	
009	R	00/09/16	5	53	3.135	143	17.486	4.5	
010	R	00/08/12	6	53	3.584	143	18.252	10.5	
010	R	00/09/06	9	52	54.432	143	20.551	12.5	7.5
010	R,L	00/09/06	24	52	54.877	143	19.485	7.3	
010	L	00/09/10	2	52	54.302	143	20.668	12.5	11.8
010	L	00/09/14	9	53	4.364	143	19.411	17.5	
011	R,L	00/06/27	1	52	51.954	143	20.860		
011	R,L	00/08/02	1	52	51.949	143	20.237	6.8	6.7
012	L	00/08/02	4	52	53.660	143	20.613	11.0	
012	L	00/08/06	5	52	48.953	143	20.880	12.0	
012	R	00/08/09	13	53	13.965	143	15.689	10.5	
012	R,F	00/08/12	7	53	4.284	143	18.312	11.5	
012	R,F	00/08/12	9	53	6.412	143	18.753	16.5	
012	R,L	00/08/13	16	53	8.783	143	16.817	8.3	
012	R	00/08/24	12	53	1.319	143	18.534	10.0	
012	R,F	00/08/25	12	53	0.584	143	20.382	14.0	
012	R,L	00/08/25	13	53	1.576	143	18.885	12.0	
012	F	00/09/02	5	53	1.459	143	19.885	17.0	
012	R,F	00/09/02	6	53	1.411	143	19.724	17.0	
012	L,F	00/09/02	7	53	1.595	143	18.566	10.5	
012	R	00/09/03	1	52	49.749	143	22.313	14.0	8.6
012	R	00/09/10	7	53	5.756	143	17.746	9.5	
012	R,L	00/09/14	6	53	3.392	143	18.115	9.0	
013	R,L	00/08/12	15	53	11.650	143	16.331	9.2	
013	R	00/08/13	5	53	1.781	143	18.512	10.5	
013	R	00/08/21	6	52	55.476	143	21.100	16.0	
013	L	00/08/21	21	52	53.738	143	20.163	10.0	
013	R,L	00/08/24	7	52	59.882	143	18.906	10.0	
013	L	00/08/24	9	52	59.068	143	19.334	11.5	
013	R,L	00/08/25	3	52	51.051	143	21.682	15.5	
013	R	00/08/29	11	53	8.947	143	16.970	8.5	
013	L	00/09/06	17	53	3.740	143	18.156	10.5	
013	R,L	00/09/08	2	52	50.526	143	21.700	17.0	
013	L	00/09/08	3	52	50.291	143	23.031	20.0	
013	L	00/09/08	5	52	50.134	143	23.122	22.0	
013	L	00/09/10	4	52	59.151	143	19.617	12.0	
013	L	00/09/14	4	52	53.639	143	21.397	16.0	7.7
013	R,L	00/09/15	9	53	10.232	143	16.669	9.5	
013	R	00/09/15	11	53	10.606	143	16.582	9.5	
014	L	00/08/12	16	53	12.596	143	16.828	13.0	
014	R,L	00/08/13	20	53	8.878	143	17.225	10.0	
014	R,F	00/08/14	11	52	56.343	143	19.895	10.5	
014	R,L,F	00/08/14	12	52	58.418	143	20.371	14.5	
014	R,L	00/08/21	13	53	2.197	143	18.189	9.5	
014	R,L	00/08/24	8	53	0.084	143	20.346	14.5	
014	R,L	00/08/24	14	53	1.806	143	19.133	13.0	13.7
014	R,L	00/08/25	9	52	55.588	143	21.043	15.5	
015	R,L	00/07/30	1	52	50.458	143	20.934	5.8	5.7
015	R	00/08/01	1	52	51.171	143	21.226	11.5	
015	R	00/08/01	2	52	51.298	143	21.467	12.5	
015	R,L	00/08/07	2	52	53.399	143	19.409	6.2	
015	R,L	00/08/08	3	53	0.686	143	18.844	18.5	
015	R	00/08/08	18	53	0.716	143	18.587	10.0	

Whale ID number	Aspect	Date	Group number	Initial sighting location (degrees north)	Initial sighting location (minutes north)	Initial sighting location (degrees east)	Initial sighting location (minutes east)	Initial depth (m)	Sea surface temperature
015	R,L	00/08/09	7	53	6.377	143	17.530	9.2	
015	R,L	00/08/13	12	53	6.929	143	17.377	9.0	
015	R	00/08/21	19	53	9.857	143	16.555	8.7	
015	R	00/08/24	15	53	4.131	143	18.537	12.5	
015	R	00/08/25	16	53	1.854	143	18.068	7.5	13.1
015	L	00/08/27	6	52	57.074	143	19.826	11.0	
015	L	00/08/28	3	52	52.413	143	21.071	12.5	8.7
015	R	00/08/29	4	52	54.458	143	20.727	13.5	
018	R,L	00/08/02	2	52	51.733	143	21.272	12.5	
019	R,L	00/07/20	1	52	50.469	143	23.687	16.0	
019	R,L	00/08/05	10	52	51.029	143	20.345	5.0	
019	R,L	00/08/07	2	52	53.399	143	19.409	6.2	
019	R	00/08/08	1	52	52.057	143	19.834	4.5	
019	R,L	00/08/14	1	52	50.194	143	20.972	4.5	
019	R,L	00/08/21	14	53	3.062	143	17.527	4.5	
019	L	00/08/24	1	52	48.440	143	19.682	3.3	11.7
019	L	00/08/25	1	52	50.695	143	20.614	4.1	
019	R,L	00/08/28	4	52	52.404	143	20.659	10.0	
019	L	00/08/28	7	52	50.050	143	22.827	17.5	
019	R	00/08/29	12	53	8.895	143	17.203	10.0	
019	L	00/09/06	6	52	54.514	143	20.897	13.5	
019	L	00/09/06	23	52	57.617	143	18.846	8.2	
019	L	00/09/10	2	52	54.302	143	20.668	12.5	11.8
019	L	00/09/11	6	52	59.765	143	18.773	9.0	
019	R,L	00/09/13	6	52	55.757	143	20.942	14.0	
019	L	00/09/14	19	53	8.708	143	16.719	7.6	
019	R	00/09/15	5	53	5.983	143	17.333	8.2	
019	L	00/09/16	4	53	3.135	143	17.486	4.5	
023	L,F	00/08/08	7	53	3.586	143	17.813	8.0	
023	R,L	00/08/09	5	53	4.114	143	18.364	11.0	
023	R,L,F	00/08/21	15	53	4.467	143	18.822	14.5	
023	R,L	00/08/27	7	52	58.198	143	19.220	11.0	
023	R,L	00/08/28	5	52	52.411	143	20.715	10.5	
023	R,L,F	00/09/06	11	52	59.072	143	18.789	8.5	
023	R	00/09/10	7	53	5.756	143	17.746	9.5	
023	R,L	00/09/14	8	53	3.876	143	21.139	27.0	
023	L	00/09/15	14	53	12.489	143	16.109	10.0	
023	L	00/09/16	1	52	52.744	143	20.368	10.5	
024	R,L	00/08/08	7	53	3.586	143	17.813	8.0	
024	R,L	00/08/09	6	53	5.806	143	17.439	8.0	
024	R,L	00/08/12	11	53	10.228	143	16.638	9.0	
024	R,L	00/08/12	13	53	9.387	143	16.847	8.7	
024	R,L	00/08/13	2	53	0.832	143	18.324	8.7	
024	L	00/08/21	17	53	9.001	143	16.735	8.5	
024	R	00/08/24	19	53	10.726	143	16.698	10.5	
024	L	00/08/25	13	53	1.576	143	18.885	12.0	
024	L	00/08/30	1	52	52.908	143	20.664	12.0	
024	L	00/09/10	12	53	12.027	143	15.775	9.0	
024	L	00/09/14	13	53	11.378	143	16.363	9.2	
024	L	00/09/14	19	53	8.708	143	16.719	7.6	
024	R	00/09/15	11	53	10.606	143	16.582	9.5	
025	R	00/07/18	1						8.0
027	R,F	00/07/18	1						8.0
028	R,L	00/08/07	6	52	55.214	143	19.642	7.3	
028	R,L	00/08/12	10	53	7.653	143	17.640	10.5	
028	R	00/08/12	14	53	10.254	143	16.607	9.0	
028	R	00/08/13	8	53	6.616	143	17.705	10.5	
028	R,L	00/08/13	11	53	6.708	143	17.363	8.7	
028	R,L	00/08/14	8	52	54.476	143	20.091	9.2	
028	L	00/08/21	22	52	53.671	143	20.153	10.0	
028	R,L	00/08/22	3	52	48.859	143	21.016	10.5	11.5
028	R	00/08/24	10	53	1.266	143	18.474	9.7	
028	R,L	00/08/24	11	53	1.272	143	18.471	9.5	
028	R,L	00/08/25	7	52	54.590	143	20.468	11.5	

Whale ID number	Aspect	Date	Group number	Initial sighting location (degrees north)	Initial sighting location (minutes north)	Initial sighting location (degrees east)	Initial sighting location (minutes east)	Initial depth (m)	Sea surface temperature
028	R	00/08/25	11	52	55.061	143	19.766	8.0	
028	L	00/08/27	4	52	54.638	143	21.415	16.5	
028	R,L	00/09/06	1	52	50.606	143	21.432	13.5	
028	R,L,F	00/09/08	8	52	50.693	143	21.393	13.5	
028	R,L	00/09/10	5	53	1.354	143	19.158	12.5	
028	R	00/09/11	5	53	0.154	143	19.280		13.2
028	L	00/09/13	5	52	54.930	143	20.648	12.5	
028	R	00/09/14	12	53	8.451	143	16.993	9.0	
028	R,L	00/09/15	6	53	6.658	143	16.915	6.0	
029	R,L	00/08/01	3	52	51.189	143	20.546	7.1	
029	R,L,F	00/08/02	1	52	51.949	143	20.237	6.8	6.7
029	R	00/08/02	5	52	51.485	143	20.137		
029	R,L	00/08/09	7	53	6.377	143	17.530	9.2	
033	R,L,F	00/08/05	1	52	51.018	143	21.142	12.0	
033	R,F	00/08/05	2	52	50.979	143	21.106	11.5	
033	R	00/08/08	11	53	4.389	143	18.421	10.5	
033	L	00/08/12	16	53	12.596	143	16.828	13.0	
033	R,L	00/08/13	12	53	6.929	143	17.377	9.0	
033	L	00/08/21	4	52	54.505	143	19.970	9.2	
033	R	00/08/21	23	52	53.624	143	20.333	11.0	
033	R	00/08/22	7	52	53.040	143	20.345	10.5	
033	R,L	00/08/24	12	53	1.319	143	18.534	10.0	
033	R	00/08/25	8	52	54.972	143	20.737	12.5	
033	L	00/08/25	9	52	55.588	143	21.043	15.5	
033	L	00/09/06	14	53	2.910	143	18.677	12.0	
033	R	00/09/14	11	53	8.355	143	17.372		
034	R,L	00/08/23	3	52	54.367	143	20.304	11.5	
034	R	00/08/23	7	52	53.661	143	20.405	11.5	
034	R	00/08/24	12	53	1.319	143	18.534	10.0	
034	R,L	00/08/27	7	52	58.198	143	19.220	11.0	
034	L	00/08/29	7	52	58.719	143	19.762	12.5	
035	R,L	00/08/01	3	52	51.189	143	20.546	7.1	
035	R,L	00/08/06	1	52	52.432	143	20.332	9.7	
035	L	00/08/08	7	53	3.586	143	17.813	8.0	
035	L	00/08/08	17	53	2.679	143	17.722	6.6	
035	R	00/08/09	14	53	13.822	143	15.578	9.7	
035	R,L,F	00/08/12	12	53	11.105	143	16.488	9.7	
035	R,L	00/08/13	3	53	1.673	143	18.242	8.7	
035	R	00/08/14	2	52	49.280	143	21.671	9.5	
035	R	00/08/14	4	52	49.675	143	21.736	12.0	
035	R,L	00/08/21	1	52	51.412	143	21.488	14.0	9.1
035	R	00/08/21	24	52	52.931	143	20.769	12.0	
035	R	00/08/22	1	52	50.085	143	21.128	9.0	
035	R	00/08/22	4	52	51.210	143	21.371	13.0	
035	L	00/08/23	4	52	51.595	143	22.226	16.5	
035	R,L	00/08/23	6	52	51.856	143	21.116	13.0	
035	R,L	00/08/24	3	52	53.985	143	21.207	14.0	
035	R	00/08/29	9	53	0.576	143	19.496	13.5	
035	R,L	00/08/30	3	52	53.143	143	21.483	17.0	7.2
035	L	00/09/02	8	53	1.583	143	18.152	8.5	
035	R	00/09/03	7	52	55.351	143	20.454	12.0	
035	L	00/09/06	15	53	2.947	143	18.458	11.0	15.1
035	L	00/09/10	10	53	11.663	143	16.605	10.5	
035	R	00/09/11	3	52	59.524	143	18.787	9.0	
035	R,L	00/09/14	17	53	19.554	143	12.905	8.5	7.0
036	R,L,F	00/07/30	3	52	51.912	143	29.169	13.0	5.1
036	R,L	00/08/01	1	52	51.171	143	21.226	11.5	
036	R	00/08/09	10	53	12.604	143	15.854	11.5	
036	R	00/08/12	17	53	12.685	143	16.322	10.5	
036	R	00/08/13	16	53	8.783	143	16.817	8.3	
036	L	00/08/13	18	53	8.835	143	16.841	8.5	
036	R	00/08/13	20	53	8.878	143	17.225	10.0	
036	R,L,F	00/08/21	13	53	2.197	143	18.189	9.5	
036	L	00/08/24	16	53	4.290	143	17.960	10.0	

Whale ID number	Aspect	Date	Group number	Initial sighting location (degrees north)	Initial sighting location (minutes north)	Initial sighting location (degrees east)	Initial sighting location (minutes east)	Initial depth (m)	Sea surface temperature
036	R	00/08/27	10	52	59.078	143	19.353	11.0	12.5
036	L	00/08/28	4	52	52.404	143	20.659	10.0	
036	R	00/08/30	2	52	52.862	143	20.947	13.0	
036	L	00/09/02	3	52	58.713	143	19.924	14.0	
036	L	00/09/03	6	52	55.469	143	20.134	11.5	
036	L	00/09/06	21	52	59.018	143	19.040	10.0	
036	L	00/09/10	9	53	11.257	143	16.076	7.8	
036	L	00/09/14	5	52	59.327	143	19.132	10.5	
036	R,L,F	00/09/15	10	53	10.465	143	16.380	8.5	
037	R,L	00/07/30	3	52	51.912	143	29.169	13.0	5.1
037	R,L	00/08/08	18	53	0.716	143	18.587	10.0	
037	L	00/08/12	8	53	4.836	143	18.908	14.5	
037	L	00/08/21	7	52	56.542	143	20.383	13.5	
037	R	00/08/24	14	53	1.806	143	19.133	13.0	13.7
037	R,L	00/08/27	7	52	58.198	143	19.220	11.0	
037	R	00/09/08	9	52	53.548	143	20.413	11.5	
037	L	00/09/14	19	53	8.708	143	16.719	7.6	
037	L	00/09/15	10	53	10.465	143	16.380	8.5	
041	R,L	00/08/05	9	52	55.700	143	21.222	18.5	5.6
041	L	00/08/09	15	53	14.034	143	15.423	9.2	
041	R,L	00/08/12	8	53	4.836	143	18.908	14.5	
041	L	00/08/13	20	53	8.878	143	17.225	10.0	
041	R,L	00/08/21	2	52	50.846	143	21.983	16.5	
041	R,L	00/08/24	3	52	53.985	143	21.207	14.0	
041	L	00/08/27	5	52	55.328	143	22.467	21.0	
041	R	00/08/28	2	52	52.196	143	21.262	13.5	
041	R,L	00/08/29	1	52	52.092	143	21.154	13.5	
041	R,L	00/08/30	3	52	53.143	143	21.483	17.0	7.2
041	L	00/09/06	19	53	0.026	143	18.209	5.5	
041	R	00/09/14	8	53	3.876	143	21.139	27.0	
041	R	00/09/15	2	52	56.776	143	20.377	14.5	10.9
041	R,L	00/09/16	2	52	53.755	143	21.380	16.0	
042	R,L,F	00/08/08	11	53	4.389	143	18.421	10.5	
042	R,L	00/08/09	4	53	1.117	143	18.879	11.5	
042	R	00/08/13	16	53	8.783	143	16.817	8.3	
042	R,L	00/08/13	18	53	8.835	143	16.841	8.5	
042	R	00/08/14	11	52	56.343	143	19.895	10.5	
042	L,F	00/08/14	12	52	58.418	143	20.371	14.5	
042	R	00/08/25	12	53	0.584	143	20.382	14.0	
042	R	00/08/27	8	52	58.792	143	19.408	11.0	
042	R	00/08/28	1	52	52.420	143	21.447	14.5	
042	L,F	00/09/08	7	52	50.522	143	22.249	13.5	
042	L,F	00/09/13	2	52	52.703	143	21.689	15.0	
042	L,F	00/09/13	6	52	55.757	143	20.942	14.0	
042	F	00/09/14	15	53	15.796	143	16.215	20.0	
043	R,F	00/08/14	4	52	49.675	143	21.736	12.0	
043	L,F	00/08/25	5	52	52.936	143	20.970	12.5	
043	R,L	00/08/25	6	52	52.997	143	21.472	15.5	12.6
043	R,L	00/08/27	3	52	53.926	143	20.604	12.0	
043	R,L,F	00/09/05	2	52	50.814	143	21.551	15.0	
043	F	00/09/10	10	53	11.663	143	16.605	10.5	
043	R,F	00/09/14	15	53	15.796	143	16.215	20.0	
043	R,L,F	00/09/15	6	53	6.658	143	16.915	6.0	
044	R,L	00/07/02	1	52	50.045	143	21.332	15.0	10.3
044	R	00/07/02	3	52	53.806	143	21.811		
044	R	00/08/08	9	53	4.272	143	17.541	7.5	
044	L	00/08/12	8	53	4.836	143	18.908	14.5	
044	L	00/08/13	3	53	1.673	143	18.242	8.7	
044	R	00/08/14	5	52	53.850	143	20.039	8.7	
044	L	00/08/14	6	52	53.914	143	20.043	8.7	
044	R	00/08/21	11	52	59.463	143	18.699	8.5	
044	L	00/08/21	12	52	59.435	143	18.718	8.7	11.9
044	R	00/08/24	8	53	0.084	143	20.346	14.5	
044	L	00/08/25	15	53	1.821	143	17.949	7.0	

Whale ID number	Aspect	Date	Group number	Initial sighting location (degrees north)	Initial sighting location (minutes north)	Initial sighting location (degrees east)	Initial sighting location (minutes east)	Initial depth (m)	Sea surface temperature
047	R	00/08/02	2	52	51.733	143	21.272	12.5	
047	L	00/08/05	1	52	51.018	143	21.142	12.0	
047	R,L,F	00/08/05	2	52	50.979	143	21.106	11.5	
047	R,L	00/08/05	6	52	52.310	143	20.382	9.7	
047	R,L	00/08/07	3	52	53.674	143	20.447		
047	R,L	00/08/09	1	52	52.328	143	21.231	13.0	
047	L	00/08/11	3	52	57.176	143	19.689	11.0	
047	R,L	00/08/12	5	52	51.203	143	21.530	14.0	
047	R,L	00/08/21	4	52	54.505	143	19.970	9.2	
047	R	00/08/22	9	52	56.137	143	19.443	8.7	10.5
047	R,L	00/08/23	4	52	51.595	143	22.226	16.5	
047	R,L	00/08/24	5	52	57.524	143	19.525	10.0	
047	L	00/08/24	6	52	57.621	143	19.830	12.0	
047	R,L,F	00/08/25	12	53	0.584	143	20.382	14.0	
047	L	00/08/27	1	52	51.508	143	22.119	16.5	
047	R,L	00/09/05	2	52	50.814	143	21.551	15.0	
047	R,F	00/09/06	10	52	55.527	143	19.875	9.5	
047	R	00/09/10	7	53	5.756	143	17.746	9.5	
047	L	00/09/11	6	52	59.765	143	18.773	9.0	
047	R	00/09/14	6	53	3.392	143	18.115	9.0	
047	R	00/09/16	3	52	56.663	143	19.952	12.0	11.8
048	L	00/08/05	11	52	51.295	143	21.270	12.0	
048	R,L	00/08/06	1	52	52.432	143	20.332	9.7	
048	R,L	00/08/12	18	53	12.659	143	16.266	10.5	
048	R,L,F	00/08/21	8	52	57.333	143	18.878	6.0	
048	L	00/08/24	13	53	1.313	143	19.212	13.0	
048	L	00/08/25	12	53	0.584	143	20.382	14.0	
049	R,L	00/08/12	3	52	52.398	143	20.129	8.6	
049	R,L	00/08/12	4	52	52.782	143	20.797	12.0	
051	R,L	00/07/30	3	52	51.912	143	29.169	13.0	5.1
051	L	00/08/12	2	52	50.484	143	21.541	17.0	
051	R,L	00/08/13	6	53	3.469	143	18.059	8.0	
051	L	00/08/21	1	52	51.412	143	21.488	14.0	9.1
051	R,L	00/08/22	5	52	52.579	143	21.324	13.0	
051	R	00/08/29	3	52	53.978	143	21.292	15.0	
051	R	00/09/03	4	52	54.475	143	19.995	9.5	
051	R	00/09/06	12	52	59.406	143	18.865	9.0	
051	L	00/09/06	23	52	57.617	143	18.846	8.2	
051	L	00/09/08	4	52	50.433	143	23.164	22.0	
051	L	00/09/10	6	53	2.876	143	19.794	18.0	
051	R	00/09/13	7	53	0.851	143	18.611	10.0	7.6
051	R,L	00/09/14	2	52	52.595	143	20.786	12.0	
051	R	00/09/15	1	52	55.959	143	19.743	10.0	
052	R,L	00/07/02	1	52	50.045	143	21.332	15.0	10.3
052	R,L	00/08/12	7	53	4.284	143	18.312	11.5	
052	R	00/08/12	9	53	6.412	143	18.753	16.5	
052	R	00/08/13	16	53	8.783	143	16.817	8.3	
052	L	00/08/13	17	53	8.841	143	16.961	9.2	
052	R	00/08/13	20	53	8.878	143	17.225	10.0	
052	L	00/08/14	3	52	49.177	143	21.758	9.5	
052	R	00/08/21	19	53	9.857	143	16.555	8.7	
052	R,L	00/08/29	2	52	53.269	143	20.724	12.5	
052	L	00/08/30	5	52	57.992	143	19.897	13.5	
052	R,L	00/09/02	5	53	1.459	143	19.885	17.0	
052	L	00/09/02	7	53	1.595	143	18.566	10.5	
052	L	00/09/03	3	52	51.121	143	21.287	12.5	
052	L	00/09/15	12	53	10.608	143	16.486	9.5	12.2
053	R,F	00/08/25	12	53	0.584	143	20.382	14.0	
053	R,F	00/09/14	11	53	8.355	143	17.372		
054	R,L	00/08/09	3	52	58.664	143	19.510	13.0	
054	R,L	00/08/10	1	52	53.809	143	20.111	9.5	
054	R,L	00/08/13	15	53	7.228	143	17.719	11.0	
054	L	00/08/14	6	52	53.914	143	20.043	8.7	
054	L	00/08/21	4	52	54.505	143	19.970	9.2	

Whale ID number	Aspect	Date	Group number	Initial sighting location (degrees north)	Initial sighting location (minutes north)	Initial sighting location (degrees east)	Initial sighting location (minutes east)	Initial depth (m)	Sea surface temperature
054	L	00/08/21	5	52	54.267	143	20.149	10.0	9.3
054	L	00/08/24	10	53	1.266	143	18.474	9.7	
054	R	00/08/25	10	52	55.121	143	19.835	8.5	
054	R,L	00/08/27	14	53	1.837	143	18.237	7.5	
054	L	00/09/10	4	52	59.151	143	19.617	12.0	
055	R,L	00/08/02	1	52	51.949	143	20.237	6.8	6.7
055	R	00/08/02	5	52	51.485	143	20.137		
055	R	00/08/06	3	52	50.928	143	20.941	10.5	
055	L	00/08/06	4	52	50.755	143	20.982	9.5	
055	R,L	00/08/13	1	52	59.905	143	18.949	10.0	
055	R	00/08/21	25					13.0	
055	R,L	00/08/22	6	52	52.616	143	21.069	13.0	
055	L,F	00/08/23	5	52	51.499	143	21.388	14.0	
055	R	00/08/24	4	52	54.075	143	21.134	14.0	13.3
055	L	00/08/26	2	52	51.548	143	21.425	14.0	
055	L	00/08/27	9	52	58.984	143	19.423	10.5	
055	R	00/09/02	4	53	0.279	143	18.581	9.5	
055	R,L	00/09/06	22	52	59.172	143	19.522	13.5	
055	R,L,F	00/09/14	10	53	6.829	143	18.561	15.0	
055	L	00/09/14	19	53	8.708	143	16.719	7.6	
055	R,F	00/09/15	7	53	7.096	143	17.887	12.0	
055	L,F	00/09/15	8	53	7.462	143	18.572	15.5	
056	R	00/08/05	4	52	50.794	143	21.000	10.5	
056	R	00/08/05	5	52	51.283	143	21.510	8.5	
056	R,L	00/08/06	1	52	52.432	143	20.332	9.7	
056	R	00/08/07	4	52	53.957	143	20.218		
056	L	00/08/08	4	53	3.209	143	18.148	9.7	
056	R,L	00/08/08	8	53	4.093	143	17.712	8.5	
056	R	00/08/08	10	53	4.634	143	17.320	6.1	
056	L	00/08/13	13	53	7.157	143	17.403	9.5	
056	R	00/08/14	13	53	1.112	143	18.581	9.5	
056	R	00/08/24	17	53	5.624	143	17.834	10.5	
056	R,L	00/09/03	5	52	55.549	143	20.066	11.0	
056	R,L	00/09/10	11	53	11.611	143	15.818	5.0	
056	L	00/09/14	14	53	11.603	143	15.953	7.2	
057	R,L	00/08/08	8	53	4.093	143	17.712	8.5	
057	R	00/08/12	20	53	13.100	143	15.799	9.7	
057	R	00/08/12	21	53	13.016	143	15.684	8.6	
057	R,L	00/08/13	10	53	6.857	143	17.419	9.2	
057	L	00/08/14	13	53	1.112	143	18.581	9.5	
057	R	00/08/21	9	52	58.295	143	19.026	8.7	
057	R	00/08/24	19	53	10.726	143	16.698	10.5	
057	R	00/08/27	11	53	0.339	143	18.930	10.0	
057	R,L	00/08/29	8	52	59.357	143	19.042	10.0	
057	R,L	00/09/06	13	53	0.417	143	19.151	12.0	
057	L	00/09/10	3	52	55.685	143	19.707	9.2	
057	L	00/09/14	12	53	8.451	143	16.993	9.0	
058	R	00/08/05	4	52	50.794	143	21.000	10.5	
058	R,L	00/08/05	5	52	51.283	143	21.510	8.5	
058	R,L	00/08/05	7	52	54.017	143	19.809	8.0	
058	L	00/08/08	8	53	4.093	143	17.712	8.5	
058	R,L	00/08/08	10	53	4.634	143	17.320	6.1	
058	R,L	00/08/09	8	53	11.838	143	15.558	5.6	
058	R	00/08/13	10	53	6.857	143	17.419	9.2	
058	R	00/08/14	13	53	1.112	143	18.581	9.5	
058	R,L	00/08/24	18	53	9.050	143	16.792	9.2	14.6
058	R	00/08/25	14	53	1.680	143	18.258	8.2	
058	R,L	00/09/03	5	52	55.549	143	20.066	11.0	
058	R,L	00/09/10	9	53	11.257	143	16.076	7.8	
058	R,L	00/09/10	11	53	11.611	143	15.818	5.0	
058	R	00/09/14	14	53	11.603	143	15.953	7.2	
062	R	00/09/15	3	53	2.130	143	18.562	11.0	
063	R,L	00/08/08	3	53	0.686	143	18.844	18.5	

Whale ID number	Aspect	Date	Group number	Initial sighting location (degrees north)	Initial sighting location (minutes north)	Initial sighting location (degrees east)	Initial sighting location (minutes east)	Initial depth (m)	Sea surface temperature
063	L	00/08/09	2	52	58.212	143	19.165	10.0	
063	L	00/08/13	9	53	6.861	143	17.314	8.7	
063	R,L,F	00/08/14	10	52	56.055	143	19.835	9.5	
063	R,L,F	00/08/21	3	52	52.802	143	20.526	11.0	
063	L	00/08/21	26	52	52.397	143	20.539	10.5	
063	L	00/08/22	7	52	53.040	143	20.345	10.5	
063	R,L	00/08/23	1	52	54.278	143	20.298	11.0	
063	L	00/08/23	3	52	54.367	143	20.304	11.5	
063	L	00/08/23	7	52	53.661	143	20.405	11.5	
063	R,L	00/08/24	2	52	52.956	143	21.159	13.5	
063	R,L	00/08/25	9	52	55.588	143	21.043	15.5	
063	R,L	00/08/27	2	52	52.886	143	20.622	10.5	12.1
063	L	00/08/28	6	52	51.581	143	22.272	14.5	
063	R,L	00/08/30	4	52	54.337	143	20.189	11.0	
063	R	00/09/02	2	52	51.436	143	21.167	12.5	
063	R	00/09/03	3	52	51.121	143	21.287	12.5	
063	L	00/09/06	3	52	55.026	143	21.277	18.0	
063	L	00/09/08	6	52	50.062	143	23.186	21.0	
063	L	00/09/10	2	52	54.302	143	20.668	12.5	11.8
063	L	00/09/11	2	52	52.344	143	20.791	11.5	
069	R,F	00/08/05	3	52	50.778	143	21.284	12.5	
069	R,L	00/08/05	4	52	50.794	143	21.000	10.5	
069	R,L	00/08/06	2	52	52.574	143	20.266	9.7	
069	R	00/08/09	12	53	13.569	143	16.418	12.5	
069	R,L	00/08/12	12	53	11.105	143	16.488	9.7	
069	R,F	00/08/13	4	53	1.846	143	18.315	9.5	
069	L	00/08/13	7	53	4.329	143	19.047	15.0	
069	R,L	00/08/13	14	53	7.095	143	17.387	9.7	
069	L	00/08/21	13	53	2.197	143	18.189	9.5	
069	L	00/08/22	8	52	53.752	143	20.127	10.0	
069	R,L	00/08/24	5	52	57.524	143	19.525	10.0	
069	L	00/08/27	1	52	51.508	143	22.119	16.5	
069	R	00/08/29	9	53	0.576	143	19.496	13.5	
069	R	00/09/03	1	52	49.749	143	22.313	14.0	8.6
069	R,L	00/09/03	3	52	51.121	143	21.287	12.5	
069	L	00/09/14	19	53	8.708	143	16.719	7.6	
069	L	00/09/15	7	53	7.096	143	17.887	12.0	
070	R,F	00/09/14	7	53	3.324	143	18.406	11.0	
074	R,L	00/07/02	1	52	50.045	143	21.332	15.0	10.3
074	R,L,F	00/07/02	2					15.5	10.8
076	R,L	00/06/25	1	52	51.411	143	21.234		6.0
081	F	00/08/07	1	52	52.487	143	20.643	11.0	
081	R,L,F	00/08/07	3	52	53.674	143	20.447		
081	R	00/08/09	14	53	13.822	143	15.578	9.7	
081	R,L,F	00/08/11	1	52	52.594	143	20.886	12.0	
081	R,L	00/08/21	12	52	59.435	143	18.718	8.7	11.9
081	R,L	00/08/22	2	52	48.742	143	21.097	9.5	
081	L	00/08/24	10	53	1.266	143	18.474	9.7	
081	R	00/08/27	12	53	1.561	143	18.518	9.0	
081	L,F	00/08/29	6	52	55.613	143	19.981	10.5	
081	R	00/09/06	6	52	54.514	143	20.897	13.5	
081	R,F	00/09/06	7	52	54.581	143	21.790	18.5	
081	R,L	00/09/10	10	53	11.663	143	16.605	10.5	
081	R,L	00/09/13	1	52	52.790	143	21.633	14.5	
081	R,L	00/09/13	2	52	52.703	143	21.689	15.0	
081	R,L	00/09/13	4	52	51.143	143	22.134	15.5	
081	L,F	00/09/14	1	52	51.170	143	21.823	17.0	
081	R	00/09/15	12	53	10.608	143	16.486	9.5	12.2
081	R	00/09/16	5	53	6.507	143	17.020	5.7	
082	R	00/08/12	20	53	13.100	143	15.799	9.7	
082	R,L	00/08/13	1	52	59.905	143	18.949	10.0	
083	R	00/08/14	11	52	56.343	143	19.895	10.5	
083	R,F	00/08/14	12	52	58.418	143	20.371	14.5	
083	R,L	00/08/24	8	53	0.084	143	20.346	14.5	

Whale ID number	Aspect	Date	Group number	Initial sighting location (degrees north)	Initial sighting location (minutes north)	Initial sighting location (degrees east)	Initial sighting location (minutes east)	Initial depth (m)	Sea surface temperature
083	R	00/09/13	4	52	51.143	143	22.134	15.5	
083	R	00/09/14	3	52	52.733	143	21.956	18.0	
084	R,L	00/07/30	4	52	55.084	143	19.926	9.2	
084	L	00/08/05	2	52	50.979	143	21.106	11.5	
084	R	00/08/05	3	52	50.778	143	21.284	12.5	
084	R	00/08/06	1	52	52.432	143	20.332	9.7	
084	R,L	00/08/06	2	52	52.574	143	20.266	9.7	
084	R	00/08/07	7	52	55.389	143	19.942		
084	L	00/08/08	4	53	3.209	143	18.148	9.7	
084	L	00/08/08	5	53	3.253	143	18.219	10.5	
084	L	00/08/08	7	53	3.586	143	17.813	8.0	
084	R,L	00/08/08	13	53	3.927	143	18.082	10.5	
084	R,L	00/08/09	6	53	5.806	143	17.439	8.0	
084	R,L	00/08/12	10	53	7.653	143	17.640	10.5	
084	L	00/08/13	13	53	7.157	143	17.403	9.5	
084	L	00/08/23	2	52	56.580	143	19.245	8.0	10.2
084	R	00/08/25	8	52	54.972	143	20.737	12.5	
084	R,L	00/08/25	11	52	55.061	143	19.766	8.0	
084	R,L	00/08/27	14	53	1.837	143	18.237	7.5	
084	R	00/08/29	11	53	8.947	143	16.970	8.5	
084	L	00/09/06	14	53	2.910	143	18.677	12.0	
084	R	00/09/06	16	53	2.688	143	17.661	5.0	
084	L	00/09/10	9	53	11.257	143	16.076	7.8	
084	R	00/09/14	6	53	3.392	143	18.115	9.0	
084	L	00/09/14	19	53	8.708	143	16.719	7.6	
087	R,L	00/08/07	8	52	55.986	143	19.106	5.2	
089	R,L	00/07/19	1						
089	L	00/07/20	1	52	50.469	143	23.687	16.0	
089	R,L	00/08/05	10	52	51.029	143	20.345	5.0	
089	R,L	00/08/06	6	52	50.365	143	20.422	3.7	
089	R,L	00/08/07	2	52	53.399	143	19.409	6.2	
089	R	00/08/08	1	52	52.057	143	19.834	4.5	
089	R,L	00/08/14	1	52	50.194	143	20.972	4.5	
089	R,L	00/08/21	14	53	3.062	143	17.527	4.5	
089	R,L	00/08/24	1	52	48.440	143	19.682	3.3	11.7
089	L	00/08/25	1	52	50.695	143	20.614	4.1	
089	R,L	00/09/14	18	53	16.889	143	13.557	6.0	
090	R,L	00/08/07	8	52	55.986	143	19.106	5.2	
090	R,L	00/08/24	20	53	12.205	143	15.683	10.0	
090	R	00/09/15	4	53	3.916	143	17.696		
091	R,L	00/09/14	16	53	19.503	143	12.511	5.3	
091	R,L	00/09/14	18	53	16.889	143	13.557	6.0	
091	R	00/09/15	4	53	3.916	143	17.696		
092	R,L	00/07/30	2	52	51.941	143	20.788	10.5	
092	R,L	00/08/08	6	53	3.492	143	17.820	8.3	
092	R,L	00/08/09	3	52	58.664	143	19.510	13.0	
092	R,L,F	00/08/10	1	52	53.809	143	20.111	9.5	
092	R,L	00/08/12	3	52	52.398	143	20.129	8.6	
092	R	00/08/12	4	52	52.782	143	20.797	12.0	
092	R,L	00/08/13	16	53	8.783	143	16.817	8.3	
092	R,L	00/08/21	19	53	9.857	143	16.555	8.7	
092	R,L	00/08/24	7	52	59.882	143	18.906	10.0	
092	L	00/08/24	9	52	59.068	143	19.334	11.5	
092	R	00/08/27	10	52	59.078	143	19.353	11.0	12.5
092	R,L	00/08/28	5	52	52.411	143	20.715	10.5	
092	L	00/09/10	13	53	12.642	143	16.228	10.0	13.5
092	L	00/09/14	17	53	19.554	143	12.905	8.5	7.0
092	R	00/09/15	10	53	10.465	143	16.380	8.5	
093	R	00/08/08	2	52	56.168	143	19.633		
093	R	00/08/21	17	53	9.001	143	16.735	8.5	
093	R	00/08/24	14	53	1.806	143	19.133	13.0	13.7
093	R,L	00/09/02	1	52	51.113	143	20.969	11.0	
093	R	00/09/02	9	52	50.470	143	21.496	15.0	
093	R	00/09/03	2	52	49.517	143	21.516	13.5	

Whale ID number	Aspect	Date	Group number	Initial sighting location (degrees north)	Initial sighting location (minutes north)	Initial sighting location (degrees east)	Initial sighting location (minutes east)	Initial depth (m)	Sea surface temperature
093	R,L	00/09/06	1	52	50.606	143	21.432	13.5	
093	R	00/09/08	2	52	50.526	143	21.700	17.0	
093	L	00/09/08	4	52	50.433	143	23.164	22.0	
093	R	00/09/10	1	52	50.685	143	21.473	14.5	
093	L	00/09/11	1	52	50.456	143	21.605	16.5	
093	R	00/09/14	8	53	3.876	143	21.139	27.0	
093	R	00/09/15	10	53	10.465	143	16.380	8.5	
093	L	00/09/16	1	52	52.744	143	20.368	10.5	
094	L	00/08/14	7	52	54.526	143	20.196	9.5	
094	R,L,F	00/08/14	9	52	55.558	143	20.308	11.0	
094	R,L	00/08/14	10	52	56.055	143	19.835	9.5	