Report

Tero Harkonen, Mart Jüssi, Mirgaly Baimukanov, Anders Bignert, Lilia Dmitrieva, Yesbol Kasimbekov, Mikhail Verevkin, Susan Wilson and Simon J. Goodman

Pup Production and Breeding Distribution of the Caspian Seal (*Phoca caspica*) in Relation to Human Impacts

Aerial surveys of Caspian seals on the winter ice field in Kazakhstan territorial waters were carried out in February 2005 and 2006 to assess the annual pup production for the species and natural predation on newborn pups. Estimated pup production was 21 063 in 2005 and 16 905 in 2006 (including an estimated figure for pups born in Russian territory in each year). The breeding population size of approximately 20 000 females is much less than published estimates from the late 1980s. Eagles were the principal natural predators of pups. Commercial icebreaker routes passed through areas of dense pup concentrations in 2006, although not in 2005. Our findings have important implications for the development of conservation strategies for the species. Natural mortality, loss to predators, and, more important, the current hunting quota substantially exceed the recruitment of the Caspian seal population. Anthropogenic sources of mortality should be managed to avoid further declines in the species.

INTRODUCTION

Recent studies of the Caspian seal (*Phoca caspica*), which is endemic to the Caspian basin, have given rise to concern over the conservation status of this species (1–7). Ecological issues and health status, including low reproductive rates, endemic canine distemper virus, and mass mortalities, may, in combination with past and present hunting practices and other human sources of mortality, be driving a continuing population decline.

Caspian seals are thought to have been highly abundant, with a population size in the region of 1 million at the end of the 19th century. However, the species was heavily hunted throughout the 20th century (8) and is still considered to be a "harvested" species by the Russian Federation. Krylov (8) expressed concern over a major decline in breeding females to an estimated 46 800 by the late 1980s. However, the elapsed time and ongoing threats warrant a new estimate. The aim of the present survey is to obtain a reliable estimate of Caspian seal pup production and distribution at the peak of the pupping season by counting the number of pups and adults on the winter ice field using a method established for surveying Baltic ringed seals (9, 10).

Caspian seals give birth on the ice in the northern section of the Caspian. Here the water is brackish and shallow, with depths of 2–10 m (11). This region freezes in winter to form the critical breeding habitat, with pups born on the ice surface at the end of January to the beginning of February and weaned after 4–5 weeks. The seals use cracks in the ice (leads) as corridors to reach the inner areas of fast ice (8); therefore, their abundance in the expanse of fast ice away from the ice edge will depend on the existence of open water corridors in late January. The seals select ice of 30- to 40-cm thickness near cracks with access to the water.

In the Caspian the majority of pups are born and nursed on the ice surface, where they are clearly visible from the air. Thus there is an opportunity in the Caspian to count white coat pups and thereby to obtain a reliable estimate of pup production as well as the total number of adults on the breeding grounds. These results on pup production will apply to the entire species because more than 99% of Caspian seal pups are actually born on the northern ice.

MATERIALS AND METHODS

Survey Design

The aim of the survey design is to sample the entire ice surface in a nonbiased manner, from the ice edge in the south to as far north, east, and west, because there is sufficient water depth beneath the ice (>1 m) to form a suitable seal habitat. Thus, the design is completely independent of the densities of seal groups or their suspected distribution.

We used a strip survey technique originally developed for surveys of Baltic ringed seals (9) and modified the methodology to Caspian conditions. Survey flights were carried out between 23 and 28 February 2005 and again between 21 and 25 February 2006, when all the pups are expected to have been born (8).

The aircraft was a fixed wing L410, which permitted a clear view of the ice surface beneath the wings. The ground speed was 190–250 km hr^{-1}, and the altitude was maintained at a constant 90 m by means of a radar altimeter. The strip width was 400 m on each side of the aircraft, totalling 800 m. The windows of the aircraft had double panes about 5 cm apart, which made it possible to mark sighting angles using marks on the outer and inner panes. Inclinometers were used to find the sighting angles at 10.2° (500 m distance from the aircraft) and 46° (100 m distance) for each side of the aircraft and for each observer. Thus, the 200-m wide strip under the aircraft was not surveyed.

Two trained observers, 2 at each side of the aircraft, made visual counts of pups, mother-pup pairs, and seals older than pups during the entire survey, while 1 additional observer on each side took digital photos (782 total in 2005; 983 total in 2006) of the seals. The geographical position of each observed seal or group of seals was noted by each observer having a hand-held global positioning system (GPS) unit. All eagles and wolves on the ice were also counted. Detailed ice maps and bathymetric charts of the area surveyed were provided by Agip KCO.

Flown transects followed evenly spaced longitudes, where the intertransect distance was 6 longitudinal minutes. Alternate transects were flown from north to south and from south to north such that the entire range of the potential seal habitat in the ice area of the Kazakh territory was covered. Transects started in the north and east where there was fast ice over a water depth exceeding 1 m. The northeastern area of solid fast ice was therefore not surveyed because there could be no seals without water. For this reason the most easterly transect flown

Table 1. Number of pups, mothers, and other seals counted in each 800-m survey strip in 2005 and 2006, with estimates calculated for the total ice area.

	Pups		Mothers		Other Seals		Eagles	
Longitude	2005	2006	2005	2006	2005	2006	2005	2006
49.2	*25*	*57*	*21*	*57*	*22*	*38*	*1*	*31*
49.3	*72*	*10*	*63*	*10*	*73*	*7*	*2*	*1*
49.4	*18*	*129*	*15*	*86*	*42*	*104*	*2*	*4*
49.5	*62*	*182*	*60*	*141*	*98*	*148*	*0*	*1*
49.6	76	155	67	112	107	81	0	4
49.7	40	10	36	10	50	7	2	1
49.8	216	58	195	58	188	37	3	31
49.9	156	512	144	430	110	249	2	26
50.0	221	250	214	215	95	276	9	9
50.1	83	128	81	85	39	23	12	3
50.2	145	0	141	0	107	1	23	4
50.3	102	7	93	5	201	13	30	11
50.4	122	45	113	25	213	27	7	19
50.5	115	10	105	6	84	9	1	5
50.6	58	42	55	20	79	21	15	30
50.7	147	18	132	6	44	17	13	2
50.8	198	26	173	19	38	16	29	3
50.9	151	19	143	15	20	26	11	35
51.0	60	52	52	33	38	24	25	10
51.1	96	24	75	20	49	11	12	2
51.2	59	95	56	67	20	8	15	4
51.3	41	1	33	0	47	1	10	1
51.4	27	11	24	10	16	1	0	4
51.5	15	7	7	4	9	2	4	1
51.6	7	2	6	2	47	5	13	0
51.7	1	4	1	3	12	2	6	1
51.8	1	0	1	0	6	1	0	0
51.9	1	2	1	2	0	4	0	0
52.0	0	2	0	1	0	6	0	0
52.1	0	2	0	2	1	5	0	0
52.2	0	1	0	1	0	2	0	0
52.3	0	Nc	0	Nc	1	Nc	1	Nc
Kazakhstan	2138	1483	1948	1151	1621	875	243	206
Russia	177	378	159	294	235	297	5	37
Total	2315	1861	2107	1445	1856	1172	248	243
Fraction	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Estimate	21 045	16 918	19 155	13 136	16 873	10 655	2255	2209
CV	5.1	16.5	5.5	15.1	6.2	15.4	10.2	19.6

Note: The italicized numbers are the numbers estimated for the Russian sector (longitude 49.2–49.5). The easternmost strip was not flown in 2006 (Nc).

in 2005 was omitted in 2006. Transects continued south as far as the ice edge in both years.

Flying 800-m wide strips at 6 longitudinal minutes apart resulted in a total survey fraction of 11% of the total ice area of ice habitat for seals within Kazakhstan territory in each of the 2 y. Past work indicates that survey fractions of approximately 11% give the optimal balance between precision and survey effort, because increasing the survey fraction above this figure does not yield significantly improved precision (9).

The flights were not able to continue into Russian territory in these years; however, the relatively small number of pups that could be born in the Russian sector (due to the small fraction of seal ice in Russian territory) was extrapolated from the known ice conditions. Where the structure of the ice (i.e., fast ice formed over a water depth exceeding 1 m) indicated the possibility of significant numbers of seals, the numbers in Russia were estimated by mirroring the counted numbers of seals on transects covering the same amount of adjacent ice in Kazakh side to the Russian unobserved ice fields of equal size (Table 1).

Data Treatment

We recorded GPS positions for each observation on numbers of different categories of seals. Next the observations from the port and starboard sides were merged to produce a total count for each 800-m strip. Finally, the total numbers of pups, mothers, other adults, eagles, and wolves were totalled over all the strips. An estimate for the breeding female population size in each year was then obtained by dividing the total numbers of pups counted by 0.11, because the survey fraction was 11% in each year.

For the mapping of seal density distribution, each 800-m transect was divided into 5-km long segments, resulting in segment areas of 4 km^2. These segments were used as the density mapping units, densities being shown as the mean number of animals km^{-2}.

An estimate of uncertainty, expressed as the coefficient of variation (CV), was obtained as follows. A grid was superimposed on the map of the survey area. The grid cell size was set to 800×800 m. The estimated number of seals in grid cells not visited were calculated by means of inverse distance-weighted interpolation from the neighboring visited cells along the transects. After the interpolation, a random exponentially distributed noise was added to restore the original range and variance in the clusters. The distributions of pup, mother, other-seal, and eagle categories were thus estimated for the entire study area. These distribution maps were stored as data matrices, after which random sampling from parallel strips, 800-m wide to imitate real transects, was carried out in the matrices. For each category the sampling was repeated 100 times, changing randomly both the angle and the origin of coordinates of transects to produce a value for 1% of coverage. Furthermore, by changing the distance between the strips,

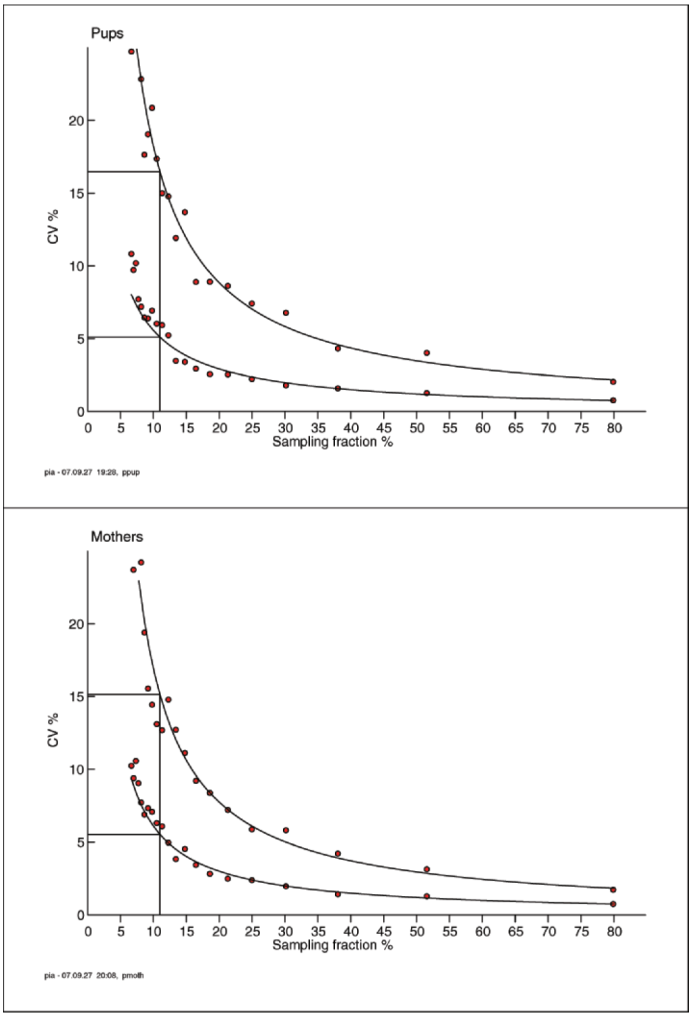

Figure 1. Estimates of the coefficient of variation (CV) vs. sampling fraction (x) for pups and mothers for the 2005 (lower lines) and 2006 (upper lines) surveys. The fitted line for pups in 2005 is described by the function CV = 1/(0.0163 x −0.016), r^2 = 0.98 and by CV = 1/(0.0058 x −0.016), r^2 = 0.98 in 2006. The graphs for mothers is given by CV = 1/(0.0170 x −0.006), r^2 = 0.99 in 2005 and by CV = 1/(0.0070 x −0.011), r^2 = 0.99 in 2006.

repeating the sampling another 100 times, estimates of various percentages of coverage were obtained (Figs. 1 and 2).

Survey from Icebreaker

An observer sailed on board a commercial icebreaker traveling through the ice field from Bautino to the Kashagan oil field on 21 February 2005. Seal occurrence visible from the ship's bridge and GPS track were recorded. The following year an observer sailed with a similar ship traveling a similar route on 25 February 2006. On this occasion, more detailed records of seal occurrence, behavior of mothers and pups, and the stage of pup development were recorded and reported. The ship in 2006 traveled at approximately 6.5–8 knots, following in the channel taken by a larger icebreaker on the previous day. The ship's track was noted from the ship's GPS. Records of seals seen from the ship were made using a digital stills camera with an 80- to 300-mm telephoto lens, camcorder with 25× optical zoom, laser rangefinder, and dictaphone. Pups were either photographed or verbally described in sufficient detail and assigned to the following developmental stages: 1 (white coat, very thin, pelvis visible), 2 (white coat, body filled out), 3 (white coat, beginning to moult or partially moulted), and 4 (fully moulted).

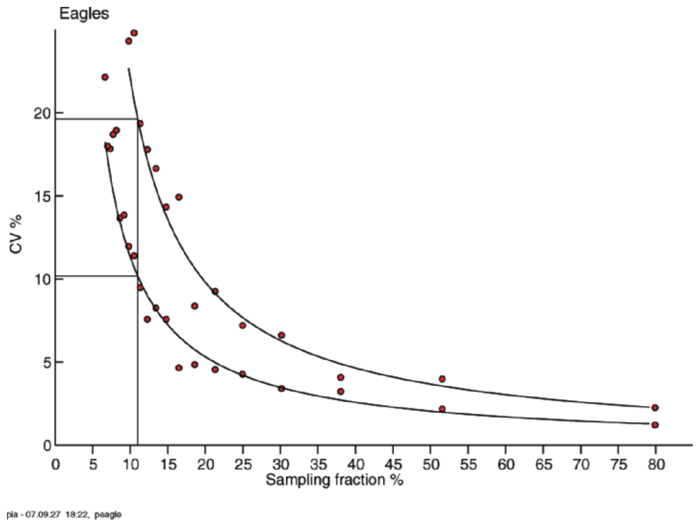

Figure 2. Estimates of the coefficient of variation (CV) vs. sampling fraction (x) for eagles in 2005 (lower line: CV = 1/(0.0100 x −0.011), r^2 = 0.98) and 2006 (upper line: CV = 1/(0.0057 x −0.011), r^2 = 0.98).

RESULTS

Number of Seals on the Ice

The total number of pups counted within the 800-m strips (including the estimates for Russia) was 2317 in 2005 and 1860 in 2006 (Table 1). Because the survey fraction was 11%, it was possible to estimate pup production on the ice as 21 045 (±95% confidence interval [CI]: 18 941–23 149) in 2005 and 16 981 (±95% CI: 11 447–22 389) in 2006 (Table 1). The greater variation for 2006 is due to the more restricted distribution of pups that year. Although the total pup production estimate was 19.7% lower in 2006 than in 2005, the CI overlapped, and therefore the difference is not statistically significant.

The total estimate for the number of mothers (adults attending pups) was 19 155 in 2005 and 13 136 in 2006. The number of mothers counted was therefore fewer than the number of pups in both years: 9% in 2005 and 22% in 2006. Of the adults observed from the aircraft, 45% in 2005 and 44% in 2006 were not attending pups (Table 1).

Numbers of Eagles and Wolves on the Ice

Eagles were frequently observed feeding on seal pups, and the main concentrations of eagles were seen in areas with moderate densities of breeding seals. The total estimate for the number of eagles on the ice was 2255 in 2005 and 2209 in 2006. Many of the eagles were found in groups of up to 15 birds at, or in the vicinity of, pools of blood. In 2005 2 wolves were observed in longitude 51.0, suggesting about 18 altogether on the total ice area, although 1 pack of 12 wolves was observed outside the strips. However, no wolves were seen either in or outside the strips in 2006.

Estimating CV vs. Sampling Fraction

We estimated CVs for counts of pups, mothers, other older seals, and eagles by resampling the density maps created for each animal category and year. We obtained 100 estimates of CVs for sampling fractions between 5% and 80% by changing the intertransect distance and found the relationship to be well described by the function (CV = 1/(bx + a), where the sampling fraction (x) is set at 11% (Figs. 1 and 2, Table 1).

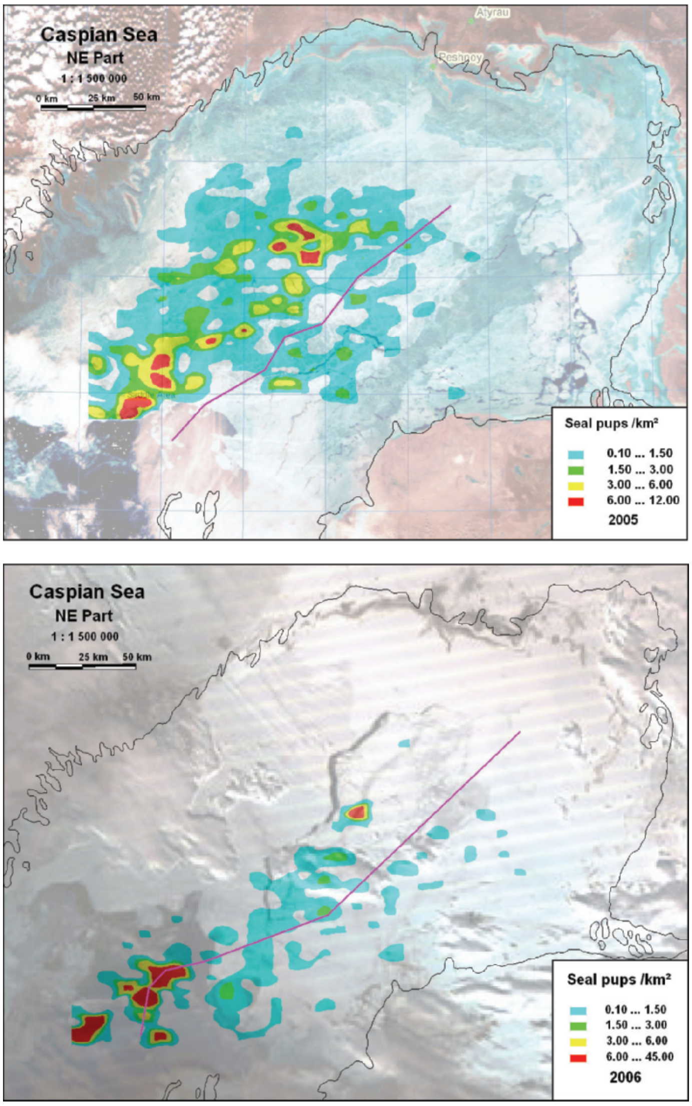

Figure 3. Seal pup density distribution, showing the icebreaker track on 21 February 2005 (top) and 25 February 2006 (bottom) through seal pupping grounds.

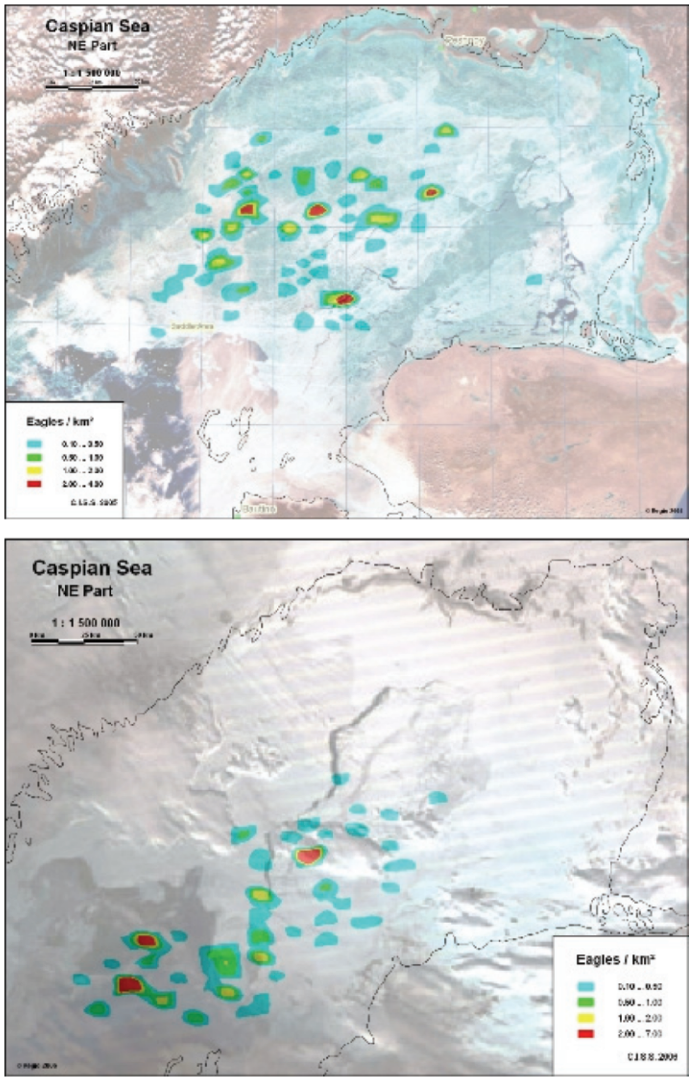

Figure 4. Density distribution of eagles in 2005 (top) and 2006 (bottom).

Density Distribution of Pups and Eagles on the Ice

In 2005 there were considerable areas of moderate mean pup densities (3–6 pups km^{-2}), sometimes surrounding a relatively few areas of hot spots of up to 12 pups km^{-2} (Fig. 3). However, in 2006 there were fewer areas of moderate density and the majority of pups were concentrated into hot spots of up to 72 pups km^{-2}. In both years there was a concentration of breeding seals in the southwest of the ice area, but in 2006 this was more marked than in 2005. Also in 2006 this breeding concentration was further to the south, reflecting the more southerly location of the ice edge (Fig. 3).

In 2005 eagles were distributed at low densities (0.1–1 eagles km^{-2}) across the seal breeding grounds. Four areas of 2–4 eagles km^{-2} were found, although these seemed not to correlate with pup concentrations. The eagle distribution appeared to be more concentrated in fewer areas in 2006, with 3 areas of 2–7 eagles km^{-2}, 2 of which coincided with the area of high pup densities in the southwest and 1 close to the only area of high pup density further north (Fig. 4).

Breeding Seals and Pups Recorded from the Icebreaker

The path taken by the ships was similar in both 2005 and 2006, but the distribution of areas of highest seal pup densities, and hence the number of seals encountered by the ship, differed (Fig. 3). In 2006, seals lined the edge of the shipping channel, particularly from approximately 45° 34′N, 50° 12′E all the way to the ice edge. Of 387 pups recorded, 270 (70%) were accompanied by mothers and 117 (30%) were pups without mothers visible to the observer. One hundred eighty-five of these mother-pup pairs were less than 30 m from the channel edge, 52 of the lone pups were less than 20 m from the channel edge, and 72 of 96 single adults recorded were less than 10 m from the channel edge. Ninety three percent of 247 pups for which the developmental stage was recorded were judged to be stage 2 or 3, that is, more than about 1 wk old but not weaned (Table 2).

The distance ahead of the ship's bow of 25 mother-pup pairs at the very edge of the channel was measured at the point where they started to move away. The distance ranged from 0 (n = 5) to 90 m (average 39 m). The speed of the ship's approach (about 4 m s^{-1}) therefore allowed less than 30 s for the pair to move away. In 91 cases of pairs fleeing from the channel edge, the pup was separated by more than 10 m from its mother as the ship passed, and in 9 (5%) cases, the distance was more than 30 m. Three pairs and 1 lone pup tried to cross the broken ice of the shipping channel just in front of the ship, and complete separation of mother and pup was recorded in 2 cases. Several thin lone pups and a few dead pups were seen close to the channel edge.

Table 2. Number of pups recorded at each developmental stage.

Stage	1	2	3	4	Total
No. pups	7	217	13	10	247

DISCUSSION

Total Pupping Estimates for the Caspian Seal

Two surveys to count adults and newborn pups on the winter ice field have now been carried out, but a complete assessment of the population dynamics will require a time series of surveys over several more consecutive years. However, we can be confident that an estimate of current pup production in the region of 20 000 is robust. The stages of development of pups, recorded from the 2006 icebreaker survey, indicated that most pups were still at the white coat stage, neither newly born nor yet weaned, and therefore that the survey was carried out when the maximum number of pups could be seen and counted.

The higher CV for 2006 is due to the greater concentration of pups in the southwest of the ice field in 2006. The distribution of ice suitable for pupping suggested that about 90% of pupping in 2006 took place in Kazakhstan waters, that is, the area surveyed, whereas the Kazakhstan share was close to 94% in 2005. A few pups are also born on ice-free islands, such as Ogurchinsky Island off Turkmenistan, but the numbers total a few tens at most (8) (P. Erokhin pers. comm.). Available data suggest that more than 99% of the total pup production occurs on the northern ice.

Our observations from the aircraft showed that the proportion of adults with and without pups was similar in both years. The proportion of pups seen to be unaccompanied by their mothers was higher in 2006 (22%) than in 2005 (9%), and this higher proportion of unaccompanied pups in 2006 was confirmed by the observations from the icebreaker. We have no explanation for this difference. Kovnat (12) stated that females spend progressively less time on the ice beside their pups as lactation progresses and less time in bad weather, so possibly a combination of these factors was responsible.

Distribution of Seals on the Ice Field

The seal distribution on the ice in 2006 differed substantially from that in 2005. In 2005 the seals formed 2 high-density breeding areas: 1 in the southwest in close drifting ice and 1 in the central and northwestern part of the fast ice. In 2006 most of the breeding animals were found in the southwestern area, and seal densities in the rest of the frozen part of the sea were moderate to low.

The distribution of breeding seals depends on the ice topography (13) and ice formation processes when pregnant females arrive as the ice forms in late January to select their pupping sites. Seals select pupping sites with access to water, either along the southerly ice edge or along cracks, known as polynias and leads, in the ice (12). The unusual breeding distribution in 2006 may be partly explained by the ice conditions; in 2006 strong ice formed very quickly in the whole northern part of the sea during the first weeks of January. Later, different types of ice were formed by ice movements, but these new formations remained isolated from the open water areas because the southwestern area was covered by a belt of fast ice. Because seals probably stayed at the ice edge in the southwestern area during the ice formation period, they would not have access to the ice fields further north.

Artificial leads are created by icebreakers. These were evidently used extensively in 2006 both as corridors and as pupping habitats, although they were little used in 2005. This raises the possibility that seals may have been using the icebreaker channel as an artificial access lead to good breeding ice, a finding supported by observations from the aerial survey. There is therefore a need to investigate how ice formation processes affect distribution and breeding densities of Caspian seals and under which conditions this may be influenced by icebreaker tracks. Grey seals (*Halichoerus grypus*) have been observed to breed in areas that are isolated from the main seal breeding habitat by very heavy ice in the northern Baltic (E. Helle pers. comm.). Because there is regular icebreaker traffic in the northern Baltic, it is believed that seals can use the channels for passing through ice that would otherwise limit their distribution. It is possible that Caspian seals may make similar use of such man-made channels, especially in years when ice conditions are severe. The potential benefits to breeding Caspian seals of exploiting the icebreaker channel habitat and also the potential costs due to disturbance from industrial shipping warrant separate study.

Mortality Caused by Predators

The 2 surveys reported here were able to produce the first detailed distribution density maps not only of different categories of seals but also of their natural predators. Wolves and eagles are the 2 main predators of seal pups in the breeding area (8). Because the numbers of wolves appeared to be low (Table 1), the impact of wolf predation on the total pup mortality on ice was probably insignificant, at least in these 2 years. By contrast, eagles could potentially be more important because of their greater numbers. There are up to 10 species of eagles in the Caspian Sea, including the white-tailed eagle (*Haliaeetus albicilla*), which is known to prey on pups of Baltic ringed seals as well as the much larger pups of the grey seal. Eagles were frequently seen feeding on seal pups during the surveys, and attacks are commonly seen from oil installations in the area. The estimate for the total number of eagles on the Kazakh ice in February was about 2200 in both years. Because the energy requirement for wild white-tailed eagles is 2500 kJ d^{-1} (0.315 kg meat) (14), each eagle would need to consume the equivalent of at least 1 seal pup over the pupping period, and therefore eagles might cause the deaths of approximately 2000 pups, or about 10% of pups currently born. Substantial takes by predators has been reported also in earlier investigations (15).

Implications for Caspian Seal Conservation

The results of the 2005 and 2006 surveys have important implications in terms of action that should be taken to conserve the species by managing human activities that may affect the survival of seals. Both surveys have suggested that the pup production for the entire Caspian seal population is in the region of 20 000 pups. This estimate is less than half the estimate from the late 1980s (8). It is essential that these new figures be considered when hunting quotas are set by regional authorities. For example, the 2007 quotas were set at 18 000 seals, according to the Caspian Bioresources Commission (16). This figure would substantially exceed the total annual recruitment to the population. Additional sources of mortality should be taken into account when calculating quotas: there is a currently an unquantified by-catch from legal and illegal fisheries; natural mortality from eagles may account for about 2000 pups per year; and icebreakers may in some years contribute to pup mortality in addition to postnatal mortality from a variety of other causes (8, 17). Therefore, measures to limit anthropogenic contributions to juvenile mortality are likely to be among the highest-priority conservation measures.

Caspian seals are adapted to a harsh and fluctuating environment and are unlikely to reproduce every year, as reported in seal species with similar life histories (16). Annual ice surveys need to be conducted for several more years to obtain a more complete understanding of annual fluctuations and trends in pup production, which are required to develop a comprehensive conservation action program.

References and Notes

1. Forsyth, M., Kennedy, S., Wilson, S., Eybatov, T. and Barrett, T. 1998. Canine distemper virus in a Caspian seal. *Vet. Rec. 143*, 662–664.
2. Hall, A.J., Duck, C.D., Law, R.J., Allchin, C.R., Wilson, S. and Eybatov, T. 1999. Organochlorine contaminants in Caspian and harbour seal blubber. *Environ. Pollut. 106*, 203–212.
3. Watanabe, M., Tanabe, S., Tatsukawa, R., Amano, M., Miyazaki, N., Petrov, E.A. and Khuraskin, S.L. 1999. Contamination levels and specific accumulation of persistent organochlorines in Caspian seal (*Phoca caspica*) from the Caspian Sea, Russia. *Arch. Environ. Contam. Toxicol. 37*, 396–407.
4. Kennedy, S., Kuiken, T., Jepson, P.D., Deaville, R., Forsyth, M., Barrett, T., van de Bildt, M.W.G., Osterhaus, A.M.D.E., et al. 2000. Mass die-off of Caspian seals caused by canine distemper virus. *Emerg. Infect. Dis. 6*, 637–639.
5. Ohashi, K., Miyazaki, N., Tanabe, S., Nakata, H., Myura, R., Fujita, K., Wakasa, C., Uema, M., et al. 2001. Seroepidemiological survey of distemper virus infection in the Caspian Sea and Lake Baikal. *Vet. Microbiol. 82*, 203–210.
6. Kajiwara, N., Niimi, S., Watanabe, M., Ito, Y., Takahashi, S., Tanabe, S., Khuraskin, L.S. and Miyazaki, N. 2002. Organochlorine and organotin compounds in Caspian seals (*Phoca caspica*) collected during an unusual mortality event in the Caspian Sea in 2000. *Environ. Pollut. 117*, 391–402.
7. Kuiken, T., Kennedy, S., Barrett, T., Borgsteede, F., Deaville, R., Duck, C., Eybatov, T., Forsyth, M., et al. 2006. The 2000 canine distemper epidemic in Caspian seals (*Phoca caspica*): pathology and analysis of contributory factors. *Vet. Pathol. 43*, 321–338.
8. Krylov, V.I. 1990. Ecology of the Caspian seal. *Finnish Game Res. 47*, 32–36.
9. Härkönen, T. and Heide-Jørgensen, M.P. 1990. Density and distribution of the ringed seal in the Bothnian Bay. *Holarctic Ecol. 13*, 122–129.
10. Härkönen, T. and Lunneryd, S.G. 1992. Estimating abundance of ringed seals in the Bothnian Bay. *Ambio 21*, 497–510.
11. Kosarev, A.N. and Yablonskaya, E.A. 1994. *The Caspian Sea*. SPB Academic Publishing, The Hague, 259 pp.
12. Kovnat, L.S. 1997. Methods for assessing the status of the Caspian seal. In: *Caspian Environment Program Proceedings from the 1st Bio-Network Workshop, Bordeaux, November 1997*. Dumont, H., Wilson, S. and Wazniewicz, B. (eds). World Bank, pp. 72–85.
13. Kouraev, A.V., Papa, F., Byharizin, P.I., Cazenave, A., Cretaux, J.-F., Dozortseva, J. and Remy, F. 2003. Ice cover variability in the Caspian and Aral seas from active and passive micriwave satellite data. *Polar Res. 22*, 42–50.
14. Popov, L.A. 1979. Caspian seal. In: *Mammals of the Seas, Vol. II. Pinniped Species Summaries and Report on Sirenians. FAO Fisheries Series 59*, 74–75.
15. Anonymous. 2006. *Protocol of the Twenty-Sixth Session of the Commission on Aquatic Bioresources of the Caspian Sea. Appendix 7. Allocation of Industrial Catch Quotas of Kilka and Seals for 2007*. 1 p.
16. Smith, T.G. 1987. The ringed seal, *Phoca hispida*, of the Canadian western Arctic. *Canadian Bulletin of Fisheries and Aquatic Sciences. 216*, 81 pp.
17. Helander, B. *Reproduction of the White-Tailed Sea Eagle* Haliaeetus albicilla *(L.) in Sweden, in Relation to Food and Residue Levels of Organochlorine and Mercury Compounds in the Eggs*. Thesis for the Doctor's Degree in Natural Sciences. University of Stockholm, Sweden, ISBN 91-7146-245–7.

18. This paper is dedicated to the memory of Hormoz Asadi, a friend and colleague, whose tireless dedication to Caspian seal conservation in Iran was an inspiration to all who knew him. We are very grateful to the Caspian Environment Programme, especially to Tim Turner, Hamid Ghaffarzadeh, Anders Poulsen, Lev Neretin, and Igor Mitrofanov, for all their support in the conception, preparation, and execution of these surveys. We also thank Agip KCO for logistical support throughout, with special thanks to Paul Bartlett, Giovanni Rivas, Gulsim Mutysheva, Vladimir Terentyev, Galiya Tukpetova, and Arman Kaltaev. The survey flights were made possible by the superb services of the Berkut Aviation Company, Uralsk. The surveys were supported in 2005 by a grant from the UNDP/GEF II project for the Caspian Environment Programme and in 2006 by a grant from Agip KCO. The project was administered by the Zoological Society of London in 2005 and by the University of Leeds in 2006.
19. First submitted 30 Apr. 2007. Accepted for publication 13 Nov. 2007.

Tero Härkönen, PhD, Associate Professor, has a research position at the Swedish Museum of Natural History. He has been, or is running projects on marine mammals in the Baltic, Greenland, the Antarctic and the Caspian Sea, and is currently engaged in establishing conservation and management plans for all Baltic seal species through work within HELCOM and the ICES. His address: Swedish Museum of Natural History, Box 50007, S-104 05 Stockholm Sweden.
E-mail: Tero.Harkonen@nrm.se

Mart Jüssi, MSci, started modern seal research in Estonia, and is engaged in several projects including EU-Life and the Caspian seal project, focussed on research and conservation of biodiversity. He has worked for prolonged periods at the Finnish Game and Fisheries Research Institute and the Sea Mammal Research Institute in the UK. His address: Estonian Fund for Nature, PO Box 245, Tartu, Estonia EE 50002.
E-mail: mart.jussi@gmail.com

Mirgaly Baimukanov, PhD, is director of the Institute of Hydrobiology and Ecology, Almaty. His scientific interests are population biology of water animals and development of the Protected Areas network for rare and endangered species as well as protection of water ecosystems. His address: Fisheries Research Centre of the Ministry of Agriculture of the Republic of Kazakhstan, Sujunbaja prospect, 89a, Almaty, 480016, Republic of Kazakhstan.
E-mail: mirgaliy@mail.ru

Anders Bignert, PhD, is a Senior Scientist at the Swedish Museum of Natural History. His research is focussed on statistical analyses of trends in concentrations of ecotoxic substances in the Baltic Biota. His address: Swedish Museum of Natural History, Box 50007, S-104 05 Stockholm Sweden.
E-mail: Anders.Bignert@nrm.se

Lilia Dmitrieva, MSci The research activities of Lilia Dmitrieva are focused on the impact of human activities on marine mammals especially land locked species of ringed seals and Caspian seals. Her address: St. Petersburg Naturalist Society, Universitetskaya emb. 7/9, St. Petersburg, 199034, Russian Federation.
E-mail: sealilia@gmail.com

Yesbol Kasimbekov, MSci, is the Caspian seal specialist at the Fisheries Research Center. His interests include the ecology of key fish and mammal species in Kazakhstan. His address: Fisheries Research Centre of the Ministry of Agriculture of the Republic of Kazakhstan, Sujunbaja prospect, 89a, Almaty, 480016, Republic of Kazakhstan.
E-mail: npcrh@itte.kz

Mikhail Verevkin, MSci, is Senior scientist at the Laboratory of Vertebrate Zoology at the Biological Institute of St. Petersburg State University. His research interests encompass the distribution, structure and dynamics of seals populations, especially anthropogenic impacts on ice breeding seals. He is the coordinator of investigations in the Ladoga Lake and the Russian part of the Gulf of Finland in the Baltic Sea. His address: 199034 Universitetskaya emb. 7/9 St. Petersburg State University, Baltic Fund for Nature, St. Petersburg, Russian Federation.
E-mail: vermiv@TV9311.spb.edu

Susan Wilson, PhD, is a consultant in seal conservation biology. Her research interests focus on behavioural ecology, including reproductive behavior and pup development. Her address: Tara Seal Research, 14 Bridge Street, Killyleagh, Co. Down BT30 9QN, N. Ireland, UK.
E-mail: suewilson@sealresearch.org

Simon Goodman, PhD, is a lecturer in evolutionary biology at the University of Leeds. His research interests span conservation biology, particularly with regard to the impact of wildlife diseases, and population genetics. His address: Institute of Integrative and Comparative Biology, University of Leeds, Leeds, LS2 9JT, UK.
E-mail: s.j.goodman@leeds.ac.uk