Structure and Assessment of Beluga Whale, *Delphinapterus leucas*, Populations in the Russian Far East

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ABSTRACT—In 2000, the International Whaling Commission conducted a global assessment of beluga whales, Delphinapterus leucas. *Following this assessment, five beluga stocks were recognized in Russian Far East waters: Western Chukchi-East Siberian Sea, Anadyr Gulf, Shelikhov, Sakhalin-Amur, and Shantar. This paper provides a revised assessment of beluga abundance, distribution, and population structure in the Russian Far East. This region encompasses the Okhotsk Sea, and the coastline of the Chukotka Autonomous Region (CAR), which includes the western Bering, western Chukchi, and eastern East Siberian seas. Published results of genetic analysis are updated with our original unpublished data. Based on information available to date, we propose recognizing seven beluga stocks in the Russian Far East. Five stocks in the Okhotsk Sea: 1) Sakhalin-Amur, 2) Ulbansky, 3) Tugursky, 4) Udskaya, 5) Shelikhov, and two stocks in the CAR: 6) Anadyr, and 7) Bering-Chukchi-Beaufort (BCB). Natural and anthropogenic threats to these stocks are described and include ice entrapment, over-fishing of key prey, live captures for aquaria, bycatch in fisheries, exposure to effluent, and seismic and military activities.*

Introduction

In the Russian Far East, the beluga, *Delphinapterus leucas*, or white whale, occurs in the Okhotsk Sea and along the coastline of the Chukotka Autonomous Region in the western Bering, western Chukchi, and eastern East Siberian seas (Fig. 1). From late 1920's to the dissolution of the Soviet Union in 1991, Soviet scientists conducted extensive studies on this species' abundance and distribution, mainly because belugas were hunted commercially (Kleinenberg et al., 1964; Matishov and Ognetov, 2006). In 2000, scientific information on belugas in Russian waters was reviewed and summarized for the global assessment of the species by the Scientific Committee of the International Whaling Commission (IWC, 2000). At that time, five beluga stocks in Russian Far-Eastern waters were recognized: Western Chukchi-East Siberian Sea (stock no. 25), Anadyr Gulf (26); Shelikhov (27); Sakhalin-Amur (28), and Shantar (29). The delineation of Stock 25 was questioned by some experts, who, based on satellite tracking data, suggested belugas migrating along Chukotka Peninsula coast belonged to United States or Canadian stocks (i.e., Eastern Bering Sea (stock no. 3), Eastern Chukchi Sea (4), or Beaufort Sea (or Eastern Beaufort) (5)). For stocks 25 and 26, no abundance estimates were provided, and the Okhotsk Sea beluga population (comprised of stocks 27, 28, and 29) was estimated at 18,000–20,000 (IWC, 2000).

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doi: https://doi.org/10.7755/MFR.81.3–4.3

Apart from nonexistent or methodologically poor abundance estimates, no genetic information was available at that time, and migration routes and winter grounds remained mostly unknown. Stock delineation was based solely on summer distribution and local movement patterns.

Since the IWC (2000) assessment, and a break in research in the 1990's following the dissolution of the Soviet Union, extensive beluga studies have been resumed in the Russian Far East in 2005. Currently management of marine resources in Russia, including belugas, is not based on the species population structure, but rather on geographically defined fishing zones. Our studies in the Okhotsk Sea have led to the Russian Federal Agency of Fisheries and the Ministry of Agriculture recognizing the necessity to consider stock distribution when issuing total allowable takes (TAT) in this region (Ministry of Agriculture, Order N 533, 27 October 2017). An updated assessment of beluga population structure would be important for effective and sustainable management.

Here, we review and summarize our previously published research results and present updated genetic results on the Far Eastern beluga population structure and status, to provide a basis for effective conservation and sustainable management. A working version of this paper was originally presented and discussed at the Global Review of Monodontids (GROM)[1] meeting held in March 2017 (Hobbs et al., 2019, provide an overview of the meeting outcomes).

Methods

Genetics

Our use of the term "biological population," or population, is defined as a group of individuals who interbreed and are genetically isolated from other biological populations due to geographical, behavioral, or any other reasons. In summer months, many beluga populations seasonally break into discrete, relatively resident "nursery aggregations" (a synonym to the term "reproductive aggregation"

[1]GROM (https://nammco.no/topics/report-global-review-monodontids-now-available/ accessed 9 Aug. 2018).

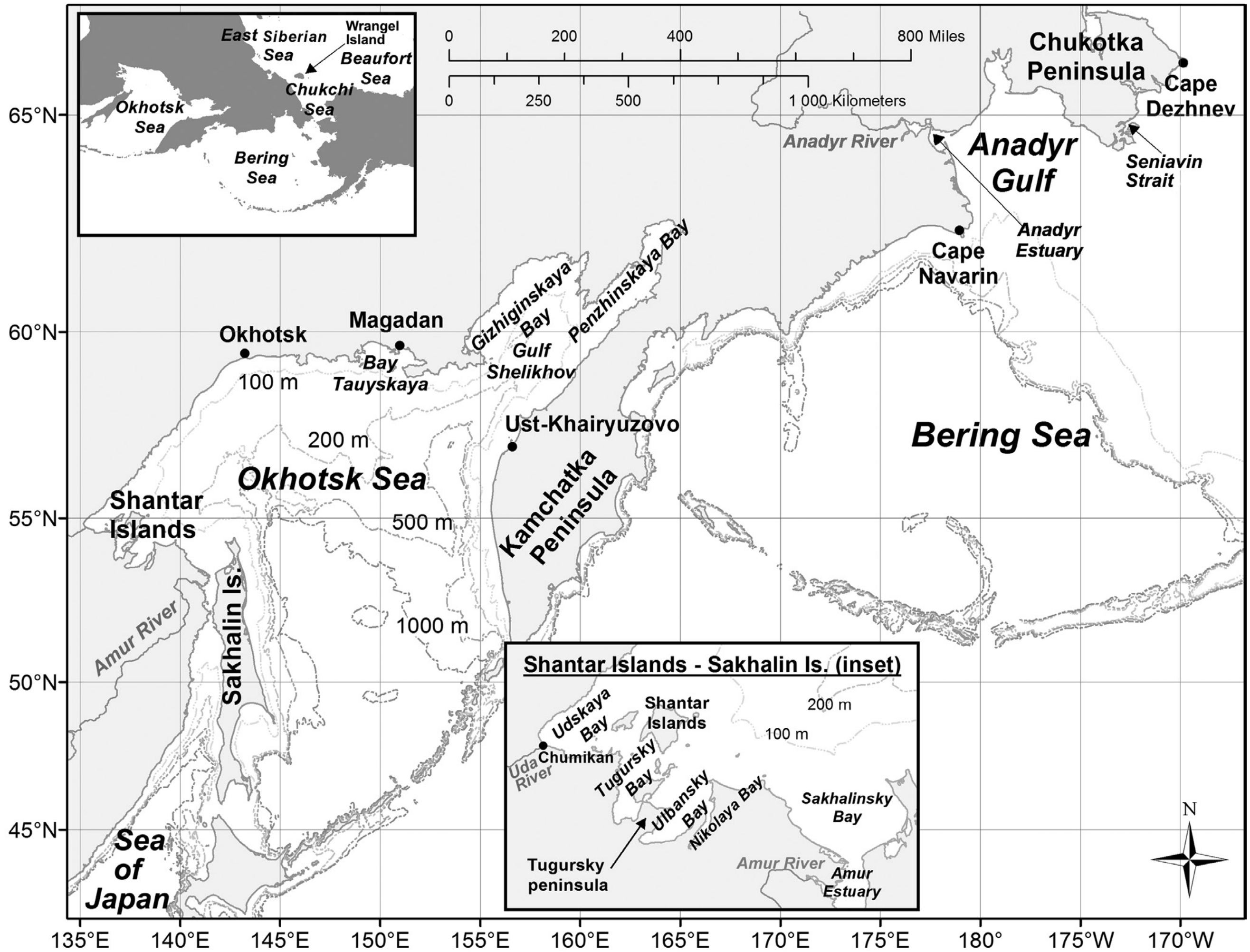

Figure 1.—Russian Far East with toponyms mentioned in the text.

sometimes used in the Russian literature), and small groups, comprised mostly of males, which are more nomadic. A "stock" (also see Hobbs et al., 2019, under "Identification of Stocks"), is a population unit which can be defined as discrete and seasonally stable and should be managed separately from other equivalent units (synonym of "management unit"). Thus, a summer nursery aggregation is considered a stock if its geographical (spatiotemporal) separation from the neighboring aggregations of the same biological population can be proved by genetics, photo-identification, or other methods. Following the guidance in IWC (2000:244), "possible stock units should be split until evidence is available to justify combining them." A "pool" is defined as a large beluga whale unit of an unknown demographic status (presumably made up of multiple stocks or even multiple biological populations), within which we cannot delineate stocks or populations due to the lack of information on their distribution ranges, movement patterns, and genetics.

For the genetic analyses presented herein, we have combined our published (Meschersky et al., 2013, 2018) and unpublished data to delineate each stock, population, or pool. The level of population isolation was evaluated using allele frequencies of 17 microsatellite loci: (Cb1, Cb2, Cb4, Cb5, Cb8, Cb10, Cb11, Cb13, Cb14, Cb16, Cb17 – Buchanan et al., 1996; Ev37Mn, Ev94Mn – Valsecchi and Amos, 1996; 415/416, 417/418, 464/465, 468/469 – Schlötterer et al., 1991; Fullard et al., 2000). The methods of genotyping and sex determination were analogous to those previously described in Meschersky et al. (2013). Sample comparison was performed using the allele frequency based Fst-criterion (Arlequin 3.1 software, Excoffier et al., 2005) and a clustering method (LOCPRIOR-Admixture model, 5 runs of 50,000 MCMC iterations of burn-in and 200,000 iterations of main analysis) using Structure 2.3.4 soft-

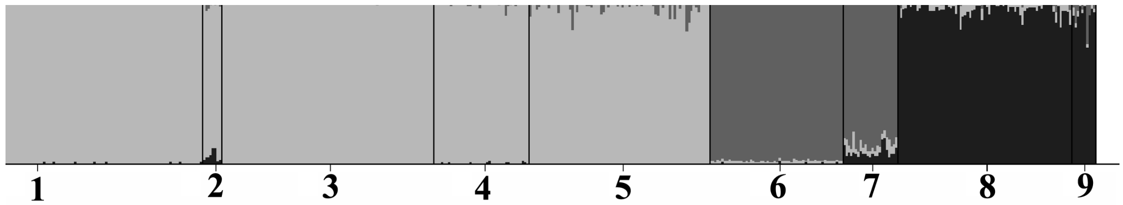

Figure 2.—The results of K = 3 hypothesis tested by clustering analysis based on 17 microsatellite loci alleles frequencies. LOCPRIOR-Admixture model. Samples = 1–Sakhalinsky Bay, 2–Nikolaya Bay, 3–Ulbansky Bay, 4–Tugursky Bay, 5–Udskaya Bay, 6–Western Kamchatka coast, 7–Gizhiginskaya Bay, 8–Anadyr Estuary, and 9–Chukotka coast. Light gray shaded area = western-Okhotsk population, dark gray shaded area = northeast Okhotsk population, and black shaded area = Anadyr-Chukotka pool.

ware (Pritchard et al., 2000). Patterns of spatial distribution within regions and populations were evaluated using maternal lineage (mtDNA haplotypes) distribution (Fst-criterion—haplotypes frequency only, Arlequin 3.1 software). In most cases, a fragment of 559 bp (see Genbank JQ716342, for instance) was used. Where appropriate, results from O'Corry-Crowe et al. (1997) were included to expand the dataset. The original samples (skin biopsies or tissues of dead animals) were collected during the period 2008–16 (and for Sakhalinsky Bay since 2004).

Distribution

Data were collected during aerial and vessel surveys and shore-based operations. Satellite-linked transmitter tags attached to belugas provided additional information on movement patterns and seasonal habitat use. We summarized information from published accounts, technical reports, and unpublished data.

Natural and Anthropogenic Concerns

The Federal Agency of Fisheries provided some numbers for beluga live-captures and traditional hunting. However, due to the obvious incompleteness of reported figures, we also collected information from the regional Fishery offices, and obtained records directly from the companies that captured belugas. Further, we listed major current and potential threats to belugas in different geographic regions based on our expertise.

Results

Okhotsk Sea

Two multi-year projects were conducted in the Okhotsk Sea during the period 2007–16. Genetic analyses (Meschersky et al., 2013), together with geographic distribution studies (Shpak et al., 2010; Solovyev et al., 2015), delineated two biological populations: 1) Western Okhotsk, which includes belugas summering in the Sakhalin-Amur and Shantar regions, and 2) Northeast Okhotsk (or Shelikhov), which spends the summer in the Gizhiginskaya and Penzhinskaya bays of Shelikhov Gulf and along the western coast of the Kamchatka Peninsula (Fig. 1).

Genetic analysis, based on a significantly increased sample (355 samples from the western Okhotsk Sea and 79 from the northeast Okhotsk Sea) compared to the earlier study (Meschersky et al., 2013), confirmed the genetic isolation between these two populations. The Fst distance based on 17 microsatellite loci was estimated at 3.52%. The high level of isolation between the two populations was also confirmed by the clustering method analysis (see samples 1–7, Fig. 2). Maximal average LnP(K) and Delta K (Evanno method, Earl and vonHoldt, 2012) values were found for K = 2 hypothesis for the total Okhotsk Sea sample set. No evidence of further subdivision in the Okhotsk Sea was found for higher K (up to 7) hypotheses. Significant differences (Fst = 32.04%, p = 0.0000) in mitochondrial lineage compositions and frequencies were found between the two Okhotsk Sea regions.

Isolation of the Okhotsk Sea belugas from whales inhabiting the Anadyr Estuary (in the Bering Sea) was demonstrated earlier (Meschersky et al., 2013; Borisova et al.[2]). With the current sample size, we unambiguously confirmed isolation of the Okhotsk Sea belugas from Bering Sea belugas. The combined Anadyr-Chukotka coast sample (n = 83) microsatellite allele distance was estimated at 4.78% for the western Okhotsk population, 4.30% for the Northeast Okhotsk (Shelikhov) population, or 4.15% for the combined Okhotsk Sea sample (n = 434). All pair-wise comparisons were statistically significant (p = 0.0000). The isolation between the Okhotsk Sea and Anadyr-Chukotka belugas was also confirmed by the clustering analysis (Fig. 2).

Western Okhotsk Population

Based on aerial surveys and coastal observations (Solovyev et al., 2015) in the western part of the Okhotsk Sea, belugas concentrate in the shallow waters of the Sakhalin-Amur and Shantar regions in several nursery aggregations during the summer (Fig. 3). Nursery aggregations tend to stay

[2]Borisova, E. A., I. G. Meschersky, O. V. Shpak, D. M. Glazov, D. I. Litovka, and V. V. Rozhnov. 2012. Evaluation of effect of geographical isolation on level of genetic distinctness in beluga whale (*Delphinapterus leucas*) populations in Russian Far East. Marine Mammals of the Holarctic: Collection of papers presented at the 7th Int. Conf., Suzdal, 2012, 1:113–117 (http://marmam.ru/upload/conf-documents/mmc2012_full.pdf).

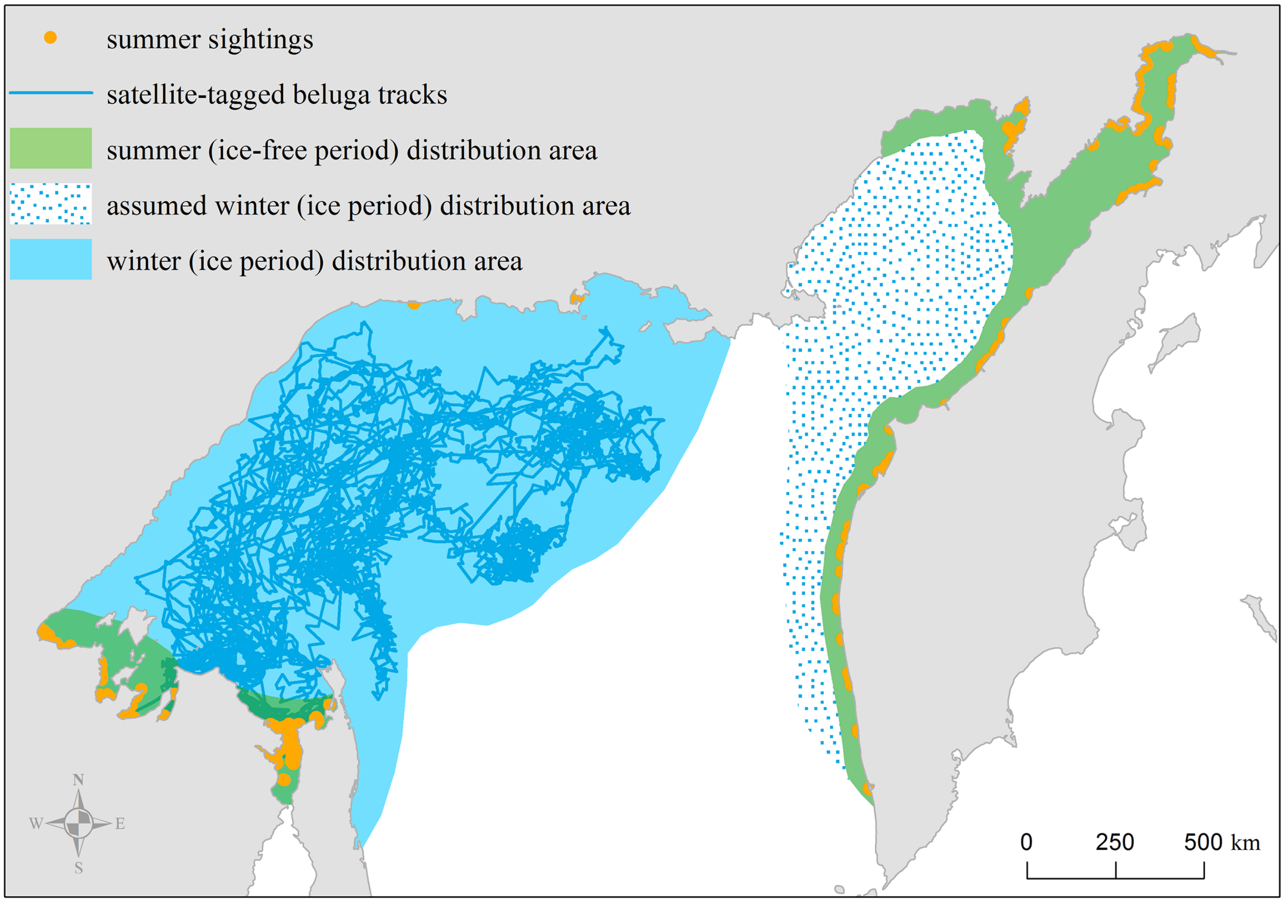

Figure 3.—Okhotsk Sea beluga summer ranges based on aerial surveys, boat and coastal observations during the period 2007–16 (modified and updated from Solovyev et al., 2015), and winter ranges based on satellite tracking data (Shpak et al., 2010; Shpak et al. text footnote 3) for the western Okhotsk population, and on unpublished data for the northeast population.

in the shallower, estuarine areas of the bays, and the lack of sightings at the exits of the bays suggests these aggregations are relatively isolated from each other in summer months. However, two belugas, one with a tag and another—with the scars caused by tagging (apparently, the animals that were tagged in Sakhalinsky Bay in August 2007 and/or July 2008) were photographed in Nikolaya Bay in July 2009 (Shpak and Glazov, 2013). It is unclear whether these belugas moved between the bays within one summer (2009), or, in different years, chose one or the other bay as a summering ground. In September–October, belugas begin to migrate. Some whales travel from Sakhalinsky Bay westward to Nikolaya Bay and may briefly visit Ulbansky Bay as well (Shpak et al., 2010; Shpak et al.[3]). An individual tagged in the middle of September in Ulbansky Bay moved to Nikolaya Bay within a week (Shpak et al.[4]), which led us think we had tagged not an Ulbansky summer resident, but one of Sakhalin-Amur “autumn nomads.” A single beluga or small groups, some with immature individuals, are sometimes observed outside areas of major concentration, between the bays or near the Shantar Islands (Solovyev et al., 2015; our unpubl. data; Fig. 3). Similar observations (including mothers with calves) have been reported in the Sea of Japan (Sato and Ichimura, 2011; Melnikov and Seryodkin[5]; our interview data) (Fig. 1), but such cases are rare and thought to be extralimital.

[3]Shpak, O. V., D. M. Glazov, D. M. Kuznetsova, L. M. Mukhametov, and V. V. Rozhnov. 2012. Migratory activity of the Okhotsk Sea belugas *Delphinapterus leucas* in winter-spring period. Marine Mammals of the Holarctic: Collection of papers presented at the 7th Int. Conf., Suzdal, 2012, 2:390–395 (http://marmam.ru/upload/conf-documents/mmc2012_full.pdf).

[4]Shpak, O.V., A. Yu. Paramonov, D. M. Glazov, I. G. Meschersky, and D. M. Kuznetsova. 2018. Results of the pilot project on the beluga whale (*Delphinapterus leucas*) satellite tagging using remote tag deployment without capturing whales. Marine Mammals of the Holarctic: Collection of papers presented at the 9th Int. Conf., Astrakhan, 2016, 2:271–278 (http://marmam.ru/upload/conf-documents/mmc2016_full.pdf).

[5]Melnikov, V. V., and I. V. Seryodkin. 2014. Sightings of beluga whales (*Delphinapterus leucas*) in the Sea of Japan. Materials of the Int. Appl. Sci. Conf.: Habitats, migrations and other movements of animals, Vladivostok, p. 196–198 [in Russ.].

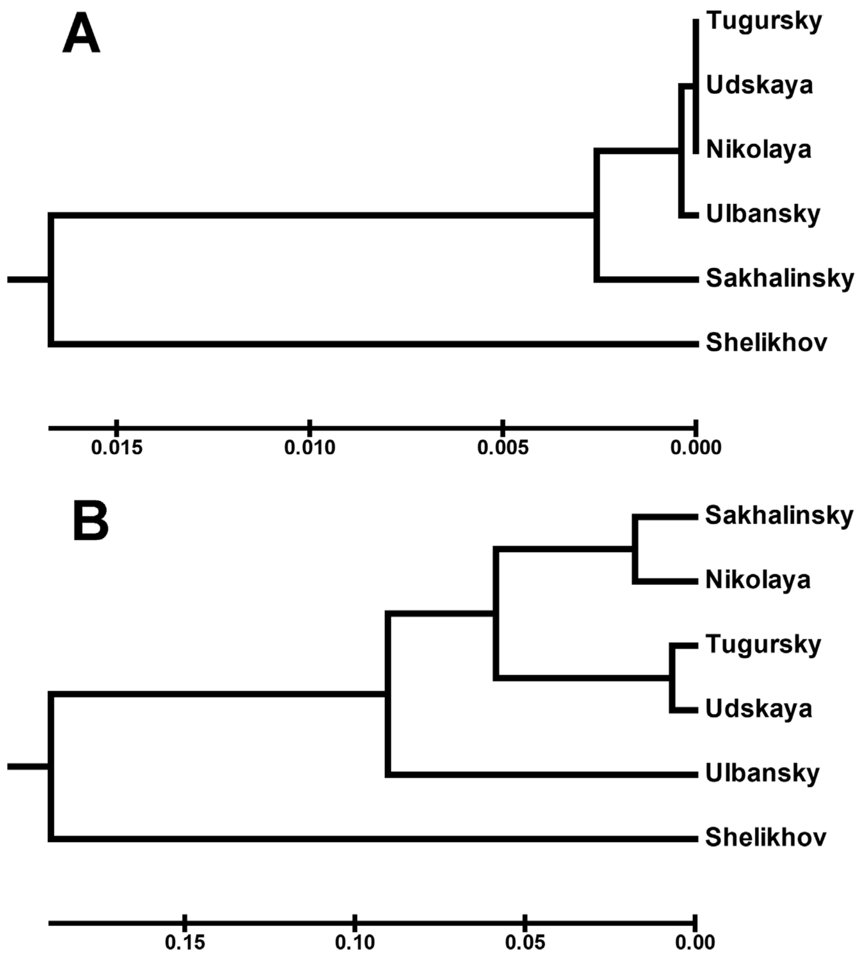

Figure 4.—UPGMA-cladogram of Fst-distances found for beluga whales in the Okhotsk Sea. A) allelic composition of 17 nuclear microsatellite loci, B) presence and frequencies of the mtDNA control region (559 bp) haplotypes.

Russian-Japanese ship-based surveys conducted in July–August 2009–10, primarily in offshore waters of the Okhotsk Sea outside the 12-mile zone, resulted in no sightings of beluga whales (Istomin et al., 2013). This supported past studies and the hypothesis that in summer belugas concentrate in coastal waters and bays (Fig. 3). Data on winter distribution of western Okhotsk belugas is limited to tracking belugas tagged in Sakhalinsky Bay in summer (Fig. 3, Shpak et al., 2010, Shpak et al.[3], Shpak and Glazov[6]). In autumn, Sakhalinsky Bay belugas move offshore north and northeast, but remain in the Okhotsk Sea throughout the year, not entering Shelikhov Gulf or approaching the Kamchatka western coast. Based on one individual tagged in Udskaya Bay (Shpak et al.), it appears these whales stay in the bay, traveling along the coast until December when the bay starts to freeze. We speculate that belugas from Sakhalin-Amur and Udskaya summer aggregations may meet in December–January on the way to wintering grounds.

The most recent abundance aerial surveys in the Okhotsk Sea were conducted in 2009 and 2010 (Shpak and Glazov, 2013; Shpak and Glazov[6]; Glazov et al.[7]). With the exception of the southern part of Sakhalinsky Bay and the Amur Estuary, which were surveyed in parallel line-transects, all other regions were covered with a single-line coastal survey (direct count). At the suggestion of the research team, an availability correction of 50% was accepted by an IUCN expert panel review (Reeves et al.[8]). The abundance estimate for the western Okhotsk population was based on the results from the aerial survey conducted in August 2010. The corrected abundance was 9,560 belugas. Due to differences in survey design across the study area, no coefficient of variation (CV) was calculated.

Genetic analyses showed that all belugas summering in the western Okhotsk Sea shared a single nuclear gene pool and thus represent a single population (Fig. 2). Microsatellite allele frequencies distances between samples collected in different bays of the Shantar region were not significantly different (Fst = 0.00–0.22%, p = 0.0723–0.6984). Belugas of Sakhalinsky Bay differed from other bays (except for Nikolaya Bay) to a greater extent – Fst = 0.41–0.82%, p = 0.0000–0.0020, but these values are incomparably smaller than differences between any sample from the western Okhotsk bays and northeast Okhotsk (Shelikhov) population (Fig. 4A). At the same time, it was shown (see Meschersky et al., 2013) that be-

[6]Shpak, O. V., and D. M. Glazov. 2013. Review of the recent scientific data on the Okhotsk Sea white whale (*Delphinapterus leucas*) population structure and its application to management. Paper SC/65a/SM23 pres. to IWC Sci. Comm., Jeju Island, June 2013, 19 p.

[7]Glazov, D. M., V. I. Chernook, O. V. Shpak, B. A. Solovyev, E. A. Nazarenko, A. N. Vasilev, N. G. Chelintsev, D. M. Kuznetsova, L. M. Mukhametov, and V. V. Rozhnov. 2012. The results of beluga whale (*Delphinapterus leucas*) aerial surveys in the Okhotsk Sea in 2009 and 2010. Marine Mammals of the Holarctic: Collection of papers presented at the 7th Int. Conf., Suzdal, 2012, 1:167–172 (http://marmam.ru/upload/conf-documents/mmc2012_full.pdf).

[8]Reeves, R. R., R. L. Brownell Jr., V. N. Burkanov, M. C. S. Kingsley, L. F. Lowry, and B. L. Taylor. 2011. Sustainability assessment of beluga (*Delphinapterus leucas*) live-capture removals in the Sakhalin–Amur region, Okhotsk Sea, Russia. Rep. of Independ. Sci. Rev. Panel. Occasional Pap. of the SSC, No. 44. IUCN, Gland, Switzerland, 34 p. (http://www.iucn-csg.org/wp-content/uploads/2010/03/Beluga-SSC-Occ-Paper-20111.pdf).

lugas summering in different bays of the western Okhotsk Sea may differ significantly in mitochondrial lineages composition. Analysis based on significantly increased sample sets confirmed these differences (Fig. 4B, Table 1).

Thus, based both on distribution patterns and results of genetic analysis, we propose the following subdivision of the western Okhotsk population into summer stocks.

Sakhalin-Amur Stock. Belugas of Sakhalinsky Bay and the Amur Estuary significantly differ by mitochondrial-lineage composition from other western Okhotsk region bays (with the exception of Nikolaya Bay, see below) and are designated as the Sakhalin-Amur stock. This stock is the largest and best studied of all western Okhotsk summer aggregations. An abundance estimate of the Sakhalin-Amur stock based on three line-transect surveys conducted in 2009 and 2010 was 1,977 (CV = 0.24) belugas. Adding a correction for availability bias (50%) resulted in an overall estimate of 3,954 (CV = 0.24) belugas (Shpak and Glazov, 2013).

During the summer, Nikolaya Bay is occupied with a relatively low number of belugas (usually less than 100), and it is unclear whether this aggregation is seasonally resident or if different groups visit the bay throughout the summer. Belugas of Nikolaya Bay differ by mitochondrial-lineage composition from Ulbansky, Tugursky, and Udskaya bays but not from Sakhalinsky Bay (Fig. 4b; Table 1). These results should be interpreted with caution, however, due to a very small sample size that is skewed towards males from Nikolaya Bay (8 males and 1 female). Nonetheless, further evidence of relatedness between Nikolaya belugas and the Sakhalin-Amur summer stock was obtained from photo-identification studies and behavioral observations. Therefore, until the status of belugas in Nikolaya Bay is confirmed with data of sufficient power, we propose that animals observed in Nikolaya Bay during the summer be assigned to the Sakhalin-Amur stock.

Table 1.—Conventional F-Statistics from haplotype frequencies: Fst (below diagonal) and P (above diagonal) values estimated for belugas of different bays of the western Okhotsk Sea and the Northeast Okhotsk (Shelikhov) population. Bold indicates bays that were not statistically different.

	Sakhalinsky Bay, *n* = 183	Nikolaya Bay, *n* = 9	Ulbansky Bay, *n* = 91	Tugursky Bay, *n* = 45	Udskaya Bay, *n* = 88	Shelikhov popul., *n* = 80
Sakhalinsky Bay		**0.1507**	0.0000	0.0001	0.0000	0.0000
Nikolaya Bay	0.0354		0.0006	0.0180	0.0021	0.0001
Ulbansky Bay	0.1377	0.3106		0.0002	0.0000	0.0000
Tugursky Bay	0.0819	0.1010	0.1130		**0.1263**	0.0000
Udskaya Bay	0.1096	0.1667	0.1606	0.0136		0.0000
Shelikhov popul.	0.3400	0.3947	0.5183	0.3253	0.3149	

Ulbansky Stock. The identity of the Ulbansky beluga summer stock as a separate demographic unit within the western Okhotsk population is based on the multi-year summer and autumn observations in Ulbansky Bay and genetic analysis (Table 1). In September–October, before winter migration, some belugas from Sakhalinsky Bay move to Nikolaya Bay and may also visit Ulbansky Bay, but overall beluga numbers in the inner part of Ulbansky Bay seem to decrease in autumn. Winter migratory routes and feeding grounds are unknown. In August 2010, 1,167 belugas were counted during a direct count aerial survey (Shpak and Glazov, 2013). Abundance, corrected for availability bias, was estimated at 2,334 belugas.

Tugursky Stock. Although genetic testing did not separate belugas found within Tugursky and Udskaya bays (Fig. 4, Table 1), nevertheless, unlike the situation with Nikolaya Bay, we propose the Tugursky belugas as a separate demographic unit within the western Okhotsk population. This designation is supported by historical information and opportunistic observations. During summer, belugas are regularly seen in the southern (estuarine) part of Tugursky Bay and sometimes along the western coast, and no belugas have been observed travelling between Tugursky and Udskaya bays; although, small groups have been reported near the south coast of Big Shantar Island and along the northeast coast of Tugursky Bay. We noted behavior differences (e.g., reaction to boat presence) between beluga groups in Tugursky and Udskaya bays. Winter migratory routes and feeding grounds are unknown. In August 2010, 753 belugas were counted during a direct count aerial survey (Shpak and Glazov, 2013), with a corrected abundance estimate of 1,506 belugas.

Udskaya Stock. Designating the Udskaya summer stock as a separate demographic unit within the western Okhotsk population is based on historical information, multi-year observations of beluga summer aggregations in the bay, and genetic analysis (with the exception of Tugursky Bay, mentioned above). Belugas are present in the estuarine area from June to October and often enter the Uda River. Belugas are also known to concentrate in the estuary of the Torom River, about 40 km east of the Uda mouth. There are no genetic samples from the Torom concentration area, but frequent beluga sightings between the two rivers suggest that all animals belong to the same stock. Upon ice formation in the Uda estuary, belugas move further from the estuary, but remain coastal. Winter migratory routes and feeding grounds are unknown. In August 2010, 1,232 (2,464, corrected for availability bias) belugas were counted during a direct count aerial survey (Shpak and Glazov, 2013).

Northeast Okhotsk (Shelikhov) Population

Recent information on the Shelikhov beluga population is very limited. Most research effort has concentrated on the western coast of the Kamchatka Peninsula. In the Shelikhov Gulf, belugas are known to approach river estuaries during herring, *Clupea pallasii*; smelt, Osmeridae; and salmon, Salmonidae, runs. Larger aggregations were observed in the lower parts of the bays (Solovyev et al., 2015), but overall distribution was more dispersed along the coastline (Fig. 3) than, for

Table 2.—Frequency based Fst distances (%/%) found between each of the two Northeast Okhotsk population sample sets (Kamchatka and Gizhiginskaya) and two regions of the western Okhotsk population (Sakhalinsky Bay/Shantar). All differences were statistically significant at $p = 0.0000$ level.

Marker	Kamchatka	Gizhiginskaya
Alleles of 17 microsat. loci	4.71 / 3.59	4.55 / 3.08
mtDNA haplotypes	31.42 / 31.68	42.22 / 36.50

example, in any of the Shantar region bays. In summer 2016, a large nursery aggregation of over 400 belugas was observed feeding on salmon in the estuarine part of Gizhiginskaya Bay, and smaller groups of up to 20, mostly adults, were encountered along its eastern coast (Filatova et al.[9]), the pattern very much resembling the distribution observed on aerial surveys during the period 2009–2010 (Fig. 3). Beluga form relatively stable summer aggregations within particular river estuaries (e.g., the Khairyuzova, see Ust-Khairyuzovo on Fig. 1) on the central west coast of the Kamchatka Peninsula. Only occasional sightings are reported along the southern west coast. No belugas have been encountered at the south tip or along the east coast of the peninsula (Solovyev et al., 2015).

Very little is known regarding Northeast Okhotsk beluga winter distribution. In the 1980's, belugas were found along the ice edge in Shelikhov Gulf and off western Kamchatka in January–February (Vladimirov and Melnikov, 1987). Fedoseev (1984) encountered belugas in Shelikhov Gulf also in April a satellite-tagged beluga remained in Shelikhov Gulf throughout the winter until April (our unpubl. data). The ice edge extent largely varies from year to year and often stretches south from Shelikhov Gulf. We suppose in such cases, Shelikhov belugas remain near the ice edge or along the west coast of Kamchatka and, when ice conditions allow, they may return to the gulf. During a coastal single-line survey in August 2010, 1,333 belugas were counted and after corrected for availability bias, abundance of the Northeast Okhotsk population was estimated as 2,666 belugas (Shpak and Glazov, 2013).

Reproductive isolation of belugas summering in the northeast part of the Okhotsk Sea, in Shelikhov Gulf and along the west coast of Kamchatka Peninsula, from whales summering in the western Okhotsk Sea was confirmed by genetics studies (Fig. 2, 4). Sightings in Shelikhov Gulf in winter suggest these whales do not overwinter with the western Okhotsk stocks. In our study, sample set "Kamchatka" consisted of 57 individuals (39 males, 15 females, sex of 4 individuals is unknown) biopsied or found dead during the period 2009–12. Whales were from the west coast of the Kamchatka Peninsula ranging from the Khairyuzova estuary ($n = 52$) to the lower part of Penzhinskaya Bay. The sample set "Gizhiginskaya" consisted of 22 biopsy samples (21 males and only one female) collected in 2016 in the Gizhiga River estuary in the north and along the east coast of Gizhiginskaya Bay. Both sample sets differed from the Sakhalinsky Bay and Shantar regions by similarly significant level (Fig. 2; Table 2).

Although summer aerial surveys showed discontinuity in the coastal distribution of belugas between Shelikhov Gulf and western Kamchatka (Solovyev et al., 2015), no strong evidence for delineating the stocks within the Northeast Okhotsk population are available. Differences between the two population sample sets were found to be significant, although at a low level: Fst = 1.46% ($p = 0.0006$) for microsatellites, and Fst = 22.86% ($p = 0.0007$) for mtDNA. However, this may be the result of inadequate sampling. This includes multi-year versus single year collecting, unusual predominance of males, and low mtDNA lineage diversity in the "Gizhiginskaya" sample set (90% of individuals had the same haplotype, H = 0.1775 vs. H = 0.5650 found for "Kamchatka"). Moreover, clustering method analysis showed only minor differences between "Kamchatka" and "Gizhiginskaya" belugas and determined the two sample sets were a single genetic cluster. Future studies will likely find some intrapopulation structuring, but at present all belugas from the Northeast Okhotsk population are considered a single stock (Shelikhov).

Thus, in the Okhotsk Sea, five beluga summer stocks should be designated based on information available to date: Sakhalin-Amur, Ulbansky, Tugursky, Udskaya, and Shelikhov.

We note that the current gap in beluga distribution in the northwest portion of the Okhotsk Sea is a relatively new pattern. Numerous Soviet literature sources state that in the first half of the 20th century, belugas regularly aggregated in Tauyskaya Bay (Fig. 1), but after several years of commercial harvest in early 1930's, they disappeared. The aggregation was either extirpated or abandoned this summer ground. In 2008, two unusual sightings of about 1,500 and 100–150 belugas were reported in Tauyskaya Bay by A.I. Grachev[10]. Apart from these two observations, there were very few encounters of single whales or small groups in the bay. Without genetic data, we are unable to determine which of the two Okhotsk Sea populations may have seasonally occupied Tauyskaya Bay in the early 20th century and during the summer of 2008.

Chukotka Autonomous Region

In Russian waters of the western Bering and western Chukchi seas, belugas occur near Wrangel Island, along the entire coast of the Chukotka Peninsula, in Anadyr Gulf, and, in winter, around Cape Navarin (Fig. 1). Only in Anadyr Gulf, are belugas known to form a summer resident aggregation (Arsenyev, 1939; Kleinenberg et al., 1964). Genetic isolation of Anadyr belugas from the populations of the Okhotsk Sea was shown by Meschersky et al. (2013), but their original stock

[9]Filatova, O. A., O. V. Shpak, A. Ju. Paramonov, D. M. Glazov, A. I. Grachev, and I. G. Meschersky. 2018. Cetacean encounters in the coastal waters of the northern Okhotsk Sea in the summer 2016. Marine Mammals of the Holarctic: Collection of papers presented at the 9th Int. Conf., Astrakhan, 2016, 2:218–222 (http://marmam.ru/upload/conf-documents/mmc2016_full.pdf).

[10]Grachev, A. I. (deceased) MagadanNIRO, Russia, unpubl. data.

designation in 2000 was based mostly on distribution studies within the Bering-Chukchi-Beaufort (BCB) region (IWC, 2000). The status of other belugas observed along Chukotka Peninsula in the Chukchi and Bering seas remains to be confirmed.

In the eastern part of the East Siberian Sea, belugas are rare. Most coastal sightings were near the mouth of the Kolyma River (Kleinenberg et al., 1964). Belikov and Boltunov (2002) mentioned only twelve offshore sightings of belugas during sea ice reconnaissance for the period 1958–1995. Satellite tracking of eastern Beaufort Sea belugas in the 1990's showed a westward autumn migration during which whales travelled as far west as Wrangel Island (Richard et al., 2001). In multiple literature sources, belugas from the BCB region and the East Siberian Sea were either grouped into one population (for ex., Klumov, 1939; Kochnev, 2003; Belikov et al., 2002[11]), or subdivided into multiple stocks or populations (Berzin and Yablokov, 1978; IWC, 2000; and many others), but either delineation lacked sufficient grounding. Until the question of population structure is clarified, we prefer to use the term "pool" for BCB belugas. The following sections summarize Russian studies conducted within this region, supplementing data collected on the other stocks in the BCB pool that have been published in English and that are readily accessible.

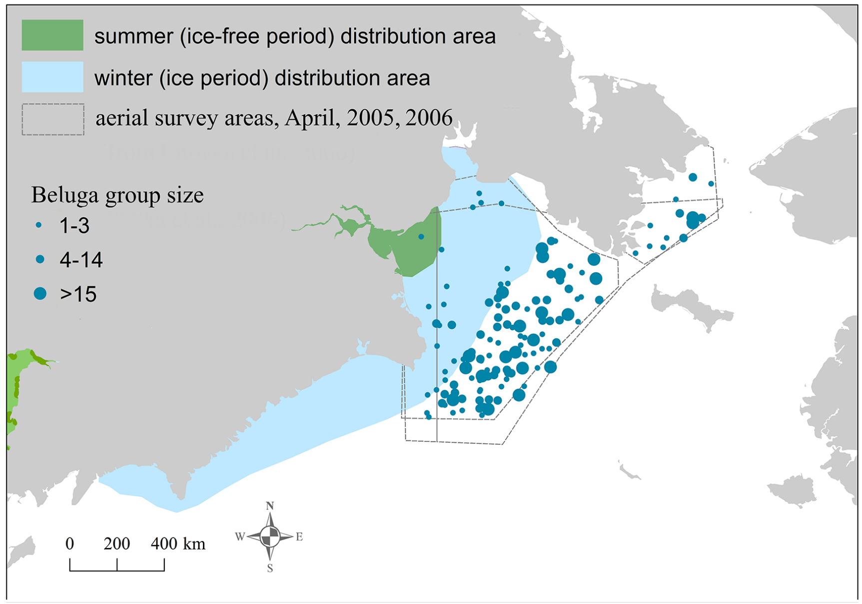

Figure 5.—Summer and winter ranges of Anadyr belugas based on observations and satellite-tracking data from published literature sources (see text) and beluga sightings and group sizes during aerial surveys in April 2005 and 2006 (redrawn from Litovka et al., text footnote 17).

Anadyr Stock

Belopol'sky[12] and Pikharev[13] described the movements of belugas into the Anadyr Estuary after ice breakup, and stated that the whales were commonly seen in groups ranging in size from dozens to thousands. In the Anadyr Estuary during the ice-free period, whales concentrated in shallow waters and traveled up to 200 miles into the estuary (Litovka, 2002). Short-term pilot photo-identification study in 2013 revealed few re-sightings within a season (Prasolova et al., 2014). Our observations support a hypothesis that in summer belugas form a resident aggregation in the Anadyr Estuary (Fig. 5). Telemetry studies of Anadyr belugas during the period 2001–10 (Litovka et al., 2013; Citta et al., 2017; Litovka et. al.[14,15]; Hobbs et al.[16]) confirmed and clarified distribution and movement patterns in the Anadyr Estuary and Anadyr Gulf, which had previously been based on coastal and aerial counts (Litovka, 2002).

Belugas spend the ice-free period (5–6 months) in the Anadyr Estuary. The latest reported sighting occurred in late November. As ice forms in the estuary, belugas leave the Anadyr River mouth. They move northeast to feed on smelt, and later migrate to the exit and southern part of Anadyr Gulf (Litovka et al., 2013). Results from telemetry studies (Citta et al., 2017; Litovka et al.[14]) and aerial surveys conducted in April (Litovka et al.[17]) suggest Anadyr belugas may mix with other BCB stocks while in feeding areas off Cape Navarin in winter–spring (December–April) (Fig. 5).

No abundance surveys have been conducted in Anadyr Gulf in sum-

[11]Belikov, S. E., A. N. Boltunov, and Yu. A. Gorbunov. 2002. Distribution and migrations of cetaceans in Russian Arctic according to multiyear aerial reconnaissance of sea ice and information from "North Pole" drift station. Marine mammals: Results of research conducted in 1995–1998. Collection of Pap. Moscow: Mar. Mamm. Counc., p. 21–51 [in Russ.].

[12]Belopol'sky, L. O. 1931. Short preliminary report on marine mammals research in Anadyr region. TINRO archive, cat. #25, 25 p. [in Russ.].

[13]Pikharev, G. A. 1943. The beluga whale and pinnipeds in coastal waters of Anadyr region. TINRO archive, cat. #2585, 29 p. [in Russ.].

[14]Litovka, D. I., R. C. Hobbs, K. L. Laidre, G. M. O'Corry-Crowe, J. R. Orr, P. R. Richard, R. S. Suydam, and A. A. Kochnev. 2002. Research of belugas *Delphinapterus leucas* in Anadyr Gulf (Chukotka) using satellite telemetry. Marine Mammals of Holarctic: Abstracts of The 2nd Int. Conf., Lake of Baikal, 2002, p. 161–163 (http://marmam.ru/upload/conf-documents/mmc2002_full.pdf).

[15]Litovka, D. I., R. C. Hobbs, K. L. Laidre, G. M. O'Corry-Crowe, J. R. Orr, P. R. Richard, and R. S. Suydam. 2004. Studying of dive patterns of belugas (*Delphinapterus leucas*) in Anadyr-Navarin region of Bering Sea using satellite telemetry. Marine Mammals of Holarctic: Collection of papers presented at the 3rd Int. Conf., Koktebel', Ukraine, 2004, p. 327–331 (avail. at http://marmam.ru/upload/conf-documents/mmc2004_full.pdf).

[16]Hobbs, R. C., D. I. Litovka, and G. M. O'Corry-Crowe. 2007. Bering Sea wintering grounds of beluga whales. Seattle, WA. N. Pac. Res. Board Final Rep. 324:1–12

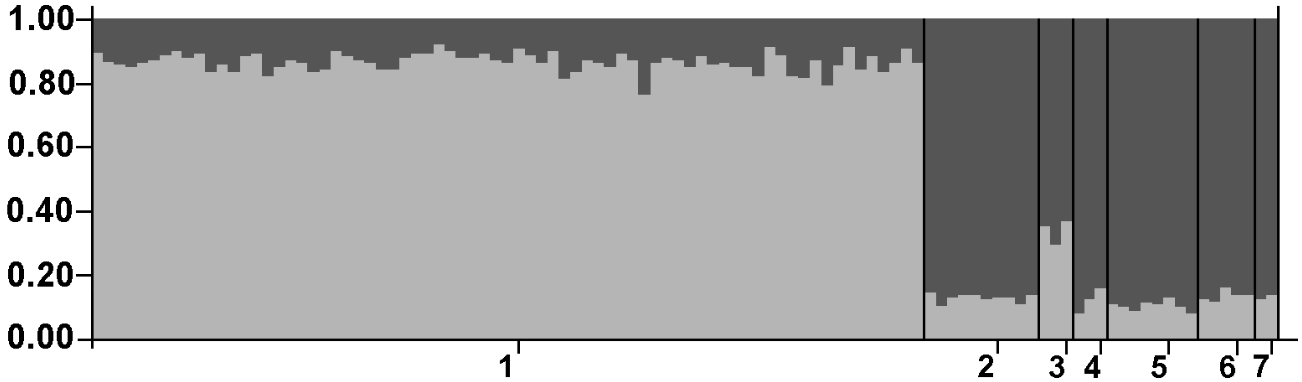

Figure 6.—Results of K = 2 hypothesis (most probable solution) tested by LOCPRIOR-Admixture model for allele frequencies of 17 microsatellite loci. 1 – Anadyr Estuary, 2 – Chukotka Peninsula coast, 3 – Beaufort Sea, 4 – Diomede Isl., 5– Eastern Chukchi Sea, 6 – Norton Sound, 7 – Bristol Bay.

mer. Coastal observations suggest two peaks in sighting rates: 1) from the end of June to the beginning of July, and 2) in the beginning of August, both of which coincide with salmon spawning. The largest concentration, 241 whales, was recorded in late June (Litovka, 2002). Pacific walrus, *Odobenus rosmarus*, aerial surveys with opportunistic beluga counts were conducted in April 2005 and 2006 (Fig. 5). The surveys did not cover the area south of Cape Navarin, where, according to satellite tracking data, part of the Anadyr beluga stock may have resided. In April 2005, 162 groups of 410 whales total were counted, and in April 2006, 195 groups with 403 individuals total (Litovka et al.[17]). The estimated beluga abundance using a correction for availability (2.86) was 15,127 (7,447–30,741) (Litovka[18]). This estimate represents "a theoretical abundance calculated as direct extrapolation of the estimated mean density to the unsurveyed areas" (Litovka[18]) and should be viewed with caution. In addition, some of the beluga whales observed in April may have belonged to one or several BCB region stocks given their overlap in winter–spring range. An estimate of the Anadyr summer stock of about 3,000 belugas (Litovka, 2002) appears more realistic and should be used for management purposes until a dedicated survey of the summering area is conducted.

Meschersky et al. (2013) show that some Anadyr belugas possess mitochondrial haplotypes phylogenetically different from those of maternal lines common elsewhere in the BCB region. The differences observed in the Anadyr sample set (n = 76) from other BCB stocks, when compared to data from O'Corry-Crowe et al. (1997), are strong, although with varying degrees of significance. For the Beaufort Sea sample (n = 96) the Fst = 4.48% (p = 0.0011), while for the eastern Chukchi Sea (n = 113) and Norton Sound samples (n = 74) the Fst = 31.4%–44.0% (p = 0.0000), respectively. These results, together with data on distribution, support delineation of Anadyr Gulf belugas as a separate stock.

We also conducted analysis of 17 microsatellite loci for the above mentioned Anadyr Estuary sample, a sample from the Chukotka Peninsula coast (n = 10), and samples from other stocks in the BCB region (provided by the Mammal Genomic Resources Collection, Univ. of Alaska Museum of the North (UAM)). These included three samples from the Beaufort Sea (UAM:Mamm: 76608, 86886, and one sample from A. N. Severtsov Institute collection), eight samples from the eastern Chukchi Sea (UAM:Mamm: 52221–25, 70322–24, 70326), three samples from the Diomede islands (UAM:Mamm: 66416, 98081–82), five samples from Norton Sound (UAM:Mamm: 70519–20, 70522–23, 70525), and two samples from Bristol Bay (UAM:Mamm 66633, 83385). Although, the Anadyr sample was not significantly different from the Chukotka Peninsula and eastern Chukchi Sea samples (n > 5) (Fst = 0.97%, p = 0.0692 and 0.86%, p = 0.12474, respectively), a cluster analysis of the entire BCB sample suggests two clusters, one represented by Anadyr belugas (Fig. 6).

O'Corry-Crowe et al. (2018) also obtained similar results showing: 1) substantial mtDNA differences between Anadyr and five other major summer coastal concentration areas within the BCB region (Bristol Bay, Norton Sound, Kotzebue Sound, Kasegaluk Lagoon, Mackenzie-Amundsen); 2) few differences in allelic composition of eight microsatellite loci; and 3) moderate differentiation of Anadyr belugas revealed by clustering analysis. These authors also concluded that the belugas of the Anadyr summering aggregation should be defined

[17]Litovka, D. I. , V. I. Chernook, A. A. Kochnev, A. N. Vasiliev, A. V. Kudriavtsev, and V. G. Myasnikov. 2006. Distribution of beluga (*Delphinapterus leucas*) and bowhead (*Balaena mysticetus*) whales in the northwestern Bering Sea according to aerial survey performed in April, 2005 and 2006. Marine Mammals of Holarctic: Collection of papers presented at the 4th Int. Conf., Saint-Petersburg, 2006, p. 323–327 (http://marmam.ru/upload/conf-documents/mmc2006_full.pdf).

[18]Litovka, D. I. 2013. Ecology of Anadyr stock of the beluga whale *Delphinapterus leucas* (Pallas, 1778). Ph.D. Dissert., Voronezh State Univ., Voronezh, Russia, 149 p. [in Russ.].

as a separate stock. Mixing of Anadyr belugas with other BCB stocks, if it exists, is more likely to occur with the eastern Beaufort Sea belugas. This hypothesis is supported both with satellite tracking data (Citta et al., 2017), which showed that Beaufort belugas migrate closer to Chukotka Peninsula and Anadyr Gulf than the other stocks, and comparatively lower genetic differences between Anadyr and eastern Beaufort Sea samples (Fig. 6).

Bering-Chukchi-Beaufort Pool

In summer, beluga sightings along the Chukotka Peninsula are relatively rare. It is not until autumn that most whales concentrate in the western Chukchi Sea, and winter and early spring in the Bering Strait and western Bering Sea. The sightings in the eastern part of the East Siberian Sea are rare, and most occurred during the period September–October (Kochnev, 2003; Belikov et al.[11]). The most recent (late September 2002) westernmost sighting of "many" belugas (at about lat. 69.75° N, long. 164.1° E) was provided to Kochnev (2003) by local hunters. This timing coincides with results from satellite-tracked belugas from the eastern Beaufort Sea stock (Richard et al., 2001; Hauser et al., 2014), that in autumn moved across the Chukchi Sea to the East Siberian Sea, some approaching Chukotka while others remained offshore (around Wrangel Island). Kochnev (personal commun.) noted that such approaches were irregular and may be linked to the ice conditions: for example, they were frequent in the 1950's–1960's, but not again until the 1990's. Belugas may enter the East Siberian Sea from the Chukchi Sea by following the mainland coastline, or approach from the north (Arctic Ocean), the latter route is supported by observations and tracking data (Richard et al., 2001; Hauser et al., 2014; Melnikov, 2014; Belikov et al.[11]).

Solovyev et al. (2013) created a good representative picture of beluga seasonal distribution and numbers based on the coastal observations from twelve villages along Chukotka Peninsula's northern, eastern, and southern coasts. The presence of belugas was low in June, July, and August. Kochnev (2003) also noted the lack of large numbers of belugas summering in the western Chukchi Sea, along the northern coast of the Chukotka Peninsula, and the waters around Wrangel Island. According to Kochnev (2003), belugas are absent near Wrangel Island in summer, and along the northern coast of the peninsula most of the year, except for autumn. The lack of a historic traditional beluga harvest to the west of long. 172°W further supports this observation (Kochnev, 2003; Bogoslovskaya and Krupnik[19]). Melnikov (2014) also states that in summer belugas are rarely observed along the Chukotka coast, both in Chukchi and Bering seas.

From all reviewed sources it is clear that most beluga sightings in terms of frequency and number occur during the spring and autumn migrations. According to Melnikov (2014), spring migration along the southern and eastern peninsula coasts starts in April, and most observations suggest that belugas approach the southeast of the peninsula from the Bering Sea rather than from Anadyr Gulf. These observations correspond well with the satellite tracking analysis (Citta et al., 2017). It is important to note that most of the data in Solovyev et al. (2013) and Melnikov (2014) were collected not by the authors personally but by "Beringia" National Park local employees and hired local residents. Although the remoteness of the study area and lack of comprehensive research make such data invaluable, they should be treated with caution, and cross-checking of information should be applied whenever possible. In addition, Melnikov (2014) does not always cite the sources of the data used in the text and figures.

Whether belugas can winter in the Chukchi Sea in the leads and polynyas is unknown, and different opinions have been expressed. Solovyev et al. (2013) acknowledges this possibility by noting a lack of "the high level of herding" as a sign of "migration activity" (cited from Matishov and Ognetov, 2006) along the northern coast of the peninsula in late autumn, and the rapid emergence of belugas following the Arctic cod, *Boreogadus saida,* in open water areas in winter months. In contrast, Kochnev (2003) and Melnikov[20] do not support this idea, and Kochnev (2003) specifically notes that from December to June belugas are absent along the northern coast of the Chukotka Peninsula. Sightings are limited to the northwest cape of the mainland—Cape Dezhnev (Fig. 1). During autumn months, the home range of eastern Beaufort Sea belugas also shifts from north of Wrangel Island toward the Bering Strait (Hauser et al., 2014).

There are no abundance estimates for belugas approaching the Chukotka Peninsula in different seasons, except for the counts by local observers (Solovyev et al., 2013) and opportunistic counts in the mouth of Anadyr Gulf during the walrus aerial surveys in 2005–06 (see Anadyr Stock section). Meschersky et al. (2018), when comparing the belugas taken in autumn and winter in different parts of Chukotka Peninsula (n = 10) with the data provided by O'Corry-Crowe et al. (1997), found that the mtDNA haplotype composition of the Chukotka sample was significantly different from the eastern Chukchi Sea and Norton Sound samples, but that it did not differ from the Beaufort Sea sample. No differences (Fst = 0.89%, p = 0.2747) in haplotype composition were found between our Chukotka Peninsula and Anadyr samples. Also, the Chukotka Peninsula sample microsatellite allele frequencies did not differ either from Anadyr

[19]Bogoslovskaya, L. S., and I. I. Krupnik. 2000. Aboriginal harvest of the beluga whale in the Far East. Marine Mammals of Holarctic: Collection of scientific papers presented at the Int. Conf., Arkhangelsk, 2000, p. 34–36 [In Russ.] (http://marmam.ru/upload/conf-documents/mmc2000_full.pdf).

[20]Melnikov, V. V. 2012. Cetaceans (*Cetacea*) of the Pacific sector of the Arctic: modern distribution, migrations, abundance. Doctor of Biol. Sci. Dissert. V. I. Ilyichov Pacific Oceanol. Inst., Vladivostok, 305 p. [In Russ.].

Table 3.—The annual beluga Total Allowed Takes (TAT) for North-Okhotsk/West Kamchatka subzones, and summary data for actual permanent removals by live-capture (LC, no. of whales) from Sakhalinsky Bay, North-Okhotsk subzone (from Shpak and Glazov text footnotes 6, 21). Supplemented with information received from the Federal Government-Financed Institution Centre of Fishery Monitoring and Communications (CFMC) for the years 2000, 2014, and 2015.

Year	2000	2001	2002	2003	2004	2005	2006
TAT	n/a	n/a	n/a	n/a	n/a	n/a	1000/0
LC	10 (16[1])	22	10	26	25	31	20
Year	2007	2008	2009	2010	2011	2012	2013
TAT	400/400	100/100	300/300	300/300	150/150	360/50	360/50
LC	0	25	24	30	33	44	81[2]
Year	2014	2015	2016	2017	2018		
TAT	150/0	150/25	0/0	150/25	150/25		
LC	8	21	0	0	n/a		

[1]According to the CFMC, all belugas taken in 2000 were landed under commercial harvest quota, while our data represent live capture numbers. Thus, in total, 26 belugas may have been taken in 2000.
[2]The number reported (Shpak and Glazov text footnote 21) was estimated based on direct observations and reports by capture teams. To compare, the beluga take for 2013 reported to the CFMC was eight whales.

or eastern Chukchi Sea samples (Fst = 0.97%, p = 0.0692, and Fst = 0.00%; p = 0.7614, respectively). Nonetheless, according to the results of the clustering analysis (Fig. 6), Chukotka Peninsula belugas do not belong to the Anadyr cluster.

In their recent study, O'Corry-Crowe et al. (2018) also analyzed 10 beluga samples from the Chukotka Peninsula described as northbound spring migrants and obtained similar results. For the mtDNA, the animals from Chukotka differed from all other BCB sample sets except the Mackenzie-Amundsen whales (eastern Beaufort Sea). No statistically significant differences were found for microsatellite loci alleles, but according to different methods of the assignment testing, Chukotka belugas were assigned to the Beaufort Sea and not to the eastern Chukchi Sea. In summary, no definitive conclusions can be made regarding the status of belugas migrating along the Chukotka Peninsula. Therefore, we recommend they continue to be classified as part of the Bering-Chukchi-Beaufort pool for management purposes in Russia, until larger samples are obtained that suggest otherwise.

Anthropogenic and Natural Concerns

Hunting and Live Captures

Total Allowed Takes (TAT) of aquatic biological resources, including marine mammals, are issued annually in autumn by the Ministry of Agriculture and reflect the maximal theoretically sustainable yield. These documents are publicly available. Corrections and changes may be provided to the issued yields of TAT's if they comply with all necessary legal procedures. The number of licenses requested for traditional harvests or live-captures may be obtained from the Federal Agency of Fisheries, but the actual capture numbers of marine mammals (at least, beluga whales), to our experience, are not reported properly by licensees or regional fisheries offices.

Okhotsk Sea. Until recently, beluga stock structure in the Okhotsk Sea has not been taken into account in the process of calculating TAT's, which in the Russian Federation are distributed across fishing zones and subzones, whether the latter coincide with stock boundaries or not. Shpak and Glazov (2013) presented abundance estimates and recommended to use PBR with a recovery factor (F) from 0.5 to 0.65 for beluga summer stocks of the western Okhotsk population, and to minimize beluga takes (limit them to traditional harvests and scientific takes) in the northeast part of the sea until more data on the Shelikhov population are available. The PBR of 42 (F = 0.65) was suggested for the Sakhalin-Amur stock with a note that, depending on the actual 2013 take, PBR may have to be recalculated with F=0.5. It was also recommended that no takes should be allowed in the little-studied Nikolaya Bay. These recommendations were partly implemented. Starting in 2017, The Ministry of Agriculture recommended distributing the TAT in the Okhotsk Sea among different summer aggregations/regions as follows: in the North Okhotsk fishing subzone, Sakhalinsky Bay and Amur Estuary – 40, Nikolaya and Ulbansky bays – 40, Tugursky Bay – 20, Udskaya Bay – 40, northern coast – 10; and in the West Kamchatka subzone, Gizhiginskaya Bay – 7, Penzhinskaya Bay – 6, and West Kamchatka coast – 12. We have compiled information on beluga live-captures in the Okhotsk Sea starting in 2000 (Table 3).

All beluga captures (Table 3) in the North Okhotsk subzone were conducted in southern Sakhalinsky Bay and, possibly in Nikolaya Bay in 2014 and 2015. Boltnev et al. (2016) mentions that on average, live-captures of Sakhalin-Amur belugas do not exceed 30 whales annually, but that the maximum take was "over 100 animals." It is unclear if the authors were provided information unavailable to us, or if they summed the numbers of belugas captured and drowned in 2013 that were provided in Shpak and Glazov[21]. The majority, if not all, live-captured belugas are immature two- to three-year old individuals. Usually, the preferred sex for takes is female.

Quotas for beluga harvest are seldom requested. A quota for traditional hunting of 90 belugas in the North Okhotsk subzone was issued in 2012, but no whales were harvested under this permit (Shpak and Glazov, 2013). To our knowledge, no belugas in the Okhotsk Sea have been landed under traditional harvest quota since 2000. Based on interviews with local people in the Shantar region (where three settlements are located) "several" belugas per settlement are harvested without permit annually. Most people reported beluga meat was used to feed dogs in the winter, and in one village, to be

[21]Shpak, O. V., and D. M. Glazov. 2014. Update report on the white whale (*Delphinapterus leucas*) live captures in the Okhotsk Sea, Russia. Paper SC/65b/SM14 pres. to IWC Sci. Comm., Bled, Slovenia, May 2014, 4 p.

Table 4.—The annual beluga Total Allowed Takes (TAT) for Chukotka Autonomous Region and total actual landings in each of the four Chukotka fishing zones, 2000–16 (from Boltnev et al., 2016, updated by D. Litovka); harvest data in 2003 was provided by the CFMC.

Year	TAT	WBSZ[1]	CFZ[2]	CSFZ[3]	ESSFZ[4]	Total take
2000	200	2	0	4	0	6
2001	200	3	0	4	0	7
2002	200	1	3	2	0	6
2003	200	?	?	?	?	22
2004	200	12	2	12	0	26
2005	200	10	0	10	0	20
2006	200	1	1	0	0	2
2007	200	0	3	0	0	3
2008	200	0	6	2	0	8
2009	200	0	50	0	0	50
2010	200	0	8	0	0	8
2011	200	0	0	0	0	0
2012	200	1	9	8	0	18
2013	200	0	11	3	0	14
2014	200	0	0	0	0	0
2015	200	0	3	0	0	3
2016	200	0	2	0	0	2
2017	200	0	2	8	0	10
2018	200	0	1	4	0	5[5]

[1]WBSZ - Western Bering Sea Fisheries Zone (from Koryak coast to long. 175°W).
[2]CFZ - Chukotskaya Fisheries Zone (from long. 175°W to Cape Dezhnev).
[3]CSFZ - Chukchi Sea Fisheries Zone (from Cape Dezhnev to Longa Strait).
[4]ESSFZ - East-Siberian Sea Fisheries Zone (from Longa Strait to the Kolyma River).
[5]Incomplete data, only spring take is included.

consumed by people. In the Sakhalin-Amur region, we did not hear about harvesting belugas for food, but there was mention of several cases of fishermen shooting beluga when the whales entered salmon traps or approached nets. We do not have any information from Shelikhov Gulf and western Kamchatka. Bogoslovskaya and Krupnik[19] relied on information from an ethnographer, who reported that beluga takes in this region were "occasional" and did not exceed 10 whales per year. Human-caused beluga incidental mortality, as bycatch in salmon traps, gillnets, and poachers' sturgeon nets, and ship-strikes, cannot be estimated. We are aware of several cases of beluga bycatch in the Sakhalin-Amur and Shantar regions. Ship strikes were not recorded or reported.

Chukotka Autonomous Region. The beluga harvest during 1915–98 for Chukotka was summarized by Bogoslovskaya et al. (2007). For the 65 years analyzed, an average of 34.2 (SE = 6.3, median = 18) belugas were taken annually, and only twice (in 1925 and 1950) did the harvest exceed currently set TAT (200 belugas). Although the authors mentioned lack of catch data from one of the villages for many years, the data in general reflect beluga takes in the Soviet Union period.

In recent decades, TAT's for Chukotka waters have been calculated as the abundance estimate multiplied by a theoretical growth rate of 4% and precaution coefficient of 0.5 due to the absence of sufficient data on beluga abundance and population parameters. Abundance estimates of 10,000 belugas for the western Bering Sea and 4,000 whales for the western Chukchi Sea (Vladimirov, 1994) have been used for these TAT calculations. These estimates were based on different sources and should be considered as an "expert opinion." In the absence of exact figures and given possible errors, the abundance of 10,000 belugas (Boltnev et al., 2016 based on Vladimirov, 1994) was used, and the TAT for Chukotka waters was set to 200 whales (Table 4).

Based on the data presented above, we recommend the Anadyr beluga stock be managed separately. Due to the lack of information on BCB pool stock structure and movement patterns, belugas from the BCB pool in Chukotka waters (Bering Sea, Chukchi Sea, East Siberian Sea) cannot be further subdivided into management units. Until more data are available, we recommend management of the BCB pool as a single stock and maintaining the currently used distribution of the TAT across the four fishing zones (Table 4).

For the entire Chukotka region, Native hunters harvested 205 belugas during the period 2000–17, or, on average, a little over 11 animals per year. Apart from 2003, for which no breakdown is available, the majority (83%) of whales were harvested in the Bering Strait area (CFZ) and along the Arctic coast of the Chukotka Peninsula (CSFZ). Belugas were taken only during the spring and fall migrations. The beluga harvest significantly decreased after the Chukotka Native harvest began including larger species of whales (bowhead whales, *Balaena mysticetus,* and gray whales, *Eschrichtius robustus*) and walruses from 2008–10.

The illegal harvest of belugas in Chukotka is considered insignificantly small. Beluga hunting requires Native skin boats, special skills and equipment; however, no more than 25% of marine mammal hunters possess them. According to other sources, in 2006, Chukotka hunters landed 13 belugas, and none were taken in 2007 (Zdor and Mymrin[22]). In 2009, according to the same authors, six belugas were landed in the region (Mymrin and Zdor[23]). These numbers do not coincide with the numbers available to us (Table 4). Despite the differences in the numbers of landed whales, it is clear that beluga harvest in Chukotka is far below the TAT set by the Russian Ministry of Agriculture.

Not included in the numbers presented above are the whales harvested during ice entrapments. In Chukotka, belugas sometimes become entrapped in ice in Seniavin Strait (Fig. 7). The most dramatic occasion happened in December 1984 when about 3,000

[22]Zdor, E. V., and N. I. Mymrin. 2008. Results of marine mammals hunting in Chukotka in 2006–2007 and environment notes. Marine Mammals of Holarctic: Collection of papers of the 5th Int. Conf., Odessa, Ukraine, p. 617–619 (http://marmam.ru/upload/conf-documents/mmc2008_full.pdf).

[23]Mymrin, N. I., and E. V. Zdor. 2010. Results of the marine mammals harvest in Chukotka in 2009. Marine Mammals of Holarctic: Collection of papers presented at the 6th Int. Conf., Kaliningrad, p. 412–415 (http://marmam.ru/upload/conf-documents/mm%D1%812010_full.pdf).

Figure 7.—Belugas entrapped in ice in Seniavin Strait (photo provided by I. Zagrebin).

whales became entrapped. Mymrin[24] described the entrapment and actions taken by locals and authorities from 13 December when a local hunter first spotted belugas, until 5 June when a few belugas were seen for the last time. Over 500 individuals from the entrapped aggregation were harvested by locals during that winter.

Another instance of beluga ice entrapment in Seniavin Strait took place in December 2011. Approximately 100 whales spent the winter in polynyas in Seniavin Strait, and most (if not all of them) died (Zagrebin[25]). On 12 January 2012 (Fig. 7), seven belugas were harvested, and one was found dead. All harvested whales had empty stomachs. The next month, two whales were found dead and three were taken. Several belugas still remained trapped in early April.

[24]Mymrin, N. I. 2006. Beluga whales (*Delphinapterus leucas P.*) in the ice trap. Bering Strait, Chukotka. Marine Mammals of Holarctic: Collection of papers presented at the 4th Int. Conf., Saint- Petersburg, 2006, p. 377–380 (http://marmam.ru/upload/conf-documents/mmc2006_full.pdf).

[25]Zagrebin, I. A. 2012. The beluga whales (*Delphinapterus leucas* Pallas) in the Senyavina strait: again in ice trap. Marine Mammals of Holarctic: Collection of papers of the 7th Int. Conf., Suzdal, 1:254–257 (http://marmam.ru/upload/conf-documents/mmc2012_full.pdf).

Other Potential Threats

Social and industrial development (fisheries, gold mining and ore transport, oil and gas exploration and production) in the Far East, together with climate change, pose new threats to belugas, who closely associate with ice in winter and demonstrate a high site-fidelity to coastal waters and shallow estuarine parts of the bays in summer. These arising challenges to the species need be considered when managing the stocks. The Sakhalin-Amur, Tugursky, Udskaya, and Shelikhov stocks were commercially harvested in the Soviet Union (mostly before the 1950’s). Information on harvest and original abundances is limited, and it is difficult to assess whether all stocks have completely recovered. The Anadyr stock has never been overharvested and is considered stable. Sakhalinsky Bay and Amur Estuary as well as Anadyr Gulf are areas intensively exploited by salmon fisheries. This type of industry has also developed in all of the bays of the Chukotka and Shantar regions. Belugas compete with fishermen, and enter salmon traps causing conflicts. The current salmon catch (together with illegal operations) is likely decreasing the carrying capacity, at least, in Sakhalinsky Bay. We do not have information on the intensity of salmon fisheries in the Shelikhov region.

Amur River flooding, leading to washing of human/pet/livestock waste and chemicals into the estuaries, is also of concern. Alekseev et al. (2017) showed that, after a catastrophic flood in 2013, the health of belugas was affected by infectious and invasive diseases, whose causative agents were associated with terrestrial animals. Flooding in the populated flat-coast lower parts of Uda and Anadyr river estuaries is also of similar concern. The gold-mining industry is highly developed across the entire Okhotsk Sea coast with the potential threat of river and estuarine pollution by toxic substances. Ship strikes have not been reported, but direct disturbance and noise should be considered as threats in, at least, the Sakhalin-Amur area, Udskaya Bay, Anadyr Estuary, and Bering Strait. Future climate change and sea ice reduction will extend the period of open water and increase the flow of marine traffic in the Bering Strait. Whether this will affect belugas is unknown, since their migration routes and timing may also change. It is also anticipated that seismic and military activities in the BCB region, including the eastern part of the East Siberian Sea, will increase with longer ice-free periods.

Conclusions

Revised assessment of beluga abundance, distribution, and population structure in the Russian Far East led to us recognizing seven beluga stocks, five stocks in the Okhotsk Sea: 1) Sakhalin-Amur, 2) Ulbansky, 3) Tugursky, 4) Udskaya, 5) Shelikhov, and two stocks in the Chukotka Autonomous region waters: 6) Anadyr and 7) Bering-Chukchi-Beaufort (BCB) pool. These new designations will help improve management of these stocks when addressing concerns about natural and anthropogenic threats.

Acknowledgments

We are thankful to A. Paramonov, B. Solovyev, A. Burdin, S. Gorin, I. Zagrebin, and inspectors of the "Beringia" NP for providing beluga genetic samples. The samples from Gizhiginskaya Bay (Okhotsk Sea, 2016) were collected by Olga Filatova during the Pew Marine Fellowship project "Protecting critical habitats of whales in the Russian Pacific." Our unpublished data presented in this paper were collected under "The White Whale Program" funded by the Russian Geographic Society, and the Project "Western Okhotsk Beluga Population Assessment" (2013–16) funded by the Ocean Park Corporation, Hong Kong. We thank all GROM participants for valuable advice and fruitful discussion during the meeting. We sincerely thank Kim W. Shelden for a thorough review and greatly improved language of this manuscript, an anonymous reviewer for the aimed comments that helped to clarify the text, and the Editor for scrupulous checking and corrections.

Literature Cited

Alekseev, A. Yu., O. V. Shpak , L. S. Adamenko, D. M. Glazov, I. V. Galkina, M. Yu. Shchelkanov, and A. M. Shestopalov. 2017. Serological indication of etiological agents of infectious and invasive diseases in white whales *Delphinapterus leucas* Pallas, 1776 (Cetacea: Monodontidae) in Sakhalin Bay after the catastrophic flood (2013). Russ. J. Mar. Biol. 43(6):425–430 (doi: https://doi.org/10.1134/S1063074017060037).

Arsenyev, V. A. 1939. Beluga distribution and migrations in the Far East. Izvestiya TINRO 15(15), 110 p. [in Russ.].

Belikov, S. E., and A. N. Boltunov. 2002. Distributions and migrations of cetaceans in the Russian Arctic according to observations from aerial ice reconnaissance. NAMMCO Sci. Publ. 4:69–86 (avail. at https://septentrio.uit.no/index.php/NAMMCOSP/article/viewFile/2838/2691).

Berzin, A. A., and A. V. Yablokov. 1978. Abundance and population structure fo main exploited species of cetaceans in the world ocean. Zoologicheskiy Zhurnal 57(18):1771–1784 [in Russ.].

Bogoslovskaya, L. S., I. V. Slugin, I. A. Zagrebin, and I. I. Krupnik. 2007. The basis of the marine mammal harvest. Scientific-methodical manual. Heritage Inst., Moscow, 480 p. [in Russ.].

Boltnev, A. I., A. I. Grachev, K. A. Zharikov, V. B. Zabavnikov, S. I. Kornev, V. V. Kuznetsov, D. I. Litovka, V. G. Myasnikov, and I. N. Shafikov. 2016. Resources of marine mammals and their harvest in 2013. Trudy VNIRO 160:230–249 [in Russ.].

Buchanan, F. C., M. K. Friesen, R. P. Littlejohn, and J. W. Clayton. 1996. Microsatellites from the beluga whale, *Delphinapterus leucas*. Mol. Ecol. 5:571–575 (doi: 10.1046/j.1365-294X.1996.00109.x).

Citta, J. J., L. F. Lowry, G. M. O'Corry-Crowe, M. A. Marcoux, R. S. Suydam, L. T. Quakenbush, R. C. Hobbs, D. I. Litovka, K. J. Frost, T. G. Ray, J. R. Orr, B. T. Inker, H. A. Derman, and M. L. Druckenmiller. 2017. Satellite telemetry reveals population specific winter ranges of beluga whales in the Bering Sea. Mar. Mammal Sci. 33(1):236–250 (doi: https://doi.org/10.1111/mms.12357).

Earl, D. A., and B. M. vonHoldt. 2012. Structure Harvester: a website and program for visualizing STRUCTURE output and implementing the Evanno method. Conserv. Genetics Resour. 4(2):359–361 (doi: https://doi.org/10.1007/s12686-011-9548-7).

Excoffier, L., G. Laval, and S. Schneider. 2005. Arlequin ver. 3.0: an integrated software package for population genetics data analysis. Evol. Bioinform. Online 1:47–50 (avail. at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2658868/pdf/ebo-01-47.pdf).

Fedoseev, G. A. 1984. Whale sightings in the ice massifs of the Okhotsk Sea. Ekologiya 3:81–83 [in Russ.].

Fullard K. J., G. Early, M. P. Heide-Jørgensen, D. Bloch, A. Rosing-Asvid, and W. Amos. 2000. Population structure of long-finned pilot whales in the North Atlantic: a correlation with sea surface temperature? Mol. Ecol. 9:949–958 (https://doi.org/10.1046/j.1365-294x.2000.00957.x).

Hauser, D. D. W., K. L. Laidre, R. S. Suydam, and P. R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (*Delphinapterus leucas*). Polar Biol. 37(8):1171–1183 (doi: https://doi.org/10.1007/s00300-014-1510-1).

Hobbs, R. C., R. R. Reeves, J. S. Prewitt, G. Desportes, K. Breton-Honeyman, T. Christensen, J. J. Citta, S. H. Ferguson, K. J. Frost, E. Garde, M. Gavrilo, M. Ghazal, D. M. Glazov, J.-F. Gosselin, M. Hammill, R. G. Hansen, L. Harwood, M. P. Heide-Jørgensen, G. Inglangasuk, K. M. Kovacs, V. V. Krasnova, D. M. Kuznetsova, D. S. Lee, V. Lesage, D. I. Litovka, E. D. Lorenzen, L. F. Lowry, C. Lydersen , C. J. D. Matthews, I. G. Meschersky, A. Mosnier, G. O'Corry-Crowe, L. Postma, L. T. Quakenbush, O. V. Shpak, M. Skovrind, R. S. Suydam, and C. A. Watt. 2019. Global review of the conservation status of monodontid stocks. Mar. Fish. Rev. 81(3–4):1–53 (doi: https://doi.org/10.7755/MFR.81.3-4.1).

Istomin, I. G., V. A. Tatarnikov, K. A. Zharikov, T. Miyashita, and V. V. Akishin. 2013. Observations of cetaceans in the sea of Okhotsk in 2009–2010. Research of water biological resources of Kamchatka and North–West Pacific. KamchatNIRO 28:116–128 [in Russ.].

IWC. 2000. Report of the Sub-Committee on Small Cetaceans. J. Cetacean Res. Manage. 2 (Suppl.), Annex 1:235–263.

Kleinenberg, S. E., A. V. Yablokov, B. M. Bel'kovich, and V. M. Tarasevich. 1964. Beluga (*Delphinapterus leucas*): Investigation of the species. Acad. Sci. USSR. Moscow, 456 p. [in Russ.].

Klumov, S. K. 1939. The belukha of the Soviet North (resource and harvest). Trudy VNIRO 12, 78 p. [in Russ.].

Kochnev, A. A. 2003. On migrations and seasonal distribution of the beluga whales *Delphinapterus leucas* in the Chukchi and East Siberian Seas. Zoologicheskiy Zhurnal 82(9):1112–1121 [in Russ.].

Litovka, D. I. 2002. Distribution of the Beluga *Delphinapterus leucas* in the Anadyr Estuary in 2000. Russ. J. Mar. Biol. 28(4):263–266 (doi: https://doi.org/10.1023/A:1020277211821).

______________, P. Yu. Andronov, and R. L. Batanov. 2013. Seasonal distribution of beluga whales *Delphinapterus leucas* depending on prey concentrations in coastal waters of the north-western Bering Sea. Research of water biological resources of Kamchatka and North-West Pacific. KamchatNIRO 28:50–71 [in Russ.].

Matishov, G. G., and G. N. Ognetov. 2006. The white whale *Delphinapterus leucas* of the Russia Arctic seas: biology, ecology, protection and exploitation of resources. Apatity: Kola Science Center of RAS, 295 p. [in Russ.].

Melnikov, V. V. 2014. Distribution, seasonal migrations and abundance of the beluga whale (*Delphinapterus leucas Linnaeus,* 1758) of the Pacific sector of the Arctic. Research of water biological resources of Kamchatka and North-West Pacific. KamchatNIRO 35:87–102 [in Russ.] (doi: 15853/2072-8212.2014.35.87-102).

Meschersky, I. G., O. V. Shpak, D. I. Litovka, D. M. Glazov, E. A. Borisova, and V. V. Rozhnov. 2013. A genetic analysis of the beluga whale *Delphinapterus leucas* (Cetacea: Monodontidae) from summer aggregations in the Russian Far East. Russ. J. Mar. Biol.

39(2):125–135 (doi: https://doi.org/10.1134/S1063074013020065).
______________, A. D. Chernetsky, V. V. Krasnova, B. A. Solovyev, D. A. Udovik, O. V. Shpak, D. M. Glazov, and V. V. Rozhnov. 2018. Mitochondrial lineages of the beluga whale *Delphinapterus leucas* in the Russian Arctic. Biol. Bull. 45(2):147–154 (doi: https://doi.org/10.1134/S1062359018020073).

O'Corry-Crowe, G. M., R. S. Suydam, A. Rosenberg, K. J. Frost, and A. E. Dizon. 1997. Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western Nearctic revealed by mitochondrial DNA. Mol. Ecol. 6:955–970 (doi: https://doi.org/10.1046/j.1365-294X.1997.00267.x).

_________, ____________, L. Quakenbush, B. Potgieter, L. Harwood, D. Litovka, T. Ferrer, J. Citta, V. Burkanov, K. Frost, and B. Mahoney. 2018. Migratory culture, population structure and stock identity in North Pacific beluga whales (*Delphinapterus leucas*). PLoS One. 2018 Mar 22:13(3):e0194201 (doi: https://doi.org/10.1371/journal.pone.0194201).

Prasolova, E. A., R. A. Belikov, A. A. Ryabov, and D. I. Litovka. 2014. Results on photo identification for beluga whale *Delphinapterus leucas* in the Anadyr estuary of the Bering Sea. Izvestiya TINRO 179:120–128 [in Russ.].

Pritchard, J. K., M. Stephen, and P. Donnelly. 2000. Inference of population structure using multilocus genotype data. Genetics 155:945–959 (avail. at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1461096/pdf/10835412.pdf).

Richard, P. R., J. R. Orr, and A. R. Martin. 2001. Summer and autumn movements of belugas of the eastern Beaufort Sea stock. Arctic 54:223–236 (doi: https://doi.org/10.14430/arctic783).

Sato, H., and M. Ichimura. 2011. The sighting record of beluga (white whale) *Delphinapterus leucas* in Shiretoko–Nemuro Strait water, Eastern Hokkaido, Japan. Bull. Shiretoko Mus. 32:45–52 (avail. at http://shiretoko-museum.mydns.jp/_media/shuppan/kempo/3209s_sato-ichimura.pdf).

Schlötterer, C., B. Amos, and D. Tautz. 1991. Conservation of polymorphic simple sequence loci in cetacean species. Nature 354:63−65 (doi: https://doi.org/10.1038/354063a0).

Shpak, O. V., R. D. Andrews, D. M. Glazov, D. I. Litovka, R. C. Hobbs, and L. M. Mukhametov. 2010. Seasonal migrations of Sea of Okhotsk beluga whales (*Delphinapterus leucas*) of the Sakhalin-Amur summer aggregation. Russ. J. Mar. Biol. 36(1):56–62 (doi: https://doi.org/10.1134/S1063074010010074).

___________ and D. M. Glazov. 2013. Sustainable commercial use of beluga whales (*Delphinapterus leucas*) in the northern Sea of Okhotsk and western Kamchatka zones. Rybnoe Khoziaystvo 6:54–61 [in Russ.].

Solovyev, B. A, I. A. Zagrebin, D. M. Glazov, D. I. Litovka, and A. V. Kosyak. 2013. Results of ashore observations on beluga whale (*Delphinapterus leucas*) in Chukotka waters. Izvestiya TINRO 174:149–157 [in Russ.].

__________, O. V. Shpak, D. M. Glazov, V. V. Rozhnov, and D. M. Kuznetsova. 2015. Summer distribution of beluga whales (*Delphinapterus leucas*) in the Sea of Okhotsk. Russ. J. Theriol. 14(2):201–215 (avail. at http://kmkjournals.com/journals/RJT/RJT_Index_Volumes).

Valsecchi, E., and W. Amos. 1996. Microsatellite markers for the study of cetacean populations. Mol. Ecol. 5:151–156 (doi: https://doi.org/10.1111/j.1365-294X.1996.tb00301.x).

Vladimirov, V. A. 1994. The modern distribution and abundance of whales in Far Eastern Russian seas. Biologiya Morya 20(1):3–13 [in Russ.].

______________ and V. V. Melnikov. 1987. Distribution and abundance of the beluga in the Okhotsk Sea. Biologiya Morya 5:65–69 [in Russ.].