

# Historical catch series for Antarctic and pygmy blue whales

T.A. BRANCH<sup>1</sup>, C. ALLISON<sup>2</sup>, Y.A. MIKHALEV<sup>3</sup>, D. TORMOSOV<sup>4</sup> & R.L. BROWNELL, JR<sup>5</sup>.

## ABSTRACT

Worldwide catch series are presented for blue whales during the modern whaling period (1868–1878), divided into five populations. There are only a handful of documented catches of blue whales prior to this period, and none afterwards. The data come from the IWC summary annual catch database and the IWC individual whale catch database, and correct for Soviet misreporting of blue whale catches in the late 1950s to early 1970s. Greatest emphasis is placed on obtaining updated catch series for Antarctic and pygmy blue whales, splitting them according to recent estimates of the proportion of each subspecies in different areas of the Southern Hemisphere and northern Indian Ocean. The total worldwide catches of blue whales were 382,595, of which 90.4% were Antarctic blue whales (345,775), 3.4% were pygmy blue whales (13,022), 1.4% were from the South-east Pacific (5,383), 2.1% were from the North Pacific (7,973) and 2.7% from the North Atlantic (10,442). These catch series are preliminary and no adjustment is made for struck and lost whales, except for a small fraction of the total that were reported to the IWC.

## INTRODUCTION

To assess the current status of cetacean populations, three important pieces of information are required: historical catch series, a rate of increase, and an estimate of the current abundance. In the 1990s, it was revealed that the USSR conducted a widespread program of illegal whaling during the 1950s to early 1970s, and misreported to the IWC their catches of many species, including blue whales (Zemsky and Sazhinov, 1982; Yablokov, 1994; Zemsky *et al.*, 1995; Zemsky *et al.*, 1996; Mikhalev, 1997; Yablokov *et al.*, 1998; Mikhalev, 2000). Since then, many of the original logbooks have been recovered and the correct total catches are now included in the IWC's annual summary database.

To further the assessment of Antarctic blue whales, a corrected catch series is produced here based on the updated catch data. This paper produces catch series for blue whales in the North Pacific, North Atlantic, South-east Pacific, pygmy blue whales (mainly in the Indian Ocean), and Antarctic blue whales (mainly in the Southern Ocean and South Atlantic). The primary emphasis of this paper is to obtain a preliminary catch series for Antarctic and pygmy blue whales, and to a lesser extent for South-east Pacific blue whales. Relatively little effort was expended to produce the catch series for the North Pacific and North Atlantic, or to examine the revised Soviet catch data in those two areas.

## METHODS

### IWC catch databases

Data were made available from the 11 February 2008 release (C. Allison, version 3.5) of the IWC data, comprising two databases. The annual database contains summaries of the total number of whales of each species caught by expedition, region, whaling country, and general location. The total number of blue whales in this database is 381,684 worldwide, although there are an additional 32,800 catches where the species was unspecified. This summary catch database is used as the basis for the catch series. The second database, the individual database, contains information for each whale, including the position, sex, species, pregnancy status and many other details. Fewer records are included in this second database, especially for the years prior to about 1920, but the individual database still contains information for 317,048 blue whales worldwide (83.1% of the total identified). The individual catch database is used to assess where catches were taken and to decide to which blue whale group to assign the catches.

Each of the regions in the database (land stations in the North Pacific, North Atlantic, South Pacific, South Atlantic, and Indian Ocean, and pelagic whaling throughout the Southern Hemisphere) is divided in this paper so as to represent the major populations of blue whales around the world. Taxonomically, the recognised subspecies are northern blue whales in the North Pacific and North Atlantic (*Balaenoptera musculus musculus*), pygmy blue whales mainly in the Indian Ocean (*B. m. breviceauda*), and Antarctic blue whales mainly in the South Atlantic and Southern Ocean (*B. m. intermedia*). Recently, it has been suggested that South-east Pacific blue whales may be distinct from pygmy and Antarctic blue whales and should therefore be managed separately (Branch *et al.*, 2007a), based on evidence from length frequencies (Branch *et al.*, 2007a), geographic distribution (Branch *et al.*, 2007b), acoustics (McDonald *et al.*, 2006), and genetics (LeDuc *et al.*, 2007).

<sup>1</sup> 20504 86<sup>th</sup> Pl, Edmonds WA 98026, USA, e-mail: tbranch@gmail.com

<sup>2</sup> International Whaling Commission, The Red House, 135 Station Road, Impington, Cambridge, CB4 9NP, UK

<sup>3</sup> South-Ukrainian Pedagogical University, Solnechnaya 10, no. 45, Odessa 65009, Ukraine

<sup>4</sup> Ulitsa Karla Marksa, D.76 KV5, Kaliningrad 236000, Russian Federation

<sup>5</sup> Southwest Fisheries Science Center, NOAA Fisheries, 1352 Lighthouse Avenue, Pacific Grove, CA 93950-2097, USA

In this paper, catch series are developed for the following groupings: North Pacific, North Atlantic, South-east Pacific, pygmy blue whales and Antarctic blue whales. These groupings are defined for obvious reasons, either geographic (North Pacific vs. North Atlantic) or taxonomic (pygmy vs. Antarctic).

#### **North Pacific**

This catch series is based solely on the summary catch database. No adjustments are made for the 10,219 catches with unspecified species, out of 1,133,851 catches in total. It should be noted that 558 catches taken by the USSR in 1960 to 1965 are footnoted in the database as being falsified, and corrected catches have not yet been obtained and entered. The resulting catch series includes 7,973 blue whales caught between 1905 and 1965.

#### **North Atlantic**

This catch series is also based only on the summary catch database, with no adjustments made for the 2,458 catches with unspecified species out of 614,295 catches of all species. No catches were taken by the USSR in this region. The resulting catch series includes 10,442 blue whales caught between 1868 and 1978.

#### **South Pacific**

In the IWC catch database, catches from this region include some from New Zealand and eastern Australia. No adjustment is made for the 1,849 unspecified catches out of 305,925 of all species. One catch in 1910 was listed under South Shetland / South Chile and has been assigned to Antarctic blue whales. Catches in New Zealand ( $n = 6$ ) and eastern Australia ( $n = 2$ ) were assumed to be pygmy blue whale catches, primarily on the basis that Soviet expeditions recorded catches in this region as being pygmy blue whales (Zemsky and Sazhinov, 1982). Note however, that catches, strandings, sightings and acoustic detections from New Zealand and the South-west Pacific islands appear to be geographically separate from pygmy blue whales off southern Australia (McDonald, 2006; Branch *et al.*, 2007b). The remaining 5,383 catches between 1908 and 1971 were recorded as occurring in Peru, Ecuador and Chile, and comprise the preliminary South-east Pacific catch series.

#### **South Atlantic**

These catches were almost exclusively taken off the west coast of Africa: Congo ( $n = 1$ ), Angola ( $n = 1,918$ ), Namibia ( $n = 1,863$ ), and western South Africa ( $n = 8,059$ ), although Brazil also recorded catches ( $n = 2$ ). There were no unspecified catches from this region. Analysis of length frequencies of the south-western African catches, excluding unreliable data from the 1914 Hangklip station, provided an estimate that 3.9% of these blue whales were pygmy blue whales, although the sample size was small ( $n = 56$ ) and the 95% credibility intervals (0.6–10.7%) were broad (Branch *et al.*, 2007a). Therefore, 3.9% of all blue whales off Congo, Angola, Namibia and western South Africa were assumed to be pygmy blue whales ( $n = 458$ ), while the rest were assumed to be Antarctic blue whales ( $n = 11,385$ ).

#### **Indian Ocean (largely Durban)**

Blue whale catches classified as “Indian Ocean” were taken from land stations around the Indian Ocean and from a few pelagic expeditions off southern Africa. All those taken off Australia ( $n = 38$ ), Madagascar ( $n = 2$ ), Mozambique ( $n = 14$ ) and in pelagic waters ( $n = 6$ ) were assumed to be pygmy blue whales, based on the high abundance of pygmy blue whales sighted off southern Madagascar in 1996 (Best *et al.*, 2003), and a variety of genetic, acoustic and morphological measurements (Branch *et al.*, 2007b). One blue whale in the database recorded off western Australia in May 1973 was excluded since this whale was not caught, it washed ashore and was processed. All of the remaining whales were taken off eastern South Africa, mostly from Durban (1910–1966,  $n = 3,211$ ), but also during a brief period from Mossel Bay (1911–1913,  $n = 112$ ) and Plettenberg Bay (1913–1916,  $n = 305$ ). No morphological measurements were recorded from Mossel Bay or Plettenberg Bay; for the analyses these whales were assumed to be similar to those caught off Durban.

#### *Durban (including Mossel Bay and Plettenberg Bay)*

These whales caught from Durban (and the other two locations) are difficult to assign to subspecies. Length measurements were taken for few pregnant females, only 12 in total, four of which were 75 ft or shorter and indicative of pygmy blue whales (Branch *et al.*, 2007a), but too few pregnant females were measured for a reliable application of the mixture model in Branch *et al.* Nevertheless, they noted a decreasing percentage over time of males and females, both immature and mature, that were > 79 ft, and thus too long to be pygmy blue whales. For females this percentage was 24.1% during 1920–1931, decreasing to 9.1% in 1932–1938 and 8.9% in 1946–1966; for males the respective percentages were 8.8%, 2.7% and 0.0% (Branch *et al.*, 2007a). For comparison, in the presumed Antarctic blue whale catches south of 56°S during 1920–1931, before minimum length regulations were introduced, 70.1% of females and 53.3% of males were longer than 79 ft, although at the time it was recognised that the blue whales at Durban and Saldanha Bay, South Africa, included a high percentage of immature individuals (Mackintosh and Wheeler, 1929).

The arguments for assuming the Durban catches were Antarctic blue whales are as follows: (1) the substantial percentages of blue whales greater than the maximum pygmy length of 79 ft combined with the fact that much higher proportions of blue whales caught at Durban were immature than in the Antarctic, and likely the Antarctic whalers could be more selective in taking the biggest individuals; (2) the length distribution off Durban during 1920–1931 was similar to that at Saldanha Bay, South Africa, where the great majority of blue whales were Antarctic blue whales; (3) catch-per-unit-effort declined until in 1964 it was just 2.8% of the levels in 1920–28 (Best, 2003), more indicative of the decline of Antarctic blue whales to <1%

of their original levels, than indicative of the much less depleted pygmy blue whale population (Branch *et al.*, 2004; Branch *et al.*, 2007a).

The arguments that some of these Durban blue whales were pygmy blue whales comes from (1) four pregnant females that were shorter than 75 ft (Branch *et al.*, 2007a); (2) a record of a pygmy blue whale caught at Durban in 1963 (Gambell, 1964); and (3) catches during 1918–1930 peaked in July when Antarctic blue whales would have migrated to Durban; catches in 1931–1938 peaked in June–July; and catches in 1946–1966 peaked in June but 7% were caught in April compared to <1% in April in the previous periods.

It seems possible that most of the Durban catches in the earlier period were Antarctic blue whales, but that in the later periods a substantial portion of the catches may have been pygmy blue whales. No quantitative measure is attempted here, but a rough guide is used to separate these catches by assuming that up to 1930, 95% of the catches ( $n = 2,707$ ) were Antarctic blue whales; from 1931–1945 ( $n = 745$ ), 70% were Antarctic blue whales; and from 1946–1966 ( $n = 182$ ), 50% were Antarctic blue whales. Following these assumptions, 3,187 of the Durban, Mossel Bay and Plettenberg Bay catches were assigned to Antarctic blue whales and 447 to pygmy blue whales.

#### *Unspecified catches*

Some Indian Ocean catches were listed as “unspecified”. There were 1,711 unspecified catches, compared to 3,687 blue whales and 148,082 in total. The unspecified catches comprised 1.16% of the total, each grouping of unspecified catches is dealt with separately here.

One unspecified catch was recorded from expedition code #6013 in 1937, which operated in the western Indian Ocean. Only 4 of 1258 catches were blue whales, while 1,223 were humpback whales. The unspecified catch was therefore highly unlikely to have been a blue whale and is excluded.

In 1916, 470 unspecified catches were recorded from Albany and Pt Cloates, on the western coast of Australia. During the preceding years (1912–1915), there were 4,916 catches, 8 of which were (pygmy) blue whales (0.16%). Assuming the same proportions in 1916, only one of the unspecified catches was a blue whale, assumed to be a pygmy blue whale.

In 1939, 1,240 unspecified catches and 61 sperm whales were taken in the western Indian Ocean by the Union Whaling Company, expedition code #6013. The same expedition had operated in the same region during 1937 and 1938. Of the non-sperm-whale catches in 1937–1938, 5 out of 3,015 were blue whales (0.17%). Applying this percentage to the 1,240 unspecified catches results in an estimate that 2 blue whales were caught in 1939, which are assumed to be pygmy blue whales.

#### **Southern Hemisphere (including all pelagic catches)**

The pelagic catches include those throughout the Indian Ocean by both Japan and the USSR, those in the South Atlantic islands, especially South Georgia, and catches throughout the Southern Ocean. Pygmy blue whale catches were taken by Japan during the 1959/60–1962/63 seasons after their initial discovery around Kerguelen Islands (Ichihara, 1961, 1963, 1966), and subsequently also by Soviet fleets during 1961/62–1972/73 (Zemsky and Sazhinov, 1982; Zemsky *et al.*, 1995; Zemsky *et al.*, 1996). Additional catches throughout the Indian Ocean north of 52°S and east of 35°E were 99.9% pygmy blue whales, based on analyses of length frequencies of sexually mature females (Branch *et al.*, 2007a). South of 52°S, however, 99.2% (95% credibility intervals 98.9–99.3%) of blue whales were Antarctic blue whales according to length frequencies (Branch *et al.*, 2007a), while according to more precise analyses based on the relationship between length and corpora counts, 99.9% (95% credibility intervals 99.6–100.0%) of the blue whales south of approximately 56°S were Antarctic blue whales (Branch *et al.*, 2008).

For this initial catch series, we first account for the Japanese and Soviet pygmy blue whale catches. Then, of the remaining pelagic catches, all those south of 52°S, west of 35°E or longer than 24.1 m are assumed to be Antarctic blue whales, while the remainder are assumed to be pygmy blue whales.

#### *Unspecified species in Southern Hemisphere catches*

There were many unspecified Southern Hemisphere catches. Unspecified whales accounted for 6,638 of the 1,649,767 Southern Hemisphere catches. The great majority (87.7%) of the unspecified catches were taken during 1906/07–1913/14, chiefly at the South Shetlands and South Georgia, but also at the South Orkneys and Kerguelen Islands. Each location and year is treated separately to estimate the proportion of blue whales that were likely caught. Where possible, the most closely related set of catches is used to estimate the proportion of blue whales among the unspecified catches, preferably from the same expedition or else from catches from all expeditions in the same area and season are used (Table 1). If even these data were not available, catches from the same area and adjacent seasons are used.

The Kerguelen Island catches in 1910 are assumed to be pygmy blue whales since the location is more northerly and is where pygmy blue whales were first caught by the Japanese (Ichihara, 1961, 1963, 1966). Similarly, unspecified catches from the Soviet fleets in 1961, 1965 and 1970 are also assumed to be pygmy blue whales; although the analysis predicts zero blue whales among the Soviet unspecified catches. Out of 6,638 unspecified catches, it was estimated that 3 were pygmy blue whales and 802 were Antarctic blue whales (Table 1).

#### *Japanese pygmy blue whale catches 1959/60 to 1963/64*

Nearly all Japanese pygmy blue whale catches were taken during the 1959/60 to 1962/63 seasons, during which they respectively caught 311, 1127, 388 and 714 pygmy blue whales (Ichihara, 1966). These numbers are generally slightly lower than the values in the IWC individual catch database for catches north of 54°S, probably because some Antarctic blue whales caught north of 54°S that are longer than 24.1 m, were excluded from the numbers presented in Ichihara's account. For 1959/60 to 1962/63 the numbers reported in Ichihara (1966) were preferred. Additional blue whale catches were recorded in later years: 31 pygmy and 7 Antarctic blue whales in 1963/64, 3 pygmy blue whales in 1966/67 and 2 pygmy blue whales in 1969/70 (Brownell and Donaghue, 1994).

#### *Soviet pygmy blue whale catches 1961/62–1972/73*

Not all individual Soviet catches have been recovered for the Southern Hemisphere. After a single catch in 1961/62, catches of pygmy blue whales greatly increased in 1962/63 and continued until 1972/73, when international observers were introduced onto the Soviet vessels. Pygmy blue whale catches for each season were obtained from Zemsky et al. (1996) for the *Slava*, *Sovietskaya Rossia*, and *Yurii Dolgurikiy* expeditions (except that the 765 from the 1964/65 *Slava* expedition was replaced with 764 from the IWC catch database), and from Zemsky et al. (1995) for the *Sovietskaya Ukraina* expedition. Data for the 1970/71 *Sovietskaya Ukraina* expedition was missing from Zemsky et al. (1995), therefore catches for this season were obtained from the IWC catch database, which matched the values in Zemsky and Sazhinov (1982).

Antarctic blue whale catches were obtained by two methods, either by subtracting the pygmy blue whale catches from the annual summaries for each expedition in the IWC catch database (Table 2, Table 3), or by examining the IWC individual catch database and assuming that all blue whales south of 56°S plus those >24.1 m long were Antarctic blue whales. Because the individual catch database only covered a variable fraction of the total catches in the IWC annual summary database, listed in Table 4, whichever method gave the greater estimate of Antarctic blue whale catch was preferred in the Antarctic blue whale catch series (Table 5). The final pygmy blue whale catch series is then obtained by subtracting the Antarctic series from the IWC annual summaries (Table 6). The resulting catch series contains 1,494 Antarctic blue whales and 9,230 pygmy blue whales caught by the Soviet expeditions during 1961/62–1972/73.

#### *Kerguelen catches (1908/09, 1909/10, 1928/29, 1929/30)*

There were 8, 4, and 113 catches in the first three of these seasons respectively. These are all considered to be pygmy blue whales since all blue whales caught here by the Japanese expeditions were pygmy blue whales (Ichihara, 1961, 1963, 1966). In 1929/30 the “Radioline Kerguelen Whale and Seal Company” operated at Kerguelen from July to November and in the Antarctic from January to March, catching 217 blue whales, 18 fin whales and 11 humpback whales. The Kerguelen catches would have been pygmy blue whales and those in the Antarctic, Antarctic blue whales, but there is no easy method to split these catches between Kerguelen and the Antarctic. Splitting by the number of months in each would yield 136 pygmy blue whales; splitting by species composition (based on species caught in the Antarctic during January-March 1930) yields an estimate of 203 pygmy blue whales; splitting according to the average Antarctic blue whale catch in those month by other expeditions implies zero pygmy blue whales. In the absence of any clear criteria, the 1929/30 catches were split “equally”, 108 pygmy blue whales, 109 Antarctic blue whales.

#### *Remainder of the Southern Hemisphere*

Other Southern Hemisphere catches not included in the Japanese and Soviet pygmy whaling years, or in Kerguelen waters, were analysed as follows: all these blue whales were assumed to be Antarctic blue whales unless they satisfied these criteria: (1) north of 52°S and east of 35°S, and (2)  $\leq 24.1$  m in length. The determination was made from the IWC individual catch database based on the findings that 99.9% of blue whales in this region were pygmy blue whales (Branch *et al.*, 2007a). This process added the following to the pygmy blue whale series: 1934 ( $n = 9$ ), 1935 ( $n = 1$ ), and 1937 ( $n = 1$ ).

## **RESULTS**

The IWC annual catch database contains annual summaries of 382,595 blue whale catches globally that were caught between 1868 and 1978 (Table 7). Of these, 7,973 were in the North Pacific (2.09%), 10,442 in the North Atlantic (2.73%), 5,383 in the South-east Pacific (1.41%), while an estimated 13,022 were pygmy blue whales (3.40% of the global catch), and 345,775 were Antarctic blue whales (90.40%). The peak of the catches was in 1930/31 when 30,727 blue whale were caught worldwide, 98.8% of which were Antarctic blue whales.

## **DISCUSSION**

### **Total catches in each region**

The total number of Antarctic blue whales, 345,775, is greater than the 329,623 catches included in the previous assessment of Antarctic blue whales (Branch *et al.*, 2004) because catches north of 40°S are included in this catch series but were previously excluded.

The total estimate of 13,022 for pygmy blue whales is greater than the 11,753 reported in Brownell and Donaghue (1994). The total Japanese catch is increased by 2 (the 1969/70 catches were inadvertently omitted in Brownell and Donaghue), the total Soviet catch is increased from 9,179 to 9,230 using the methods described above, and pygmy blue whale catches were

added from Australia, New Zealand, the South Atlantic (mainly the west coast of South Africa), the Indian Ocean (mainly the east coast of South Africa) and the Kerguelen Islands.

Catches of unspecified species were examined in detail for Antarctic and pygmy blue whales, i.e. all catches recorded in the South Atlantic, Indian Ocean and Southern Hemisphere. But unspecified catches in the North Pacific ( $n = 10,219$ ), North Atlantic ( $n = 2,458$ ) and South-east Pacific ( $n = 1,849$ ) have not been analysed in this paper; if taken into account the blue whale catch series for those three regions would increase.

### **Adjustment for struck and lost**

Only partial account is taken of blue whales that were harpooned, but not flagged, or were killed but lost after being flagged or while in tow. The IWC catch database does include some “struck and lost” blue whales (344 out of 317,048 in the individual catch database, or 0.11% of the total), but these include only a small fraction of the true number. A future analysis is planned to examine the struck and lost proportions for expeditions where these were recorded, and apply the proportions to expeditions where none were reported.

Previous analyses have provided quite divergent estimates of struck and loss percentages. At Akutan and Port Hobron, Alaska during 1917–1939 the struck and lost correction factor was estimated to be 1.02 for blue, fin, humpback and sperm whales (Reeves *et al.*, 1985). From a Newfoundland station this factor was estimated to be 1.06 for humpback whales, assumed by them to apply to 1898–1971 (Mitchell and Reeves, 1983). Progress reports from nations currently whaling also report struck and lost percentages. For example, in 2005/06 and 2006/07, 853 Antarctic minke whales were killed and three struck and lost, for a correction factor of 1.003 (Fujise *et al.*, 2007).

Tønnessen and Johnsen (1982) include several estimates of struck and lost factors for different time periods and regions, but these are mostly anecdotal. On p. 83, they suggest that 1.30 would have been appropriate for Iceland (1883–1915) and North Norway (1868–1904), but note further that subsequently the loss of whales are almost entirely eliminated. On p. 332–337, they mention discussion that in Norway before 1935, a factor of 1.22–1.25 was likely, while in the Antarctic they assume 1.1 was possible up to 1931. Some seasons were worse than others. Immediately after World War II, there was trouble obtaining good quality lines, and on p. 507 Tønnessen and Johnsen suggests that a correction factor for that season should be 1.25–1.43.

These accounts taken together, suggest that struck and lost rates could require a correction factor as high as 1.10–1.30 in the early years (up to say 1930), but that this was much reduced in more recent years to 1.003–1.06 in more recent years.

### **Relative status of blue whale populations**

Five catch series are presented here. Although it is not possible to conduct complete assessments of each population, their relative status can be inferred from the ratio of current abundance to total catches. If the rate of increase for the population was zero, this would reflect the current depletion levels; if, as is more likely, the rates of increase are positive, then these ratios are a lower bound on current depletion levels. For Antarctic blue whales, the current abundance is 2,280 (Branch, 2008), and the ratio is 0.7%. For pygmy blue whales, a minimum current abundance is the sum of 424 (Best *et al.*, 2003) and 671 (Kato *et al.*, 2007), and the ratio is therefore >8%. For South-east Pacific blue whales, a partial estimate of 452 based on non-random survey effort (Branch *et al.*, 2007c), implies a ratio of >8%. For the North Pacific, current abundance is ~1,000 in the west and 3,000 in the east (Calambokidis and Barlow, 2004), providing a ratio of 50%. For the North Atlantic, photographs have been taken of at least 400 in the Gulf of St Lawrence (Ramp *et al.*, 2006) plus 1,100–1,900 in the central North Pacific (Pike *et al.*, 2004), resulting in a ratio of >14–22%. The abundance estimates cited above do not refer to the entire populations, and several have associated issues of bias. Nevertheless, it is clear that Antarctic blue whales remain far more depleted than the other populations.

## **ACKNOWLEDGEMENTS**

T.A.B. is grateful for funding for this project from the International Whaling Commission.

## **REFERENCES**

- Best, P.B. 2003. How low did they go? An historical comparison of indices of abundance for some baleen whales on the Durban whaling ground. *IWC Paper SC/55/SH18*.
- Best, P.B., Rademeyer, R.A., Burton, C., Ljungblad, D., Sekiguchi, K., Shimada, H., Thiele, D., Reeb, D. and Butterworth, D.S. 2003. The abundance of blue whales on the Madagascar Plateau, December 1996. *J. Cetacean Res. Manage.* 5:253-260.
- Branch, T.A. 2008. Abundance of Antarctic blue whales south of 60°S from three complete circumpolar sets of surveys. *J. Cetacean Res. Manage.* 9:87-96.
- Branch, T.A., Abubaker, E.M.N., Mkango, S. and Butterworth, D.S. 2007a. Separating southern blue whale subspecies based on length frequencies of sexually mature females. *Mar. Mamm. Sci.* 23:803-833.
- Branch, T.A., Matsuoka, K. and Miyashita, T. 2004. Evidence for increases in Antarctic blue whales based on Bayesian modelling. *Mar. Mamm. Sci.* 20:726-754.

- Branch, T.A., Mikhalev, Y.A. and Kato, H. 2008. Separating pygmy and Antarctic blue whales using long-forgotten ovarian data. *IWC Paper SC/60/For Info 12*.
- Branch, T.A., Stafford, K.M., Palacios, D.M., Allison, C., Bannister, J.L., Burton, C.L.K., Cabrera, E., Carlson, C.A., Galletti Vernazzani, B., Gill, P.C., Hucke-Gaete, R., Jenner, K.C.S., Jenner, M.-N.M., Matsuoka, K., Mikhalev, Y.A., Miyashita, T., Morrice, M.G., Nishiwaki, S., Sturrock, V.J., Tormosov, D., Anderson, R.C., Baker, A.N., Best, P.B., Borsa, P., Brownell Jr, R.L., Childerhouse, S., Findlay, K.P., Gerrodette, T., Ilangakoon, A.D., Joergensen, M., Kahn, B., Ljungblad, D.K., Maughan, B., McCauley, R.D., McKay, S., Norris, T.F., Oman Whale and Dolphin Research Group, Rankin, S., Samaran, F., Thiele, D., Van Waerebeek, K. and Warneke, R.M. 2007b. Past and present distribution, densities and movements of blue whales *Balaenoptera musculus* in the Southern Hemisphere and northern Indian Ocean. *Mammal Rev.* 37:116-175.
- Branch, T.A., Zerbini, A.N. and Findlay, K. 2007c. Abundance of blue whales off Chile from the 1997/98 SOWER survey. *IWC Paper SC/59/SH8:9pp*.
- Brownell, R.L.J. and Donaghue, M.A. 1994. Southern Hemisphere pelagic whaling for pygmy blue whales: review of catch statistics. *IWC Paper SC/46/SH6:9pp*.
- Calambokidis, J. and Barlow, J. 2004. Abundance of blue and humpback whales in the Eastern North Pacific estimated by capture-recapture and line-transect methods. *Mar. Mamm. Sci.* 20:63-85.
- Fujise, Y., Pastene, L.A., Hatanaka, H., Ohsumi, S. and Miyashita, T. 2007. Evaluation of 2005/06 and 2006/07 feasibility study of the second phase of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA II). *IWC Paper SC/59/O3:23pp*.
- Gambell, R.G. 1964. A pygmy blue whale at Durban. *Norsk Hvalfangst-Tidende* 53:66-68.
- Ichihara, T. 1961. Blue whales in the waters around Kerguelen Island. *Norsk Hvalfangst-Tidende* 50(1):1-20.
- Ichihara, T. 1963. Identification of the pigmy blue whale in the Antarctic. *Norsk Hvalfangst-Tidende* 52(6):128-130.
- Ichihara, T. 1966. The pygmy blue whale, *Balaenoptera musculus breviceauda*, a new subspecies from the Antarctic. Pages 79-111 in K. S. Norris, editor. Whales, dolphins, and porpoises. University of California Press, Berkeley and Los Angeles.
- Kato, H., Matsuoka, K., Nishiwaki, S. and Bannister, J.L. 2007. Distributions and abundances of pygmy blue whales and southern right whales in waters off southern coast of Australia, based on data from the JAPAN/IWC blue whale cruise 1995-96. *IWC Paper SC/59/SH10:14pp*.
- LeDuc, R.G., Dizon, A.E., Goto, M., Pastene, L.A., Kato, H., Nishiwaki, S., LeDuc, C.A. and Brownell, R.L. 2007. Patterns of genetic variation in Southern Hemisphere blue whales and the use of assignment test to detect mixing on the feeding grounds. *J. Cetacean Res. Manage.* 9:73-80.
- Mackintosh, N.A. and Wheeler, J.F.G. 1929. Southern blue and fin whales. *Discovery Reports* 1:257-540.
- McDonald, M.A. 2006. An acoustic survey of baleen whales off Great Barrier Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 40:519-529.
- McDonald, M.A., Hildebrand, J.A. and Mesnick, S.L. 2006. Biogeographic characterization of blue whale song worldwide: using song to identify populations. *J. Cetacean Res. Manage.* 8:55-65.
- Mikhalev, Y.A. 1997. Additional information about the catches of Soviet whaling fleet *Sovetskaya Ukraina*. *Rep Int Whal Commn* 47:147-150.
- Mikhalev, Y.A. 2000. Whaling in the Arabian Sea by the whaling fleets *Slava* and *Sovetskaya Ukraina*. Pages 141-181 in A. V. Yablokov and V. A. Zemsky, editors. Soviet Whaling Data (1949-1979). Center for Russian Environmental Policy Marine Mammal Council, Moscow.
- Mitchell, E. and Reeves, R.R. 1983. Catch history, abundance, and present status of northwest Atlantic humpback whales. *Rep Int Whal Commn (Spec Iss)* 5:153-212.
- Pike, D.G., Vikingsson, G.A. and Gunnlaugsson, T. 2004. Abundance estimates for blue whales *Balaenoptera musculus* in Icelandic and adjacent waters. *IWC Paper SC/56/O6:10pp*.
- Ramp, C., Bérubé, M., Hagren, W. and Sears, R. 2006. Survival in blue whales *Balaenoptera musculus* in the Gulf of St. Lawrence, Canada. *Mar. Ecol. Prog. Ser.* 319:287-295.
- Reeves, R.R., Leatherwood, S., Karl, S.A. and Yohe, E.R. 1985. Whaling results at Akutan (1912-39) and Port Hobron (1926-37), Alaska. *Rep Int Whal Commn* 35:441-457.
- Tønnessen, J.N. and Johnsen, A.O. 1982. *The history of modern whaling*. C. Hurst & Co., London.
- Yablokov, A.V. 1994. Validity of whaling data. *Nature* 367:108.
- Yablokov, A.V., Zemsky, V.A., Mikhalev, Y.A., Tormosov, V.V. and Berzin, A.A. 1998. Data on Soviet whaling in the Antarctic in 1947-1972 (population aspects). *Russian Journal of Ecology* 29:38-42.
- Zemsky, V.A., Berzin, A.A., Mikhalev, Y.A. and Tormosov, D.D. 1995. Soviet Antarctic pelagic whaling after WWII: review of actual catch data. *Rep Int Whal Commn* 45:131-135.
- Zemsky, V.A., Mikhalev, Y.A. and Berzin, A.A. 1996. Supplementary information about Soviet whaling in the Southern Hemisphere. *Rep Int Whal Commn* 46:131-138.
- Zemsky, V.A. and Sazhinov, E.G. 1982. Distribution and current abundance of pygmy blue whales. Pages 53-70 in V. A. Arsen'ev, editor. Marine Mammals. All-Union Research Institute of Marine Fisheries and Oceanography, Moscow. Translated by V.S. Gurevich in February 1994, translation edited by M.A. Donahue and R.L. Brownell, Jr., as

**Table 1.** Treatment of catches with unspecified species in the Southern Hemisphere, listing the region and expedition number (0=none), season and number of unspecified catches; the comparative seasons (or the same expedition) used to obtain the fraction of blue whales caught compared to all specified catches; and the implied blue whale catches, both pygmy and Antarctic blue whale subspecies. Implied = Blue / All × Unsp

Region	Unspecified species			Comparison		Implied blue catches		
	Expedition	Season	Unsp	Seasons	Blue	All	Pygmy	Antarctic
Kerguelen	0	1910	87	1908–1910	14	355	3	
South Orkneys	0	1912	127	1911–1915	389	2,207		22
South Shetlands	5030	1906	300	1908–1908	22	392		17
South Shetlands	0+5290	1910	481	1910–1910	269	2,988		43
South Shetlands	5051+5210	1911	823	1911–1911	876	3,964		182
South Shetlands	0	1913	3	1913–1913	1,703	5,256		1
S. Shetl. / S. Chile	0	1906	128	1905–1907	164	802		26
S. Shetl. / S. Chile	0	1907	600	1906–1908	352	2,223		95
S. Shetl. / S. Chile	250	1911	103	1909–1913	13	1,021		1
South Georgia	0+5200+180	1910	2193	1909–1911	367	14,387		56
South Georgia	5200+5220	1912	944	1912–1912	233	3,911		56
South Georgia	5220	1913	32	1913–1913	940	3,351		9
South Georgia	80	1938	4	1938–1938	233	1,679		1
South Georgia	80	1939	6	1939–1939	88	1,196		0
South Georgia	80	1955	1	1955–1955	3	3,049		0
Antarctic	5690	1929	1	Expedition	136	250		1
Antarctic	5700	1929	9	Expedition	422	474		8
Antarctic	6010	1939	703	1939–1939	11,407	31,052		258
Antarctic	0	1940	26	Expedition	502	2,017		6
Antarctic	5630	1946	6	Expedition	662	1,510		3
Antarctic	5940	1946	15	Expedition	648	1,890		5
Antarctic	6061	1946	5	Expedition	396	685		3
Antarctic	6290	1946	5	Expedition	297	490		3
Antarctic	5630	1947	3	Expedition	268	1,471		1
Antarctic	6190	1947	9	Expedition	394	2,452		1
Antarctic	6301	1948	3	Expedition	213	1,113		1
Antarctic	6340	1948	10	Expedition	474	1,889		3
Antarctic	5630	1949	1	Expedition	143	1,730		0
USSR pelagic SH	6490	1961	8	Expedition	120	4,162	0	
USSR pelagic SH	6490	1965	1	Expedition	93	5,823	0	
USSR pelagic SH	6460	1970	1	Expedition	2	3,304	0	
<b>Total</b>			<b>6,638</b>				<b>3</b>	<b>802</b>

**Table 2.** Number of pygmy blue whales caught by each Soviet expedition from Zemsky *et al.* (1995; 1996) and the IWC catch database (see text for details).

Season	<i>Sovetskaya</i>		<i>Yury</i>	<i>Sovetskaya</i>	Total
	<i>Slava</i>	<i>Rossia</i>	<i>Dolgoruky</i>	<i>Ukraina</i>	
1961/62			1		1
1962/63	189		488		677
1963/64	243	507	503	40	1,293
1964/65	794	7	488	1,818	3,107
1965/66	466	88		312	866
1966/67		224		46	270
1967/68		22	7	310	339
1968/69		94	464	21	579
1969/70		68	265	544	877
1970/71		192		607	799
1971/72		449		71	520
1972/73		2		2	4
Total	1,692	1,653	2,216	3,771	9,332

**Table 3.** Total number of blue whales (both subspecies) caught by Soviet expeditions during 1961/62–1972/73 recorded in the IWC annual summary catch database.

Season	<i>Sovetskaya</i>		<i>Yury</i>	<i>Sovetskaya</i>	Total
	<i>Slava</i>	<i>Rossia</i>	<i>Dolgoruky</i>	<i>Ukraina</i>	
1961/62	45	120	38	75	278
1962/63	189	107	572	105	973
1963/64	251	530	598	52	1,431
1964/65	794	86	507	1,843	3,230
1965/66	471	93	38	418	1,020
1966/67		258	50	112	420
1967/68		34	43	319	396
1968/69		113	475	86	674
1969/70		92	275	551	918
1970/71		225	2	607	834
1971/72		455	12	76	543
1972/73		3	2	2	7
Total	1,750	2,116	2,612	4,246	10,724

**Table 4.** Percentage of total Soviet blue whale catches that are included in the IWC individual catch database. Grey colors indicate expedition-season combinations for which no pygmy blue whales were recorded.

Season	<i>Sovetskaya</i>		<i>Yury</i>	<i>Sovetskaya</i>
	<i>Slava</i>	<i>Rossia</i>	<i>Dolgoruky</i>	<i>Ukraina</i>
1961/62	100.0%	100.0%	97.4%	100.0%
1962/63	100.0%	0.0%	14.7%	100.0%
1963/64	100.0%	1.9%	15.9%	100.0%
1964/65	100.0%	91.9%	3.7%	91.7%
1965/66	72.0%	0.0%	100.0%	99.5%
1966/67		60.1%	100.0%	79.5%
1967/68		41.2%	83.7%	38.2%
1968/69		0.0%	2.3%	75.6%
1969/70		32.6%	3.6%	0.2%
1970/71		14.7%	100.0%	6.1%
1971/72		0.4%	100.0%	17.1%
1972/73		33.3%	100.0%	0.0%

**Table 5.** Final Soviet catch series for Antarctic blue whales, obtained by either (A) subtracting Table 2 from Table 3, or (B) blue whale catches from the IWC individual catch database that were south of 56°S or >24.1m in length; numbers in bold indicate where method B was preferred because the estimates were higher than from method A.

Season	<i>Sovetskaya</i>		<i>Yury</i>	<i>Sovetskaya</i>	
	<i>Slava</i>	<i>Rossia</i>	<i>Dolgoruky</i>	<i>Ukraina</i>	Total
1961/62	45	120	37	75	277
1962/63	<b>54</b>	107	84	105	350
1963/64	<b>13</b>	23	95	<b>40</b>	171
1964/65	<b>2</b>	79	19	25	125
1965/66	<b>8</b>	5	38	106	157
1966/67		<b>35</b>	50	<b>67</b>	152
1967/68		12	36	9	57
1968/69		19	11	65	95
1969/70		<b>30</b>	10	7	47
1970/71		33	2	<b>2</b>	37
1971/72		6	12	5	23
1972/73		1	2	0	3
Total	122	470	396	506	1,494

**Table 6.** Final Soviet catch series for pygmy blue whales, obtained by subtracting Table 5 from Table 3.

Season	<i>Sovetskaya</i>		<i>Yury</i>	<i>Sovetskaya</i>	
	<i>Slava</i>	<i>Rossia</i>	<i>Dolgoruky</i>	<i>Ukraina</i>	Total
1961/62	0	0	1	0	1
1962/63	135	0	488	0	623
1963/64	238	507	503	12	1,260
1964/65	792	7	488	1,818	3,105
1965/66	463	88	0	312	863
1966/67		223	0	45	268
1967/68		22	7	310	339
1968/69		94	464	21	579
1969/70		62	265	544	871
1970/71		192	0	605	797
1971/72		449	0	71	520
1972/73		2	0	2	4
Total	1,628	1,646	2,216	3,740	9,230

**Table 7.** Final catch series for blue whales in all categories. The year refers to the start year of the season for the Antarctic catches. If Southern Hemisphere summer catches in a particular location were mostly after 1 July then all those catches would be allocated to the Antarctic season starting in that year, if mostly before 1 July then all those catches would be allocated to the preceding Antarctic season. \*No adjustment for catches of unspecified species.

Year	N		SE	Pygmy blue	Antarctic blue	Total
	Pacific*	Atlantic*	Atlantic*			
1868	0	30	0	0	0	30
1869	0	17	0	0	0	17
1870	0	36	0	0	0	36
1871	0	20	0	0	0	20
1872	0	40	0	0	0	40
1873	0	36	0	0	0	36
1874	0	0	0	0	0	0
1875	0	0	0	0	0	0
1876	0	42	0	0	0	42

1877	0	28	0	0	0	28
1878	0	26	0	0	0	26
1879	0	90	0	0	0	90
1880	0	113	0	0	0	113
1881	0	221	0	0	0	221
1882	0	101	0	0	0	101
1883	0	186	0	0	0	186
1884	0	170	0	0	0	170
1885	0	60	0	0	0	60
1886	0	149	0	0	0	149
1887	0	109	0	0	0	109
1888	0	79	0	0	0	79
1889	0	44	0	0	0	44
1890	0	109	0	0	0	109
1891	0	109	0	0	0	109
1892	0	125	0	0	0	125
1893	0	147	0	0	0	147
1894	0	251	0	0	0	251
1895	0	319	0	0	0	319
1896	0	402	0	0	0	402
1897	0	305	0	0	0	305
1898	0	214	0	0	0	214
1899	0	372	0	0	0	372
1900	0	294	0	0	0	294
1901	0	228	0	0	0	228
1902	0	130	0	0	0	130
1903	0	492	0	0	0	492
1904	0	862	0	0	11	873
1905	1	988	0	0	51	1,040
1906	62	477	0	0	111	650
1907	7	384	0	0	201	592
1908	98	304	64	8	244	718
1909	61	311	32	4	176	584
1910	208	128	0	3	422	761
1911	450	127	0	2	1,477	2,056
1912	519	86	185	8	2,391	3,189
1913	154	48	0	30	3,113	3,345
1914	323	59	96	41	5,125	5,644
1915	128	38	100	35	5,503	5,804
1916	157	7	64	22	4,356	4,606
1917	235	0	76	22	3,061	3,394
1918	137	3	68	8	2,143	2,359
1919	161	0	15	5	1,987	2,168
1920	145	96	54	14	2,955	3,264
1921	53	7	78	7	4,552	4,697
1922	118	45	85	29	6,694	6,971
1923	126	48	50	47	4,829	5,100
1924	132	129	48	37	6,629	6,975
1925	257	64	112	56	6,028	6,517
1926	302	49	444	76	8,143	9,014
1927	219	34	199	73	10,006	10,531
1928	323	72	48	155	14,130	14,728

1929	347	62	139	138	18,608	19,294
1930	144	92	85	41	30,365	30,727
1931	20	55	43	37	6,577	6,732
1932	95	62	29	33	18,961	19,180
1933	17	59	15	28	17,413	17,532
1934	69	25	18	30	16,578	16,720
1935	162	10	40	37	17,815	18,064
1936	54	31	174	17	14,414	14,690
1937	66	57	96	27	15,019	15,265
1938	41	15	15	14	14,110	14,195
1939	15	26	2	11	11,772	11,826
1940	52	1	0	8	4,973	5,034
1941	76	3	0	2	63	144
1942	15	5	0	1	126	147
1943	15	1	0	3	346	365
1944	2	5	2	1	1,047	1,057
1945	13	14	42	1	3,603	3,673
1946	10	36	11	6	9,234	9,297
1947	34	32	24	10	6,936	7,036
1948	53	89	86	8	7,641	7,877
1949	19	79	35	9	6,196	6,338
1950	18	55	45	5	7,057	7,180
1951	72	53	81	10	5,111	5,327
1952	122	15	150	4	3,851	4,142
1953	142	15	182	2	2,704	3,045
1954	207	16	358	6	2,171	2,758
1955	142	13	158	3	1,578	1,894
1956	151	9	209	2	1,504	1,875
1957	143	11	100	2	1,667	1,923
1958	125	7	165	3	1,082	1,382
1959	149	7	80	324	534	1,094
1960	86	0	131	1,131	481	1,829
1961	92	0	142	392	611	1,237
1962	112	1	11	1,342	395	1,861
1963	443	0	31	1,294	183	1,951
1964	140	3	113	3,107	129	3,492
1965	134	1	449	866	164	1,614
1966	0	1	237	273	155	666
1967	0	3	65	339	58	465
1968	0	0	0	579	95	674
1969	0	1	0	873	47	921
1970	0	1	1	797	37	836
1971	0	1	1	520	23	545
1972	0	0	0	4	3	7
1973	0	1	0	0	0	1
1974	0	0	0	0	0	0
1975	0	0	0	0	0	0
1976	0	1	0	0	0	1
1977	0	2	0	0	0	2
1978	0	6	0	0	0	6
Total	7,973	10,442	5,383	13,022	345,775	382,595