THE DISTRIBUTION OF THE SOUTHERN BLUE WHALE IN RELATION TO RECENT ESTIMATES OF ABUNDANCE

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ABSTRACT

Based on data from systematic sightings surveys for minke whales a recent stock estimate was obtained of blue whales in the Antarctic. This study reviews previous information on the distribution of blue whales and confirms that the time and extent of the surveys was suitable to provide information on the abundance of blue whales. It would appear that the number of blue whales in the Antarctic is less than 2000; much less than previous estimates indicated.

INTRODUCTION

Blue whales (*Balaenoptera musculus* L.) have been caught in the Antarctic since at least 1905 when C A Larsen caught three from the land station at Grytviken in January, (Tønnessen and Johnsen, 1982). Hjort, Lie and Ruud (1932) described how whaling was initially restricted to the shore stations, mainly from islands in the South Atlantic, but in the season of 1923/24 shore based whaling extended into the area of the Ross Sea. True pelagic operations started in the season of 1925/26. After forty years of exploitation all member governments of the International Whaling Commission (IWC) agreed to cease whaling for blue whales in the Southern Hemisphere from the beginning of the 1965/66 season and catches after this date are very small. Tønnessen and Johnsen noted that the recorded catch of blue whales from the Antarctic was over 331,000. Part of this catch is of the pygmy blue whale (*B. musculus brevicaudata*) which is to be found from 0°–80°E and between 40°–55°S (Ichihara, 1966).

The Committee of Three of the IWC undertook a stock assessment of blue whales which was reported by Chapman (1964). The various techniques they used gave different estimates of stock size and were related to different years depending upon the type of data used. Using catch per unit of effort (CPUE) and Schaeffer's method gave an initial, exploited population of about 220,000. Mackintosh and Brown (1956) reported sightings of all large whales south of

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the Antarctic Convergence (AC) over the period 1933/34 to 1938/39 and these data led to an estimate of the blue whale population in this region of 33,000, at that time and a standard De Lury analysis, using CPUE, gave an estimate of exploited stock in 1953/54 of 13,000, but a range of 6–10,000 was accepted from subsets of the data. Masaki and Yamamura (1978) reported on sightings of blue whales by Japanese, whaling, research ships over the period 1965 to 1977. They considered that the population of blue whales, south of 30°S, was about 12,000 over that period. Gulland (1981) reviewed these estimates. He deducted the whales sighted in the region where pygmy blue whales were found to give a modified sightings estimate of 5400 and concluded that this estimate combined with others based on analyses of CPUE indicated that the exploited population of blue whales in 1963 was around 4000. His postulated rate of increase of 4 to 5 percent would give a current population of about 10,000.

The techniques used to provide the above estimates utilize rather crude data. The analyses based on CPUE have to accommodate changes in catching efficiency, species selection, time and location of whaling and operations other than searching. The sightings do not come from systematic surveys. Consequently, the estimates should only be regarded as very approximate. In contrast, Butterworth and Dudley (1984) presented an estimate of blue whale numbers based on systematic sightings surveys. The background to these surveys, designed primarily to estimate numbers of minke whales, is given by Best and Ohsumi (1980) and Horwood, Best and Ohsumi (1981). The analysis of Butterworth and Dudley yielded the result that south of approximately 60°S there were about 1000 or 1600 blue whales. The lower figure is based upon 'primary' sightings which are those seen when actively searching rather than those seen whilst engaging in other operations such as confirming the identity of a previously observed school; these others are called 'secondary' sightings. The second figure is based upon both combined and Butterworth and Dudley refer to the value 1000 as negatively biased, in respect of the selection of the number of sightings utilised, and the 1600 as positively biased. Other sources of bias are discussed later. This analysis must be regarded as the most reliable to date and gives a figure much lower than any previous estimate. The numbers are also small in absolute terms especially as the blue whale has not been hunted for twenty years. Numbers in 1965 may have been half as many.

As the estimates are so low it is especially necessary to enquire if the surveys were carried out at a time when and in the locations where blue whales were formerly abundant. Such a concern is expressed by Butterworth and Dudley. In order to clarify this point this study reviews the previous literature on blue whale distributions and reports on the distribution of catches from the data originally held by the Bureau of International Whaling Statistics (BIWS).

PREVIOUS DESCRIPTIONS

Many of the early Antarctic expeditions noted the occurrence of large numbers of whales particularly in the regions of the Antarctic Peninsula and the Ross Sea but most did not refer reliably to the species concerned. From a variety of observations Racovitza (1903) and Hjort (1920) showed that blue whales were common in these two localities. More detailed information arose with the introduction of pelagic whaling. In a series of articles Hjort, Lie and Ruud (1932, 1933a, 1933b, 1934) described the Norwegian pelagic whaling for the seasons 1929/30 to 1933/34. They show that very little whaling took place between 70°–150°W but throughout the rest of the Antarctic whaling concentrated on particular grounds. The highest densities of blue whales were found from 0° eastwards to 170°W. A review of early exploratory cruises seemed to confirm that the region between 70°–150°W held few whales. Their studies show that during October and November catches were mainly north of 60°S but, as the ice receded, catching was mainly south of 60° or 65°S. In the area of the Ross Sea catches were taken primarily between 65° and 70°S. Before January blue whales represented a higher percentage of the catch than fin whales but after January fin whale catches dominated. The position of the catches each month in December to February show that blue whales were taken over several degrees of latitude.

Omura (1973) published the catches of blue whales from the period 1931/32 to 1971/72 by ten-degree squares and Ichihara (1966) has plotted out the catch, by the Japanese pelagic fleets, of blue and pygmy blue whales by rectangles of five degrees of longitude and one degree of latitude from the seasons of 1946/47 to 1962/63. The Japanese catches show that blue whales were caught between 55° and 65°S from 35°E to 105°E, south of 60°S from 105°E to 165°E and south of 65°S from 165°E to 90°W. Substantial catches were taken from 90°W to 180°W, an area where the early Norwegian whaling did not operate.

The early pelagic catch statistics (IWS, 1937) show that from October to December blue whales were usually over 90 per cent of the catch with the proportion of fin whales increasing in January and February. Kellog (1928), Mackintosh (1965) and Omura (1973) interpreted this as a difference in the timing of the migrations of the two species and this is supported by sightings data (Gambell, 1976).

Mackintosh (1966) considered that blue and fin whales were found throughout the Antarctic and were distributed in a very similar way, the only difference was that blue whales tended to frequent slightly colder waters. This opinion is at some variance with the opinions of Ohsumi, Masaki and Kawamura (1970) who considered the distribution of the blue whale to be more like that of the minke whale, a species that is found in greatest numbers around the ice edge. Racovitza (1903) considered that blue whales seek the ice. Nishiwaki and Hayashi (1950) presented the catch of blue and fin whales

from the Ross Sea in 1947/48 by one degree squares and showed that the two species occurred together in those waters but Nishiwaki and Oye (1951) also commented that few blue whales were being caught in one expedition as they were whaling on an aggregation of fin whales over 50 miles from the edge of the pack ice. Nemoto (1959) plotted the relative distribution of blue and fin whales between 170°E–162°W for catches from 1949 to 1950 (his Figure 31). Along the ice edge blue whales comprised between 20–100% but over 60 nautical miles away from the ice edge the percentage of blue whales was 8–78%. He reported that "Whalers usually say they hunt blue whales in the pack ice and chase fin whales in the off-waters." Slijper (1962) says that it is well known that blue whales keep to the drifting ice whereas fin whales are found outside it.

B.I.W.S CATCH DATA

The BIWS, Norway, kept a record of all whales caught in the Antarctic from the 1931/32 season. These data are now held on computer by the Secretariat of the IWC. Tillman and Ohsumi (1981) compared the computerized records of Japanese pelagic catches with Japanese government statistics and they found that over the seasons 1939/40 and 1940/41 records published by the BIWS were correct but the computerized records did not include many fin and blue whales taken in these seasons. However, these omissions represent only a small proportion of the total number of records and the following describes the spatial and temporal distribution of pelagic catches of blue whales from the Antarctic based on the computerized records. Tønnessen and Johnsen (1982) recorded that 331,042 blue whales were caught between 1904 and 1978 in the Antarctic. The catch records show that from 1931/32 180,676 were taken by the pelagic fleets. Of these 123,346 were taken south of 60°S and 57,330 were taken to the north of 60°S.

Fig. 1 shows the catch of blue whales by day by the pelagic fleets south of 60°S. Data from 29 February are omitted. Catches reach peak numbers at the beginning of February but are high from mid-December to the beginning of March. However, various commercial, national and international agreements have regulated the beginning and ending of whaling seasons and, consequently, catches will not necessarily reflect abundance on the grounds. The whaling period has varied with species in order to give protection to humpback and blue whales. Table 1 gives the whaling periods for blue whales for the pelagic fleets extracted mainly from various volumes of the International Whaling Statistics. Before the International Agreement for the Regulation of Whaling, 1937, the allowed whaling periods and areas were regulated by whaling agreements amongst companies primarily of Norway and the UK. Not all whaling countries were bound by the periods shown in any one season.

Table 1 shows that before 1948 whaling was allowed from before the second week in December, but after 1950 catches were to be taken from January onwards. Catches of blue whales after 1950 were relatively small,

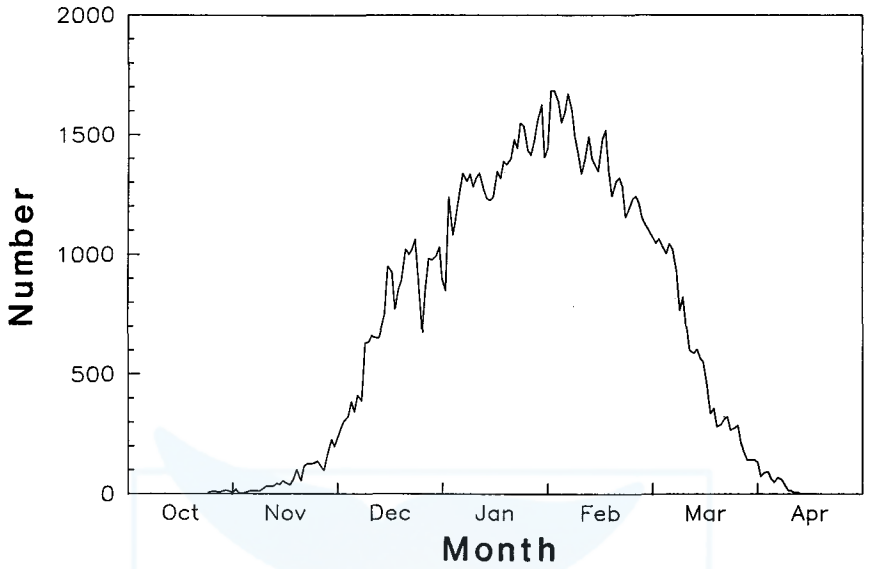

Fig. 1. The catch of blue whales by pelagic fleets in the Southern Hemisphere south of 60°S from the 1931/32 whaling season. The value for 29 February has not been included.

(Horwood, 1981a). Consequently, the pattern from mid-December should not be much affected by the regulations although other operational considerations may have played a part. The rapid decline in catches at the beginning of March does look to have occurred at about the times that the closing dates for the period have operated.

The six research cruises that provided the data for the assessment by Butterworth and Dudley (1984) took place over the seasons 1978/79 to 1983/84 and covered the extreme times of 24 December to 18 February; consequently there is interest in the spatial distribution of pelagic catches over these dates. South of 60°S 75,878 blue whales were recorded as caught between these dates from 1931/32. (Another 114 whales were recorded as having been caught between these dates but their positions of capture are uncertain). The distribution of these catches, plotted as numbers caught in a rectangle of ten degrees of longitude and one of latitude, is shown in Fig. 2. The cross-hatched region is where 500 or more whales were caught. The blank regions represent areas in which less than 50 whales were caught; on average, over a period of 30 years (within the above dates) and in rectangles of about 15,000 square miles, this represents less than two whales caught per year. Unfortunately whaling regulations have also affected the spatial movements of the fleets and these have also been summarised in Table 1.

Pelagic whaling was restricted to south of 40°S from the 1935/36 season but, for two years from the beginning of the 1938/39 season, an area from

TABLE 1. REGULATIONS AFFECTING THE PELAGIC CATCHING OF BLUE WHALES IN THE ANTARCTIC

Season	Whaling period (closing date if different)[1]	Area	Notes
1932/33	20.10.32–30.4.33 (14.4.33)	No restrictions	Geneva Convention 1931 production agreement June 1932[2]
33/34	25.10.33–		Production agreement[2]
34/35	1.12.34–31.3.35	S of 50°S (Norway only)	Norwegian law[2] production agreement[3]
35/36	1.12.35–15.3.36	S of 40°S	Production agreement[3]
36/37	8.12.36– 7.3.37	"	Production agreement
37/38	8.12.37– 7.3.38	"	Int. Agreement for Regulation of Whaling June 1937
38/39	8.12.38– 7.3.39	S of 40°S 70°W–160°W closed for 2 yrs.	Protocol of 1938
39/40	8.12.39– 7.3.40	"	"
40/41	8.12.40– 7.3.41	S of 40°	"
41/42	no pelagic whaling		"
42/43	8.12.42– 7.3.43	"	"
43/44	8.12.43– 7.3.44	"	"
44/45	24.11.44–24.3.45	"	Protocol of 1944 (not ratified)
45/46	24.11.45–24.3.46	"	Protocol of 1944 and 1945
46/47	8.12.46– 7.4.47	"	Protocol of 1945
47/48	8.12.47– 7.4.48 (31.3.48)	S of 40°S 70°W–160°W closed[4]	Protocol of 1946
48/49	15.12.48– 7.4.49 (26.3.49)	"	Convention of 1946 and subsequent schedule changes apply to 1966
49/50	22.12.49– 7.4.50 (15.3.50)	"	
50/51	22.12.50– 7.4.50 (9.3.50)	"	
51/52	2.1.51– 7.4.51 (5.3.51)	"	
52/53	2.1.53– 7.4.53 (16.3.53)	"	
53/54	16.1.54– 7.4.54 (18.3.54)	"	Longer period for sei and fin
54/55	21.1.55– 7.4.55 (19.3.55)	"	
55/56	1.2.56– 7.4.56 (4.3.56)	S of 40°S 70°W opened	IWC 10th Meeting
56/57	1.2.57– 7.4.57 (16.3.57)	"	
57/58	1.2.58– 7.4.58 (16.3.58)	"	
58/59	1.2.59– 7.4.59 (16.3.59)	"	

(Continued)

TABLE 1. (Continued)

59/60	1.2.60– 7.4.60 (Netherlands continued until 15.4.60)	"	
60/61	1.2.61– 7.4.61	"	
61/62	1.2.62– 7.4.62	"	
62/63	1.2.63– 7.4.63	"	
63/64	1.2.64– 7.4.64	40°–55°S;0°–80°E	Pygmy blue area
64/65	1.2.65– 7.4.65	All areas closed	Pelagic whaling nations objected and thus restricted to 63/64 area
65/66	–	All areas closed	–

1) Actual whaling period is less if quota was reached before the end of the season. (IWS XLVI, LIV)
2) Tønnessen and Johnsen, 1982, pp402–408.
3) Tønnessen and Johnsen, 1982, pp433–439.
4) This appears to be the earliest date that the closed area could be binding following the IWC meeting of December 1946. The agreement was implemented by the 1949/50 season but it also appears that the area was not operated in, in practice, until the season of 1955/56 (Omura, 1973).

70°W to 160°W was closed for two years. This has become known as the Sanctuary. It was also legally closed from about 1947/48 to the beginning of the 1955/56 season. There does appear to have been the intention not to whale in the area of 70°–160°W but legislation did not keep pace with events and Omura (1973) showed that no catches or effort were expended in the Sanctuary over the periods 1931/32 to 1938/39 and from 1945/46 to 1954/55. This then leaves the region with only 10 years of whaling and means that accumulated catches will not portray relative abundance inside and outside this area.

The distributions of Fig. 2 show that catches were mainly taken in whaling Areas II to V, 60°W eastwards to 170°W. Highest numbers were taken from Area II (0°–60°W) between 60° and 63°S, in Areas III (0°–70°E) between 60°S and the ice edge and in a few localities in Area V (130°E–170°W). Very few blue whales were caught from 60°–120°W. From 120°W to 130°E the AC is further south than in the rest of the Antarctic and few blue whales were caught north of 64°S in this region. As noted by Omura (1973) the distributions show substantial heterogeneity with longitude but also the distribution with latitude varies with Area.

DISCUSSION

The estimate arrived at by Butterworth and Dudley (1984), of between 1000 and 1600 blue whales in the Antarctic, was based upon data acquired during surveys for minke whales over the period 1978/79 to 1983/84. In the survey period 30 schools of blue whales were found with an average school size of 1.7, and the positions where these schools were seen are given in Fig. 2. The

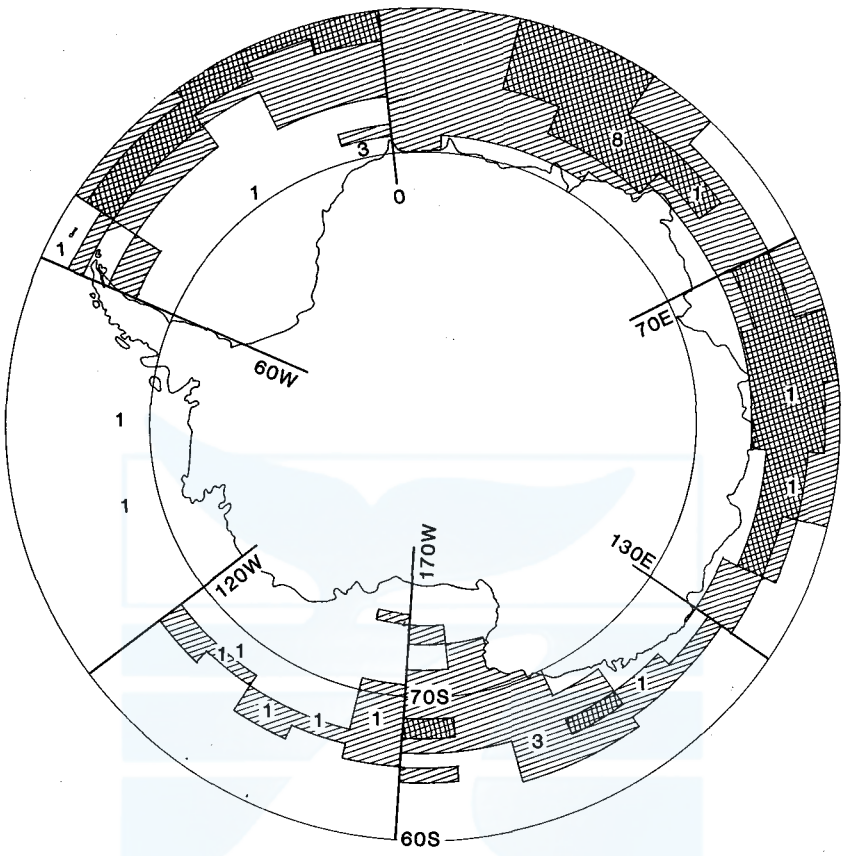

Fig. 2. The distribution of pelagic catches of blue whales south of 60°S from 1931/32 over the period 24 December to 18 February by groupings of 10 degrees of longitude and one degree of latitude. Cross hatched regions are rectangles in which over 500 were caught over the period, hatched regions are where 50 were caught and blank regions where less than 50 where caught. The numbers represent blue whale schools found on the surveys: deleted as the two figures have been replaced by one.

estimate of 1000 was obtained using the 17 primary sightings seen in over 41,000 miles travelled in a searching mode. The higher figure of 1600 was arrived at by ignoring the distinction between primary and secondary sightings but at the same time not increasing the miles travelled.

The review of previous studies has shown that blue whales dominated the early Antarctic catches until the new year, after which catches of fin whales were more important. Sightings data confirm that blue whales do arrive in the Antarctic earlier than do fin whales, and the lower percentage of blue whales in the catch from January onwards reflects more the arrival of fin whales than the departure of blue whales. Fig. 1 shows the distribution of

catches of blue whales south of 60°S and it can be seen that over the periods in which the research cruises operated, late December to mid-February, catches of blue whales reached their peak. It has been shown that whaling regulations would not have distorted this feature and that consequently, it can be concluded that south of 60°S the research took place over the time of maximum catches and probably maximum abundance.

The area over which the sightings estimate apply is mainly south of 60°S but in fact only about 75 per cent of the area is used to obtain the estimate. Large areas are not included particularly between 60° and 65°S from 0°–35°W and between 60° and 64°S from 0°–35°E. Whaling Area IV (70°–130°E) was surveyed from 60°S and between 35° to 60°W the region was surveyed south of 58°S but the rest of the Antarctic was surveyed from latitudes below 60°S. However, the previous literature does not precisely define the distribution and behaviour of blue whales. Mackintosh (1966) referred to blue and fin whales as being similarly distributed and all authors agree that blue whales tend to be relatively more abundant near the ice than are fin whales. Surveys for minke whales have shown significant differences in density between sighting transects along the ice and those over 50 miles away from the ice (Horwood, 1981b), and Ohsumi *et al.* (1970) considered minke whales to be distributed in a similar way to blue whales. Other authors have referred to blue whales as being ice loving and the rather imprecise descriptions of blue whale distribution is summarised by Ruud (1956) who reported that "blue whales are supported to penetrate further into the icy regions than any other species".

The distribution of catches gives a more quantitative representation of blue whale distribution than do the previous comments. Fig. 2 shows the distribution of pelagic catches over the period of the sighting surveys. Over most of the Antarctic the whales were caught over several degrees of latitude and in general an extensive latitudinal distribution can be seen. Over the time period of the surveys 20.2% were caught north of 60°S, some of these would have been pygmy blue whales but, from the position of the catches, they would have been few. It can be seen that over late December to mid-February blue whales are distributed from the ice edge to north of 60°S. Longitudinally there is great variation. The evidence suggests that blue whales did not occur in large numbers from the Antarctic Peninsula westwards to the Ross Sea. From 120°W westwards to about 110°E the AC is further south than throughout the rest of the Antarctic and catches have largely been south of about 64°S. Catches are concentrated to the north in the sectors from 60°W to 70°E with large catches to the north of 60°S from 40°W to 60°E. It would therefore appear that the sightings cruises largely covered an area appropriate for estimating the number of blue whales. In some areas large numbers of blue whales were caught much further north than the ice edge and so the surveys, designed to count numbers of minke whales, expended too much effort along the ice edge. This would have resulted in a higher variance than if the survey had been designed for blue whales. In some locations large catches were taken

north of 60°S and the estimates from the surveys neglected this component of the population.

Butterworth and Dudley (1984) discuss possible biasses in their analyses and two aspects are particularly important. Firstly not all whales near to the vessel (strictly on the track line) will be seen. For blue whales long dive times will mean that some will be missed but this is mitigated by large, visible blows. Butterworth and Dudley comment that a correction factor discussed for minke whales of 1.35 still leaves the sightings estimates much lower than others. Secondly the area used is 75% of that south of 60°S. The catch data show that significant numbers of whales are likely to have been neglected mainly from 35°W to 35°E due to the survey area being south of about 64°S in this region. At these longitudes substantial catches were also taken north of 60°S.

It is not clear that a substantial correction factor for whales missed near the ship is warranted and cumulative catches over the survey period, but outside the area used for estimation, are about 35% of the total. The review indicates that the surveys for minke whales took place at a time and in locations appropriate to extending the analysis to blue whales and that any correction factors are unlikely to increase the estimate to that given by Masaki and Yamamura (1978). Consequently, it can be concluded that the estimates provided by Butterworth and Dudley (1984), of between 1000 and 1600 blue whales in 75% of the area south of 60°S, are the most reliable to date and that previous estimates were too high. If cumulative catches are used to raise the estimates to blue whales in the area south of 40°S then this still yields a population estimate of less than 2000 animals.

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