The Plight of the Whales

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Between the end of World War I and 1960, several species of whales in the ocean around the Antarctic continent were the basis of an important industry. These giant mammals, the largest that have ever existed on the earth, were sought for animal oil and, to a lesser extent, meal and meat (the latter for human consumption) as well as a myriad of by-products. In antiquity, whalers went out in small boats and endured great risks to capture such large sources of meat. Men continued to hunt whales in small boats with primitive weapons, as portrayed in *Moby Dick,* until late in the nineteenth century. In the twentieth century, whaling has been highly modernized with explosive harpoons, large ships, and powerful radar-equipped catcher boats, which enable the whaling industry to operate in the stormy and inhospitable oceans next to the Antarctic ice cap.

This area of the world, while unfriendly to humans, is very inviting to whales, for during the southern summer the waters bloom with small plants that feed myriads of minute animals, known generally as krill. Certain species of whales

catch these by straining large volumes of water in their huge mouths through sievelike filters called baleen plates (hence this group of whales is referred to as baleen whales). These whales have no teeth and do not eat fish or other marine mammals. The largest of the baleen whales, and indeed of all whales, are the blue whales, which may reach a length of 100 feet, though 70 to 80 feet is a more usual size.

BLUE WHALES

Immediately following World War II, Europe and Japan were in desperate need of many things, including animal oil. It was not surprising, therefore, that the number of Antarctic whaling catcher boats increased; furthermore, technologies developed during the War made whaling more efficient. As a result, some conservationists feared that Antarctic whales, particularly the blue whales, would be completely eliminated. Figure 1 shows the annual catch of blue whales in the southern oceans in the decade before the War and in the postwar period to 1960. The basis for concern for the blue whales was easy to document, but the catch of other species was stable or increasing. Some of those associated with the industry suggested reasons other than a decline in population for the decline of the blue whale catch and were reluctant to accept restrictions on catches. Thus the International Whaling Commission, set up in 1946 to manage the resource, found itself the center of controversy. The Commission has representatives from all interested countries; it establishes size regulations and quotas, and it also has the authority to ban hunting of species that appear to be endangered.

The Commission set up a study group to bring together all the data and develop statistical methods for attacking such questions as: How many whales are in the stock that feed in the Antarctic? How many young are born each year?

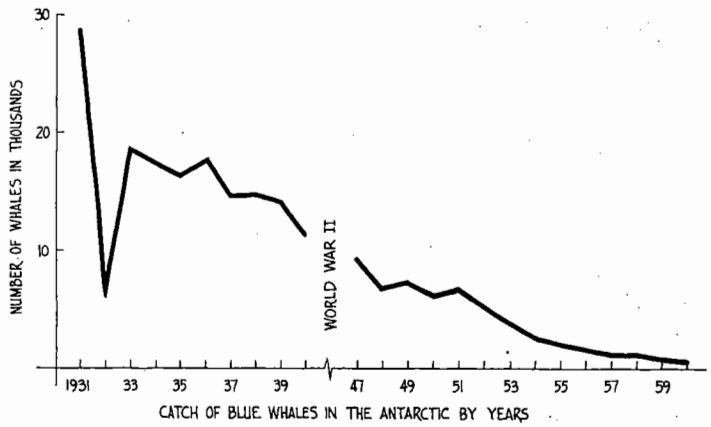

Figure 1 *Catch of blue whales in the Antarctic, seasons 1930–31 to 1959–60 excluding World War II period.*

How many whales die from natural causes each year? How are these birth and death rates affected by factors over which humans have some control?

COUNTING METHODS

Let us consider the first, and perhaps most basic, question: How many whales are there of a particular species? Whales unfortunately don't stay still to be counted. They roam over large areas, spending most of their time under water, though they do surface at regular intervals to breathe. Furthermore, the southern oceans cover a vast part of the world; the whaling area exceeds 10 million square miles, an area larger than all of North America. There are several standard ways to estimate wild animal populations, all of which involve some statistical techniques. We shall describe three of them.

Marking Method or Capture–Recapture. The first method of estimation involves marking a number of whales; a foot-long metal cylinder is fired into the thick blubber that lies just under the skin. If and when marked whales are later caught, some information is available on their movement, on their rate of capture, and on the proportion of marked members in the whole herd. The usefulness of the latter information is easily seen by simulating such an experiment with a can of marbles. Assume that, like the whale population, the number of marbles in the can is unknown. Now pick a few marbles (say, 10) out of the can, mark them, and return them to the can. Next, stir the whole can thoroughly and draw another sample. Count separately the marked and unmarked marbles. If the unmarked ones are four times as numerous in the sample as the marked ones, we reason that the same is true of the whole canful; but because there is a total of 10 marked marbles, we infer there are 40 unmarked marbles, or 50 marbles in total.

This simple scheme has been used with many animal populations, although there are many obvious complications in practice, and for whales this is especially true. How do we know, for example, that the metal mark fired into the blubber actually penetrated and did not ricochet off? Did the crew who cut up the captured whale carefully look for the mark—even a foot-long metal cylinder is easy to overlook in cold, stormy working conditions when the volume being cut up is approximately the size of a house. Also, unlike the marbles, whales are born and die over a period of years. All of these complications require refinements and extensions of the simple experiment outlined here. It is necessary to have a series of experiments extending over many years and to use comparative procedures. For example, if a group of whales is marked in year 1 and a group of the same size is marked in year 2, then, after year 2, the ratio of recoveries of whales marked in year 1 to the recoveries of whales marked in year 2 reflects the proportion of marked whales of group 1 that died in the intervening year. These deaths may have been natural or caused by hunters. Moreover, the *ratio* is a valid measure of this mortality because its numerator and denominator are equally affected by the possible errors listed above. Such a comparative study is only one of the several statistical procedures used to analyze whale-marking data.

Catch-per-Day Method. The second estimation method is based on changes in the rate of catching whales. The rate of catching depends mainly on the frequency with which whales are seen and, other things being equal, this depends on their density. Thus the catch per day reflects the density. How can this be translated into absolute numbers? If the change in catch per day is entirely a result of the removal by man, then it is easy to make this translation; if catching 25,000 whales in one season lowers the catch rate for the next season by 10%, then at the outset of the first season there must have been 25,000/0.10, or 250,000 whales.

Again, the situation is more complex than this simple example. Whaling ships hunt over a vast area in difficult conditions, so that the catches fluctuate violently. Whaling companies introduce new technology to improve their efficiency. Moreover, we reemphasize that there are other causes of whale mortality, and that there are new births as well; both of these factors must be taken into account in adjusting the population estimate. One way to overcome some of these difficulties is to adjust for changes in efficiency and also to follow the change in catch per day (adjusted) over a period of several seasons. Figure 2 shows the catch per day of blue whales plotted against the cumulative catch by the whaling factory ships over the seasons 1953–1954 to 1962–1963 when natural deaths and births were numerically quite small. As more whales were caught, the catch per day went steadily down. This graph suggests that there were only 10,000 to 12,000 blue whales in 1953 and this number declined to about 1,000 in 1963. As pointed out, there are statistical refinements, and the result obtained in this way must be combined with estimates obtained in other ways.

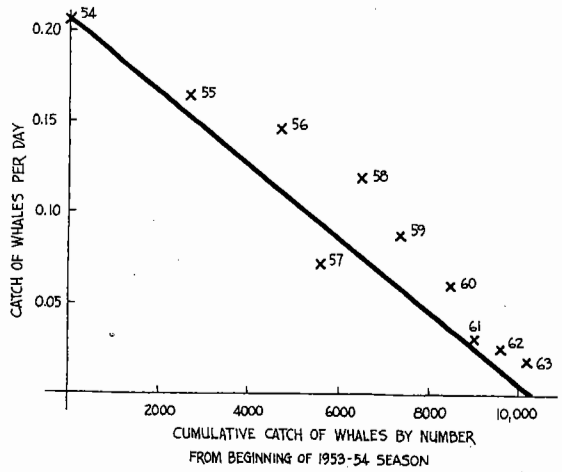

Figure 2 *Blue whale catch per day (adjusted for efficiency improvements) versus cumulative catch, 1953–54 to 1962–63.*

Age Analysis. The catch-per-day method works well with rapidly declining populations, but in other situations the complications and corrections make it less useful. Still a third method is available, however, which uses the ages of whales. Just as trees have annual rings in their trunks and fish have annual rings in their scales, whales have annual rings in a waxy secretion in the ear (earplugs). The ages of a sample of the whales killed each year were determined by the rings of their earplugs. In addition, information on the length of every whale killed commercially made it possible to relate age to length and to calculate an estimated age for every captured whale.

It was thus possible to make a statistical estimation of the number of 4-year-old whales in any season and the number of 5-year-olds in the following season. Because one year's 5-year-olds are the survivors of the previous year's 4-year-olds, a survival rate or, conversely, a mortality rate can be determined. Because all ages are estimated and because some adjustments have to be made, the estimated mortality rates fluctuate wildly. But by averaging over several year's classes, over areas and seasons, useful results can be obtained. Furthermore, with additional statistical analysis, it is even possible to assess the magnitudes of possible errors in such estimations. These mortality rates help us to predict the future of the whale population.

Results. Thus we have three methods of estimating population sizes and mortality rates: the marking method, the catch-per-day method, and age analysis. The results of different methods were checked against one another, and fortunately the different estimates were in good agreement. Sources of error were carefully checked and ruled out, so that the study group finally concluded that the blue whales numbered at most a few thousand and might total even less than 1,000. Thus there was and is a real danger of extinction of this species in the Antarctic (there are also small numbers of blue whales in the northern oceans). Fortunately, the International Whaling Commission banned the taking of blue whales as soon as the study was finished—first, in a large part of the southern oceans and eventually in all waters south of the equator. It is too soon to predict the long-term survival of the species; blue whales are occasionally seen, but these are probably the survivors noted above (whales can live, in the absence of hunting, to more than 40 years of age). We can ask whether the population has been reduced to such low levels that reproduction is reduced below the level necessary for species continuation, but it will be a number of years before this can be answered.

FIN WHALES

The second-largest whale species in the world, also part of the baleen family, is the fin whale. It averages about 10 feet less than the blue whale in length. During the 1950s this stock annually yielded in excess of 1 million barrels of oil per year. With the decline of the blue whales, fin whales bore the brunt of the exploitation. The same methods of analysis used for the blue whales

were applied to the fin whales; in fact, the analysis was more critically needed because the condition of the fin whale stock was not obvious as was that of the blue whales. Moreover, fin whale catches were still very high: in the 1961–1962 season over 27,000 fin whales were killed. The study group recommended that the fin whale catch should be reduced to 7,000, or less, if the fin whale stock was not to be further depleted. The proposal for such a drastic reduction came as a shock to the Commission; the study group forecast that the next season's catch, regardless of quotas, would drop to 14,000. When actual figures proved the forecast right, most countries wanted to move toward the drastic reductions required, but some of the whaling nations were able to block action. Another disastrous season caused a revision in the thinking of the commissioners, and in 1965 a substantial schedule of reductions in the quota was agreed upon. Nevertheless, the delay in reaching this agreement, and the subsequent delay in reducing the quota, meant that permitted catches have had to be lowered even further, and, in fact by the mid-1970s the Commission gave total protection to fin whales in the Antarctic and in the North Pacific.

MORATORIUM ON COMMERCIAL WHALING

By the time the major species, blue and fin whales, were placed in protected status, Antarctic pelagic whaling was carried on by only two countries, Japan and the U.S.S.R. These countries turned to other species, first the sei whale and then the minke whale. The latter is, by comparison, a very small whale. Its maximum length is about 30 feet. Little was known about these species—only a few had been marked. The methods of determining their age are uncertain and controversial. Furthermore, scientists had no long series of data on catches so that the data base for determining the status of these stocks was totally inadequate. Thus through the late 1970s and early 1980s the International Whaling Commission found itself in great controversy. Many felt that it should not permit whaling of stocks on which so little was known. Also, new countries that favored a conservative approach joined the Commission. Finally, in 1982, the Commission voted to establish a moratorium on all commercial whaling not only in the Antarctic but worldwide. In passing this resolution the Commission also agreed to undertake by 1990 a comprehensive assessment of all whale stocks to hopefully resolve the uncertainties that had given rise to the controversy.

THE FUTURE OF WHALE STOCKS

Some stocks of whales have now been protected for nearly 25 years, yet there is no information available to determine whether they are beginning to recover. If the comprehensive assessment is to resolve the status of such seriously depleted stocks and the more recently exploited ones, new methods of obtaining and analyzing information need to be found. Most of the information now

available on whales was collected from dead animals taken in commercial kills. Such data has its limitations and in any case is not available during the moratorium. New methods include sighting expeditions from ships or aircraft. While considerable work has been done to extrapolate such sighting information to determine population numbers, other biological information is more difficult to collect in this way. Other potential methods are photography and skin samples. Whales have natural marks that can be identified visually or from photographs and these can be used as a basis of mark recapture procedures. This can substitute for the marks used heretofore (the metal cylinders), which are recovered only when the whale is killed. All of this opens up new areas of research both in techniques and in statistical analysis of the data so acquired.

In the meantime, the whole question of killing whales for commercial purposes is being seriously debated. Some agree that whales are a resource that should be harvested like fish or trees, and further, only by harvesting whales can humans efficiently harvest the great krill resources of the oceans. Others assert that whales are intelligent animals with a complex social structure and that whaling is not only cruel but also destroys this social structure. Such persons believe that preserving whales is symbolic of our intent to live in harmony with the natural world.

PROBLEMS

1. Refer to Figure 1. What was the approximate catch of blue whales in the Antarctic in the season 1931–1932? 1937–1938? What is the percentage reduction between the two seasons? When was the catch the highest? The lowest?
2. What are the three counting methods discussed in the text? Describe each briefly.
3. Describe an experiment whose purpose is to estimate the size of a human population on an isolated island, using one of the methods mentioned in the article. What assumptions are you making?
4. Refer to Figure 2. What was the approximate catch of blue whales per day (adjusted) in the season 1955–1956 (plotted as 1956)?
5. Refer to Figure 2. Can you explain the relative "high" for the 1958 figure?
6. From Figure 2 it was concluded that there were only 10,000 to 12,000 blue whales in 1953. How was this number obtained?
7. Suppose it was determined by the age analysis method that the mortality rate of blue whales is 0.25 per year. Furthermore, suppose that by the marking method it was estimated that there were about 7,000 blue whales at the start of 1960. How many whales would you expect to be still living at the end of 1961, assuming that the mortality rate does not change over the years?
8. What is meant by the "optimum stock size" of whales? Why should there be an optimum size at all?

REFERENCES

D. G. Chapman, K. R. Allen, and S. J. Holt. 1964. "Reports of the Committee of Three Scientists on the Special Antarctic Investigations of the Antarctic Whale Stocks." *Fourteenth Report of the International Whaling Commission.* London: International Whaling Commission, pp. 32–106.

J. A. Gulland. 1966. "The Effect of Regulation on Antarctic Whale Catches." *Journal du Conseil,* 30:308–315.

N. A. Mackintosh. 1965. *The Stocks of Whales.* London: Fishing News.

Scott McVay. 1966. "The Last of the Great Whales." *Scientific American* 215(2): 13–21.