The Effect of Regulation on Antarctic Whale Catches

By

J. A. Gulland

Fisheries Laboratory, Lowestoft*

Since 1948 the International Whaling Commission has restricted the catch of whales from the Antarctic by an annual limitation on total catch. This restriction has made the decline of the blue and fin whale stocks slower than would have occurred with no regulation. Assuming that the regulation has affected the length of season, but not the number or composition of the expeditions, the probable effort in each season in the absence of regulation has been calculated. From the relation between stocks abundance and total effort since 1946 the differences in adult stock with and without regulation, and hence in recruits four years later, and ultimately in total catch, were calculated. It is estimated that the quota regulations have increased the total catch since 1946 by some 4,300 blue whales and 45,000 fin whales. Despite this comparative success the International Whaling Commission has failed in its primary task of maintaining a viable whaling industry in the Antarctic.

Introduction

It is well known that the International Whaling Commission has failed to achieve proper management of the Antarctic whale stocks. Of the two major stocks the blue whales (*Balaenoptera musculus*) have been reduced to a few hundred individuals, and will not be able to sustain substantial catches until the stock has been built up by complete protection for perhaps fifty years. The stock of fin whales (*Balaenoptera physalus*) is less severely depleted, but even this can at present sustain only a very small catch, and requires several years' complete protection before large catches can be sustained. This failure in the whale fisheries of the Antarctic, compared with for example, the still thriving fisheries for plaice in the North Sea, where heavy fishing has been going on for sixty years or more, is due to a difference in the biology of the animals concerned (the recruitment in whales being closely proportional to adult stock, and that for plaice remaining about constant, independent of fluctuations in the adult stock) rather than to the activities of the two Commissions concerned.

In fact, the International Whaling Commission has enacted a considerable number of regulatory measures in the Antarctic and elsewhere. In particular, the catch quota for Antarctic baleen whales (blue whales, fin whales, sei whales, *B. borealis*, and humpback whales, *Megaptera nodosa*) has, especially between 1949 and 1960, substantially reduced the effort on the Antarctic stocks of these

* At present with Fisheries Department, FAO, Rome.

| J. Cons. perm. int. Explor. Mer | 30 | No. 3 | 308–15 | Copenhague, Novembre 1966 |

Table 1

Post-war effort and catches of Antarctic pelagic whaling, together with the potential effort estimated on the basis of a 121-day season in all years

		Catcher-days × tonnage × 10^{-3}			Total catch	
Season	Length of season	Total	Blue whales	Potential	Blue whales	Fin whales
1945/6	121	–	–	–	3,526	7,729
1946/7	121	4,727	–	4,727	8,865	12,877
1947/8	115	6,158	–	6,482	6,862	18,999
1948/9	102	7,542	–	8,940	7,399	17,201
1949/50	84	7,724	–	11,130	6,168	18,061
1950/1	78	8,424	–	13,059	6,966	17,474
1951/2	64	7,995	–	15,112	5,124	20,520
1952/3	74	8,448	–	13,803	3,866	21,197
1953/4	76	7,784	6,351	12,394	2,684	24,986
1954/5	72	8,492	6,855	14,272	2,163	25,878
1955/6	58	7,640	4,350	15,950	1,611	25,289
1956/7	69	8,409	5,343	16,500	1,505	25,700
1957/8	69	9,316	5,933	16,344	1,684	25,222
1958/9	69	9,749	6,230	17,103	1,191	25,837
1959/60	102	13,518	8,564	16,036	1,230	26,415
1960/1	101	15,407	9,477	18,451	1,740	27,374
1961/2	117	19,678	9,686	20,350	1,118	26,438
1962/3	117	15,820	8,707	16,360	947	18,668
1963/4	118	14,092		14,452	112	13,870
				Total 1946–64	61,235	392,006
				Total 1945–64	64,761	399,735

species. In order to put the achievements of the International Whaling Commission into perspective it was considered valuable to attempt to make some quantitative estimate of the effect of these catch quotas, in terms of the increase (if any) in catches and present stock.

Changes in Effort

Any estimate of the effect of regulation must make some assumptions about the pattern of catching in the absence of regulation (i.e. when there are no catch quotas and no closed seasons). A simple assumption is that the number of expeditions, and their associated catchers operating each season, would have remained unchanged, but that catching would have continued for the whole of the potential Antarctic season. This has been taken as 121 days, equal to the longest post-war season. Therefore the potential effort in each post-war season has been estimated from the actual effort (expressed as catcher-days × average tonnage), increased by the ratio of 121 : length of season, in days. These estimates, together with the actual values of effort and catch, are given in Table 1. (Professor RUUD has suggested that with no quota there would not have been a scramble to catch as big a share of the quota as possible before the season ended, so that the assumption used overestimates the likely increase of the number, power and efficiency of the catchers in each expedition. Against this it is possible that with a longer season the incentive to send more expeditions to the Antarctic would have been greater. For the present purpose the assumptions made are probably satisfactory).

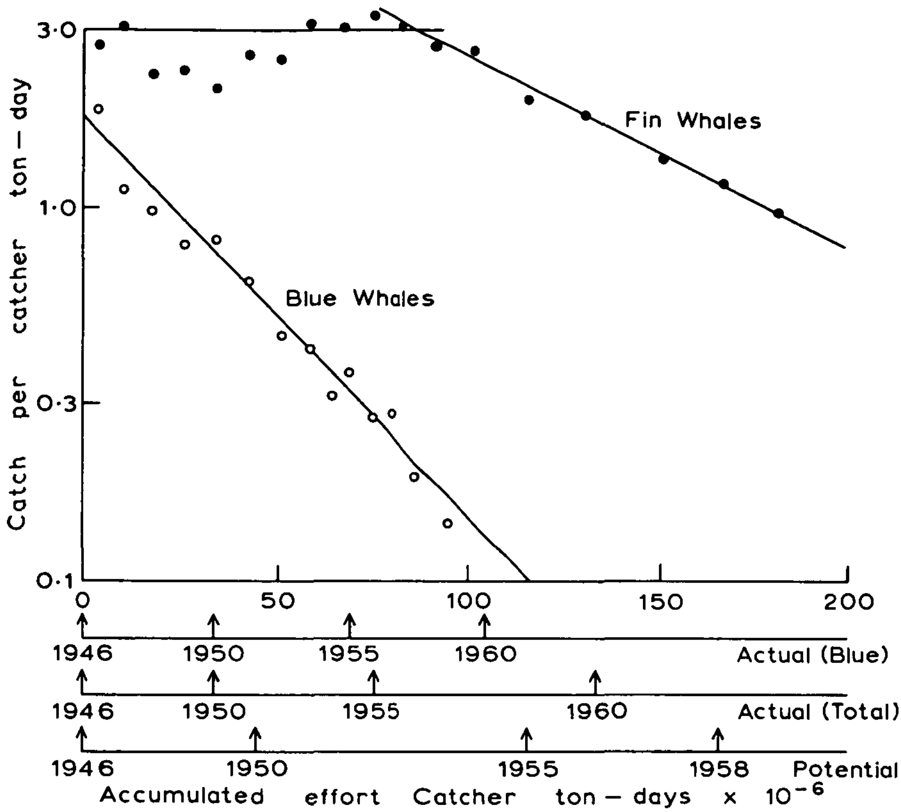

Figure 1. Relation between the stocks of whales, as estimated from the catch per unit effort, and the total accumulated effort on those stocks since 1946.

Changes in Stock

Probably the most direct method of estimating the catch since 1947 with this potential catching effort would be to use the best estimate of the stock in 1947, and calculate successively the catch in each season, the natural deaths, the recruitment from the earlier stock and hence the number at the beginning of the next season, in the same way as the effects of future catch quotas have been predicted. However, over a fifteen-year period, small differences in the estimates used of recruitment and natural mortality will make a very big difference to the final estimates of catch and stock. Another method has therefore been used. The whales caught since 1946, plus those surviving in 1965, can be considered as the sum of the stock in 1946 and the net recruitment (recruitment less natural deaths). As the survivors in 1965 are the potential future catch, the effect of different patterns of fishing may be measured by the difference in net recruitment. This may be estimated from the difference in the stock in each year. Although a precise estimate of the stock in each year in the absence of any regulation is not easy to obtain, an overestimate (which will give an underestimate of the effect of regulation) can be obtained from the accumulated effort.

Table 2

Accumulated effort, and catches per unit effort, of Antarctic pelagic whaling

Season	Accumulated effort (ton-days) Actual Fin whales	Blue whales	Potential	Observed catch/ton-day Blue whales	Fin whales	Catch/ton-day estimated from the regressions of Figure 1 Blue whales Actual	Blue whales Potential	Fin whales Actual	Fin whales Potential
1946/7	4,727	–	4,727	1·875	2·724	1·60	1·60	3·0	3·0
1947/8	10,885	–	11,209	1·114	3·085	1·38	1·40	3·0	3·0
1948/9	18,427	–	20,149	0·981	2·281	1·14	1·10	3·0	3·0
1949/50	26,151	–	31,279	0·799	2·338	0·93	0·83	3·0	3·0
1950/1	34,575	–	44,338	0·827	2·074	0·77	0·60	3·0	3·0
1951/2	42,570	–	59,450	0·641	2·567	0·62	0·41	3·0	3·0
1952/3	51,018	–	73,253	0·458	2·509	0·51	0·30	3·0	3·0
1953/4	58,802	57,369	85,647	0·423	3·210	0·44	0·22	3·0	2·94
1954/5	67,294	64,224	99,219	0·316	3·047	0·37	0·15	3·0	2·48
1955/6	74,934	68,574	115,869	0·370	3·310	0·33	0·105	3·0	2·07
1956/7	83,343	73,917	132,369	0·282	3·056	0·28	0·066	3·0	1·70
1957/8	92,659	79,850	148,713	0·284	2·707	0·25	0·045	2·70	1·42
1958/9	102,408	86,080	165,816	0·191	2·650	0·21	0·029	2·42	1·18
1959/60	115,926	94,644	181,852	0·144	1·954	0·17	0·020	2·08	0·96
1960/1	131,333	104,121	200,303	–	1·777	–	–	1·73	0·77
1961/2	151,011	113,807	220,653	–	1·344	–	–	1·38	0·61
1962/3	166,831	122,514	237,013	–	1·180	–	–	1·15	0·50
1963/4	180,923	–	251,465	–	0·984	–	–	0·97	0·43

If the observed data of catch per unit effort are plotted against accumulated effort since 1946, the result is, on a logarithmic scale, very close to a straight line for blue whale catches, and also for fin whales after 1956 (Figure 1). Before 1956 any decrease in fin whale stocks was probably masked by increased efficiency of the catchers and increased concentration on fin whales as the blue whale stock decreased. This relation between stock and accumulated effort will, of course, only hold for the particular value of the average annual effort. If the annual effort is greater, then the same total effort, spread over fewer years, will reduce the stock more (since there will be recruitment from fewer years to counteract the effect of catching). Therefore, if for a particular season the accumulated potential effort since 1946 is used to estimate the catch per unit effort from the regression in Figure 1, the result will be an overestimate of the true catch per unit effort in that season, if no regulations had been in force. The estimates are given in Table 2. The difference between this estimate of catch per unit effort and the observed value gives the difference in stock, and hence if multiplied by the ratio (r — M) of net recruitment to parent stock, will give the difference in the net recruitment some four years later. (Mr. K. R. Allen has pointed out that these differences in net recruitment could be used to give a better estimate of the population than the one obtained directly from the regression). To eliminate effects unconnected with the differences in effort the catch per unit effort for the actual pattern of effort was estimated from the regressions of Figure 1 (see Table 2), and this value, rather than the observed value (which is subject to other sources of variation) was used to calculate the differences in Table 3. In this table it appears that there is no difference in the stock of fin whales until the 1953/4 season, and so none in the recruits until the 1957/8 season. This is because of the probable underestimate of the fin whale population stock in the early years when blue whales were still abundant.

Table 3

Estimates of difference in net recruitments of Antarctic whales

Season*	Difference in catch/effort Blue	Fin	Difference in net recruitment Blue	Fin
1946/7	0	0	0	0
1947/8	0·02	0	0·002	0
1948/9	0·04	0	0·004	0
1949/50	0·10	0	0·010	0
1950/1	0·17	0	0·017	0
1951/2	0·21	0	0·021	0
1952/3	0·21	0	0·021	0
1953/4	0·22	0·06	0·022	0·007
1954/5	0·22	0·52	0·022	0·062
1955/6	0·225	0·93	0·0225	0·112
1956/7	0·214	1·30	0·0214	0·156
1957/8	0·205	1·28	0·0215	0·154
1958/9	0·181	1·24	0·0181	0·149
1959/60	0·150	1·12	0·0150	0·134
1960/1	0	0·96	0	0·115
1961/2	0	0·77	0	0·092
1962/3	0	0·65	0	0·078
1963/4	0	0·54	0	0·065
Total (c/e units)			0·216	1·124
Total (No. of whales)			4,300	45,000

* The season refers to the parent stock. The actual difference in recruitment would occur some four years later.

However, at that time the fin whale stock was probably around the level giving the maximum sustainable yield (i.e. the maximum net recruitment), so that the net recruitment probably would not be greatly affected by the difference in effort. Thus in the column in Table 3 giving the difference in net recruitment, the figures for the early years may be quite close to the true value even if the values for the difference in population are wrong.

The values of $r - M$ used to estimate in Table 3 the difference in net recruitment from the differences in stock were 0·12 for fin whales and 0·10 for blue whales (CHAPMAN, 1964, para. 58 and Figure 6). These give a total reduction in net recruitment, in units of catch/catcher-day × tonnage, of 0·216 for blue whales and 1·124 for fin whales. These can be converted into actual numbers from the fact that in 1953/4 the blue whale stock was around 10,000 animals or less (CHAPMAN, 1964, para. 66) with a catch/effort of 0·42 (i.e. one unit of catch per unit effort equals about 20,000 whales) and that the 1963/4 stock of fin whales was about 40,000, with a catch/effort of about unity (CHAPMAN, 1965, Table 1). Therefore the estimate of the loss in the net recruitment if there had been no regulation, expressed as number of whales, is about 4,300 blue whales and 45,000 fin whales. Remembering that this figure is an underestimate, and that no account has been taken of other regulations, such as the protection of undersized whales and of females with calves, it is clear that the achievements of the International Whaling Commission have been considerable. The value of the increased catch, using a conservative figure of £ 2,000 per blue whale unit, is over £ 50 million, several times the cost not only of the Commission, but probably of all whale research.

Discussion

These calculations suggest that the International Whaling Commission has increased the total yield of whales from the Antarctic, but this achievement must be measured against what could have been achieved. Perfect management would consist of bringing the stocks as quickly as possible to the level giving the maximum sustainable yield, and thereafter taking the greatest possible harvest. Any comparison between the actual events in Antarctic whaling since the war, and the ideal situation of perfect management, may be quantitatively difficult, but would show a very important qualitative difference. Perfect management should provide sustained annual catches of 6,000 blue whales and 20,000 fin whales (CHAPMAN, 1964); immediately after the war the catches of blue whales should probably have been less, to allow the stocks to build up to the optimum level; and conversely the fin whale stock was probably above the optimum level, so that more than 20,000 per season could have been caught. The annual catch under perfect management would therefore have averaged about 15,000 Blue Whale Units (1 blue whale = 2 fin whales = 6 sei whales), i.e. much the same as actually occurred.

The vital difference lies in the possible catches in the immediate future. Properly managed, the Antarctic whale stocks could have continued to provide some 15,000 BWU per year indefinitely. In the 1965/6 season no blue whales should be caught (and even if there had not been an agreement to ban the killing of blue whales, the possible catch would have been only a few hundred), and the total catch was only 4,000 BWU. Even this total, probably less than a third of the combined maximum sustainable yields of blue and fin whales, is more than the present total sustainable yields of all whales. The present sustainable yield of fin whales is around 4,000 animals, and it is very desirable, in order to increase the long-term catches, that the actual catch should be considerably less than this so that the stocks can build up as quickly as possible. These low catches, perhaps 1,000 BWU, or only enough for the economic operations of a couple of expeditions, can hardly be considered a substantial industry.

It is, of course, unreasonable to compare the results achieved by the Commission with perfect management; in 1946 no estimates had been made of the sustainable yields, nor were there data on which precise estimates could have been made. A more reasonable comparison is with what might have happened if the Commission had always acted promptly on the basis of the best scientific knowledge that could be made available. Even soon after the war the decline in the blue whale stocks was apparent to all. Also enough was known about whale biology (especially the low reproductive rate) and about the theoretical basis of population dynamics for fairly good predictions to be made of the likely effects of too heavy fishing (see OTTESTAD, 1956). Available theoretical models could also show quite clearly the loss in long-term catches as the result of consistently taking rather more than the sustainable yield, compared with taking rather less. Thus the Commission should have been able to take action to keep the stocks at a reasonable level, and hence preserve a substantial industry, even in the absence of precise estimates of sustainable yields etc. One tragedy of the Commission has been its failure to act until the scientific evidence is complete, precise and incontrovertible, although the evidence can only become completely convincing by observing the decline in the stocks, which it is the duty of the Commission to prevent.

The comparative success of the Commission in achieving a larger catch than would have been taken with no regulation must therefore be considered, in absolute terms, as a failure to achieve its main responsibility to catchers and consumers of maintaining a substantial industry in the Antarctic. However, the difference in value of catch between this failure and the greater failure which would have occurred if there had been no regulation is large compared with the costs of the Commission.

Similar calculations could presumably be made of the effects of regulations of major fish stocks. For these, complete failure in the sense of extinction of the fishery is unlikely because, due to their high fecundity (with a few exceptions such as dogfish), fish stocks cannot easily be reduced to commercial extinction. Failure in the sense of causing the catches, over a period, to be less than they would have been in the absence of regulation is more likely, especially in fisheries where only one country is concerned, and regulations can be quite easily introduced. In international fisheries a wider agreement is necessary before regulations can be brought into effect, so that they are more likely to be soundly based, and their effect has, on the average, been to increase the long-term catches, probably the most outstanding example being the Pacific halibut, though the economic, but not the biological, success of this regulation has been criticized (CRUTCHFIELD, 1962). These increases may often be only a small percentage of the total catch, but in the major fisheries even one or two per cent of the total may far exceed not only the cost of the Commission concerned, but also the associated costs of research etc.

Thus, while conservation of the Antarctic whale stocks has almost completely failed, and a proper management of the major international fisheries is only just beginning, there have nevertheless been achievements in international conservation which, in relation to the costs of the research and other effort involved, have been very substantial.

Summary

The effect of the quota regulations on Antarctic whale stocks has been calculated on the assumption that in the absence of quotas the same expeditions would have gone to the Antarctic but each season would have lasted 121 days (equal to the longest post-war season). When the catch per unit effort is plotted, on a logarithmic scale, against the accumulated effort the result is a straight line. Using this relation, for both the accumulated potential (121-day season) effort, and the actual effort, the difference in catch per unit effort between a regulated and an unregulated fishery can be estimated. Multiplying by the ratio ($r - M$) of stock to net recruitment gives the difference in net recruitment, and, knowing the relation of catch per unit effort to actual numbers for each stock, enables this difference to be given in actual numbers.

Using these methods, which underestimate the effect of the regulations, the estimated increases in net recruitment are 4,300 blue whales, and 45,000 fin whales.

References

CHAPMAN, D. G., 1964. "Final report of the Committee of Three Scientists on the Special Scientific Investigation of the Antarctic Whale Stocks". 14th Rep. int. Whal. Commn., 40–92.

CHAPMAN, D. G., 1965. "Report of the Committee of Four Scientists on the Special Scientific Investigation of the Antarctic Whale Stocks". 15th Rep. int. Whal. Commn., 47–60.

CRUTCHFIELD, J. A., 1962. "Regulation of the Pacific coast halibut fishery". Fish. Rep. F.A.O., No. 5; 354–92.

"International Whaling Statistics". Published annually by Det Norske Hvalråds Statistiske Publikasjoner, Oslo.

OTTESTAD, P., 1956. "On the size of Antarctic fin whales relative to the size of the catch". Norsk Hvalfangsttid., No. 6; 298–308.