

HUMPBACK WHALING AT MADAGASCAR, 1910-1950

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Abstract

In two episodes of whaling, the *Uniwaleco* (1937-39) and the *Anglo Norse* (1949-50) expeditions took a total of 6,083 humpback whales from the coastal waters of Madagascar. This paper attempts to provide indices of relative abundance for both episodes for use in the comprehensive assessment of southwest Indian Ocean humpback whales. Both episodes were characterized by substantial and statistically significant declines in catch per unit effort (CPUE), and the second episode by marked changes in the size and gender composition of the catch. In the 1937 season the *Uniwaleco* expedition also operated on the east coast of southern Africa, where the CPUE proved to be about 21% of that off Madagascar and the proportion of mature animals much lower, suggesting that the migratory streams on the east African and Madagascar coasts had been subject to different catch histories.

INTRODUCTION

The first modern whaling enterprise in the waters of Madagascar was that of Johan Bryde, who according to Budker (1954) sent the steamer *Mangoro* (2,054 tons) to the southern part of the island near Tulear in the winter of 1910. However another account states that the *Mangoro* was on a whaling voyage at or near Kerguelen from 8 March to June 1910, and then undertook whaling trials near Bazaruto Island, Mozambique, from 3 August to 11 October 1910 (Arnaud and Beurois 1996), so the length and timing of the operations off Madagascar are unclear. Budker (1954) gives the catch there as 79 whales (species unidentified) in 35-40 days.

The efforts of the Chr. Salvesen company in 1912 with the factory ship *Horatio* (3,239 tons) and two catchers seem to have fared no better, perhaps because they arrived at Tulear rather late in the year (at the beginning of September): a total of 25 humpback and 9 sperm whales was taken, and the whole enterprise was described as a total failure (Budker 1954, Tønnessen 1967, Tønnessen and Johnsen 1982). Also in 1912, authorization was obtained from the Governor of Madagascar for the establishment of a

whale fishery on 3 hectares of land in St Augustine Bay (Arnaud and Beurois 1996), but I can find no information on whether this opportunity was ever taken up.

Because of these inauspicious beginnings, an impression seems to have been created that it was impossible to make a profit out of the existing stocks of whales in the region (Budker 1954), and for 25 years there were no further attempts to catch whales in the waters of Madagascar.

Between 1937 and 1939, however, the Union Whaling Company in Durban sent the factory ship *Uniwaleco* and 6-7 catchers for three successive winter seasons to Madagascar, and in 1949 and 1950 the *Anglo-Norse* expedition with 7-8 catchers whaled for two successive seasons in the same area. Catches in all five seasons (particularly of humpback whales) were two orders of magnitude higher than in the earlier expeditions, and resulted in obvious depletion of the stock (Angot 1951, Bermond 1950).

In this paper we investigate the pattern of catching in both these latter episodes of exploitation and attempt to develop relative indices of abundance that might be useful in the comprehensive assessment of humpback whale breeding stock C.

MATERIAL AND METHODS

Apart from published material, the following original data sources have been consulted

- Individual catch records for the 1937 *Uniwaleco* expedition to Madagascar, as reported to the Bureau for International Whaling Statistics (BIWS). These comprised 53 typed pages giving (for each catcher) the date, species, length, sex and position of every whale landed (nine records of foetal length and sex were included). Only one position was recorded for each day for all whales taken, and presumably represented the noon position of the factory ship. Coded versions of the data were also provided by the International Whaling Commission Secretariat.
- Individual catch record data for the 1938 and 1939 *Uniwaleco* expeditions to Madagascar have not yet been traced, and summarized data provided by Bermond (1950) had to be used instead. However, microfilm records of the *Natal Mercury* (NM) for 1937, 1938 and 1939 and the *Natal Witness* for 1938 and 1939 were consulted for contemporary information and comments on the movements of the fleet in and out of Durban.
- Coded versions of individual catch records for the 1949 and 1950 *Anglo-Norse* expeditions to Madagascar, as reported to the BIWS, and provided by the IWC Secretariat. Two sets of data were available when these data were coded, those from the Day Book completed by the company and a second set from the BIWS. These were not always consistent, and where differences arose the data from the Day Book was usually preferred as it was considered to be the likely source of the BIWS records. The same basic data as for the *Uniwaleco* were provided, but not

on an individual catcher basis. Total monthly catches per catcher, however, were available for the 1950 season.

- Coded versions of individual catch records for the 1936 and 1937 whaling seasons for the Union Whaling Company's land station at The Bluff, Durban, South Africa, as reported to the BIWS, and provided by the IWC Secretariat.

RESULTS

The *Uniwaleco* expeditions, 1937-1939

In 1937 the Union Whaling Company in Durban purchased the Danish-registered factory ship *Fraternitas* (9,755 tons) and five of its associated catchers. Renamed the *Uniwaleco*, the factory sailed from Durban with six catchers (*Uni I* – 249 tons, *Uni II* – 250 tons, *Uni III* – 240 tons, *Uni IV*- 197 tons, *Uni V*- 198 tons, and *Sydney Smith* – 250 tons) on 9 June 1937 (NM 8-10 June 1937). Local media described her intention as “to hunt for whales in the Indian Ocean some distance from Durban”, and commented that “her actual destination has not been revealed” (NM 10 June 1937). As events will show, it seems this vagueness reflected the exploratory nature of the venture rather than any deliberate obfuscation. The subsequent cruise track of the expedition has been reconstructed from newspaper records and the locations of all whales caught (probably equivalent to the noon position of the factory – see above). This has the disadvantage that days with no catch are not represented, making some interpolation necessary (Fig. 1).

After departing Durban, the expedition travelled up the Natal coast and into Mozambique waters before leaving the coast and transiting the Mozambique Channel between 16 and 19 June. For the next 16 days the fleet operated in the vicinity of Cap Sainte-Marie at the southern tip of Madagascar, before transiting back to the Mozambique coast between 5 and 8 July. At some time between 9 and 13 July the expedition returned to the southwest coast of Madagascar, where they stayed until 26 August. On 16 and 17 July operations were extended as far north as Toliara on the west coast (23° 22' S) but returned to the southern coast by 18 July. By 29 August the fleet was back on the Mozambique coast, possibly on a rescue mission for the third officer, who had injured his knee and had to be landed at Inhambane (NM 9 September 1937). On 8 September the *Uniwaleco* docked in Durban to partially offload production: one catcher (*Uni II*) had docked 2 days earlier for repairs. On 11 September the expedition left port to resume whaling (NM 8, 9, 13 September 1937). It arrived back on the southern coast of Madagascar on 20 September, where it stayed till the end of the month. There are no further catches recorded after 30 September, when the expedition apparently ceased whaling and left the area. The factory ship arrived in Durban on 5 October 1937, with the catchers having come in one and two days earlier (NM 5, 6 October 1937).

The total catch of the *Uniwaleco* consisted of 1,223 humpback, 22 fin whales, 4 blue and 8 sei whales – one additional fin whale was killed but lost. Although the Committee for Whaling Statistics (1939) attributes these catches in total to “south of Madagascar”, it is clear that some should rather be allocated to the East African coast, or even the

Mozambique Channel itself. We have attempted to reallocate the catches, but because the whereabouts of the expedition can only be determined from a single location every day (possibly at noon), the exercise is not straightforward. The principal uncertainties arise when the expedition makes a crossing of the Mozambique Channel, as although the noon position may be some distance off the coast, the catches may well have been taken (or be about to be taken) in coastal waters. The allocation in Table 1 suggests that of the 1,223 humpback whales, 1,126 (or 92%) were taken in the waters of Madagascar, 70 (6%) on the African coast and 27 (2%) in the Channel. Realistically speaking, given their proximity to either coastline, 17 of the Channel whales could probably be allocated to Madagascar and 7 to Africa, but for the purposes of estimating relative abundance we have retained the allocations as in Table 1. The location on 6 September 1937 seems suspicious, in that it implies a considerable offshore diversion. Two catchers took whales on this day, both were given the same position, and because there are no positions for 4, 5, or 7 September it is impossible to use estimated speed to test for feasibility: we have allocated these catches and effort to the Channel.

Daily catches of humpback whales were generally high when the expedition was at the southern tip of Madagascar, but dropped sharply once the expedition left the coast or travelled across to the eastern seaboard of Africa (Fig. 2). At such times the catch was often supplemented by other species such as fin, sei or blue whales, indicating that the expedition was still operational but unable to find high concentrations of humpback whales. When the *Uniwaleco* docked in September, the captain commented that the results to date had indicated that whales were not altogether plentiful and a great deal of cruising had been necessary: perhaps appropriately, the article termed the three months of operations as an “experimental season” (NM 9 September 1937).

Within the Madagascar catch there were 706 males and 420 females, or a ratio of 62.7%:37.3%. Such a male-biased sex ratio is typical of low latitude breeding grounds for humpback whales (Clapham 2000). Assuming males ≥ 37 ft and females ≥ 39 ft are sexually mature (Chittleborough 1955a, 1955b), the majority of the catch of both sexes consisted of mature individuals (72.2% in males and 59% in females). On the African coast, however, the sex ratio in the catch was no different from parity (37 males: 32 females; chi-square = 0.24, $p = 0.6242$), and there were far fewer large individuals than in the catch off Madagascar (Fig. 3), with the proportions of mature individuals significantly less (51.4% in males, chi-square (Yates correction) = 6.5, $p = 0.0108$; and 31.3% in females, chi square (Yates correction) = 8.28, $p = 0.004$). The composition of the catch for the Union Whaling Company’s land station at Durban for 1936 and 1937 combined is similar to that of the *Uniwaleco* on the African coast (Fig. 3): a sex ratio of 277 males: 265 females, with 36.1% of males and 27.5% of females being mature (not significantly different from those for the *Uniwaleco*’s African catch; chi-square (Yates correction) = 2.61 and 0.05, $p = 0.106$ and 0.823 respectively).

Although individual catch position data could not be traced for the 1938 and 1939 *Uniwaleco* expeditions, Bermond (1950) published a table showing the numbers of humpback whales taken (and the number of days catching effort spent) in 5 sectors of the Madagascar coast (Fig. 4) for both seasons, as well as a cumulative plot of catches

against date. These have been compared with movements of the expedition in and out of port as recorded in local newspapers.

On 16 May 1938 the *Uniwaleco* left Durban with 6 catchers (NM 11 and 17 May 1938) and (judging by the timing of the first catches as plotted by Bermond) must have proceeded directly to Madagascar. The season is said to have lasted from 22 May to 9 October (NM 12 October 1938), or for 141 days. Bermond (1950), however, gives a duration of 136 days, during which time 1,738 humpback whales were taken. This compares with a total catch of 1,752 humpback, 48 sperm, 1 blue, 2 fin and 2 sei whales for this expedition as published by the Committee for Whaling Statistics (1939). We have assumed that the differences in the length of season and catch composition arise largely from operations that took place away from the coast of Madagascar (and so were excluded by Bermond). Following the 1937 results it would have been a logical strategy for the expedition to restrict itself to operating on the coast of Madagascar, and this was confirmed by a press statement at the end of the voyage. A mid-cruise return to their home port for discharging accumulated production (as happened in 1937) was also obviated by transshipping to the tanker *Havsten* at sea on the whaling grounds (NM 12 October 1938). On arrival back in Durban on 11 October, the *Uniwaleco* was reportedly accompanied by 7 catchers (NM 12 October 1938). The Committee for Whaling Statistics has consistently reported this expedition as having 6 catchers (CWS, 1939 et seq.), and although it is possible a seventh catcher joined the fleet later (see *Anglo Norse* below), we have preferred to assume that the size and composition of the catcher fleet remained the same as in the preceding season.

In 1939 the expedition left Durban on 22 May with 6 catchers with their destination given as Madagascar (NM 15 and 23 May 1939). The Committee for Whaling Statistics initially gave the number of catchers with this expedition as “ca. 5” (CWS, 1947), but subsequently as “?” (CWS, 1948) and finally as “5” (CWS, 1952 et seq): given this uncertainty we have preferred to accept the more contemporary account and have assumed that the size and composition of the catcher fleet remained as in 1938. From the timing of the catches plotted by Bermond (1950), the expedition must have proceeded directly to their announced destination. The whaling season in Madagascar extended until late September, for a total of 119 days, during which time 1,162 humpback whales were taken (Bermond 1950). Unfortunately, apart from 61 sperm whales, the catch of 1,240 other whales given by the Committee for Whaling Statistics (1961) for “south of Madagascar” in 1939 has never been specified (Committee for Whaling Statistics, 1961), but one could assume that the same logic prevailed as in 1938, and that the majority of the catch was of humpback whales taken on the coast of Madagascar. Given the overall length of the voyage (130 days), this would seem a reasonable assumption. The *Uniwaleco* arrived back in Durban on 29 September 1939, where it was reported that the catch had not been as good as was anticipated (NM 30 September 1939).

The Anglo Norse expeditions, 1949-50

The floating factory *Anglo Norse* (8,268 tons), under charter to the Norwegian-American Spermacete Whaling Co., and flying the British flag, arrived with its fleet of seven catchers (*AN-5* – 246 tons, *Kos 4* - 248 tons, *Kos 6* – 248 tons, *Kos 8* – 248 tons, *Kos 11* – 258 tons, *Kos 13*- 258 tons, and *Kos 18* – 258 tons) in the coastal waters of Madagascar on 11 June 1949. An eighth catcher (*Kos 15* – 258 tons) from Walvis Bay arrived on 10 August. One catcher operated principally as a buoy-boat, collecting whales killed by the other boats and delivering them to the factory ship (Bermond, 1950; IWC Secretariat, pers. comm.). Operations continued until 10 October, when the expedition left the Fort Dauphin area for Europe via South Africa (Angot 1951). The noon positions of the factory ship show that the expedition confined itself to operating on the south and south east coasts of Madagascar, including an excursion up the east coast between 13 and 28 August as far as Ile Sainte-Marie, where the *Anglo Norse* was refueled by the tanker *Jaspis* in the lee of the island and some of the oil production trans-shipped (Angot 1951). Catches in the waters of Madagascar consisted entirely of humpback whales, totaling 1,333 animals.

The 1950 expedition followed a very similar pattern, with the expedition (that now included an eighth catcher, *Kos 43*, with the original seven from 1949) arriving on the coast of Madagascar on 24 June 1950. A ninth catcher, *Kos 7* (248 tons), seems to have arrived sometime in August (taken here as 15 August). Judging by the differential catch rates, it is likely that either the *Kos 43* or *Kos 7* acted principally as a buoy boat. Operations continued until 20 September, when the expedition left for a sperm whaling cruise up the Mozambique Channel and towards the Seychelles. The cruise track followed by the expedition while on the coast of Madagascar was almost identical to that in 1949, including an excursion up the east coast to Ile Sainte Marie for refueling from and trans-shipment of production to the tanker *Peik* (Angot 1951).

Catches in the waters of Madagascar consisted of 714 humpback whales, 1 blue, 10 fin, 3 sei and 11 sperm whales; this catch included 8 fender whales, 2 of which were not worked up, and 2 lost whales – all were believed to be humpback whales. Catches per day were noticeably lower than in 1949 (Angot 1951), particularly in the second half of the season, despite the existence of an additional catcher. The incidence of other species in the catch presumably reflected the shortage of humpbacks, and may have precipitated the earlier departure of the expedition from the coast.

Trends in relative abundance of humpback whales

Despite the two periods of exploitation at Madagascar being extremely brief, providing little in the way of a time series of relative abundance indices, the catches in each period were substantial and thus increase the chances of detecting a significant decline in abundance.

The development of such indices within each period is assisted by the following factors:

- Only one expedition was involved
- Humpback whales were effectively the sole target species
- The start and end dates and areas of exploitation are similar for each season

Because there was no information on the numbers of hours spent searching, chasing and handling, we have had to use the gross catcher day as the basic unit of effort – that is, the number of catchers in the expedition multiplied by the number of days they were on the ground (Tables 2 and 3). Although we have not had access to the original catch records from *Uniwaleco* for the 1938 and 1939 seasons, independent data have tended to confirm the accuracy of the catch and effort distribution for those expeditions in the waters off Madagascar as published by Bermond (1950). Furthermore, our analysis of the original catch records for the 1949 *Anglo Norse* expedition has agreed very closely with a similar summary provided by Bermond. Nevertheless, the use of gross catcher days assumes by default that there was no inter-annual trend in the time spent searching, an assumption that could be questioned. The effect of weather has also been assumed to be a random variable.

Comparisons between periods are more fraught with problems. Both factory ships were small by later standards, with the *Uniwaleco* being the larger but older (launched 1905 and converted to factory ship 1923) compared to the *Anglo Norse* (launched 1914). Both possessed a stern ramp, and both seemed to be equipped only for the production of oil with no by-products (Bermond 1951). The catchers in 1937-39 were significantly smaller than in 1959-60 (means 230.7 (SE 10.6) tons vs 252.8 (SE 2.0) tons; $t = -2.36$, $p = 0.036$, $df = 12$), but this difference was mainly due to the *Uni IV and V*: the other 12 catchers from both expeditions ranged between 240 and 258 tons in size. The expression of efficiency brought about by the larger vessel size was considered to lie mainly in its greater speed and hence ability to search further per unit time: the designed maximum speed of *Uni IV* and *Uni V* was 10.5 knots, for instance, compared to 12 knots for *Uni I* and *Uni II* (Du Toit 1992). Assuming the increase in searching distance was proportional to this increase in cruising speed, the relative efficiency of the two smaller catchers was taken to be $10.5/12$ or 87.5% of the larger, and catch effort for the *Uniwaleco* expeditions adjusted accordingly.

Another problem involves the use of a buoy boat by the *Anglo Norse* in both seasons, but apparently not by the *Uniwaleco*. Apart from the few whales it might take itself (the *Kos 43* took only 16 whales in 1950, compared to 76-125 for the other full-time catchers), the buoy boat presumably had its greatest effect in reducing towing time (and hence increasing hunting time) for the other catchers. Without knowing the relative times spent searching for, chasing, handling and towing whales each day, however, it is difficult to account for the increase in overall efficiency brought about by the buoy boat. Somewhat arbitrarily it has been assigned half the value of a normal catcher when estimating total catching effort.

Although catch and effort data are available for five adjacent sectors of the Madagascar coast each year (Fig. 4), only one (sector B) was whaled in all five seasons, complicating

inter-annual comparisons. Accordingly a GLM (Generalised Linear Model), assuming an overdispersed Poisson distribution, was used to estimate year factors as indices of abundance. The model made the further assumption of comparability between the 1937–39 and 1949–50 operations. The form of the model was:

$$C_{y,s} = qn_{y,s}e^{\alpha_y + \beta_s}$$

where:

- $C_{y,s}$ is the catch in year y in coastal sector s ;
- q is a catchability coefficient;
- $n_{y,s}$ is the number of catcher-days (cd) spent catching in year y in coastal sector s ;
- α_y is a year factor with $\alpha_{1937} = 1$; and
- β_s is a coastal sector factor with $\beta_B = 1$.

The results are reported in Table 4 with the year factors plotted in Fig. 5. There is a decline of almost 50% from 1937 to 1939, and this is statistically significant at the 5% level. The index estimated for 1949 is slightly below that for 1939, although the difference is not significant and this comparison is in any case dependent on the assumption of comparability (in terms of catchability q) of the two operations. However the decrease of some 35% from 1949 to 1950 is significant at the 5% level.

In developing an index of abundance for the African coast in 1937, we have used all the days allocated to this region in Table 1. These specifically exclude the 4 days spent in Durban between 8 and 11 September, plus the preceding day when it is assumed there was no whaling prior to the factory arriving in port. The overall humpback catch per catcher day (allowing for the reduced efficiency of the two smaller catchers) is estimated at 0.58, or about 21% of that for the *Uniwaleco* off Madagascar in the same year (2.72).

DISCUSSION

It seems fairly clear that the two episodes of whaling either side of World War 2 were both accompanied by a decline in the abundance of humpback whales in Madagascar, and there is some confirmation of this either by implication in press reports (NM 30 September 1939) or from subsequent analyses. Angot (1951) concluded that the population underwent a considerable decline in numbers from 1949 to 1950, but was unable to decide whether this was a direct result of the hunt or was a consequence of an earlier arrival of the whales on the coast and a later start to whaling in 1950. There were marked changes in the composition of the catch, with the sex ratio changing from 807 males: 522 females in 1949 to 234 males: 461 females in 1950, and with the almost complete absence of males over 38-39 ft in 1950 and far fewer females between 38 and 43 ft. Angot's explanation of this phenomenon was that successive age or reproductive (lactating vs non-lactating) classes were differentially exploited between years, but this involved an unrealistic scenario of growth rate: undoubtedly the application of a sex-structured population model would help resolve this question. Whatever the mechanism, the reduction in the stock was such that the profitability of another expedition similar to

those in 1949 and 1950 was considered problematic or even non-existent, and a suspension of all whaling activities around Madagascar for a number of years was recommended, to allow the population to recover (Angot 1951). Such a conclusion would not be inconsistent with the trends in humpback whale availability calculated here, which if taken at face value would indicate that the population in 1950 was at 31% (see Table 4) of its level in 1937.

The contrast between the whaling results experienced by the *Uniwaleco* on the coasts of Madagascar and eastern Africa in 1937 is particularly interesting. Humpback whales migrating along the eastern seaboard of southern Africa (referred to as C1 by the IWC) had been heavily exploited by shore stations in Natal and Mozambique between 1908 and 1915, estimated total removals being about 7,500 animals. This had produced a marked decline in availability such that stations either closed down or switched to other whale species. Humpback catches from this migratory stream had not ceased but averaged 173 per year over the intervening 21 years, and at least during the 1920s there had been no signs of an increase in availability off Durban (Best 2003). That this population was still depleted seems to have been reinforced by the very low catch rate, and the relative absence of large, mature individuals, experienced by the *Uniwaleco* on the coast of Mozambique and Natal in 1937.

The much higher catch rates on the southern coast of Madagascar (referred to as C3 by the IWC) in 1937 by themselves do not necessarily imply that interchange between the two regions was low (as they could simply reflect an intrinsically higher density of whales in Madagascar). However if the C1 and C3 populations are considered to be all part of one migratory stream, it would be difficult to account for the strikingly different size and sex composition of the catches taken in the same season in both areas by the same expedition, unless there is some age/sex segregation between the two regions. As the differences are similar to those seen over time within populations that have been heavily impacted by whaling, and given the very different densities of whales in the two areas, the simplest explanation would seem to be that the two migratory streams were not homogeneous, and had undergone very different histories of exploitation. If there was any exchange rate between the C1 and C3 populations, it would seem to have been insufficient over the 22-year period for the population composition in the two regions to have equilibrated.

The similar sex-ratio and size composition “signatures” between the Natal catch for 1936 and 1937 and the *Uniwaleco* catch in 1937, and the difference between these signatures and that for the *Uniwaleco* in southern Madagascar, are consistent with both sets of African catches being part of the same migratory stream, but inconsistent with the hypothesis that there is commonality between the whales migrating past KwaZulu-Natal and those migrating to Madagascar.

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Table 1: Allocation of 1937 catches by the *Uniwaleco* to geographical region

Period	Noon position	Whales taken				Allocation
		Hump	Fin	Blue	Sei	
10-15 June		3	5	1		Africa
16 June	24.667°S 39.933°E				4	Channel
17 June	24.833°S 41.8°E	1	6		1	Channel
18 June	25.2°S 43.35°E	2	1	1	2	Channel
19 June – 4 July		277				Madagascar
5 July	25.867°S 44.300°E	15				Channel
6 July						Channel
7 July						Channel
8-9 July		4	6	1		Africa
10 July						Channel
11 July						Channel
12 July						Channel
13 July – 26 August		708	5			Madagascar
27 August						Channel
28 August						Channel
29 Aug – 5 Sept		61			1	Africa
6 September		2		1		Channel
7 – 11 September						In port
12-16 September		2				Africa
17 September	25.050°S 35.867°E	7				Channel
18 September						Channel
19 September						Channel
20-30 September		141				Madagascar
TOTALS		70	11	2	1	Africa
		27	7	2	7	Channel
		1126	5			Madagascar

Table 2: Catches of humpback whales and CPUE by sector of the Madagascar coast, *Uniwaleco* expedition, 1937-39 (assuming six catchers in operation each year, with two at 87.5% of efficiency of others)

Coastal Sector	1937			1938			1939		
	Catch	No. of days	C/cd	Catch	No. of days	C/cd	Catch	No. of days	C/cd
A	151	13	2.020	8	8	0.174	36	16	0.391
B	975	59	2.874	808	71	1.979	336	36	1.623
C				766	46	2.896	572	49	2.030
D				166	11	2.625	119	11	1.881
E							99	7	2.460
Total	1126	72	2.720	1748	136	2.235	1162	119	1.698
African coast	70		0.580						
Mozambique Channel	27		0.313						

Table 3: Catches of humpback whales and CPUE by sector of the Madagascar coast, *Anglo Norse* expedition, 1949-50 (assuming buoy boat equivalent to 0.5 catcher)

Coastal sector	1949				1950			
	Catch	No. of days		C/cd	Catch	No. of days		C/cd
		with 6.5 catchers	with 7.5 catchers			with 7.5 catchers	with 8.5 catchers	
A								
B	580	22	26	1.715	362	24	18	1.087
C	470	31	15	1.496	251	18	12	1.059
D	170	6	11	1.399	59	6	1	1.102
E	113		9	1.674	42	4	6	0.518
Total	1333	59	61	1.585	714	52	37	1.013

Table 4: Results of Poisson GLM standardization of CPUE data from the *Uniwaleco* and *Anglo Norse* expeditions. Quantities are given as multiplicative factors (i.e. exponentiated values from analyses conducted in log space), with 95% CIs shown in parentheses

Year factor		Coastal sector factor	
1937	1	A	0.406 (0.220; 0.748)
1938	0.705 (0.505; 0.986)	B	1
1939	0.550 (0.377; 0.801)	C	1.198 (0.927; 1.549)
1949	0.476 (0.330; 0.687)	D	1.097 (0.730; 1.650)
1950	0.308 (0.203; 0.467)	E	1.052 (0.603; 1.836)
1950 (relative to 1949)	0.647 (0.441; 0.948)	Overdispersion factor	17.5

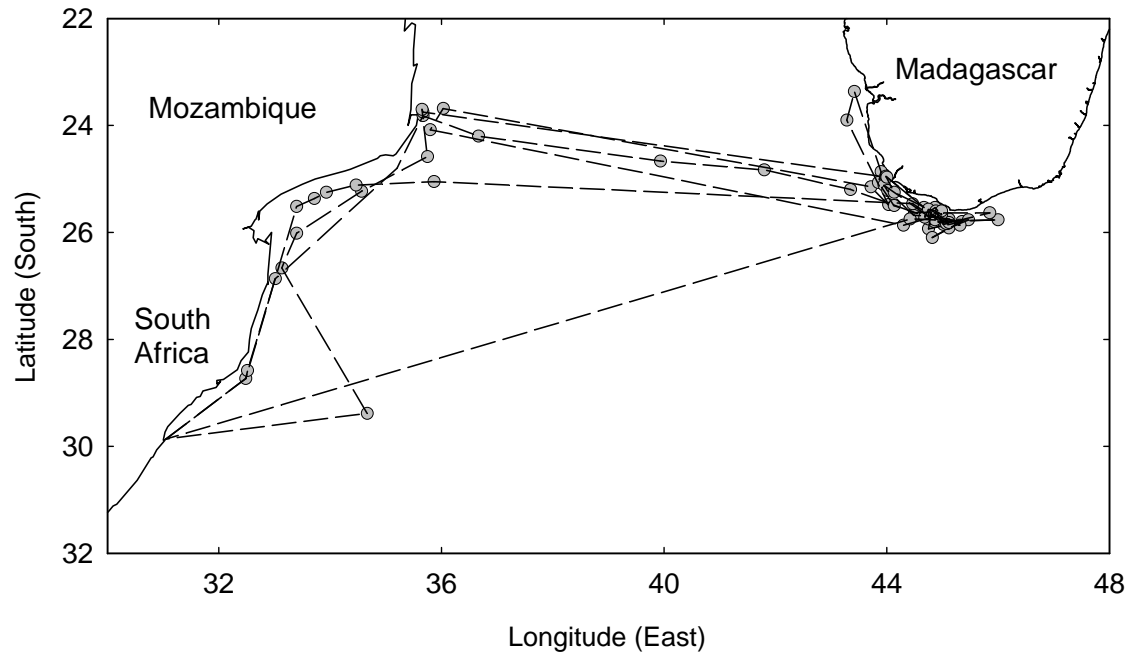


Fig. 1: Noon positions of the *Uniwaleco* 1937 expedition on days on which whales were caught (symbols), plus interpolated track line (dashed line)

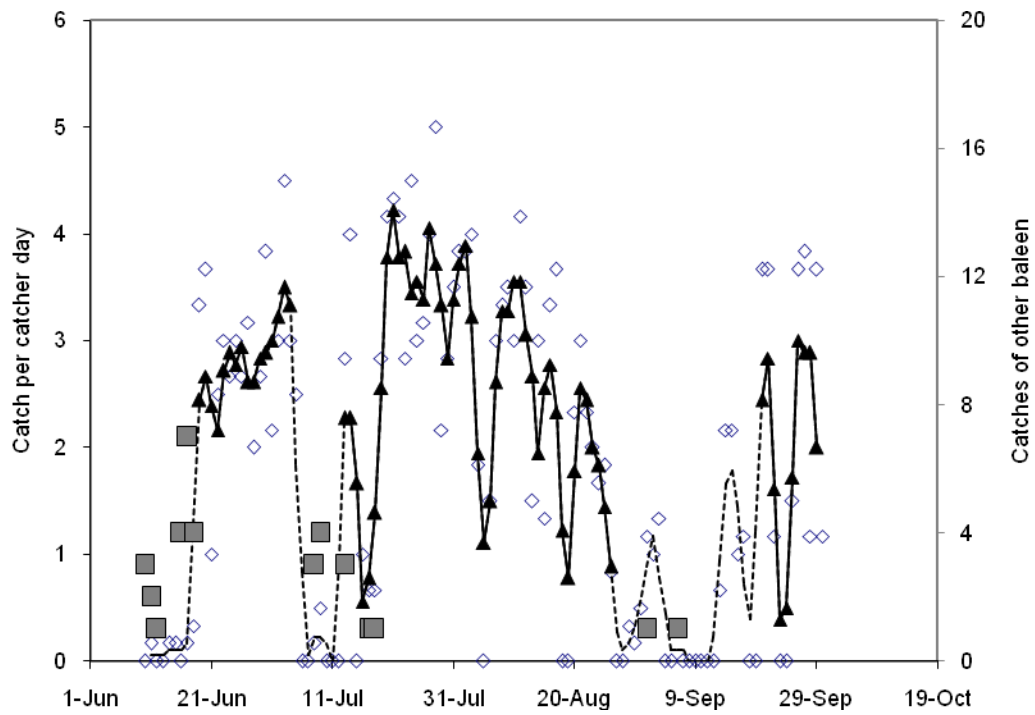


Fig. 2: Daily availability of humpback whales (open symbols) and catches of other baleen whale species (solid symbols) by the 1937 *Uniwaleco* expedition, with availability trend line smoothed by threes (broken line indicates periods outside the coastal waters of Madagascar)

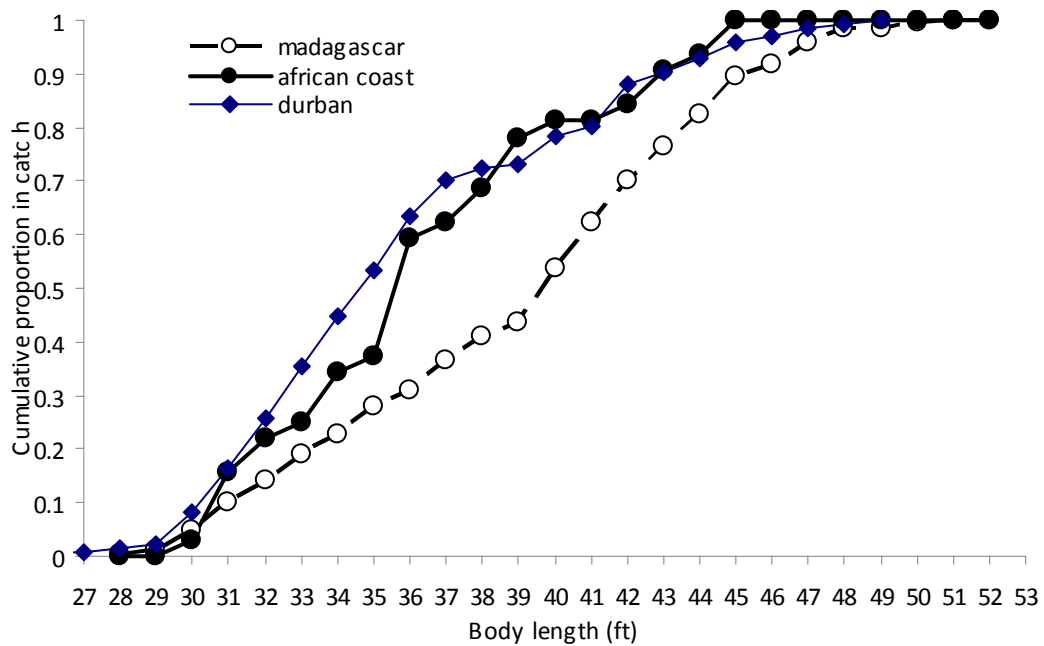
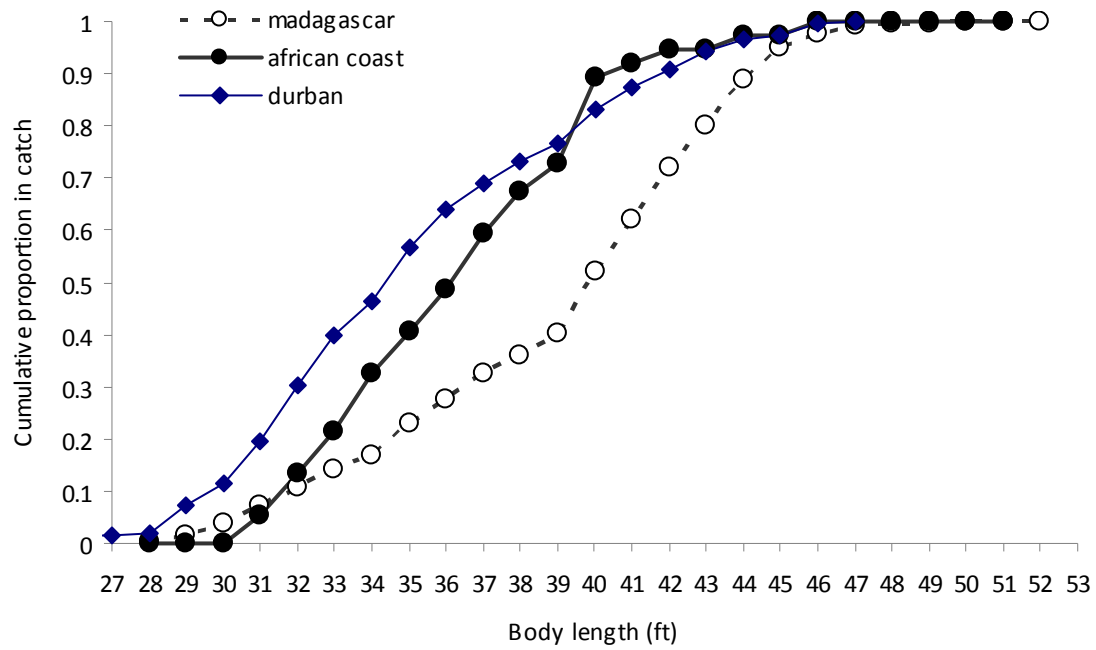


Fig. 3: Cumulative size frequency distribution of (above) males and (below) females in the *Uniwaleco* catch of humpback whales off Madagascar and the African coast in 1937, and in the Union Whaling Company's catch at Durban in 1936 and 1937.

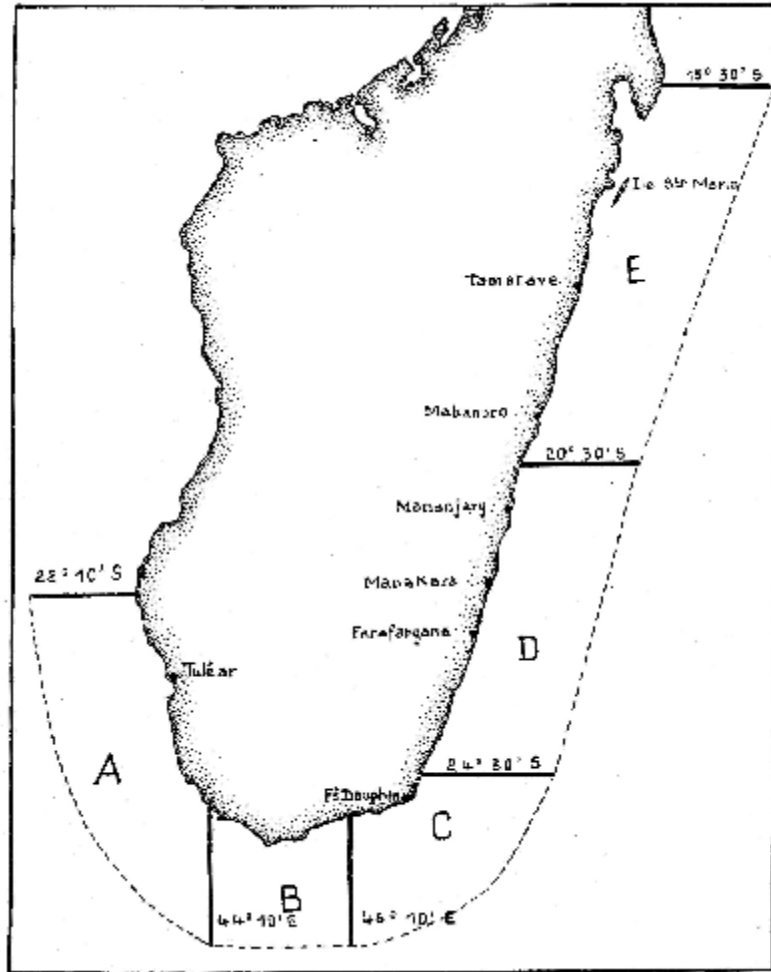


Fig. 4: Southern coast of Madagascar, showing the sectors used by Bermond (1950) in allocating the coastal catch of humpback whales.

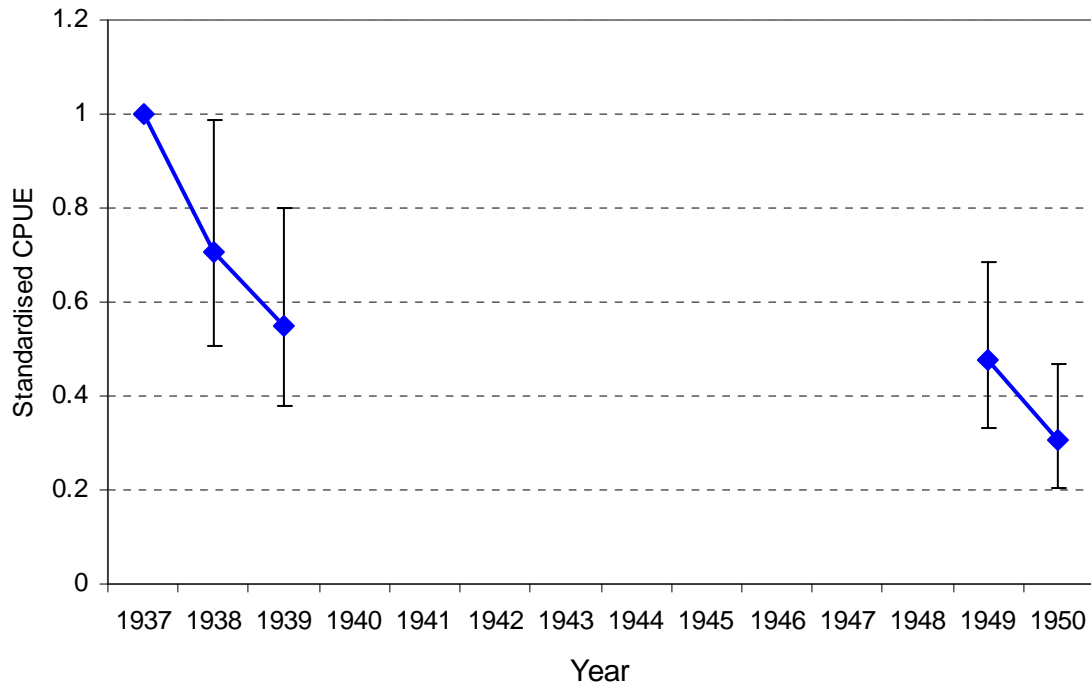


Fig. 5: Indices of humpback whale availability off Madagascar on the *Uniwaleco* and *Anglo Norse* expeditions, 1937-39 and 1949-50 respectively, standardised for coastal area of operation. The error bars reflect 95% confidence intervals relative to 1937.