Helicopters and the Whaling Industry

By A E BRISTOW*

Mr Chairman, Ladies and Gentlemen I have been in some dilemma about the type of paper to read before such a technical body I would like very much to include a brief history of whaling, the zoology of whales, and the economics of whaling I would like to describe rounding Cape Horn in a full gale, and to tell you in an informal way of experiences during a hurricane in latitude 68 South last season , of terrible accidents and suicides , of personal sacrifice , of brilliant seamanship , of bitter disappointment , and of super-humān efforts I would also like to recall some amusing, some sad and some frightening personal experiences that I had during two whaling seasons

Instead, I shall describe the structure of a whaling expedition and summarise last season's work, trying to make a comparison between present whaling methods and new techniques offered to the whaling industry by the use of helicopters I shall conclude with a summary of the advantages to be gained by the use of helicopters for whaling

To set the scene of this paper, I shall show you a few photographs taken in both seasons and a film, and, during the showing, I shall add a little commentary

Pelagic whaling, or whaling from a floating factory ship in the Antarctic, commenced in 1926, and has increased in activity, becoming more and more highly mechanised, elaborate and intensive with each succeeding season

Reliable information is so scanty and unrepresentative that it is almost impossible to draw definite conclusions on the state of the Antarctic whale stock The general belief in the industry that stricter controls and protective measures were needed, led to the formation of an International Whaling Commission, and in 1944 it was agreed amongst all the participating nations (and there are 17 member nations, of which 7 nations are preresented by expeditions in the Antarctic) that the catch should be limited to 16,000 blue whale units This control of the catch heightened competition and increased the number of whale catcher days expended per blue whale unit—the race for larger catcher fleets and more and more complicated and costly equipment had begun The seasons became shorter and shorter, and more and more

* I wish to express my thanks and appreciation of help given by the Netherlands Whaling Co United Whalers Chr Salvesen & Co Westland Aircraft Ltd and John Wolley

emphasis was placed on saving time to achieve the same production Between 1947 and 1950, the price of oil was £85—95 per ton, and in 1950/51 increased to £100—110 per ton In these times little consideration was given to long term economy Each expedition sought only—and for that matter is still seeking—to find some special equipment or method whereby it could gain temporary, if not permanent, advanatge over its competitors

In the last 18 months, the world market for edible fats has become more stable with the increase in supply of vegetable oils, and the stage has now been reached when there is no longer an acute shortage

1952/53 saw a sharp decline in the price of whale oil from £100 to £72 per ton Two of the smaller whaling companies found that this drop made it uneconomical for them to send out their expeditions Another whaling company has failed to sell its oil from the last two seasons This recession in the whale oil market, with the desire to preserve the Antartic whale stock, has brought about agreement between all whaling companies to reduce their catcher fleets in the coming season and this has been scaled in accordance with the productive capacity of the factory ships, giving the smaller factories 10—12 catchers and the rest 13, with the exception of Baleena which will have 14

Today, economy in whaling methods is paramount if pelagic whaling is to survive It is my earnest conviction that helicopters offer the solution to more efficient and cheaper whale oil production

From the days when pelagic whaling began there has always been anxiety about the Antarctic whale stock, and this dread of exterminating " the whale that gives the golden oil " has resulted in united efforts through the medium of the International Whaling Commission to enforce protective measures

Among the more important regulations laid down by the International Whaling Commission are the following

(1) The duration of the Baleen whaling season has been shortened It now commences on the 2nd January of each year, and continues until April 15th, or until a total of 15,500 blue whale units have been taken, whichever is the sooner The blue whale unit represents one blue whale, two fin whales, 2½ humpback whales, or six Sei whales

(2) The whale must be of specified length, according to its species, before it cane be killed , namely blue whales 70 ft , fin whales 60 ft , Sei whales 40 ft , humpback whales 35 ft and sperm whales 38 ft

(3) A gunner who kills an under-sized whale or a lactating whale forfeits a bonus on the oil produced from such whales

(4) It is forbidden to kill calves, or female whales accompanied by calves

(The catching of sperm whales is not limited by seasonal or regional restrictions, but rather by the world market demands for this sort of oil)

(5) Certain areas have been classified as non-catching areas

(The value of this method is in some doubt, because the prohibited area is not populated by many whales)

Each expedition now consists of a factory ship and 12 to 14 attendant catchers Of this catcher fleet perhaps three or four are used throughout the season as tow-boats and/or for long range reconnaissance Very roughly, the catchers hunt and kill the whales and the tow-boats steam all over the hunting area collecting the flagged whales and towing them back to the factory ship for processing There are very few modern catchers or tow-boats that are not equipped with M F /D F , Radar, D M E , W T /R T and Ekco Sounding apparatus Some catcher fleets employ a modification of the war-time A S D I C to assist them in finding whales Each catcher has a crew of 18 to 20 men, and the larger expeditions may be composed of as many as 600 men in total

Command of a whaling expedition is usually vested in the Master or Manager of the factory ship, and he decides where the fleet shall hunt for whales Moreover he controls the tactical disposition of the catcher fleet

It has become fairly wide-spread practice in recent years for catchers to hunt in an arc four points on either side of the general direction of movement of the factory ship, and at a distance from 50 to 120 nautical miles

The area of sea between the nearest catcher and the factory ship may be considered, therefore, a thoroughly searched area, and if maximum productive benefit is to be derived from aerial reconnaissance, the helicopter patrol must extend at least 50 nautical miles beyond the catcher furthermost from the factory ship, or be restricted to a narrow sector on either extremity of the main catcher sweep In short, there is little value to be gained if whales are found by the helicopter more than 40 nautical miles from the nearest catcher This requirement alone dictates a flight endurance of at least nine hours and the need for more than one reconnaissance helicopter per expedition In fact finding whales and not being sure that any will be killed by the catchers is a little futile ; this surely emphasises the increased value to be gained from aerial killing

The uses for helicopters in Antarctic whaling may be summarised under the following headings

(1) Search for whales

(2) Ice reconnaissance

(3) Search for flagged whales

(4) Direction of catchers on to targets

(5) Transfer of sick or injured from the catchers to the factory ship

(6) Killing, inflating and flagging whales from the helicopter

(7) Marking whales to give more reliable and representative data on migratory movements

Before getting involved in detailed discussion on these issues, I would just like to mention the limitations of fixed wing aircraft operating from a whaling factory vessel To my mind they are prohibitive, and I very much doubt if one will ever see them used again, for the following reasons

(1) The sea and weather conditions for operating aeroplanes must be favourable, and there must be good prospects that fair and stable weather will prevail for at least four to six hours from the moment that a requirement arises for aerial reconnaissance until the machine returns

https://doi.org/10.1017/S2753447200001967 Published online by Cambridge University Press

(2) The aeroplane cannot be operated from the factory ship when
- (*a*) a catcher is alongside for bunkering or repairs,
- (*b*) a catcher is delivering whales,
- (*c*) a supply tanker or depot ship is alongside,
- (*d*) there is drift ice or pack ice in the vicinity,
- (*e*) the wind force exceeds Beaufort 6 (24 knots) ,

  (It is very common in the Antarctic to experience a heavy swell for many days on end, and this state of sea, combined with the wind force above Beaufort 4 or 5, makes water landings for an aeroplane rather perilous)

Time is precious in a season lasting perhaps 75 to 80 days Therefore minutes count, and from the moment there is a requirement for aerial reconnaissance, such delaying factors as I have mentioned above only detract from the value of aerial search The helicopter suffers none of these limitations and fits ideally into the whaling routine

It is not surprising that prior to the use of helicopters in 1950/51, the experience of whaling companies with aeroplanes in the Antarctic was disastrous There was a legacy of ' mistrust ' in flying machines in general, and on my first Antarctic expedition with the Hiller 360, I thought it had been passed on to helicopters in particular One of the most difficult, if less tangible obstacles, has been to overcome the reluctance of whalers to accept the potentialities of the helicopter There is only one solution to this lingering, though dwindling, unhappy inheritance flying, more flying, and more flying still , flying in all weathers with perfect safety and reliability There is no easy or quick way Whalers had to be convinced, and I am pleased to say that they now accept the helicopter as a robust, reliable and effective piece of equioment which, in the hands of experienced and trained personnel, can be used to their advantage and to the advantage of the whaling industry as a whole

The experience of my first season has been extremely valuable to me, although the results obtained from the flying point of view were most disheartening I think in the final analysis that the low utilisation was due to the absence of adequate preparations and planning, rather than to the performance of that particular helicopter

After the 1950/51 season I drew up a specification for an Antarctic whaling helicopter, and amongst the features of this specification I called for a helicopter witn a more powerful engine, preferably with two engines, an endurance of eight to ten hours, with an auto-pilot, comprehensive radio navigational aids and a crew of two, a cruising speed of 75 knots, and assisted by special deck facilities Details of this specification are given in the appendix

Unfortunately there were no machines in Europe that could come anywhere near meeting these requirements, and consequently one season passed without further helicopter trials Before passing on to review the work with the S 51 last season, I would like to make some detailed observations concerning rotor blade icing which I experienced with the Hiller helicopter

In the initial stages of ice formation on the main rotor blades of a Hiller 360 helicopter there was no variation in power settings nor any change in the vibratory characteristics of the stick or fuselage

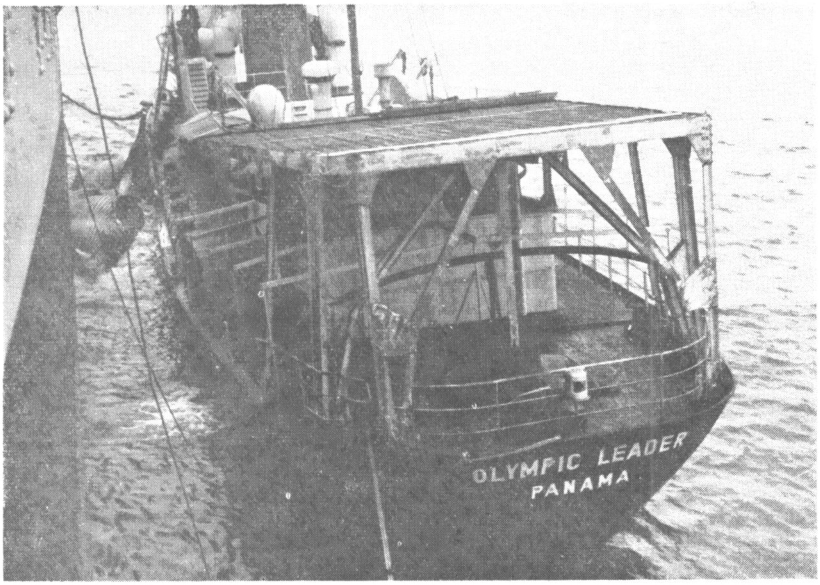

Fig 1 A small platform on the "Olympic Leader" as arranged for the Hiller 360

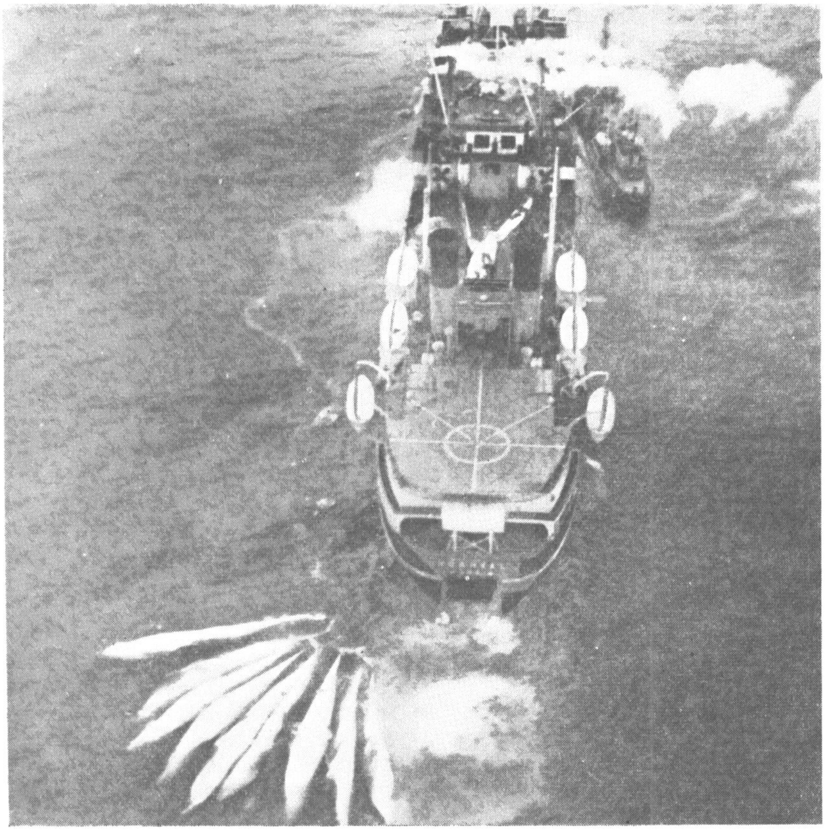

Fig 2 The landing platform for the Sikorsky S 51

https://doi.org/10.1017/S2753447200001967 Published online by Cambridge University Press

The time between the first layers of thin ice becoming firmly established and the commencement of what I have called the " critical building-up period " varied considerably with ambient conditions After some experience it was found that the formation of clear ice on the windscreen usually marked the beginning of the critical build-up period which was invariably characterised by a sharp drop in r p m attended by a noticeable but by no means abnormal increase in stick vibration During some hovering tests ice was allowed to build up on the blades until flight became impossible, and immediately prior to landing in this state vibration became severe to violent throughout the machine

Several flights were made in driving snow, which apart from adhering to the windscreen, did not tend to form as ice on the blades

On one occasion the critical build up period was reached immediately prior to commencing an approach to land Application of collective pitch in the final stages of the approach resulted in very sluggish response and failed to adequately arrest the descent A heavy landing was made , in the recovery from this baulked landing the machine was hovered somewhat unsteadily for a few seconds, and in this brief period severe large amplitude vibration was experienced throughout the helicopter This was attributed to a large piece of ice about 3 ft long and 3 inches wide being thrown off one blade thereby causing considerable unbalance in the system This unbalance did not impose any limitations on the amount of control available No structural failure was suffered

In a power-off autorotative descent icing of such a severe nature would have made a controlled landing impossible

When ground running in icing conditions it was observed that ice formed much more readily on the rotor blades at high rather than low collective pitch settings

Whenever severe icing conditions prevailed a thin layer of ice about $\frac{1}{4}''$ to $\frac{1}{2}''$ thick was observed on the main rotor head components This in no way prejudiced the normal operation of the control links even after long periods of ground running Movement of the exposed control cables to the tail rotor became rather stiff on occasions due to ice forming in the vicinity of the cable guide channels This never became serious The tail rotor was mysteriously immune from ice

Application of de-icing compound to the main and tail rotor blades was found extremely difficult Even distribution of the substance was quite impossible on freezing surfaces What little was applied was completely dissipated after about 15 minutes flying

The ice formations encountered may be classified in two categories clear smooth formations and rough irregular formations

The clear smooth formation extended forward of the leading edge in identical pattern on each blade to give the blades the appearance of high speed wing sections The ice was more or less evenly distributed from root to tip with the extension varying in thickness between $\frac{1}{2}''$ at the root to $1''$ at the blade tip This type of ice was brittle and could be chipped off quite easily, although it could not be dislodged in flight

The rough irregular, partially opaque ice formation which built-up like a snow-plough blade ahead of the leading edge extended the whole span of each blade in similar pattern It was thickest at the blade C G datum point and tapered towards the tip and root very gradually It varied in

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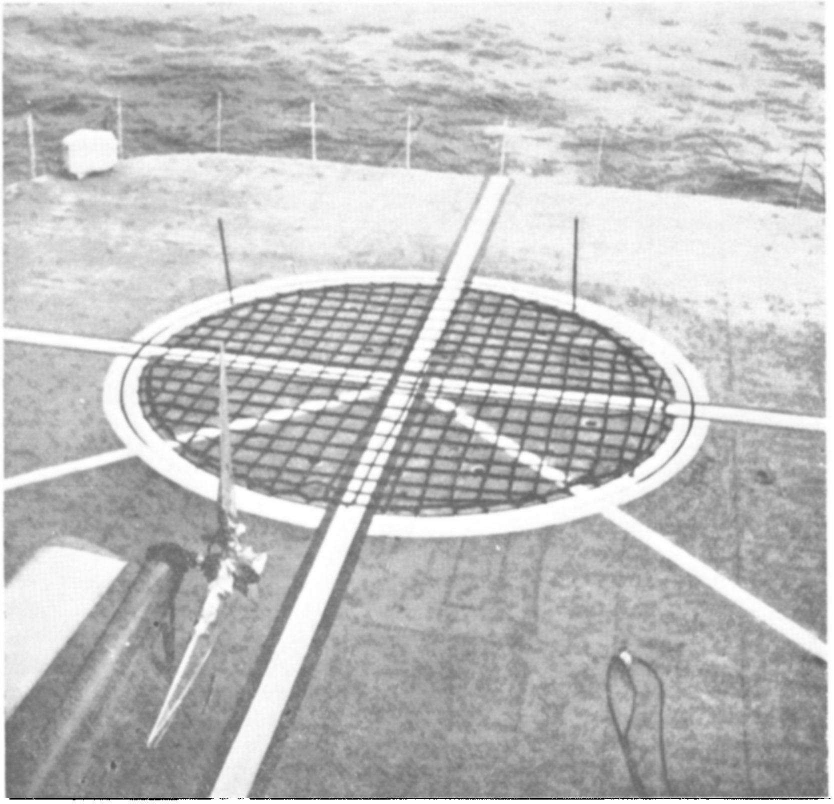

Fig 3 A close view of the Sikorsky landing turntable

thickness between ½″ at the root to 1¼″ at the C G datum point to ¾″ at the blade tip It was very adhesive

In both cases the ice extended chordwise on the top and bottom surfaces in a thin layer ⅛″ to ¼″ thick for about 2″ to 3″ with occasional thin streams of ice extending diagonally across the blade top surface to the trailing edge No formation was observed on the trailing edge Chordwise coverage was slightly greater on the bottom surface of the blade in the case of the rough ice deposits

It was found impossible to dislodge the rough ice by harsh movement of the cyclic and/or collective pitch controls

CONCLUSIONS

(1) There is no reliable warning of ice formation on the main rotor blades until an advanced condition is reached

(2) The symptoms of the commencement of the "critical build-up period" are always the same *viz*, drop in r p m and increase in stick and fuselage vibration

(3) The critical build-up period is sufficiently long to enable a precautionary landing to be made in most circumstances One has between three and five minutes in severe icing conditions before deposits reach such dimensions and so completely destroy the aerofoil efficiency that flight becomes impossible

(5) Early detection of blade icing is essential

(6) De-icing equipment must permit speedy dispersal of all ice This equipment should remain operative under power off conditions to cater for prolonged descents in severe icing conditions

(7) Structural damage to a rotor system must be considered a positive

hazard if large unbalanced forces cannot be quickly eliminated, *e g* , when only one blade sheds all or part of its ice

Violent vibrations might, to a limited extent, be self corrective but the damage that could be done by flying ice would be sufficient to wreck a tail rotor or twin main rotor assembly and therefore means of preventing large accumulation of ice should be mandatory

(8) The necessity for de-icing and/or anti-icing equipment cannot be emphasised strongly enough Rotors do ice up and no amount of blade flexing or harsh movement of the controls will dislodge it The availability of such equipment in conjunction with blind flying instrumentation and automatic pilot equipment would greatly extend the operational value of helicopters, and perhaps indirectly hasten their tardy development

When I was asked last year to take charge of an S 51 belonging to Melsom and Melsom, I was very doubtful if the performance of this machine would show any marked improvement and give better results than were achieved on the first season with the Hiller However, my anxiety was not justified, and I am sure this was due entirely to the very careful planning and preparations that were made, and the excellent co-operation given us by the manager and officers of the expedition Moreover, deck facilities were vastly improved, and a hangar was provided to give protection for major maintenance work

To give you a proper understanding of the remarks that are to follow, I list the performance of the S 51, which we used last season

Endurance (Less 40 minutes reserve)	4 hours, 35 mins
Indicated Air Speed (with 'doughnut' type emergency floats permanently inflated)	57 5 nautical miles
Still Air Range, with 40 minutes reserve	260 nautical miles
Safe Radius of Action	100 to 130 nautical miles depending on weather conditions
WEATHER MINIMA	
Wind Speed	40 knots
Visibility	¼ mile
Cloud Base	50 ft
Sea Conditions	15 ft rise and fall sumultaneously with 15° of roll

Some people may think that I was taking unnecessary risks, but I was convinced that only practical proof would earn us the respect and confidence that we so urgently sought from the whalers In criticising these risks, I would ask you to bear in mind that last season's work constituted in my mind just the continuation of the first experiment

To achieve worthwhile results with a machine of this performance and at the same time ensure a safe margin of endurance to overcome unfavourable changes in wind speed and/or direction, it was necessary to exceed the Civil maximum gross weight by 235 lbs This brought the maximum operating weight to 5,935 lbs It is fair to say that the machine's handling qualities at this gross weight were entirely satisfactory, and I would like to see the S 51 approved for Civil use at a maximum gross weight of 5,970 lbs in keeping with the Naval loading One cannot divorce endurance from speed when examining the S 51's performance in whale reconnaissance work, but it would nevertheless be true to say that it was the slow speed rather than the endurance limit which was the biggest single handicap In winds above 30 knots, the slow cruising speed introduced an element of risk and seriously reduced the time that could be spent in positively identifying whales or following them until catchers could be brought close enough to the area to be sure of finding the whales themselves

At all times, careful flight planning coupled with accurate assessment of wind speed and direction and any variation thereof, were of utmost importance if any reliance was to be placed on the air plot With a little practice, accurate assessment of wind velocities was soon achieved, and a great deal of trust placed in the D R plot which was kept by the non-flying pilot in the radio room aboard the factory ship In this way, the Master was given accurate whale position reports, and it was a simple matter for him to direct the required number of catchers to the area where whales had been located

In winds up to 25 knots and with a visibility of three nautical miles, no difficulty was encountered maintaining a regular patrol distance of 80 to 110 nautical miles from the factory ship Of course, we flew in much worse weather than the above, and it was not an uncommon occurrence to find oneself flying in visibility of 100 yds or slightly less, and in wind speeds of 35 to 40 knots Many flights were made in heavy snow storms and through fog to reach clear weather areas reported by the catchers Although ice did not form at a dangerous rate in these conditions, it did serve to indicate, however, the ultimate need for efficient rotor blade de-icing equipment I think the greater flexibility of the S 51 metal blades, compared with the Hiller composite wood blades, helped to prevent serious ice accretion on the blades

Throughout the operation, taking 3½ hours as the average duration of each flight, the estimated time of arrivals given by the helicopter plotter, were always within plus or minus seven minutes of the actual arrival times considering the helicopter flew out 80 to 110 nautical miles regularly, this was a most creditable achievement In this connection it was appreciated from the beginning that without a navigator in the helicopter flight safety would be linked very closely with reliable radio communication Unfortunately, time and space do not permit me to describe the equipment and relate any experiences For flights in wind speeds above 25 knots, an additional fuel allowance was made to combat the appearance of unexpected or unfavourable wind components on the homeward leg Several flights of four hours duration were made, and experience proved that the best results were obtained and a good safety margin maintained if flights were planned not to exceed four hours After this period of being strapped in an uncomfortable seat, striving every moment to see " blows ", one's limbs became stiff, cold and cramped, and one's alertness deteriorated rapidly In an S 55 the crew can move about, take food and hot drinks in the cabin, and return comfortable and refreshed to their flight duties, which may well last eight to ten hours per flight

The amount of flying a helicopter pilot can perform regularly day after day will vary directly with his flying experience, stamina, and the extent of his other duties On days when three flights were required, I confess that I was extremely tired after 7 to 8 hours flying, three to four hours plotting and one and a half hours deck-handling

I do value this opportunity to sweep away many of the bogies and false stories to the effect that helicopters are exceedingly difficult to handle aboard ship

The best landing technique, to give the pilot the least obstructed view of the landing area—a circle of 20 ft in diameter—and to avoid flying in excessive turbulance from the funnel smoke and gases during the approach, was found in an approach line 45° on either quarter Red and white approach lines and limit marks were painted on the flight deck to facilitate both the approach and the final accurate positioning for touch-down Throughout the season and in all weathers and ship conditions when flying took place, the landing accuracy was maintained in the order of plus or minus six inches You will understand the reason for such precision landings when you study the photograph showing the bag clearance from the edge of the turntable If one bag over-lapped the turntable the machine had to be re-landed or the bag deflated to eliminate the risk of puncturing during orientation of the turntable This poor design feature in the flight deck is to be avoided

Quite apart from simplifying deck handling in such a confined space and saving the ship from manoeuvring into wind every time the helicopter wished to land or take off, the turntable gave another freedom and also greater safety in starting the rotor in high and gusty wind conditions I feel sure that the Royal Navy would do well to incorporate turntables in all ships carrying helicopters, in order to extend the utilisation of these machines I am confident that rotors could be started and stopped in perfect safety in winds of 50 to 55 knots if the helicopter is positioned " Tail into wind " for both these operations

By virtue of the relative airflow in this state, the region of most downward flapping of the blades is transferred from a sector near to the tail cone to a position over the nose of the helicopter This eliminates the danger of the blades striking the fuselage Upward movement of the blades during starting and stopping in strong winds has been overcome by the introduction of an anti-coning device in the rotor head mechanism

Although the precaution had been taken of installing wind baffles, or screens to break the full force of the wind and to avoid excessive turbulance for starting and stopping the rotors, they were never used The maximum relative wind in which flying took place was 52 knots, and no difficulties were encountered

For the records, it can be stated that the rotor blades were folded on a completely exposed flight deck in winds up to 55 knots without accident

In whaling, helicopters have to be ready to fly at a few minutes notice and in consequence methods of deck handling must be stream-lined the luxury and comfort of the hangar is reserved for extensive repairs or overhaul work The helicopter therefore, when not airborne, must remain moored and ready on the take-off area or turntable It was in this exposed position last season that it rode out—without the slightest damage—the force of a hurricane In retrospect, I think the helicopter crew keeping watch on the

https://doi.org/10.1017/S2753447200001967 Published online by Cambridge University Press

flight deck during the hurricane were in far greater peril of injury or of being swept overboard than the helicopter was

To give this readiness at short notice and to maintain the maximum safety against the full fury of the elements, a simple permanent mooring system had to be devised which could be easily operated by two persons

Folding main rotor blades of whaling helicopters in all the weather conditions which they must fly, takes from four to ten minutes and needs the physical effort of two to four men, according to how hard the wind is blowing at the time The solution is obvious don't fold the rotors

Blade tip covers might at first appear to offer the solution, but their safety in winds above 25 knots for long periods is in grave doubt I am inclined to believe that they do more harm than good, and consequently I introduced the blade-mooring stanchions The blade stanchions relieved all stress and strain on the blade root that would occur if blade tip covers were used Moreover, it is much quicker and easier to fit or remove these fittings than it is to fold the blades, and the handling can be done by one person

As an example of speed in deck handling, it is recorded that it took four men only 17 minutes to fold the blades, unlash the helicopter from the turntable, push it into the hangar and moor it securely in its new position

Aerial reconnaissance provides the following information

(1) Exact information on the type, size, number and whereabouts of whales, their speed and direction of movement

> (An expedition leader in possession of this information can direct the correct number of catchers to a definite position to hunt a known number of whales, and in this way save each catcher precious steaming time and increase oil production)

(2) Confirmation that there are no whales in a sector extending 250 nautical miles from the factory ship

> (This information likewise enables economies to be made in catcher steaming time and above all can prevent an expedition from moving into areas where there are known to be no whales)

(3) Exact knowledge of the factory's distance from the main ice barrier or large areas of ice pack

In my opinion the direct productive value of whale reconnaissance with small helicopters of 4—5 hours endurance reaches its maximum when whales are found within 15 to 20 nautical miles of one or more of the catchers Beyond this range the value becomes progressively and rapidly less, especially if the whales are on the move in search of food

With a helicopter capable of remaining airborne say eight to ten hours, this distance may be profitably extended to 50—60 nautical miles for with such flight endurance it becomes possible to keep in touch with whales much longer, and to ensure that catchers reach the scene with the minimum of steaming and delay Moreover the helicopters with 8—10 hours endurance will be able to shadow a pack of whales dispersed by catcher attacks without disturbing them, until the catchers have completed their immediate task and can be directed to the new targets In this way the reconnaissance helicopter can directly improve the ratio of killings to sightings For efficient aerial coverage at least two helicopters are required per expedition the following example only serves to endorse this statement

One reconnaissance helicopter with a safe endurance of say nine hours and a maximum endurance of 10 hours will efficiently cover an area of 13,500 square miles, estimating a range of 10 miles visibility or with a reduced visibility of 3 nautical miles will cover 4,050 square miles in the course of *one* flight

Compare this range with that of a whale catcher which has a maximum radius of vision of 7½ miles from the Crow's Nest, and covers in favourable conditions 4,500 square miles in 20 hours, or 1,800 square miles in the same period when the range of vision is reduced to a radius of 3 nautical miles There can be no doubt as to which is the most efficient method of reconnaissance

To expand the scope of aerial reconnaissance one might consider the use of a flight or hovering re-fuelling system from the catchers or, alternatively, landing platforms of say 30 by 45 ft might be fitted on each of the catchers With the adaptation of helicopters for aerial killing, landing platforms on the tow-boats will, I feel sure, become essential to facilitate re-loading the helicopters with harpoons as well as have an advance re-fuelling base In this connection I foresee the necessity for an automatic mooring system wherein the helicopter is securely gripped on contact with the installation

In aerial reconnaissance whales are detected in several ways and one soon learns to interpret the meaning of Krill in the water, the presence of certain types of birds and oily foot-prints in the water, quite apart from determining the size and type of whales from their " blow " or " blast " The best height for observing " blows " varies considerably with prevailing sea, wind and cloud conditions, and it would be unwise to try to state any hard and fast limits for aerial observation Much will depend on the individual pilot or observer In general terms the calmer the sea and darker the horizon, the higher becomes the best observing altitude up to a maximum of 1,000 ft In rough seas and/or with a light, hazy horizon, the best lookout is kept from 50 to 100 ft and in these circumstances recognition of the " blows " becomes a lot plainer flying cross-wind and sea Down wind and sea the " blows " stand out well from 300 ft In conditions of reduced visibility and when flying low, surveillance of the sea on each quarter is advisable if one is not to over-fly whales

" Blows " are visible from the helicopter up to ten miles without binoculars, but become more difficult to see directly in the sun lane when the sun is low in azimuth In these conditions patrols are best made at 500 ft or very low (wave-top level) Flying into strong winds when the sea is covered with breaking white wave crests which often trail deceiving wisps of fine spray resembling the fading particles of a " blow," it is hard to see the " blows " when beyond three or four miles

Similarly aerial observation of the whales under-water movements is influenced by the sea, sun and cloud conditions The least troublesome is the state of the sea it can be quite rough, but if the sky is light the whales remain clearly visible swimming many fathoms down Heavy dark clouds make the surface of the water opaque and it is difficult in these conditions, if not at times impossible, to see the whales deeper than five fathoms Once " blows " have been sighted it is necessary to positively identify the whales, estimate their size, kind and numbers, and keep them continually in view

The best height to do this is between 300 and 500 ft Accurate judgement of size depends a lot on one's experience

Krill patches are easily seen from the air and often give positive indication of the presence of whales, especially if there are birds over the Krill

There is no longer any doubt that the helicopter observer can follow whales easily when they are swimming between normal " blowing " cycles during the chase up to depths of the order of 30 fathoms, and he can detect the beginning of a cut Unfortunately when a whale cuts or alters direction in a sounding dive during the chase, it passes out of the sight of aerial observer and catcher look-out alike, although nine times out of ten the helicopter observer can easily see the direction in which the whales alter course, but he cannot forecast the exact position in which they will break surface to " blow "

The helicopter, having sighted whales, can close range with the whales about eight times faster than the catcher, and can determine in a matter of seconds whether or not the whale is of right size and species to be worth killing By comparison the catcher suffers a severe speed handicap and although the experience of gunner and catcher crews reduce the chance of error to a minimum, much time is still wasted by a catcher closing range after sighting a whale to determine its size Even now a good percentage of under-sized whales are being killed each season, and this is most detrimental to the preservation of the whale stock in the Antarctic I believe that all helicopters for reconnaissance and/or killing purposes should be equipped with a whale measuring sight to eliminate the risk of directing catchers on to under-sized whales or to inadvertent killing by the helicopter gunner of the future

The estimation of whale size by aerial reconnaissance is of particular time-saving value on an expedition because it prevents time being wasted by the catchers in pursuit of worthless targets All too frequently last season the helicopter's endurance proved inadequate for on most flights the whales were not sighted until about 2 to 2½ hours had elapsed from the time of take-off and on occasions the whales sounded before the pilot could come close enough to positively measure their size In these circumstances it was often necessary to circle the area where the whales were last seen for 10 or 15 minutes to await their re-appearance, and on several occasions the helicopter had to abandon positive identification due to lack of fuel The machine of eight to ten hours endurance would not suffer this limitation

From the search we go to the chase This is one of the operations which varies tremendously in terms of time with prevailing sea conditions, visibility, behaviour of the whales being chased and the skill and tactics of the gunner With catcher killing the whale is always given some warning of its impending fate by the propeller noises of the approaching catcher, and my observations show that whales can hear these under-water vibrations when the catcher is still five miles distant and usually they start to take evasive action before the catcher is within three miles

It sometimes happens that whales do not move away from an approaching catcher due to their pre-occupation with feeding in a patch of Krill, but even in this case the catcher can seldom get within a range of one mile before the whales start to move off in one direction or another and frequently at high speeds

Fin whales, which appear to be far the most plentiful in the Antarctic in recent years, are found usually in herds varying in number from 2 to 200, or even more in some exceptional cases On the approach of danger these herds disperse in all directions, and the catcher has to decide which group it is to chase I have watched chases last only 20 or 30 minutes, and again I have been the helmsman on a catcher on a chase lasting six to seven hours Many chases are abandoned because the whales escape into pack ice or under a curtain of fog or into the murk of a snow storm This would seldom, if ever, occur if helicopters were used for killing as well as for reconnaissance purposes

It is the aim of all gunners after sighting whales to kill the maximum number in the minimum of time, but unfortunately the present ratio of catcher sightings to catcher killings is an adverse one from the oil production point of view

Last season 1,334 Baleen type whales were sighted from one S 51 helicopter in 185 flying hours which were logged in the first 36 days of the whaling season It has been estimated that the helicopter reconnaissance and catcher direction work last season produced 75 blue whale units Had the machine been capable of longer endurance and of carrying a co-pilot or observer, the results would have been many times more impressive Flying had to cease on the 11/2/53 due to lack of one vital spare part

To return to the catcher in full chase of its target, I would like to describe the characteristics of the harpoon gun to give you a better understanding of the present whaling methods The guns used today are of two principal makes, namely the Kongsberg and the Bofors Both of these are of the breech-loading type The harpoon, which weighs approximately 175 lbs is loaded into the muzzle of the gun with its barbes or flukes, which prevent the harpoon from being withdrawn from the body of the whale, securely lashed with two or three turns of yarn To the business end of the harpoon, beyond the flukes, is screwed a war-head, which is made of metal, with a very high fragmentation factor Inside this explosive head is fitted a delayed action detonator and 200 to 220 grms of explosive black powder A nylon forerunner is attached to the harpoon by means of two wire strops made out of 11 gauge " Fagerstic " wire These strops travel down a channel in the shank of the harpoon when the gun is fired and allow the forerunner to trail with a minimum of deflection behind the harpoon in flight The forerunner is usually of 3″ to $3\frac{1}{2}$″ nylon rope and measures perhaps 70 to 80 fathoms in length Between the forerunner and the main whale line is a manilla rope known as the " forehand," which forms a taper between the forerunner and the main whale line The main whale line is usually of 6″ to $6\frac{1}{2}$″ manilla rope and measures somewhere in the region of 600 fathoms

To attain a reasonable degree of accuracy with the harpoon gun of today, the firing range must be fairly close, and it is generally considered that the normal firing range is 20 to 30 fathoms—a shot of 55 to 60 fathoms is an extreme range and quite a chance shot When one takes into account the rising and falling of the catcher and the evasive manoeuvres of the whale, one appreciates all the skill, patience and seamanship that the gunners display in getting this cumbersome missile to strike a whale Unfortunately, even the best of gunners cannot forecast with any certainty where the harpoon will land on the whale, and consequently this rather variable target accuracy often leads to a very prolonged death of the whale I have actually witnessed many kills which have taken three or four harpoons to end the whale's death struggles In exceptional circumstances I have seen whales which have been hit by five or six harpoons before being finally killed This total has, I believe, on rare occasions been exceeded

The time from the first harpoon striking the whale until it is dead or partially dead and alongside the catcher may vary from 15 minutes to an hour and three quarters To this time one has to add the period for inflating the whale and for marking it with the company's flag—perhaps another 20 minutes if conditions are favourable

Ignoring the cruelty and primitivity of this method of killing whales, one cannot help feeling that there is much room for improvement, and I am confident that the introduction of airborne electrical whale killing equipment will accelerate the killing process and make it more humane

When the whale is alongside the catcher it is inflated with compressed air at a pressure of about 80 to 100 lbs per square inch In rough conditions the inflating and flagging process can be extremely tedious and take as much as an hour and a half Here again everything depends on the skill of the crew and the prevailing weather conditions

These inflating and flagging operations would be very much easier and more straightforward from a helicopter, and I am sure the helicopter would have absolutely no difficulty in keeping station over a whale even in the worst conditions It is, surely, no more difficult than rescuing a man from a life-boat in an open sea in a wind of 45 knots, where a tiny craft bobs about all over the place, rising and falling as much as 20 or 25 ft —a commonplace enough helicopter task

Once the whale is marked and flagged, it is left to be collected by one of the tow boats On some occasions the catcher returns at the end of its day's work to collect its own whales and tow them to the factory The number of times that this is done is usually determined by the bunker requirements of the individual catchers Sometimes finding the flagged whales can take a lot of time and even end in failure to find them The latter represents a serious loss both to the company and the catcher crew It has long been my view that the certainty of retrieving flagged whales can be greatly increased by the use of radio marker beacons Some research already has been made in this direction, and I feel sure that with the availability of the latest Ultra V H F emergency transmitter and the corresponding airborne installations, one might see the reconnaissance helicopter providing another valuable service and the general speeding up of whaling by finding flagged whales with this equipment

It has been proved beyond any doubt that the helicopter can approach whales unseen and unheard, to within 50 ft Beyond this range the whales are completely unaware of the helicopter's presence Closer than 50 ft the whales sense something unfamiliar and become frightened Whether it is the effect of the rotor down-wash striking the surface of the water in their immediate surroundings, or whether it is the noise or even the sight of the helicopter that disturbs them, remains in some doubt It is perhaps interesting to note that the helicopter can make whales move in any required direction, much the same as sheep and cattle can be herded into pens by a helicopter

In the closing chapter I would like to present a case for the introduction of airborne killing equipment, and to summarise what has already been achieved with helicopters in Antarctic whaling The latest shipborne electrical gear has achieved excellent results and it can now be said that instantaneous paralysation or death is inflicted directly the missile strikes the whale With this method of killing, the corpse retains its inherent positive buoyancy for four or five minutes from the moment of paralysation or death This is, in my opinion, ample time to inflate the whale from the helicopter It is reported that about 10% of the whales killed electrically do not float and it is my belief that the period of buoyancy is closely linked with when and where the missile strikes the whale during the " blowing " cycle after sounding Although I have no positive evidence to support this theory, I believe that whales struck in the stomach or lung area with an electrical missile always float and exert virtually no load on the harpoon line When the missile strikes towards the tail or anal region of the whale, the contortion of the whale's body collapses the stomach and lung regions, and forces the locked air to escape This results in the whale sinking One of the limitations of shipborne electrical equipment is that of target accuracy, and if this theory holds good then airborne electrical killing, with its target accuracy of a circle of 2 ft in diameter, will prevent whales from sinking I believe that the best position for striking the whale with an electrical missile is below the Dorsal bone and slightly behind the flippers This virtually pin-points the lung region It is my claim that many of the problems which have so long retarded the perfection of a shipborne electrical system disappear in the helicopter application The helicopter moves quickly and freely over large distances, and does not announce its approach, as does the catcher, by its propeller noises, and consequently can position itself within 30 ft of the whale within a few minutes from the time of first sighting Therefore it is argued that with proven airborne killing equipment the helicopter can take at least 90% of the whales sighted Moreover, firing from a steady platform on a virtually stationary target, one can guarantee great target accuracy—an accuracy hitherto undreamed of in catcher killing Obviously when large packs of whales are found it would require several helicopters in the same area to maintain the ratio of sightings to killings It must be remembered, however, that the rate of killing is ultimately controlled by the productive capacity of the factory which in most factory vessels varies between 2,800 to 3,300 barrels per day Last season I have said that one S 51 found 1,334 whales

Let us assume in the most pessimistic tone that the ratio of aerial sightings to aerial killings in the future is 2 1 and with last season's helicopter results as an example we would have killed 667 whales Of these 667, let us say 550 are Fin whales and only 117 are blue whales (a most adverse proportion, incidentally) Taking an average oil production of 60 barrels per fin and 150 barrels per blue whale, we arrive at a total whale oil production from the use of one helicopter for aerial killing of 50,550 barrels At £72 per ton the gross value would be £606,600 and with two or three helicopters equipped with killing equipment the results would be even more remarkable

One of the time wasting and costly features in present whaling is that whales are chased over large distances before being killed Such dispersal of corpses or flagged whales would not occur with airborne killing as it would take a helicopter about 15 minutes to kill, inflate and flag a whale from the time of first sighting, and it would never be more than a quarter of a mile from the position first sighted in It is claimed, therefore, that aerial killing will increase the factory utilisation and ensure a much more even delivery rate of whales

The introduction of airborne killing equipment means that one helicopter would do the work of four catchers at a fraction of the cost The accomplishment of such a plan means that there would be a transformation of the whaling business whereas the typical expedition today consists of a floating factory with 10—14 catchers, it is proposed to replace more than half the catcher fleet with six or eight large helicopters of the S 55 type The long term benefits of this development would mean cheaper oil production by the whole of the whaling industry, and this is offered at a time when present whaling costs make it hardly worth the gamble of sending out a whaling expedition to the Antarctic

Since the 1950/51 season it has been proved conclusively that helicopters are of immense value for whale and ice reconnaissance and catcher direction purposes Moreover, I would strongly urge the International Whaling Commission to introduce as soon as possible a blue whale unit quota per expedition within the present total catch quota of 15,500 blue whale units The catch of each expedition in the last five consecutive seasons might be taken as a fair basis on which to make such an assessment The agreement of the Commission to such a proposal would be a major step forward to preserve the whale stock in the Antarctic

In case the reasons for this scheme may be a little obscure, let me point out that at the moment there is an accepted but quite unofficial practice of turning a blind eye to a whale which is a foot or eighteen inches under size, and the gunners get the benefit of the doubt This laxity in putting the regulations into effect will cause, if it continues unchecked, a far-reaching and, I believe, serious depletion of the whale stock The productive value from a 68½—69-foot blue whale or from a 58½—59-foot Fin is vastly different from that of a 70½—71-foot blue whale or a 60½—61-foot Fin This difference is estimated to be about 30% The quota per expedition system which I am proposing, especially if used in conjunction with a whale measuring sight, would guarantee that only the larger whales of each species are killed An overall rise in production would be assured for each expedition and at the same time more effective protection would be given to the whale stock

Since the 1950/51 season it has been proved conclusively that helicopters are of immense value for whale and ice reconnaisance and catcher direction purposes

In these roles helicopters provided greater effectiveness in search coverage both for area and accuracy and show a tremendous reduction in an expedition's steaming time It has also been proved beyond any doubt that helicopters can be operated safely at high utilisation levels (400 to 500 hours per season) in the Antarctic from whaling factory vessels and find several thousands of whales even at times under the most adverse weather conditions In fact, helicopters have flown and found whales in weather conditions so severe that catcher killing operations were impracticable or even impossible Deck-landing and take-off techniques have proved that it is perfectly safe to operate when the deck is rising and falling 20 ft to 25 ft and rolling 10° at the same time Moreover, radio navigational equipment and techniques have been evaluated for long distance reconnaissance and flying through heavy snow and thick fog Flying crew requirements have been determined and best designs for flight deck, hangar and special appliances have been assessed The experimental phase is over, and helicopters are in the whaling industry to stay

APPENDIX

DRAFT SPECIFICATION OF HELICOPTER FOR ANTARCTIC WHALING

Disposable load 2,000 lb payload plus crew of two and fuel for 10 hours at maximum range speed

Engines Two or more Capable of maintaining level flight for five hours at maximum range speed with one engine inoperative

Hovering Performance With full load outside ground cushion on 1 hour power of all engines

Max range speed 75 knots at economical cruising power

Max level flight speed 100 knots at maximum continuous engine power

Controls Dual

Alighting gear Positive stable unlimited buoyancy available without delay Preferably sealed floating hull Wide track skids for deck landings

Flight handling qualities Positive static and dynamic stability in all normal states of flight Auto-pilot permissible

Starting qualities Rotor starting and stopping in winds up to 50 knots in any direction must not involve risks of blade interference Anti-coning device permissible The time interval from engine starting to take off must not exceed three minutes

Deck handling Blade folding to be possible, not exceeding five minutes for crew of two Alighting gear provided with deck handling wheels of which front wheels are castoring

Ice protection Reliable anti-icing or de-icing for main and auxiliary rotor(s) Engine air intake de-icing Cockpit heating and windscreen de-misting Clear view panel

Flying instrumentation To include full blind flying instrumentation

Navigational instrumentation To include gyrosyn compass and drift sight, distance measuring equipment, direction finding equipment

Approach instrumentation Blind approach facilities desirable

Communications equipment Reliable voice communication over sea by day at distances of not less than 150 nautical miles Reliable morse communication over sea by day over distances of not less than 300 miles

Safety equipment Dinghy, immersion suits, marking equipment, emergency communication equipment, etc

Discussion

The Chairman The time is getting on, but I am sure that we all now know very much more about whaling than we did before One of the lessons from this afternoon's Papers is that new fields are being discovered for helicopter operation which will ultimately be for the good of industry as a whole

I have the names of certain people who have indicated their desire to take part in the discussion, but before calling on them I should like briefly to refer to Lieut-Commander Spedding's opening remarks about the interest of the Royal Navy in helicopters That interest dates back well prior to 1943 In fact to the early years of Autogiro development The very first time that a rotary wing aircraft was landed on a ship of any sort was during October, 1931, when Lieut Pride, a United States Navy pilot, carried out trials on the U S Carrier *Langley* In 1935 with a C 30 Autogiro, I myself made several landings and take-offs from the Italian cruiser *Fiume*, and I was the first rotary-wing pilot to land on a British carrier, the *Courageous*, in mid-1935 The Royal Navy's interest continued and an order was placed for five C 40 "direct take-off" Autogiros and a Naval flight formed before the war In 1941, I was sent to America on behalf of the Admiralty and with a Pitcairn PA39 Autogiro made the very first landing and take-off from a merchant ship, the *Empire Mersey* I indicate that as a background of the Royal Navy's interest, which Commander Spedding could not enlarge upon, because probably he was not aware of it Some of us who have been in this business for a long time ought to let people know more about what has happened in the past, so that the historical background may be properly built up